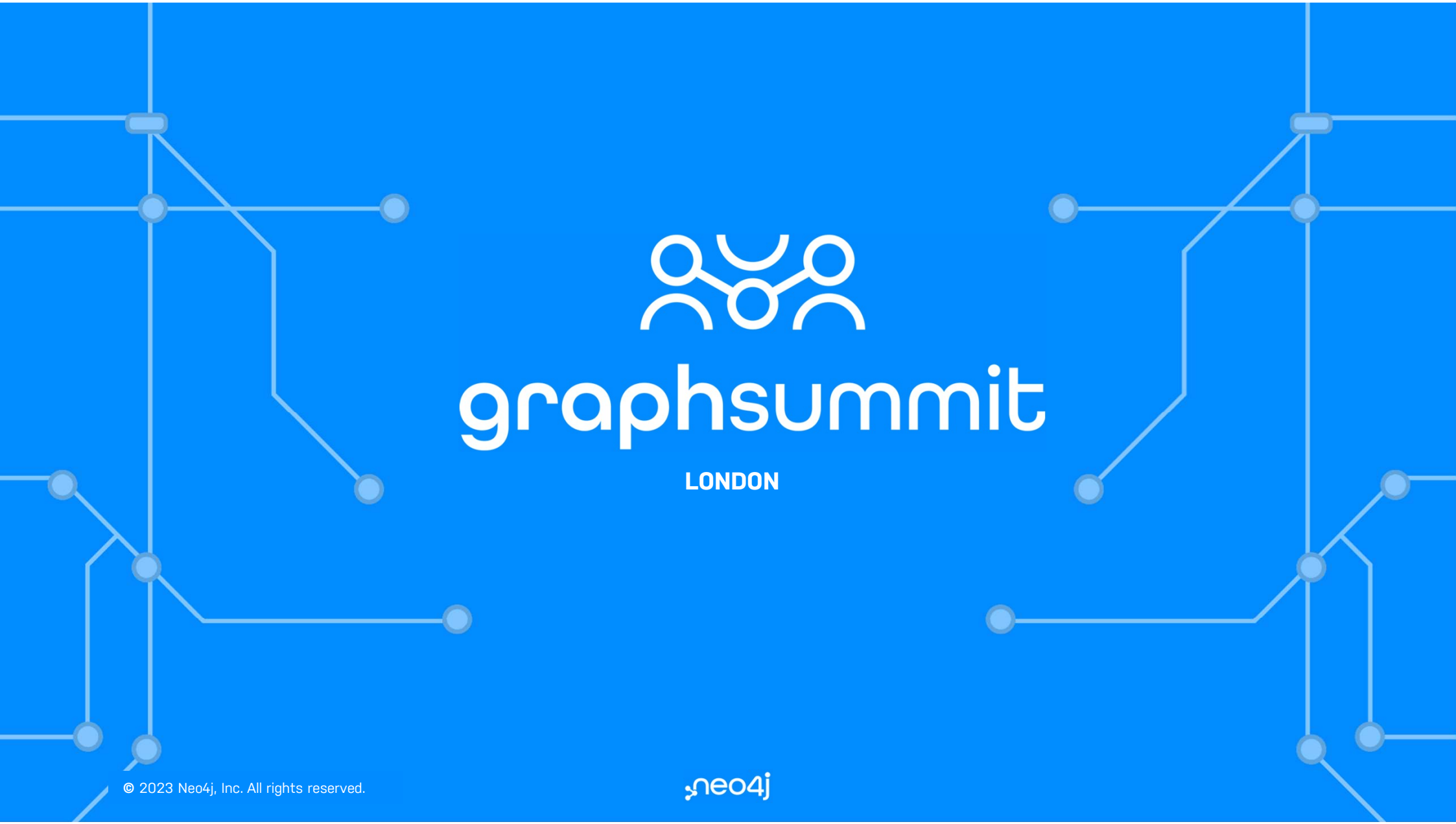

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Building a Graph Solution

Using a real world digital twin data set

neo4j

Agenda

1. Logistics
2. Introduction
3. Use Case Explanation
4. Modeling

BREAK

5. Building the solution
6. Q & A

Logistics

WIFI Access:	
Restrooms:	
Chargers:	
Material for the workshop:	https://github.com/cskardon/gsummit2023

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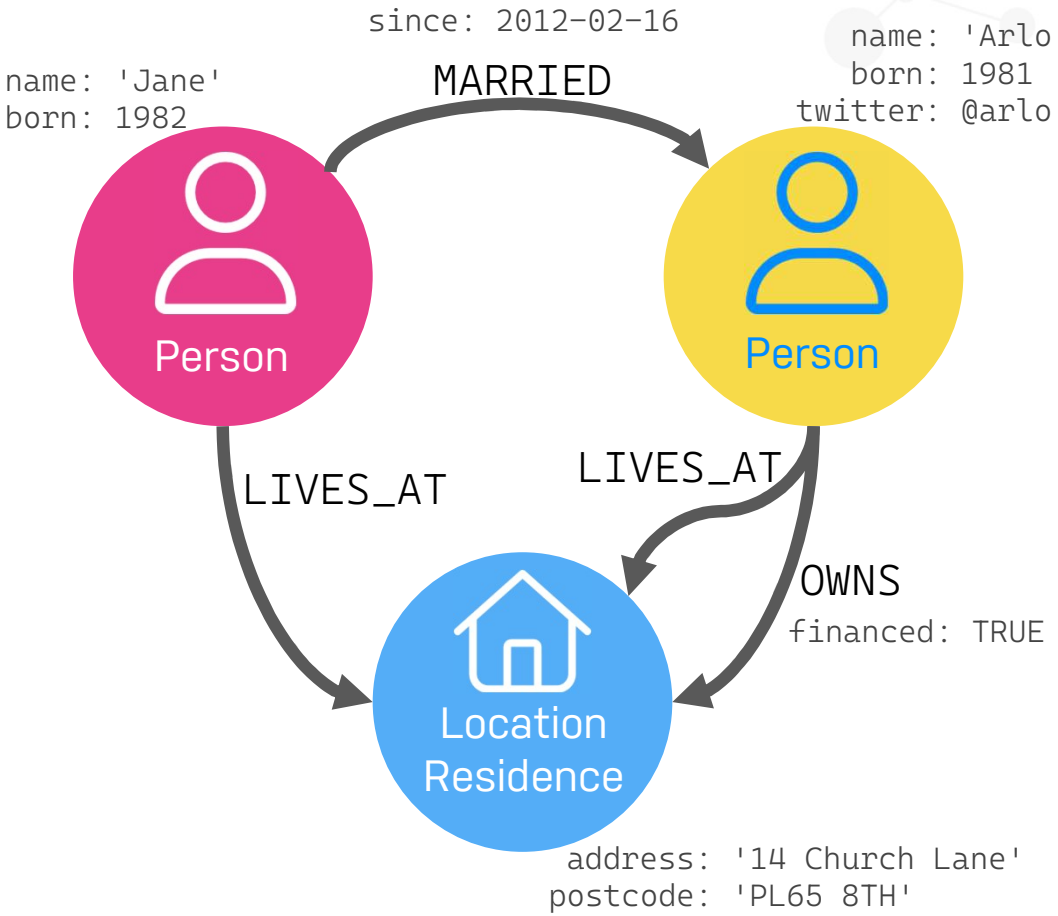
Introduction

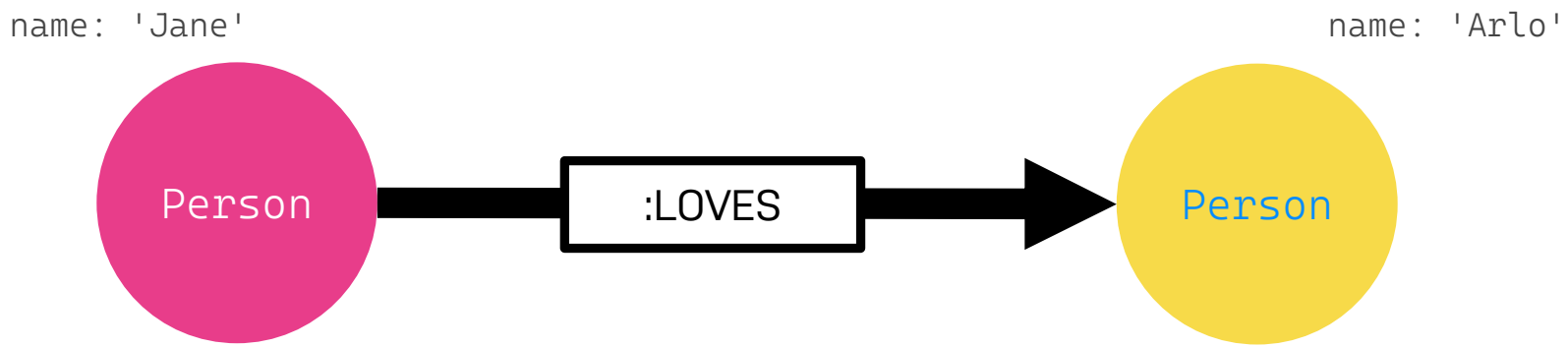
A short overview of the Neo4j Product

Labeled Property Graph Model Components

- **Nodes**
  - Represent objects in the graph
- **Labels**
  - Group nodes
  - Shape the domain
- **Relationships**
  - Relate nodes by type and direction
- **Properties**
  - Name-value pairs that can go on nodes and relationships
  - Can have indexes and composite indexes (types: String, Number, Long, Date, Spatial, byte and arrays of those)



