

# Introduction to Graph Databases

# Overview

At the end of this module, you should be able to:

- Describe what a graph database is.
- Describe some common use cases for using a graph database.
- Describe how real-world scenarios are modeled as a graph.



# Relational databases cannot handle relationships

1

## Wrong Model

They cannot model or store relationships without complexity

2

## Degraded Performance

Speed plummets as data grows and as the number of joins grows

3

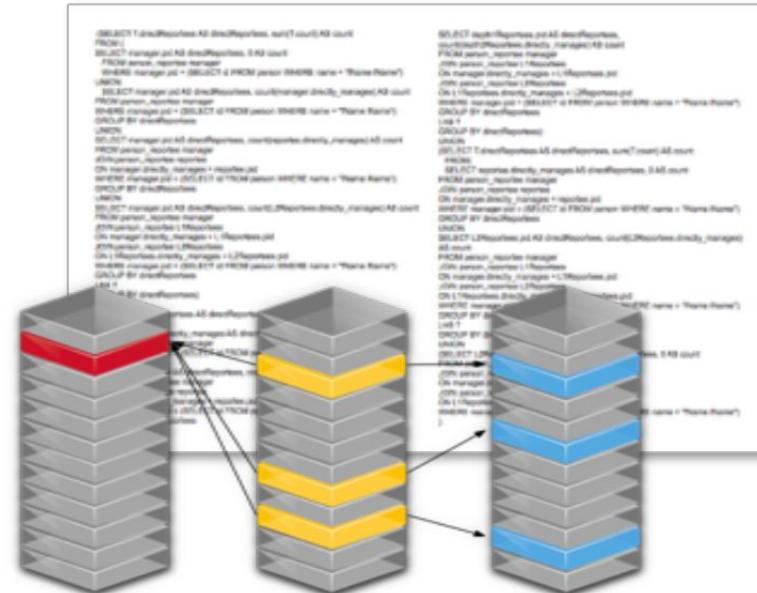
## Wrong Language

SQL was built with Set Theory in mind, not Graph Theory

4

## Not Flexible

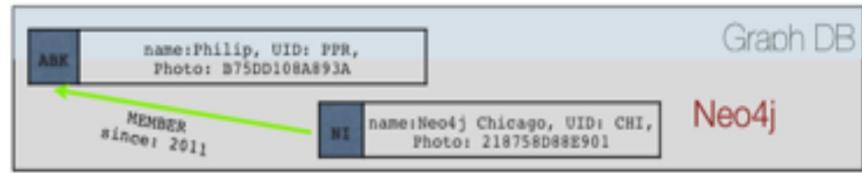
New types of data and relationships require schema redesign



# NoSQL databases cannot handle relationships

## 1 Wrong Model

They cannot model or store relationships without complexity



## 2 Degraded Performance

Speed plummets as you try to join data together in the application

0x235C	{name:Philip, UID: PPR, Groups: [CHI,SFO,BOS]}	Document DB
0xCD21	{name:Neo4j Chicago, UID: PPR, Members:[PPR,RB,NL], Where:(city:Chicago, State: IL)}	MongoDB CouchDB

## 3 Wrong Languages

Lots of wacky “almost sql” languages terrible at “joins”

	Name	UID	Members	Groups	Photo	Column Family
0x235C	Philip	PPR		CHI, SFO, BOS	B75DD108A893A	HBase Cassandra
0xCD21	Neo4j Chicago	CHI	PPR, RB, NL		218758D88E901	

## 4 Not ACID

Eventually Consistent means Eventually Corrupt

0x235C	Philip	Kv-Value
0xCD21	Neo4j Chicago	
0x2014	[PPR,RB,NL]	membase
0x3821	(CHI, SFO, BOS)	Riak
0x3890	B75DD108A	Redis

# What is a graph database?

## 1 Right Model

Graphs simplify how you think

## 2 Better Performance

Query relationships in real time

## 3 Right Language

Cypher was purpose built for  
Graphs

## 4 Flexible and Consistent

Evolve your schema seamlessly  
while keeping transactions

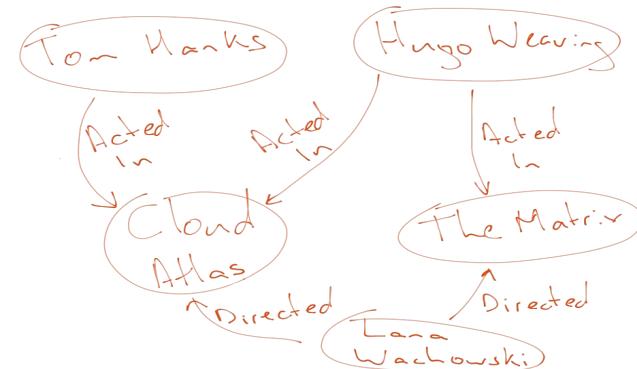


Agile, High Performance  
and Scalable without Sacrifice

ACID

# The case for graph databases

- Intuitiveness
  - Create and maintain data in a logical fashion
  - Lessening the translation “friction”
  - Whiteboard model is the physical model
- Speed
  - Development
  - Execution
- Agility
  - Naturally adaptive, schema optional database
- Cypher query language for graphs
  - Less time writing queries
  - More time asking the next questions about the data