Cypher: powerful and expressive query language

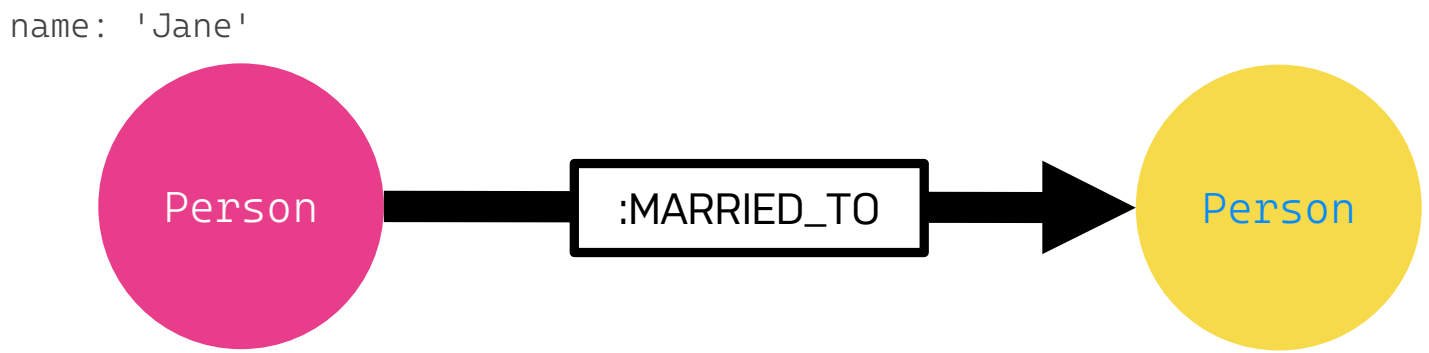


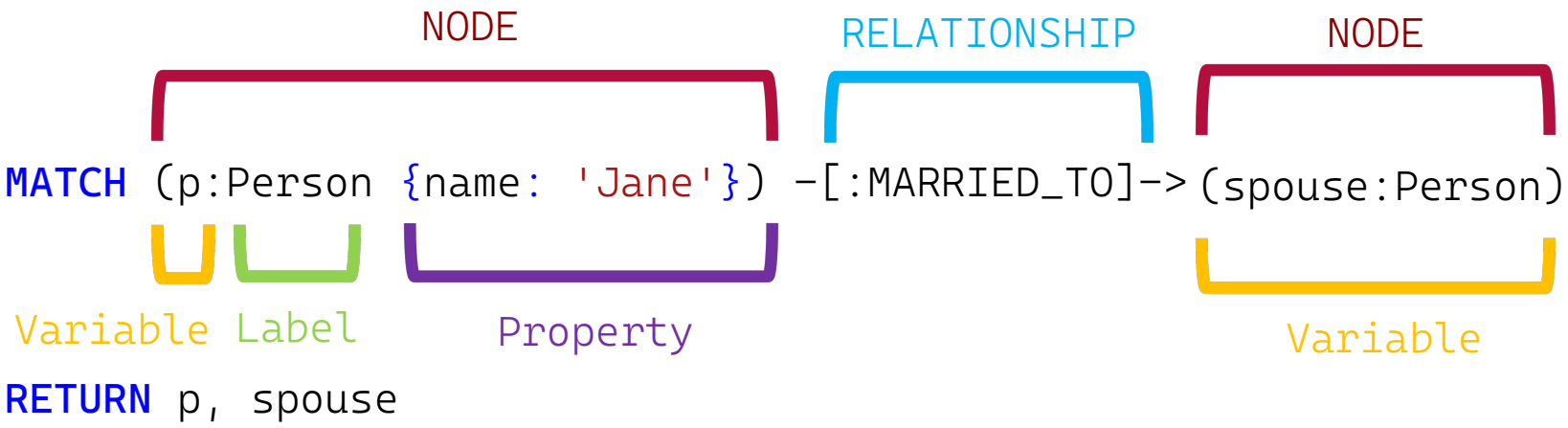

```
CREATE (:Person {name: 'Jane'})-[:LOVES]->(:Person { name: 'Arlo' })
```

NODE — RELATIONSHIP — NODE

Label — Property — Label — Property

Cypher: Matching





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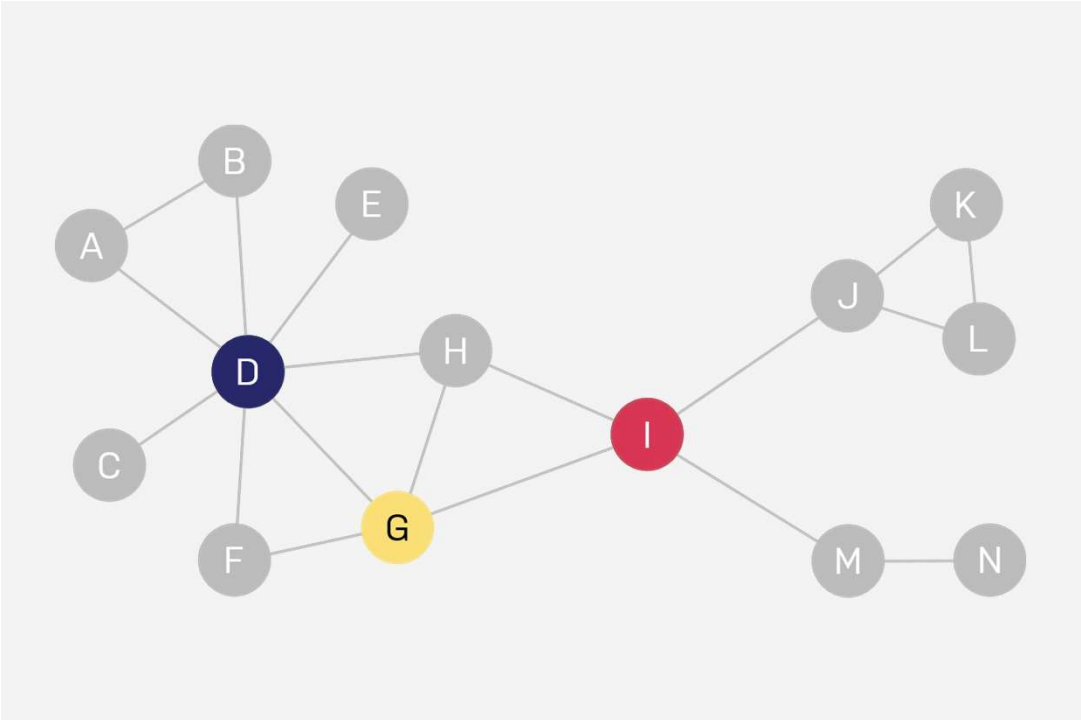
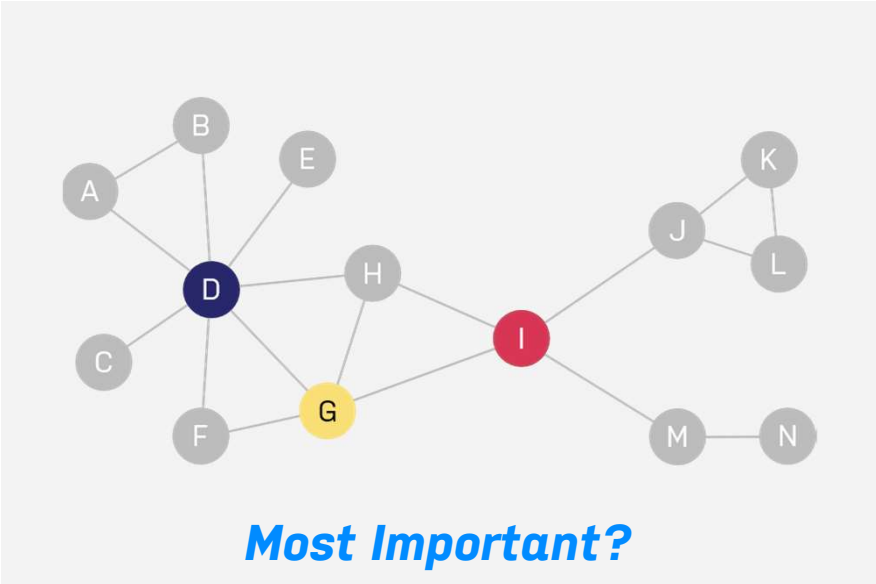
Neo4j Graph Data Science

Pop Quiz



Which of the coloured nodes would be considered the ***most "important"?***

Graphs Contain Implicit Knowledge



D

D has the highest degree centrality (7)
This is the most connected individual in the network. If important is now well you are personally known, you pick D.

G

G has the highest closeness centrality (0.52)
Information will disperse through the network more quickly through this individual. If you need to get a message out rapidly, choose G.

I

I has the highest betweenness centrality (0.59)
This person is an efficient connector of other people. Risk of network disruption is higher if you lose this individual

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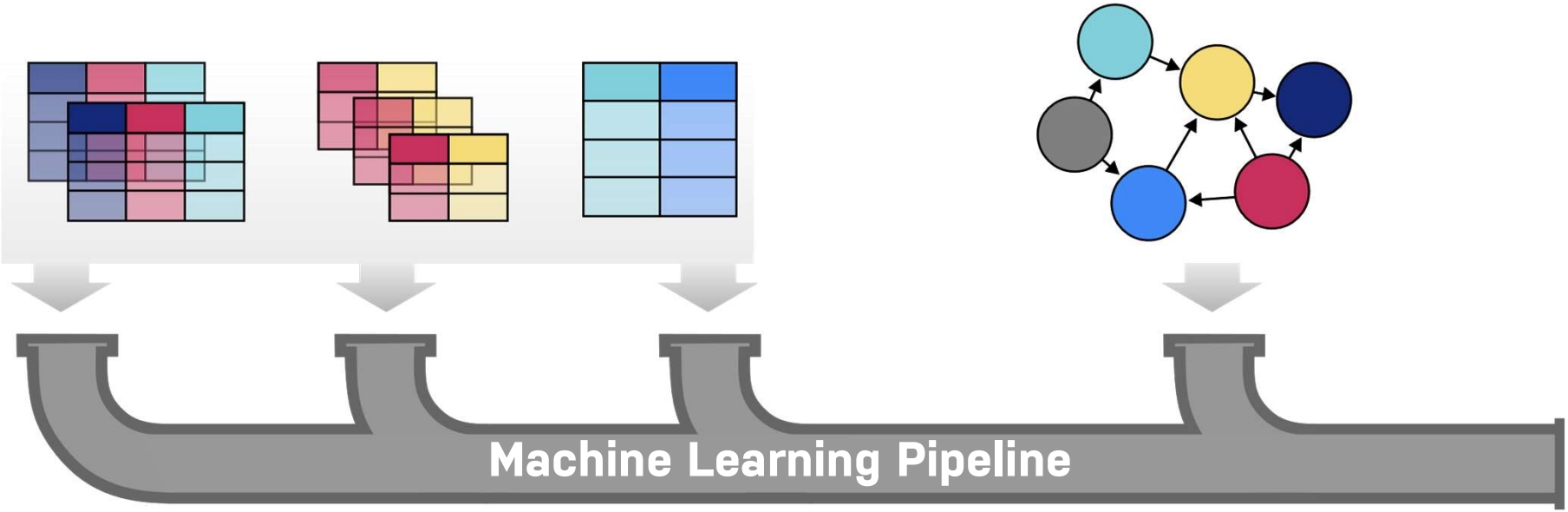
Better Predictions With Data You Already Have

- Traditional ML ignores network structure because it's difficult to extract
- Graphs use relationships to unlock otherwise unattainable predictions
- Add graphy data to existing ML pipelines to increase accuracy