# SQL vs Cypher

## SQL Query

```
(SELECT T.directReports AS directReports, sum(T.count) AS count
FROM (
SELECT manager.pid AS directReports, 0 AS count
FROM person_reports manager
WHERE manager.pid = (SELECT id FROM person WHERE name = "Name Name")
UNION
SELECT manager.pid AS directReports, count(manager.directly_manages) AS count
FROM person_reports manager
WHERE manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
UNION
SELECT T.manager.pid AS directReports, count(T.reports.directly_manager) AS count
FROM person_reports manager
JOIN person_reports T ON manager.pid = T.manager.pid
WHERE T.manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
UNION
SELECT manager.pid AS directReports, count((SELECT reports.directly_manager) AS count)
FROM person_reports manager
JOIN person_reports T ON manager.pid = T.manager.pid
WHERE T.manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
UNION
SELECT T.manager.pid AS directReports, count((SELECT reports.directly_manager) AS count)
FROM person_reports manager
JOIN person_reports T ON manager.pid = T.manager.pid
JOIN person_reports reports ON manager.pid = reports.manager.pid
WHERE T.manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
| AS T
GROUP BY directReports)
UNION
SELECT T.directReports AS directReports, sum(T.count) AS count
FROM (
SELECT SELECT reports.directly_manager AS directReports, 0 AS count
FROM person_reports manager
WHERE manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
UNION
SELECT reports.pid AS directReports, count(reports.directly_manager) AS count
FROM person_reports reports
JOIN person_reports T ON reports.pid = T.manager.pid
WHERE T.manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
| AS T
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UNION
SELECT reports.pid AS directReports, count(reports.directly_manager) AS count
FROM person_reports manager
JOIN person_reports reports ON manager.pid = reports.manager.pid
WHERE T.manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
| AS T
GROUP BY directReports)
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SELECT manager.directly_manages AS directReports, 0 AS count
FROM person_reports manager
WHERE manager.pid = (SELECT id FROM person WHERE name = "Name Name")
GROUP BY directReports
| AS T
GROUP BY directReports)
```

## Cypher Query

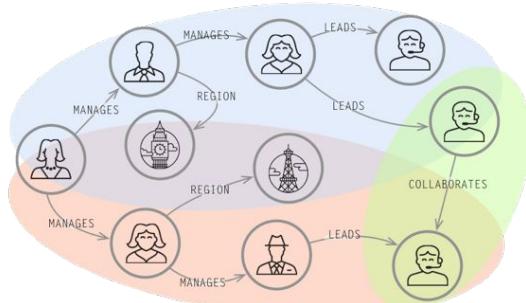
```
MATCH (boss)-[:MANAGES*0..3]->(sub),
      (sub)-[:MANAGES*1..3]->(report)
WHERE boss.name = "John Doe"
RETURN sub.name AS Subordinate,
       count(report) AS Total
```

Find all direct reports and  
how many people they manage,  
up to 3 levels down

# Use cases

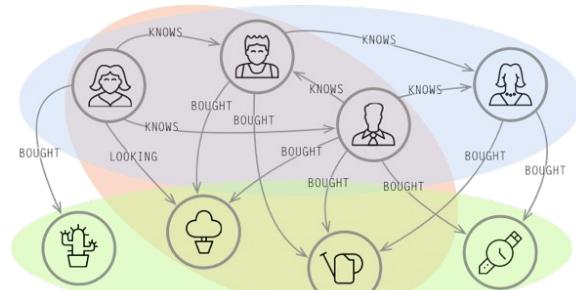
## Internal Applications

- Master data management
- Network and IT operations
- Fraud detection



## Customer-Facing Applications

- Real-Time Recommendations
- Graph-Based Search
- Identity and Access Management