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Graph Algorithm Categories

Pathfinding & Search

Finds optimal paths or evaluates route availability and quality

Centrality / Importance

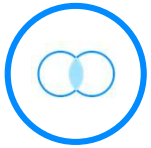
Determines the importance of distinct nodes in the network

Community Detection

Detects group clustering or partition

Link Prediction

Estimates the likelihood of nodes forming a future relationship



Similarity

Evaluates how alike nodes are by neighbours and relationships

Embeddings & ML

Compute low-dimensional vector representations of nodes in a graph, and allow you to train supervised machine learning models

Available Algorithms (as of 2.3)

Pathfinding & Search

- Delta-Stepping Single Source Shortest Path
- Dijkstra Source-Target Shortest Path
- Dijkstra Single Source Shortest Path
- A* Shortest Path
- Yen's Shortest Path
- Breadth First Search
- Depth First Search
- Random Walk
- Minimum Weight Spanning Tree
- Minimum Directed Steiner Tree
- Minimum Weight k-Spanning Tree
- All Pairs Shortest Path

Centrality / Importance

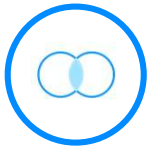
- Page Rank
- Article Rank
- Eigenvector Centrality
- Betweenness Centrality
- Degree Centrality
- Closeness Centrality
- Harmonic Centrality
- Hyperlink Induced Topic Search (HITS)
- Influence Maximization

Community Detection

- Louvain
- Label Propagation
- Weakly Connected Components
- Triangle Count
- Local Clustering Coefficient
- K-1 Colouring
- Modularity Optimization
- K-Means Clustering
- Leiden
- Strongly Connected Components
- Speaker-Listener Label Propagation
- Approximate Maximum k-cut
- Conductance Metric
- Modularity Metrix

Link Prediction

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



Similarity

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

Embeddings & ML

- FastRP
- GraphSAGE
- Node2Vec
- HashGNN
- Node Classifaction Pipelines
- Link Prediction Pipelines
- Node Regression Pipelines

https://neo4j.com/docs/graph-data-science/current

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Visualisation

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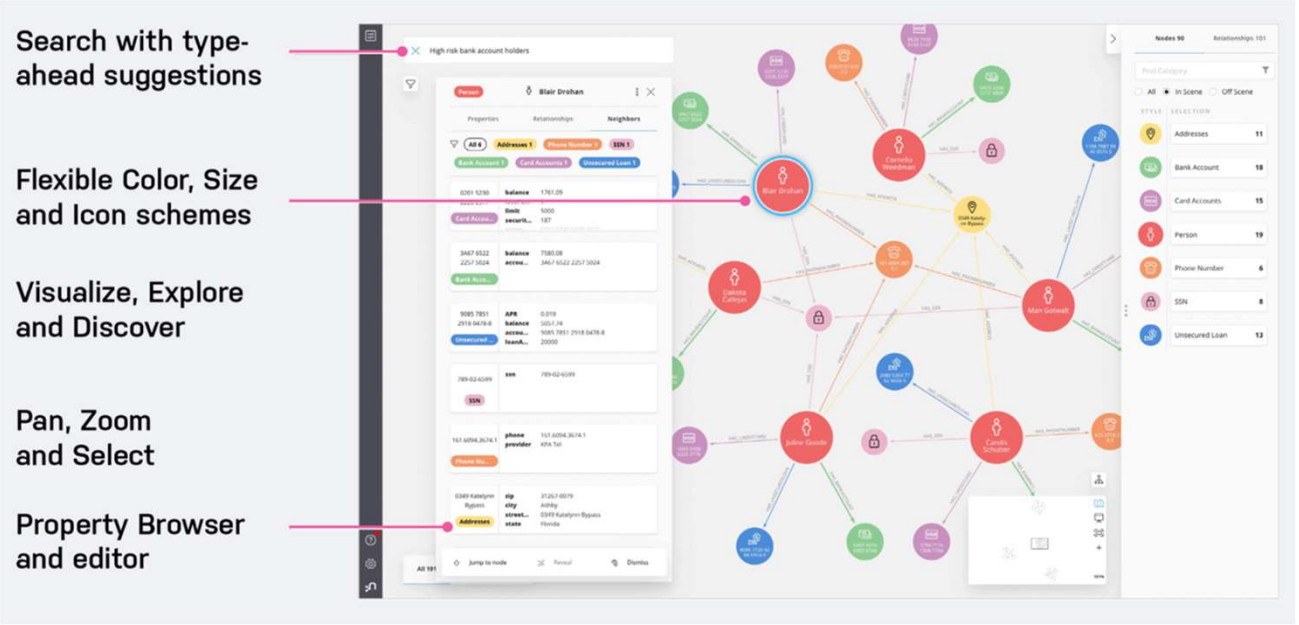
Data Visualization with Neo4j Bloom

Neo4j's user-friendly graph database visualization, exploration and collaboration tool.

- Visually explore graphs
- Prototype faster
- Visualize and discover
- Easy for non-technical users



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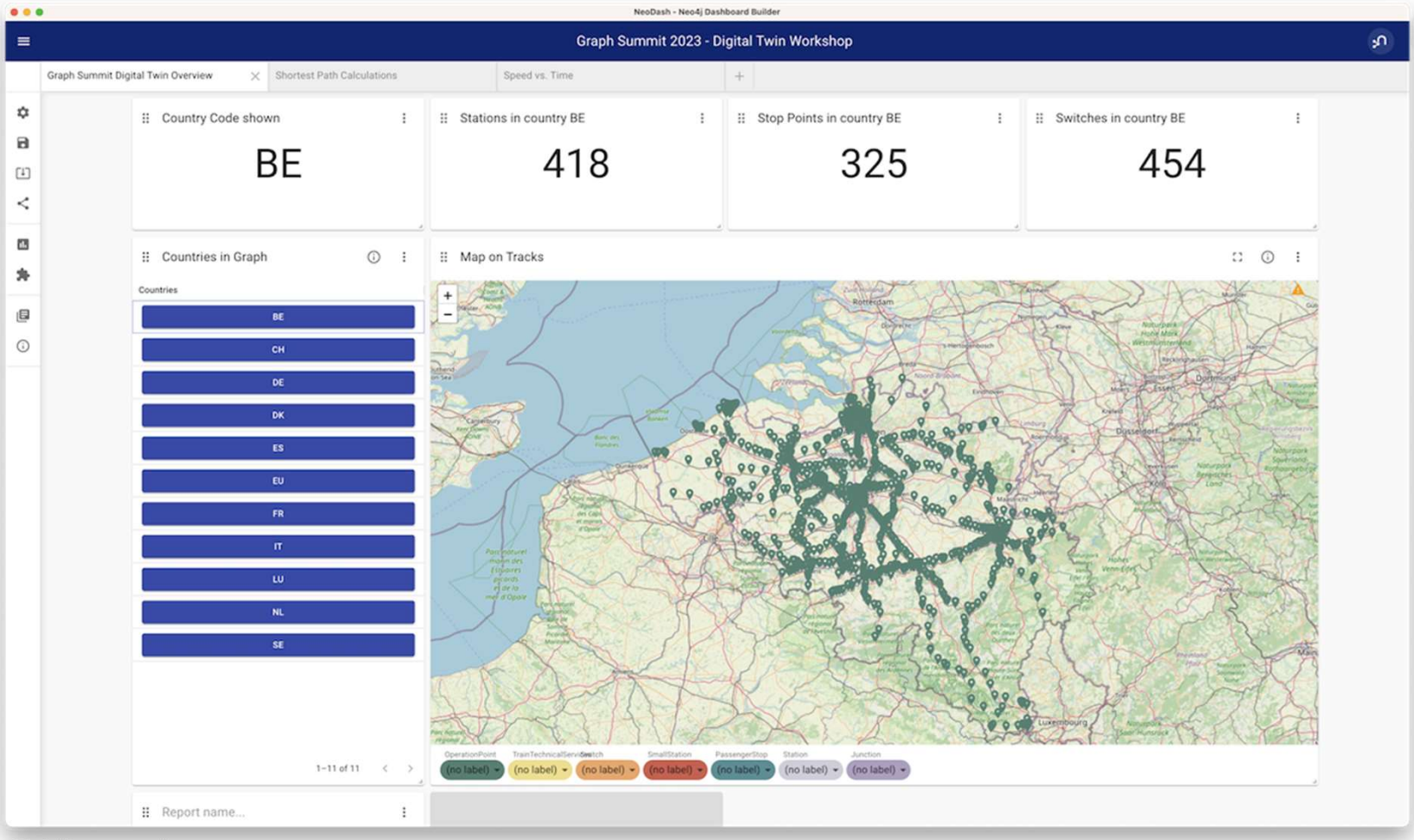
NeoDash - Dashboarding with Graph Data



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Use Case Explanation

Digital Twin - An Overview

What is a **Digital Twin?**

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A Digital Twin is a digital representation of a … real-world physical product, system, or process … that serves as the effectively indistinguishable digital counterpart of it for practical purposes, such as simulation, integration, testing, monitoring and maintenance.

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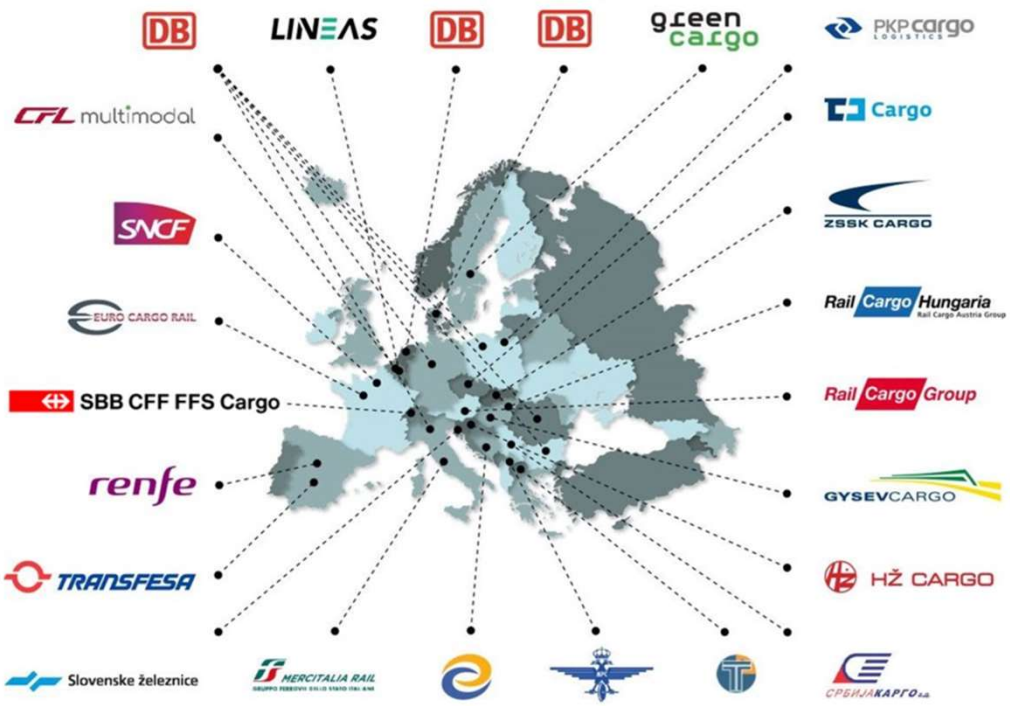
It has been done before

- **Challenge:** Legacy technology could not section and analyse train journeys
- **Solution:** Neo4j Knowledge Graph
- Identify and avoid bottlenecks

EU Rail Network



Why do we need a Digital Twin?

Improved efficiency

Optimize operations and reduce costs by simulating different scenarios and making data-driven decisions.

Enhanced safety

Identify potential hazards and test safety measures to improve safety for passengers and employees.

Predictive maintenance

Monitor asset condition in real-time, predict maintenance needs, and increase asset lifespan.

Improved customer experience

Simulate disruptions and help proactively address issues to enhance the customer experience and increase satisfaction.

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Modeling the solution

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What is graph data modeling?

Collaborative effort where the application domain is analysed by **stakeholders** and **developers** to come up with the optimal model for use with Neo4j.

Who are the stakeholders?

- Business analysts
- Architects
- Managers
- Project leaders
- Data Scientists

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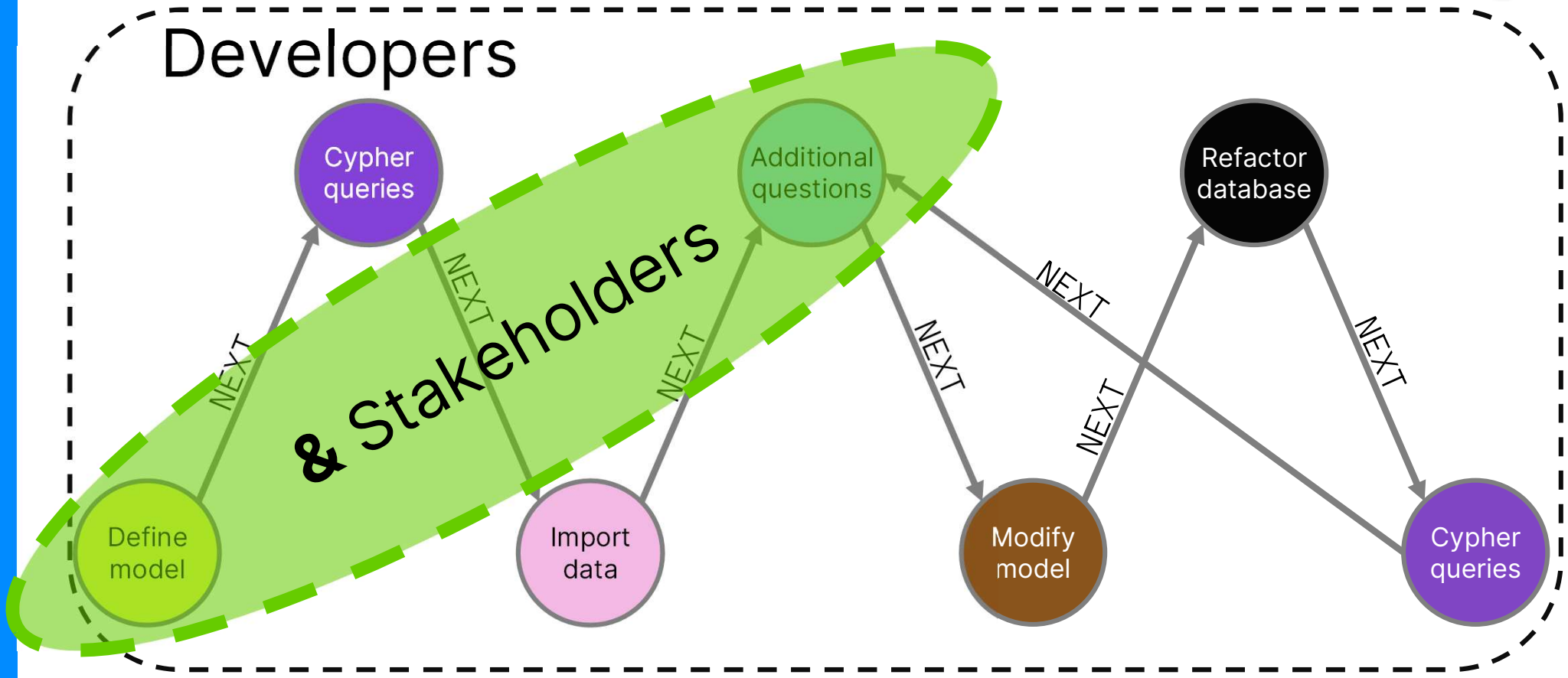
Graph data modeling workflow



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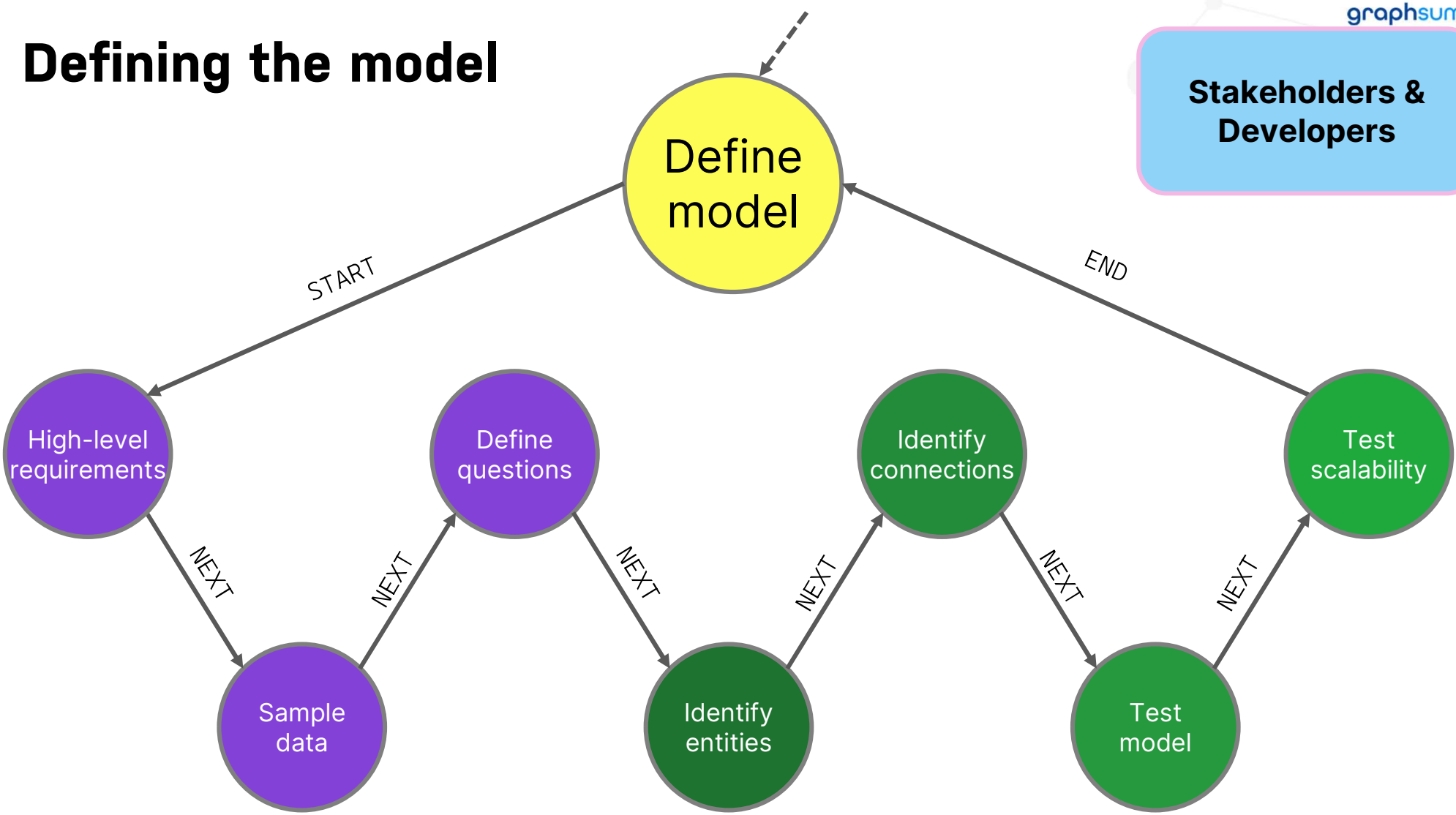
Defining the model