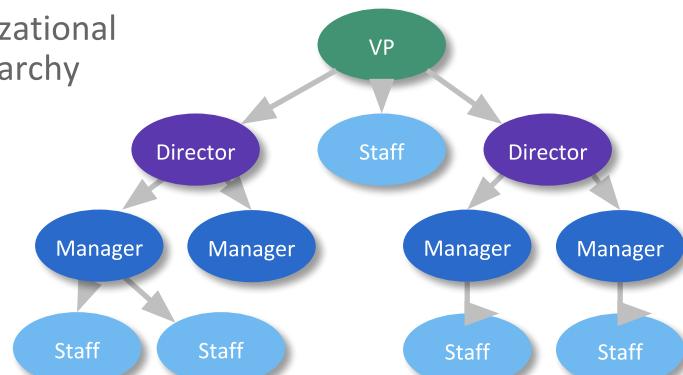


# Use case: Real-time recommendations



# Use cases: Master data management.

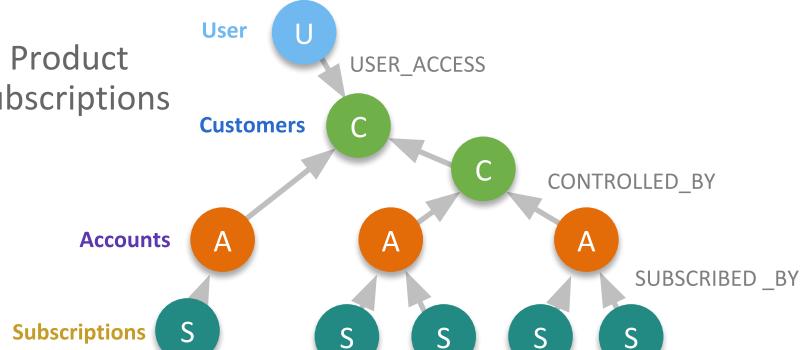
Organizational Hierarchy



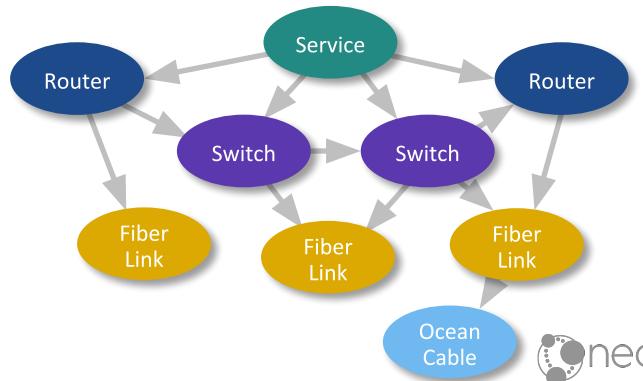
Customer 360



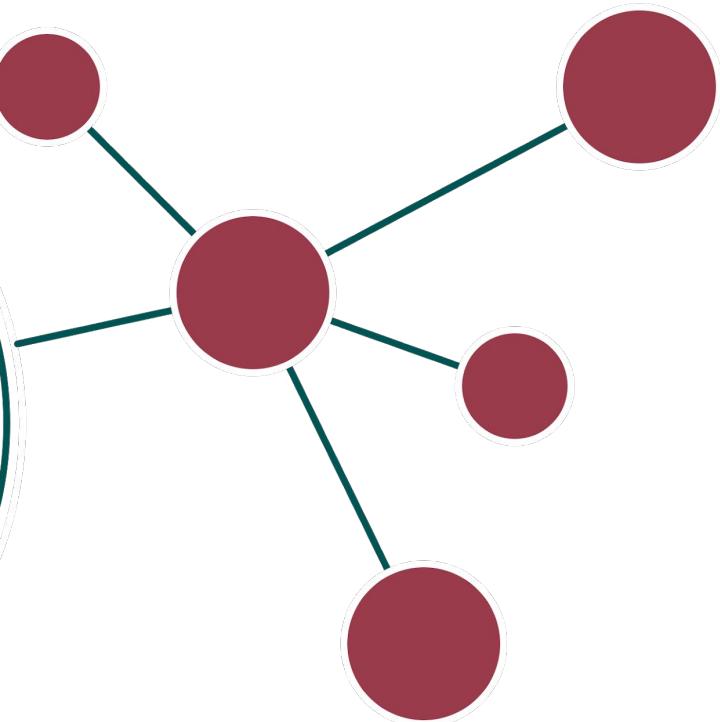
Product Subscriptions