Stakeholders & Developers

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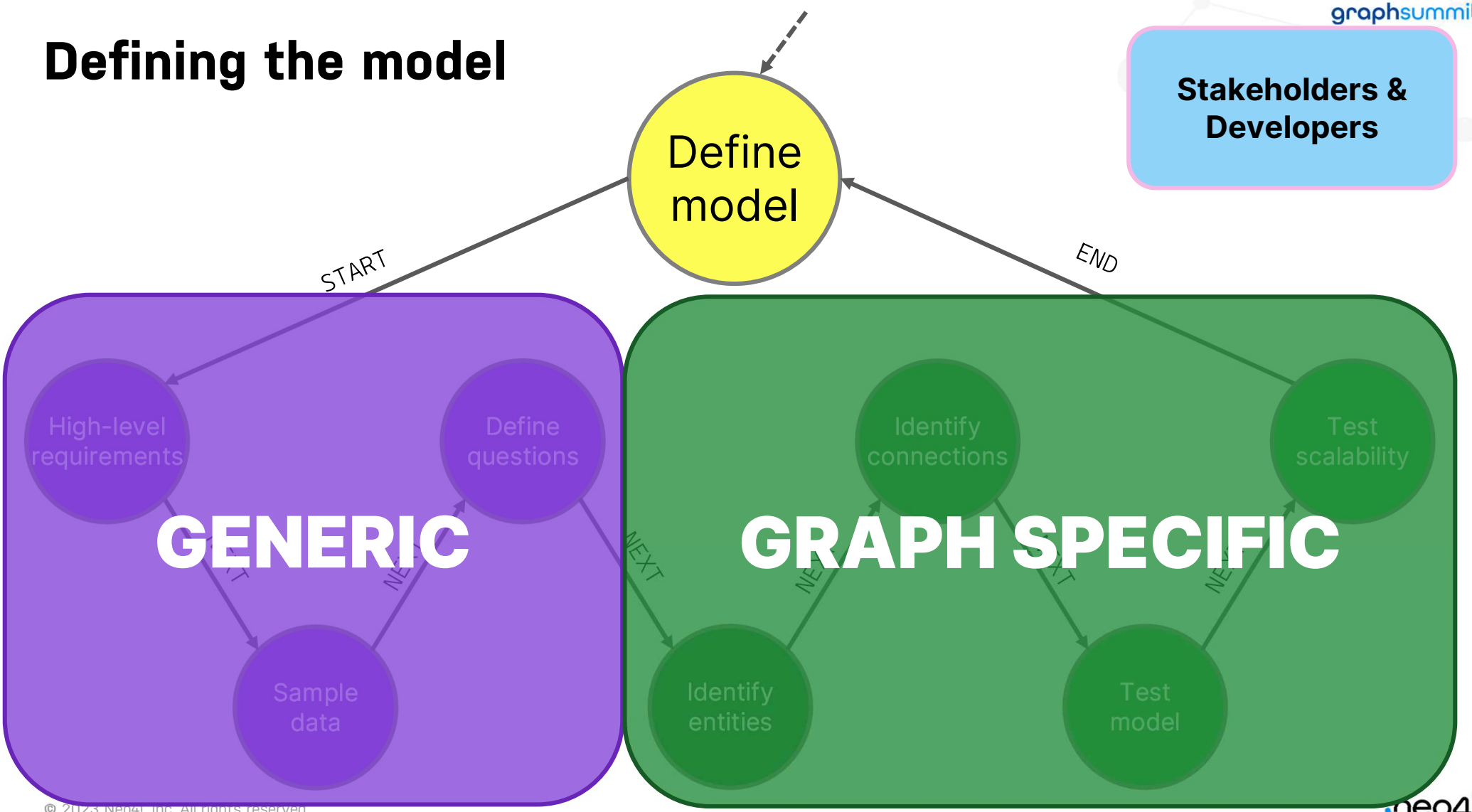
Defining the model



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Modeling – Step 1

Domain knowledge – High level requirements

We've already got this!

- Normally…
- In this case we've talked about the Domain
- You will have the knowledge of your own Domain

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Modeling – Step 2

Sample Data

Get Sample Data

Static Rail Network*

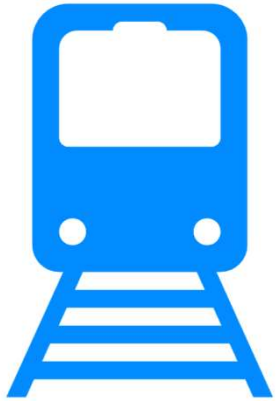
- Sections of lines
  - Length,
  - Speed
- Operational Points (Stations etc)
  - Geolocation information,
- Points of Interest (POI) along lines

**Source: Register of Infrastructure (RINF) - https://data-interop.era.europa.eu/*

Operational Points (OP) - Data Explanation

CSV Header titles:

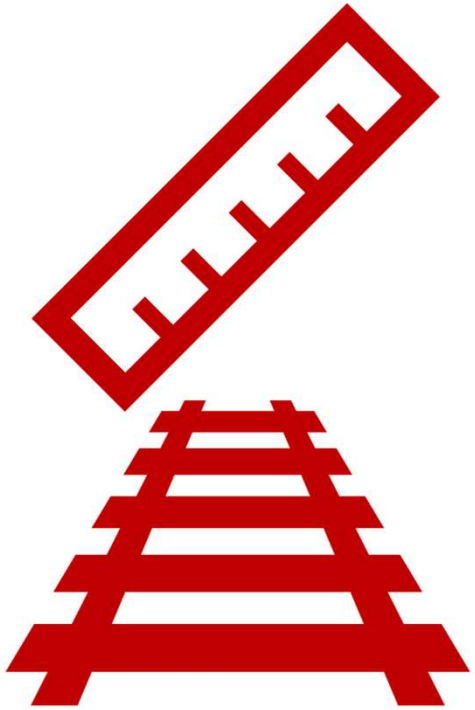
- `id (string)`: The identifier of the OP
- `extralabel (string)`: The type of the OP (Station, Switch, Border Point…)
- `name (string)`: The name of the OP
- `latitude (float)`: The latitude of the OP
- `longtitude (float)`: The longitude of the OP



Section Length Data

CSV Header titles:

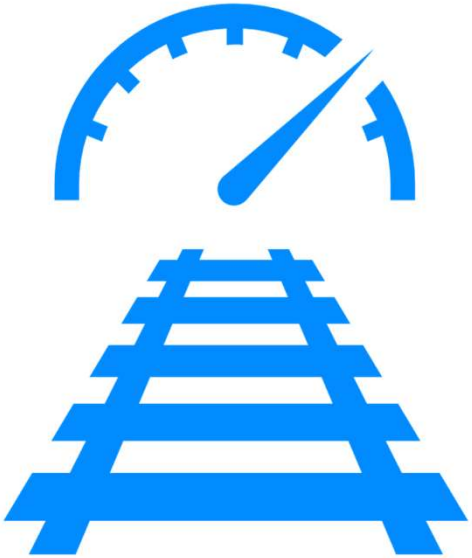
- `source (string)`: The identifier of the *start* OP for the section
- `target (string)`: The identifier of the *end* OP for the section
- `sectionlength (float)`: The distince (in Kilometers) of the section



Section Speed Data

CSV Header titles:

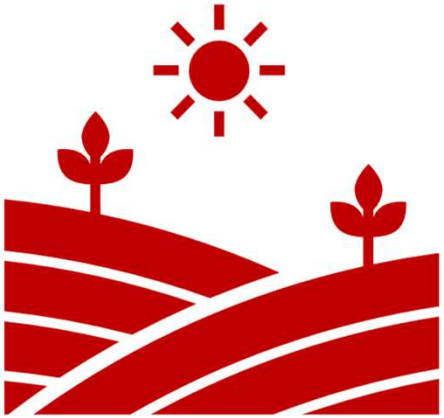
- `source (string)`: The identifier of the *start* OP for the section
- `target (string)`: The identifier of the *end* OP for the section
- `trackspeed (float)`: The maximum speed allowed on that section



Point of Interest (POI) Data

CSV Header titles:

- `CITY (string):` The name of the City the POI is in, or close to
- `POI_DESCRIPTION (string):` A short description of of the POI
- `LINK_FOTO (string):` A link to a picture of the POI
- `LINK_WEBSITE (string):` A link to a web page about the POI
- `LAT (float):` The latitude of the POI
- `LONG (float):` The Longitude of the POI



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Modeling – Step 3

Domain Questions

Data Modeling – Example Domain Questions

1. What is the route from Operational Point X to Operational Point Y?
    - What's the quickest way to get a repair crew from Technical Services to a given Switch?
2. What is an alternative route if an Operational Point on a route is closed?
    - A Switch *is* broken and we need to reroute Trains
3. How many routes are affected if I need to upgrade an Operational Point?
    - A Switch needs to be upgraded to support the network
4. What POIs are along a route?
    - Can we make revenue from referral commissions? Find busier routes during tourism season?

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Modeling – Step 4

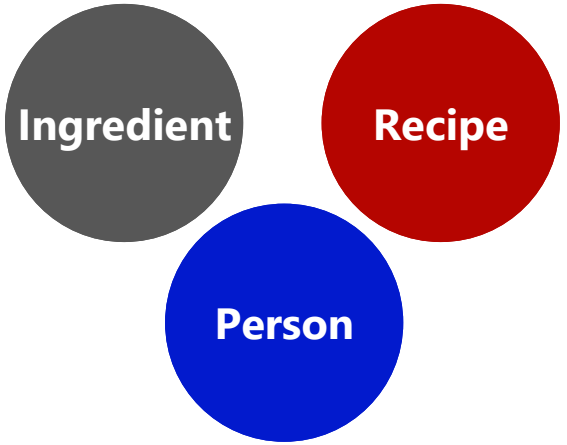
Identifying entities and connections

Identify Entities from Questions

Entities are the **nouns** in the domain questions:

1. What **ingredients** are used in a **recipe**?

2. Who is married to this **person**?

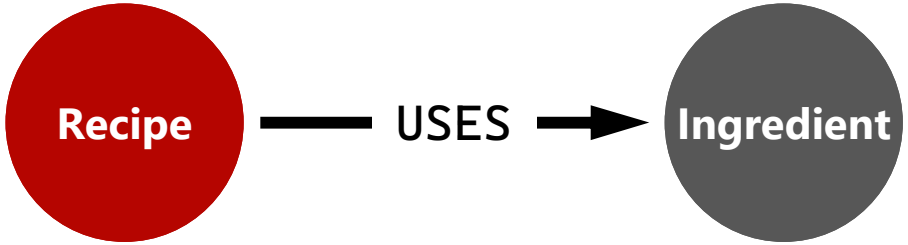


- The generic *nouns* often become labels in the model
- Use *domain knowledge* deciding how to further group or differentiate entities

Identify Connections between Entities

Connections are the **verbs** in the domain questions:

- What ingredients are **used** in a recipe?



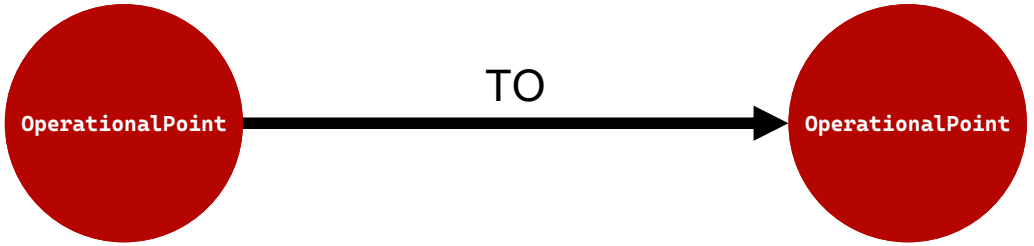
- Who is **married** to this person?

Using our Questions – Question 1

1. What is the route from Operational Point X to Operational Point Y?
    - What's the quickest way to get a repair crew from Technical Services to a given Switch?
2. What is an alternative route if an Operational Point on a Section is closed?
    - A Switch is broken and we need to reroute Trains
3. How many routes are affected if I need to upgrade an Operational Point?
    - A Switch needs to be upgraded to support the network
4. What POIs are near Station Operational Points on a Section?
    - Can we make revenue from referral commissions? Find busier routes during tourism season?