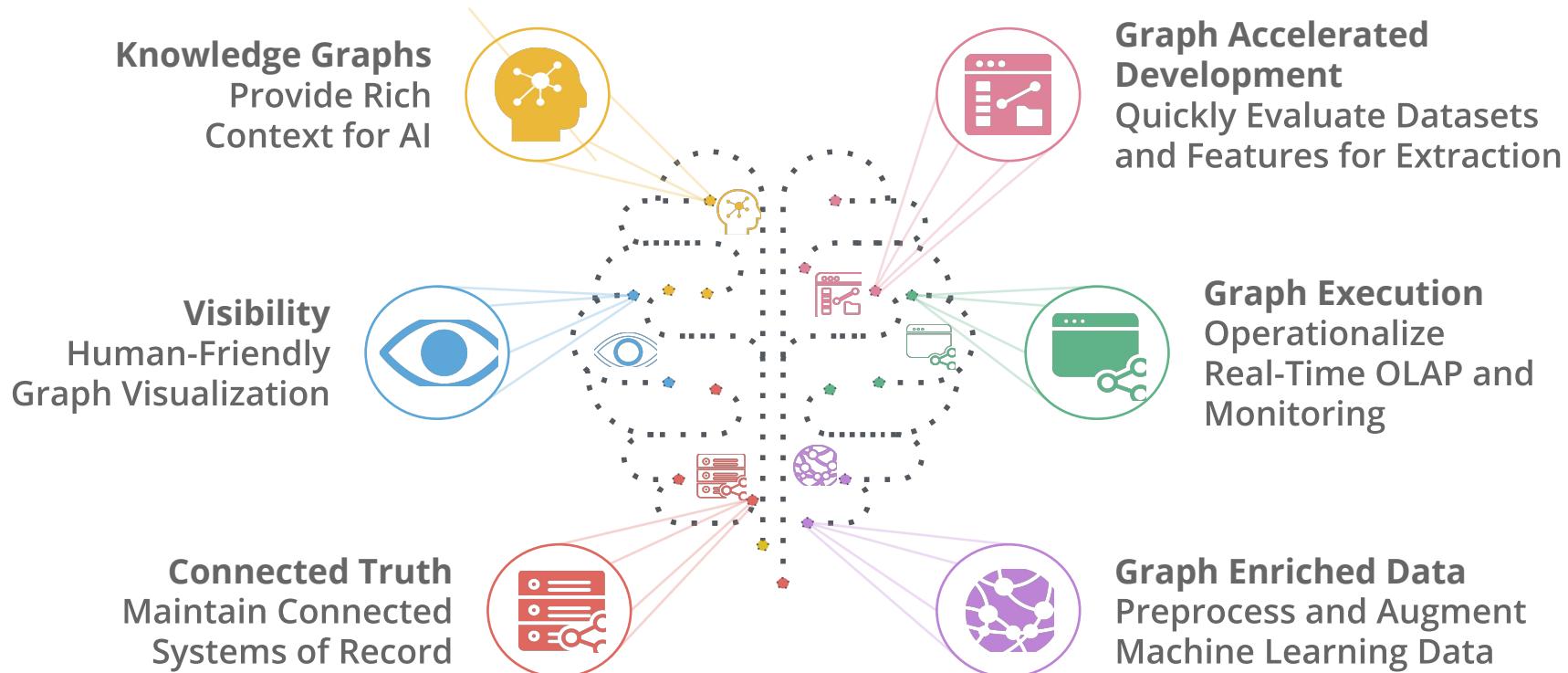
CMDB Network Inventory



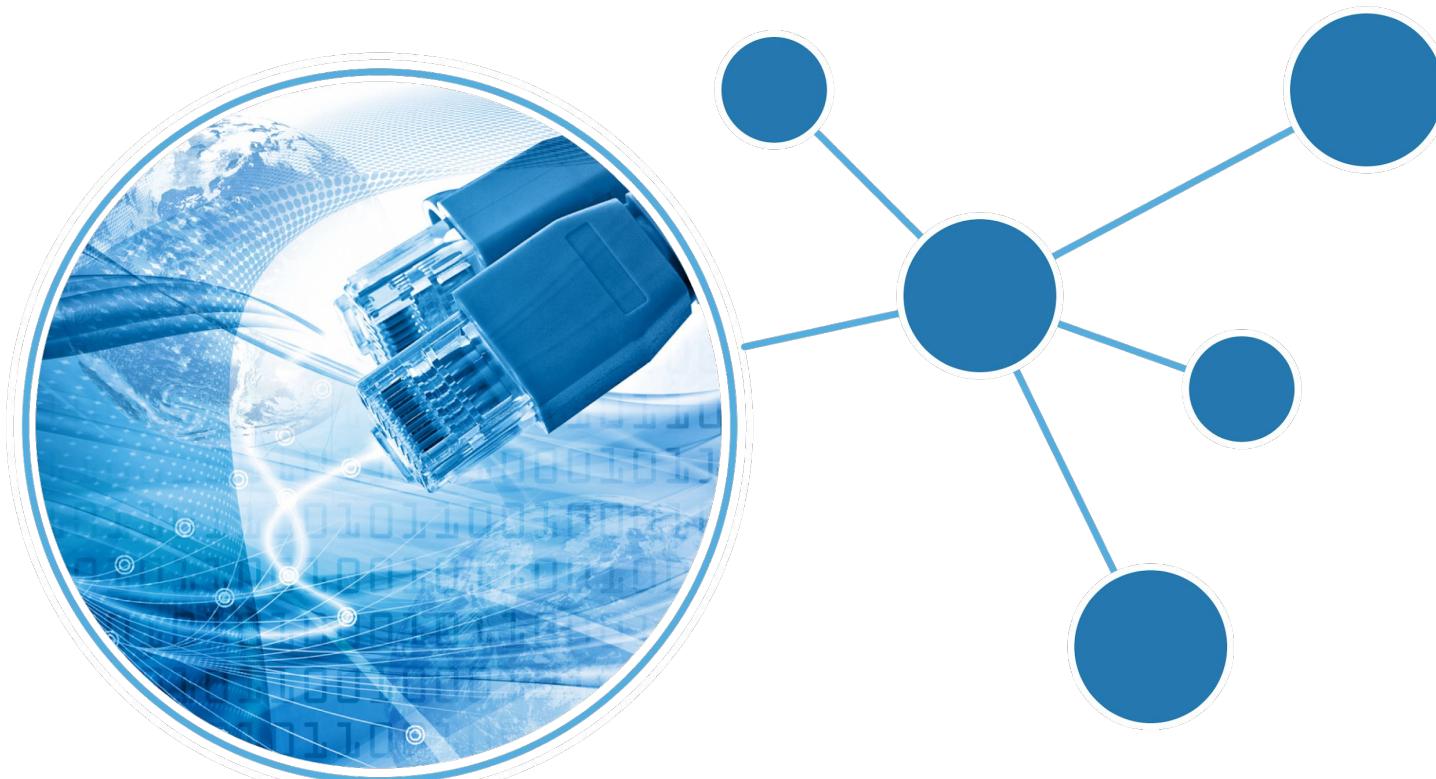
# Use case: Fraud detection



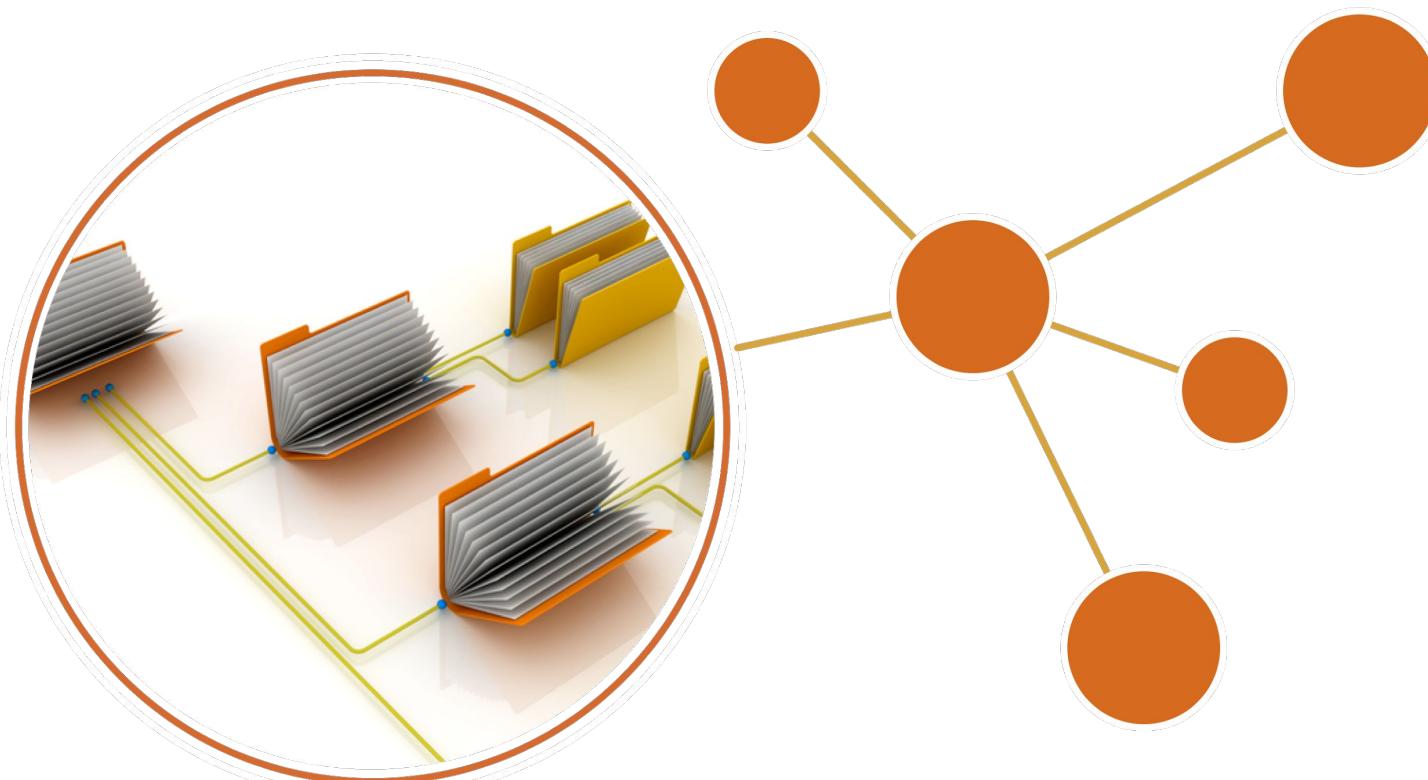
# Use case: Graph-based search



# Use case: Network and IT operations



# Use case: Identity and access management

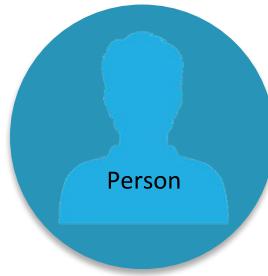