Using our Questions – Question 1 – Model

1. What is the route from Operational Point X to Operational Point Y?
    - What's the quickest way to get a repair crew from Technical Services to a given Switch?

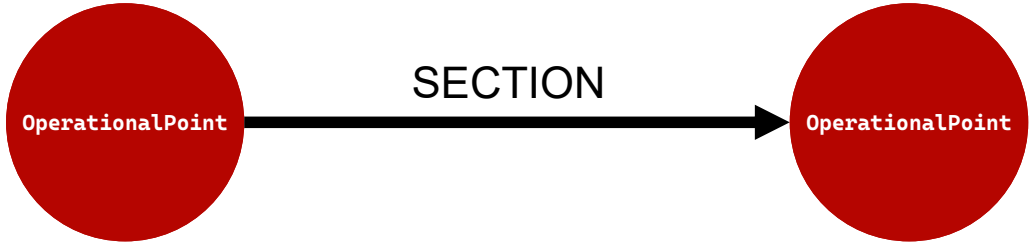


Using our Questions – Question 2

1. What is the route from Operational Point X to Operational Point Y?
    - What's the quickest way to get a repair crew from Technical Services to a given Switch?
2. What is an alternative route if an Operational Point on a Section is closed?
    - A Switch is broken and we need to reroute Trains
3. How many routes are affected if I need to upgrade an Operational Point?
    - A Switch needs to be upgraded to support the network
4. What POIs are near Station Operational Points on a Section?
    - Can we make revenue from referral commissions? Find busier routes during tourism season?

Using our Questions – Question 2 – Model

2. What is an alternative route if an Operational Point on a Section is closed?
    - A Switch is broken and we need to reroute Trains

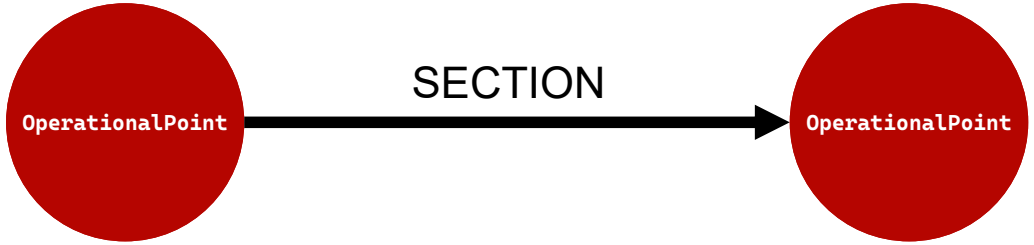


Using our Questions – Question 3

1. What is the route from Operational Point X to Operational Point Y?
    - What's the quickest way to get a repair crew from Technical Services to a given Switch?
2. What is an alternative route if an Operational Point on a Section is closed?
    - A Switch is broken and we need to reroute Trains
3. How many routes are affected if I need to upgrade an Operational Point ?
    - A Switch needs to be upgraded to support the network
4. What POIs are near Station Operational Points on a Section?
    - Can we make revenue from referral commissions? Find busier routes during tourism season?

Using our Questions – Question 3 – Model

3. How many routes are affected if I need to upgrade an Operational Point?
    - A Switch needs to be upgraded to support the network

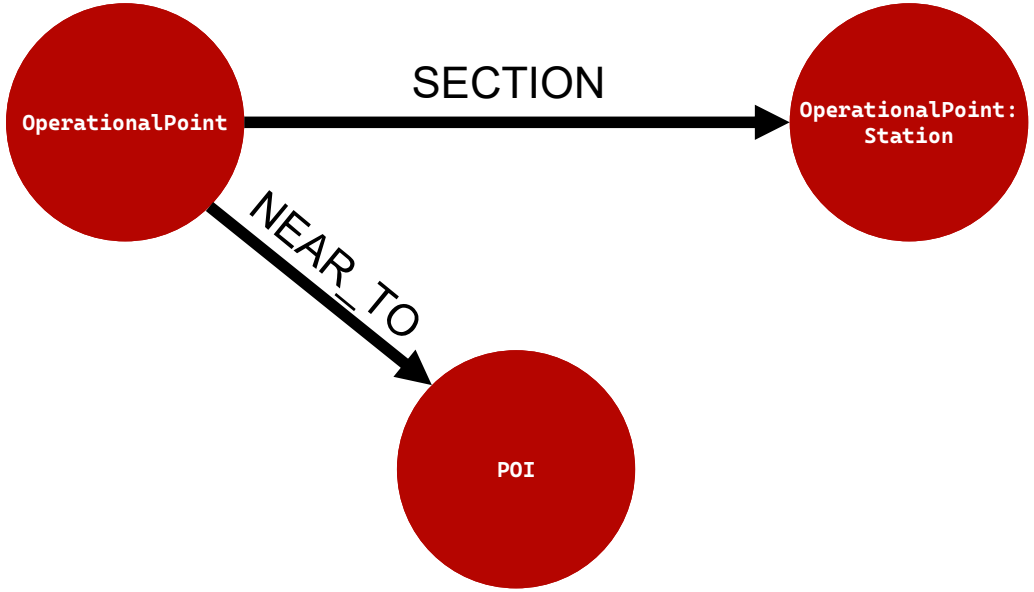


Using our Questions – Question 4

1. What is the route from Operational Point X to Operational Point Y?
   - What's the quickest way to get a repair crew from Technical Services to a given Switch?
2. What is an alternative route if an Operational Point on a Section is closed?
   - A Switch is broken and we need to reroute Trains
3. How many routes are affected if I need to upgrade an Operational Point?
   - A Switch needs to be upgraded to support the network
4. What POIs are near Station Operational Points on a Section?
   - Can we make revenue from referral commissions? Find busier routes during tourism season?

Using our Questions – Question 4 – Model

4. What POIs are near Station Operational Points on a Section?
    - Can we make revenue from referral commissions? Find busier routes during tourism season?



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Before we go further – Environment for later

- Neo4j Desktop
- Sandbox

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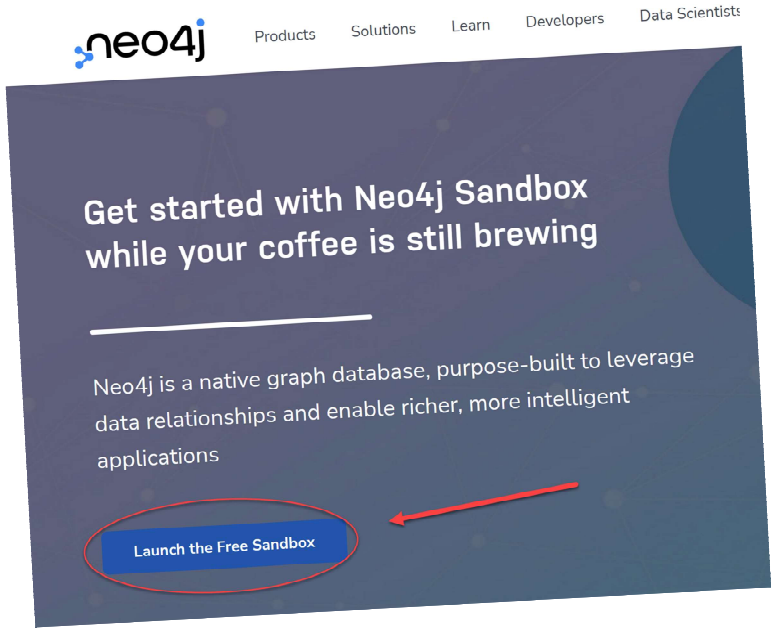
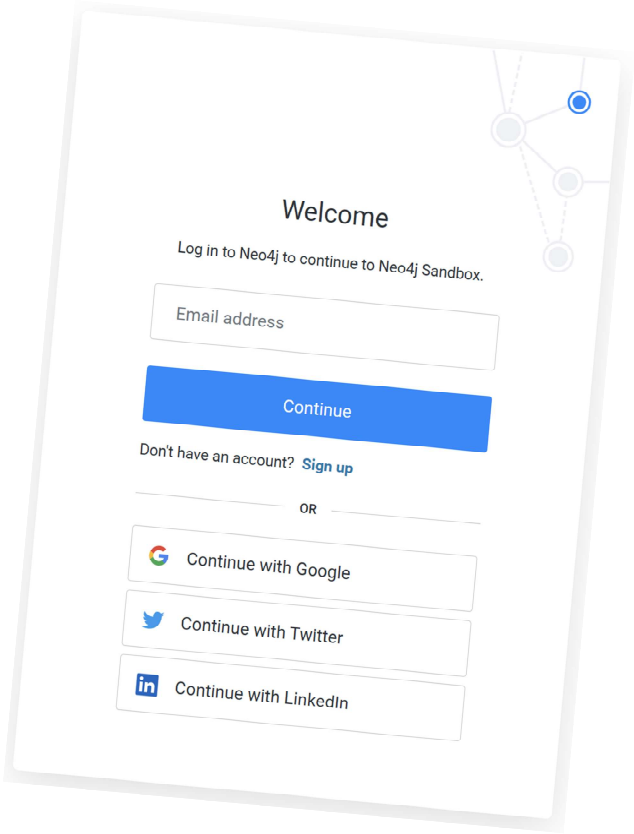
Before we go further – Sandbox Login

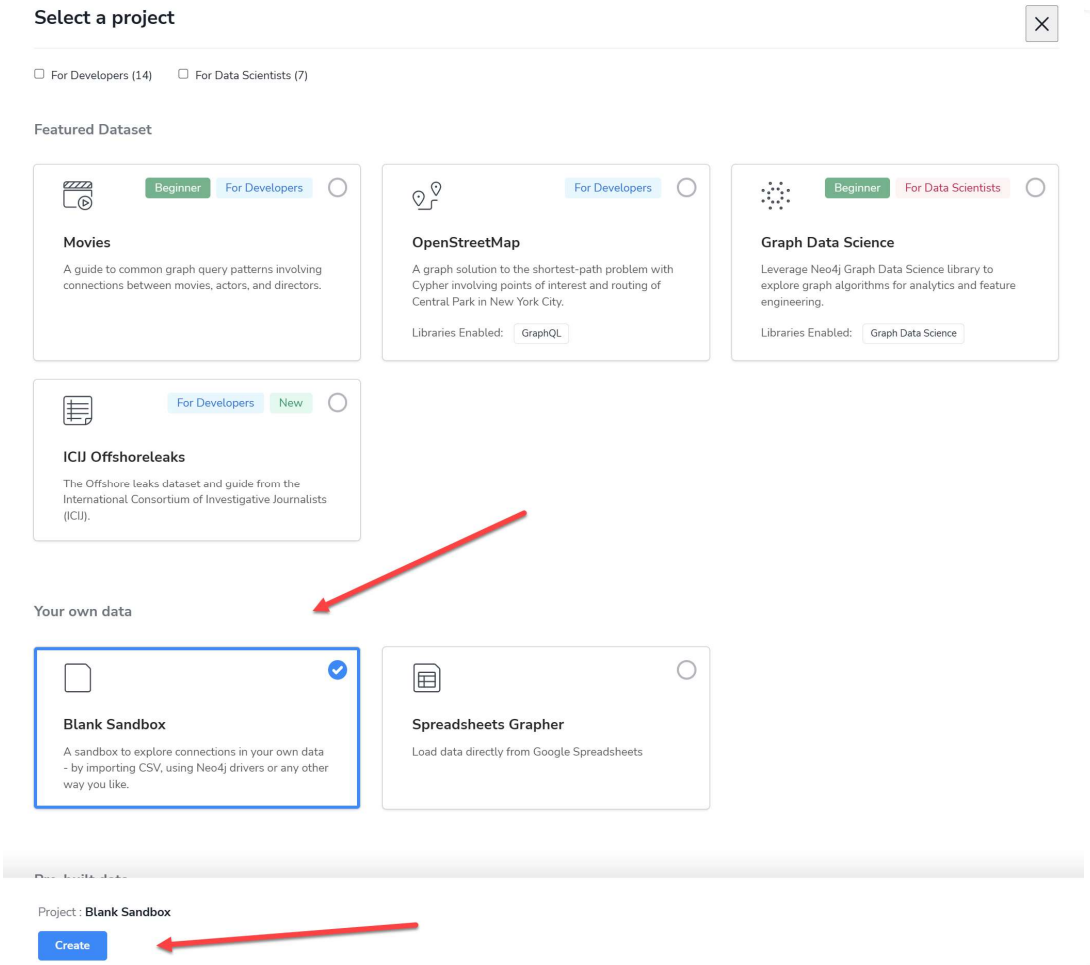
- Create a sandbox for later
- https://sandbox.neo4j.com/





Before we go further – Blank Sandbox

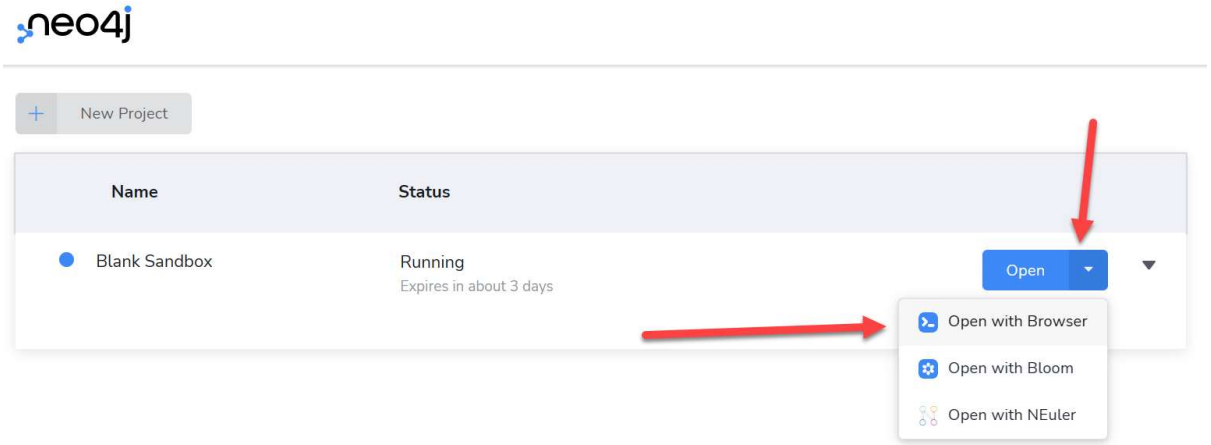
- https://sandbox.neo4j.com/
- Create a ‘Blank Sandbox'



Workshop

Examples

- Go to the Neo4j Sandbox you created earlier (or Desktop!)
  - https://sandbox.neo4j.com/
- 'Open with Browser'



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Get the code

- Open the Github page:
- https://github.com/cskardon/gsummit2023

neo4j

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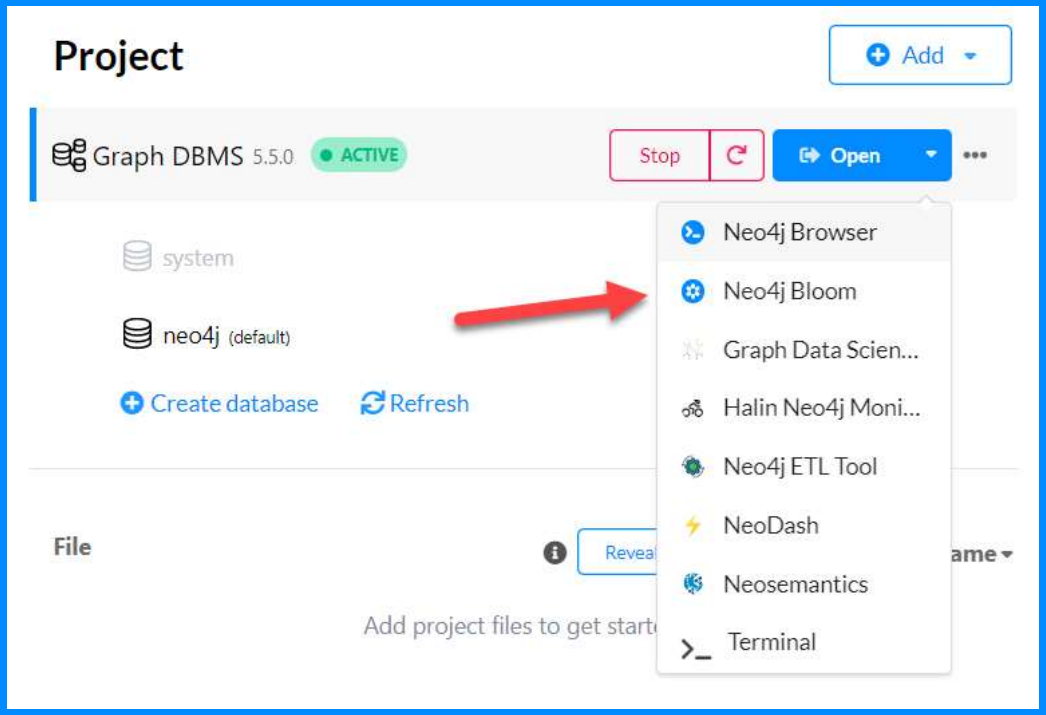
Visualisation - Bloom