# What is a graph?

- Nodes
- Relationships
- Properties
- Labels

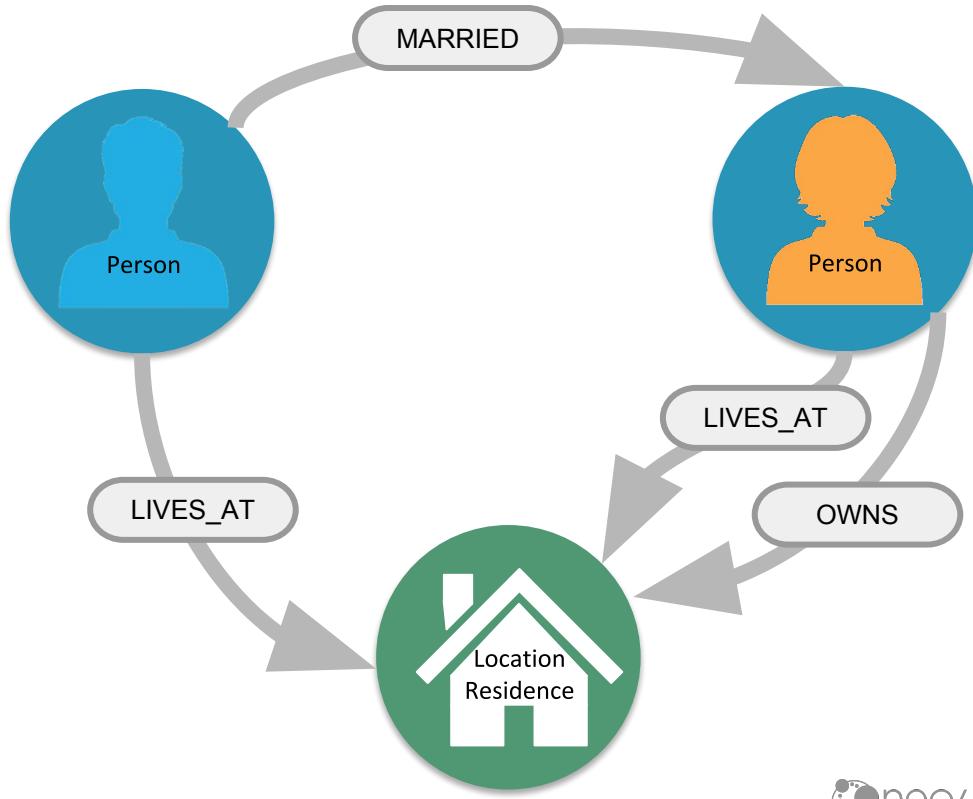
# Nodes

- Nouns in your model
- Represent the objects or entities in the graph
- Can be *labeled*:
  - Person
  - Location
  - Residence
  - Business



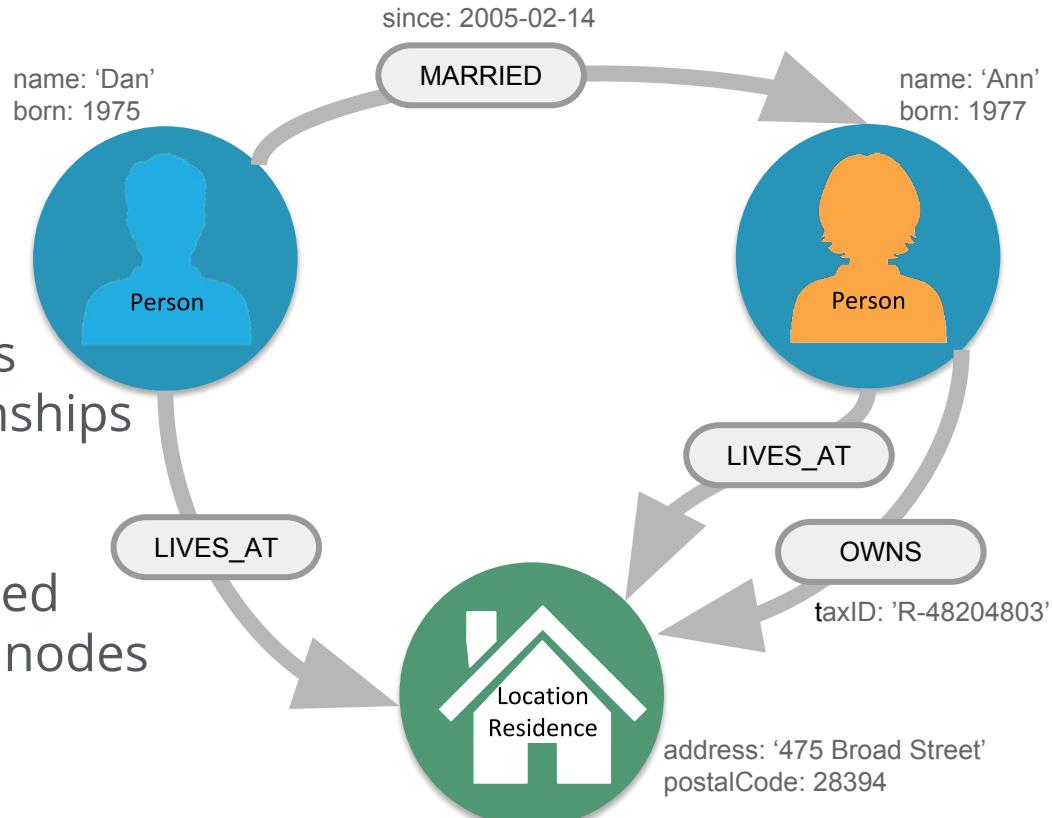
# Relationships

- Verbs in your model
- Represent the connection between nodes in the graph
- Has a type:
  - MARRIED
  - LIVES\_AT
  - OWNS
- Directed relationship



# Properties

- Adjectives to describe nodes
- Adverbs to describe relationships
- Property:
  - Key/value pair
  - Can be optional or required
  - Values can be unique for nodes
  - Values have no type



# Group exercise

Can you identify nodes and relationships in the room?

# Modeling relational to graph

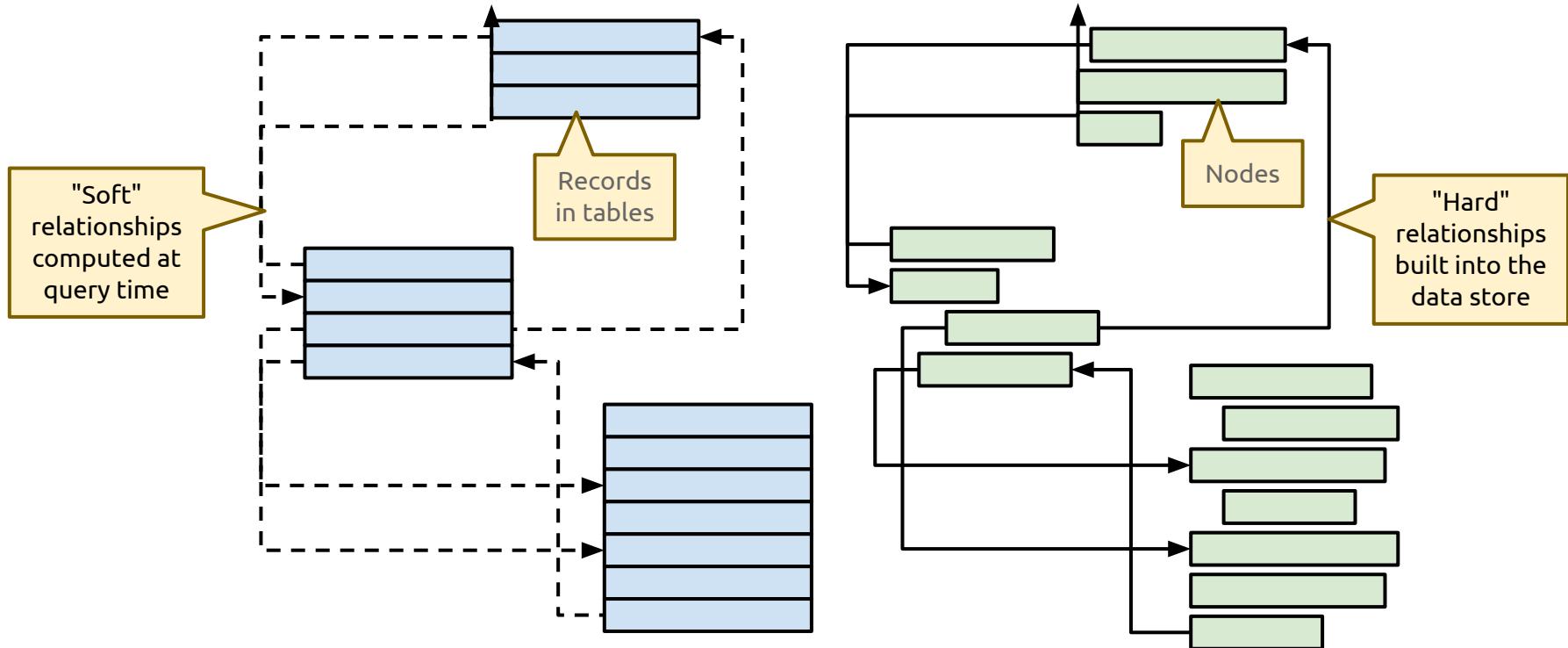
In some ways they're similar:

Relational	Graph
Rows	Nodes
Joins	Relationships
Table names	Labels
Columns	Properties

In some ways they're not:

Relational	Graph
Each column must have a field value.	Nodes with the same label aren't required to have the same set of properties.
Joins are calculated at query time.	Relationships are stored on disk when they are created.
A row can belong to one table.	A node can have many labels.