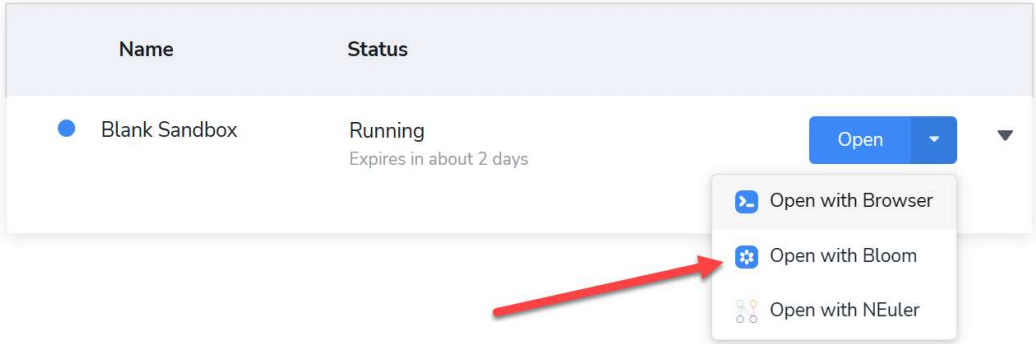
Bloom - Desktop

- Open Bloom

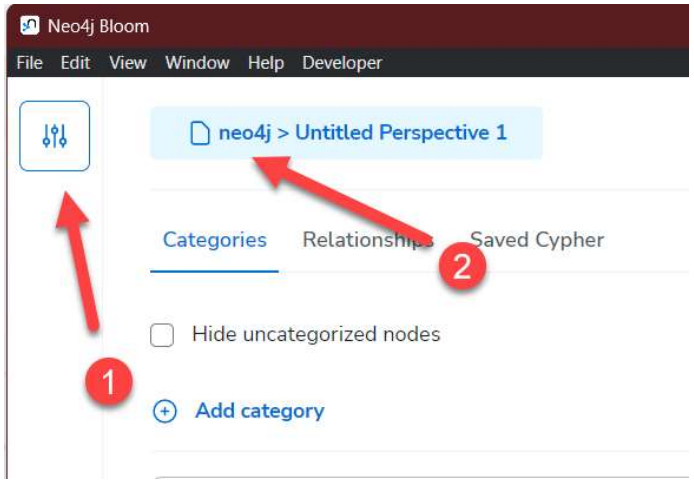


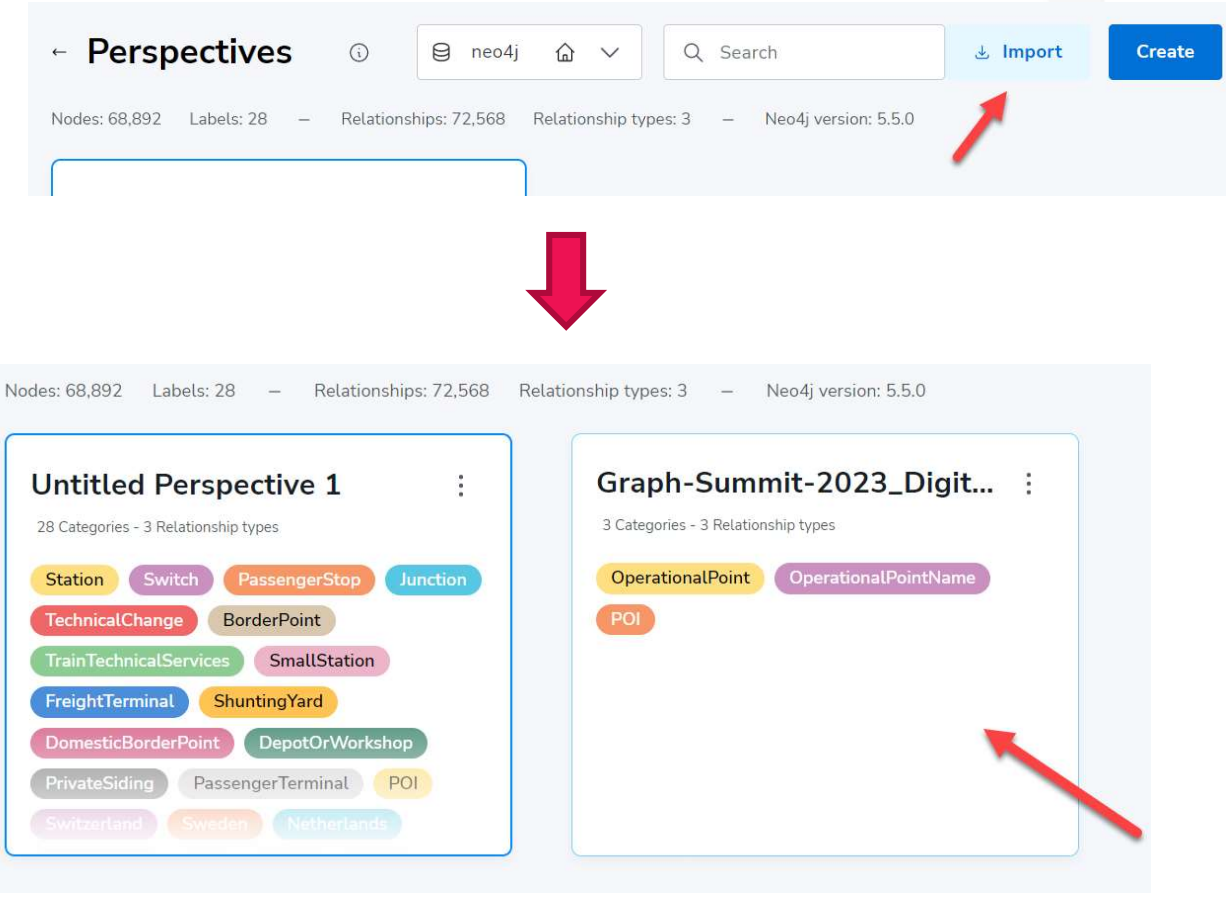
Bloom - Sandbox

- Open Bloom



Bloom – Import Perspective





graphsummit

Visualisation - NeoDash

graphsummit

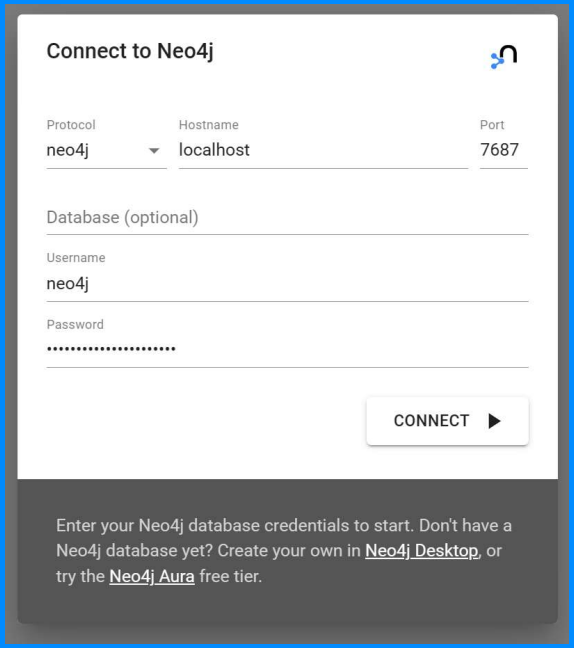
NeoDash

- Open NeoDash:
  - http://neodash.graphapp.io/

neo4j

NeoDash - Desktop

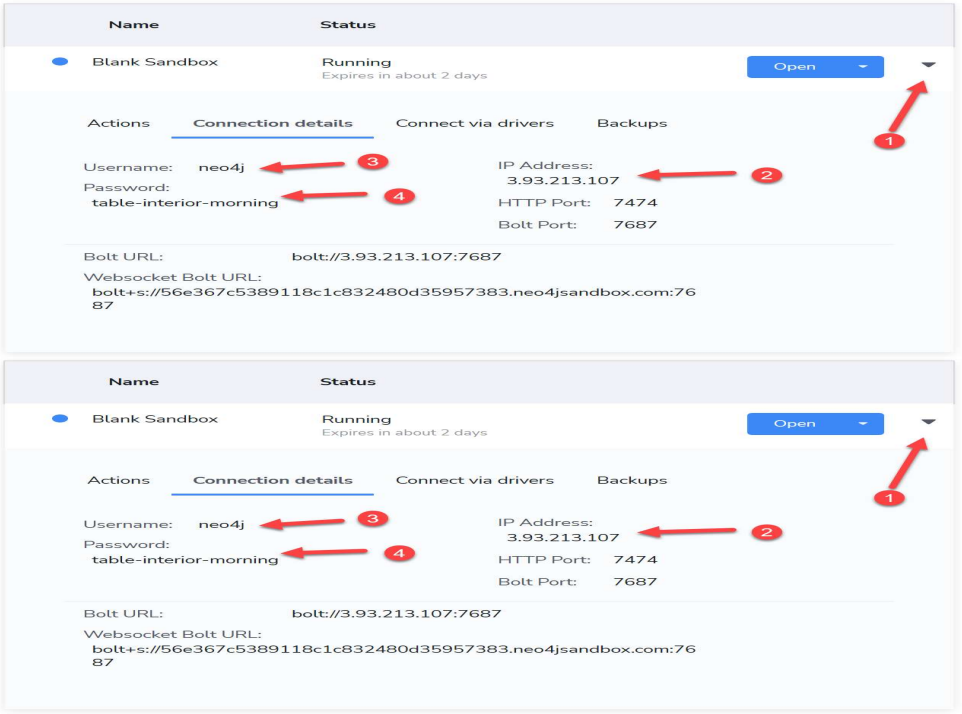
- Host: localhost
- User: neo4j
- Password: YOURS!



graphsummit

NeoDash - Sandbox

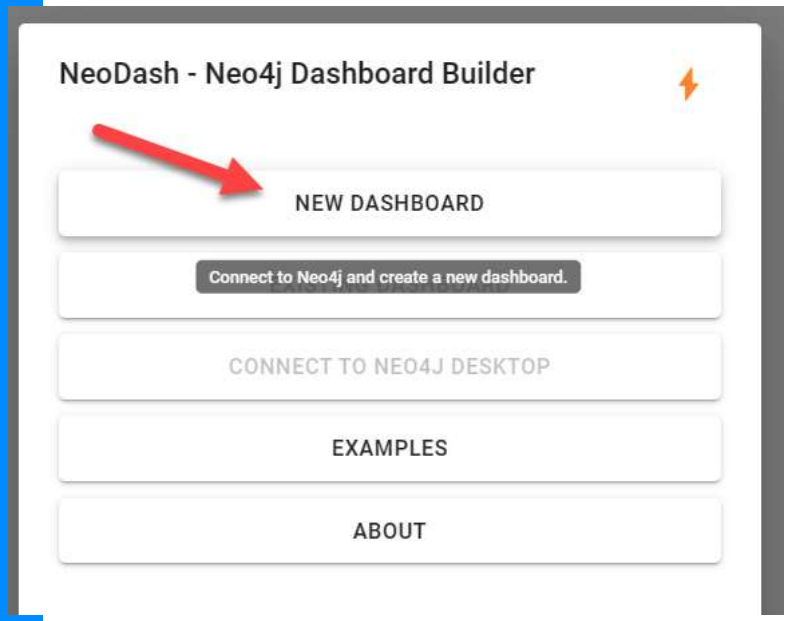
- Open Sandbox
- Get connection details

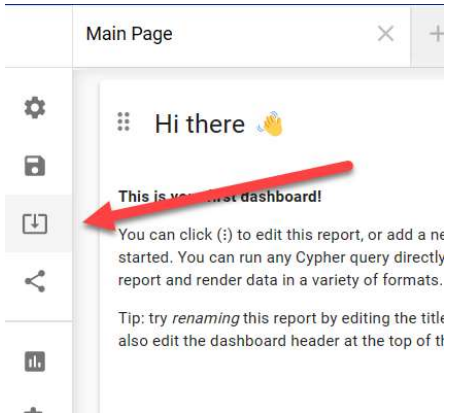


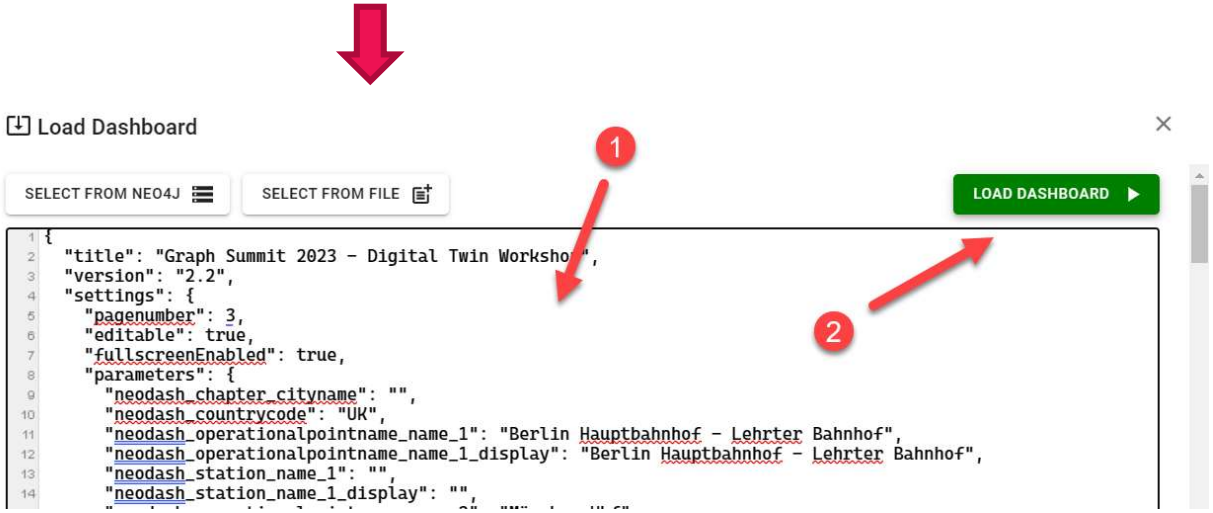
neo4j

NeoDash – Import Dashboard

- Create New Dashboard
- Import from Source files







Q & A