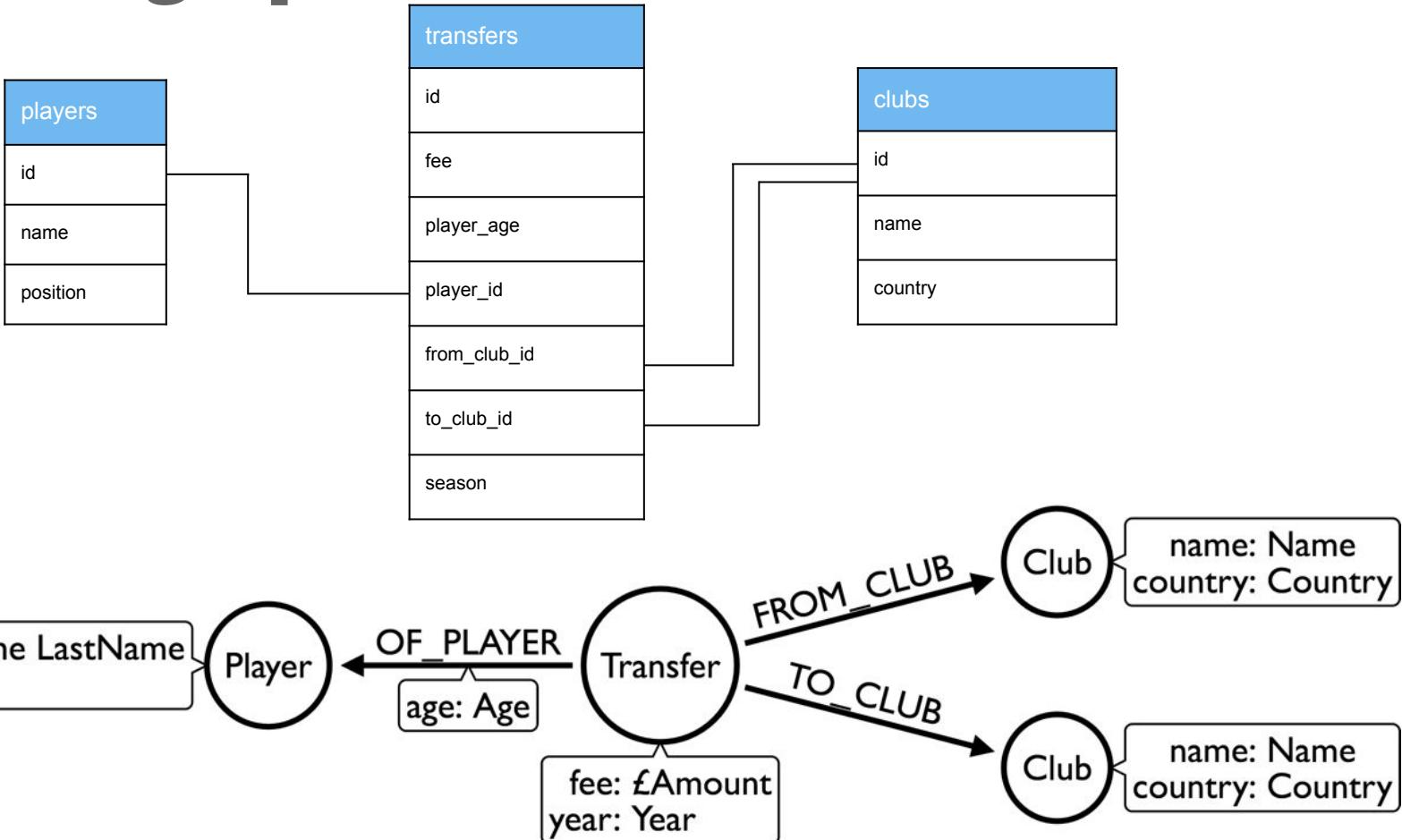
# Run-time behavior: RDBMS vs graph



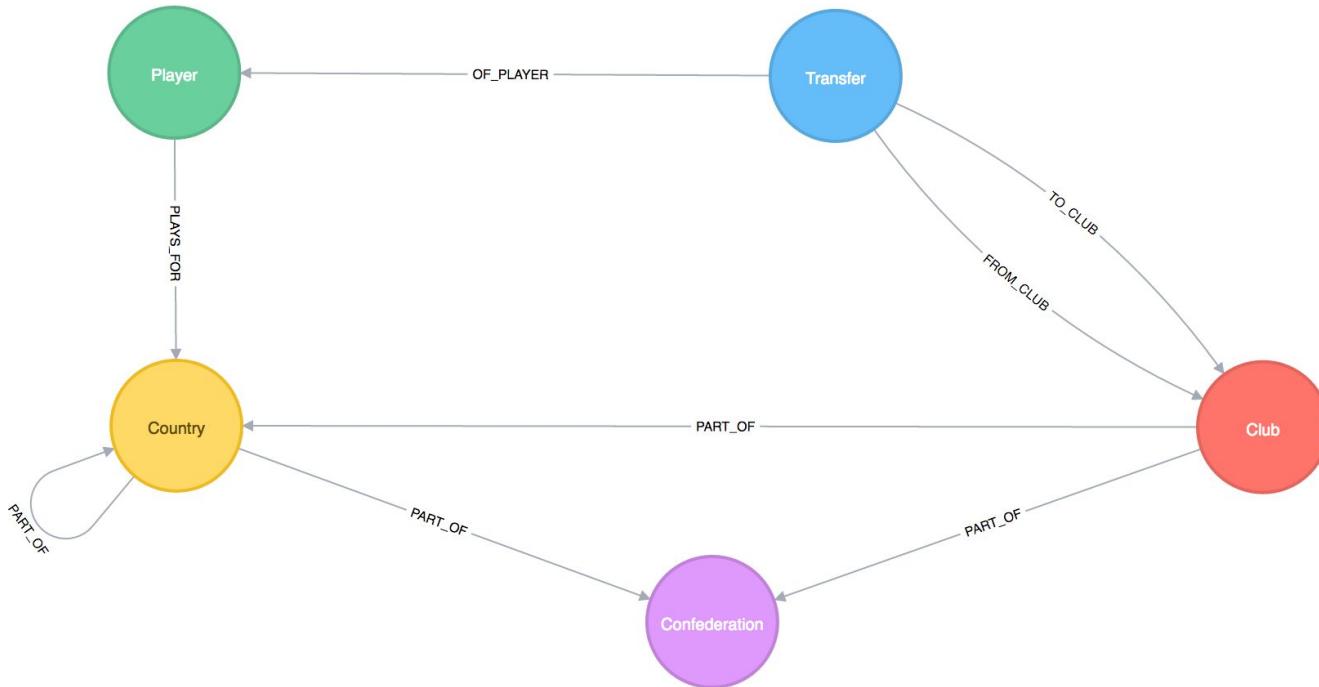
# How we model: RDBMS vs graph

Relational	Graph
Try and get the schema defined and then make minimal changes to it after that.	It's common for the schema to evolve with the application.
More abstract focus when modeling. i.e. Focus on classes rather than objects.	Common to use actual data items when modeling.

# RDBMS vs graph models



# Neo4j data model: CALL db.schema()



# How does Neo4j support the property graph model?

- Neo4j is a **Database** - use it to reliably **store** information and **find** it later.
- Neo4j's data model is a **Graph**, in particular a **Property Graph**.
- **Cypher** is Neo4j's graph query language (**SQL for graphs!**).
- Cypher is a declarative query language: it describes **what** you are interested in, not **how** it is acquired.
- Cypher is meant to be very **readable** and **expressive**.



# Check your understanding

# Question 1

What elements make up a graph?

Select the correct answers.

- tuples
- nodes
- documents
- relationships

# Answer 1

What elements make up a graph?

Select the correct answers.

- tuples
- nodes
- documents
- relationships

# Question 2

Suppose that you want to create a graph to model customers, products, what products a customer buys, and what products a customer rated. You have created nodes in the graph to represent the customers and products. In this graph, what relationships would you define?

Select the correct answers.

- BOUGHT
- IS\_A\_CUSTOMER
- IS\_A\_PRODUCT
- RATED

# Answer 2

Suppose that you want to create a graph to model customers, products, what products a customer buys, and what products a customer rated. You have created nodes in the graph to represent the customers and products. In this graph, what relationships would you define?

Select the correct answers.

- BOUGHT
- IS\_A\_CUSTOMER
- IS\_A\_PRODUCT
- RATED

# Question 3

What query language is used with a Neo4j Database?

Select the correct answer.

- SQL
- CQL
- Cypher
- OPath

# Answer 3

What query language is used with a Neo4j Database?

Select the correct answer.

- SQL
- CQL
- Cypher
- OPath

# Summary

You should be able to:

- Describe what a graph database is.
- Describe some common use cases for using a graph database.
- Describe how real-world scenarios are modeled as a graph.

# Introduction to Neo4j

v 1.0



# Overview

At the end of this module, you should be able to:

- Describe the components and benefits of the Neo4j Graph Platform.

# Neo4j Graph Platform

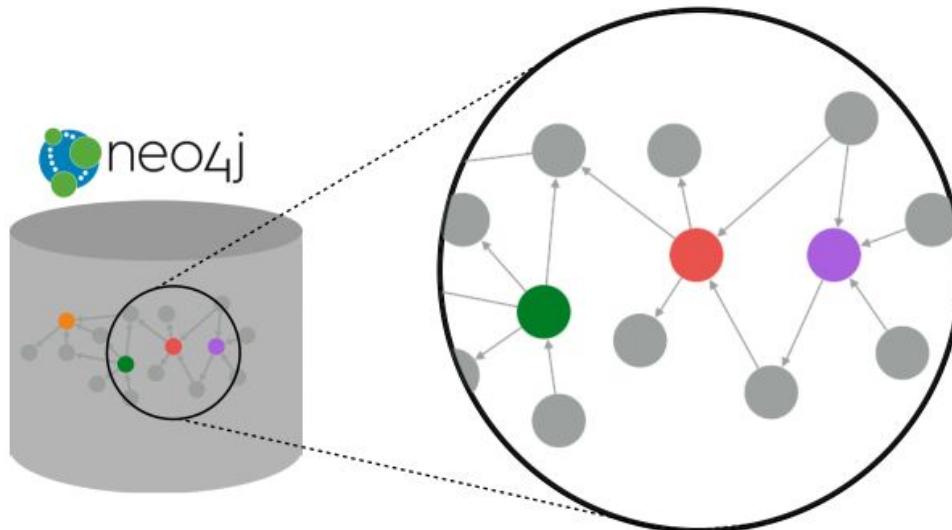
The Neo4j Graph Platform includes components that enable you to develop your graph-enabled application. To better understand the Neo4j Graph Platform, you will learn about these components and the benefits they provide.

The heart of the Neo4j Graph Platform is the Neo4j Database.



# Neo4j Database: Index-free adjacency

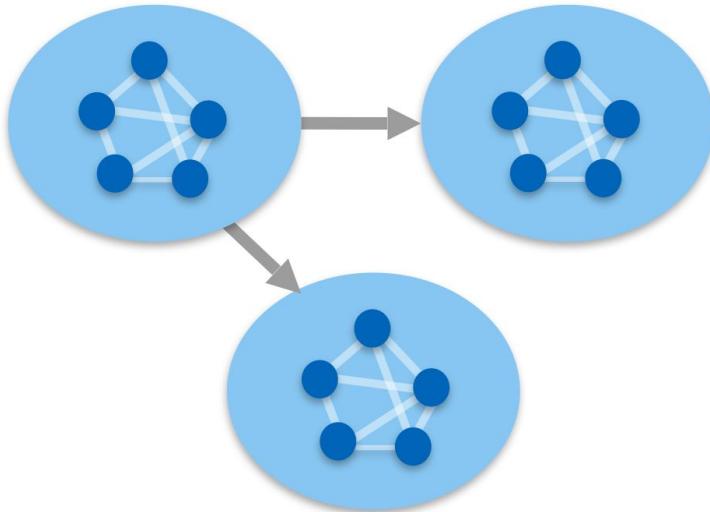
Nodes and relationships are stored on disk as a graph for fast navigational access using pointers.



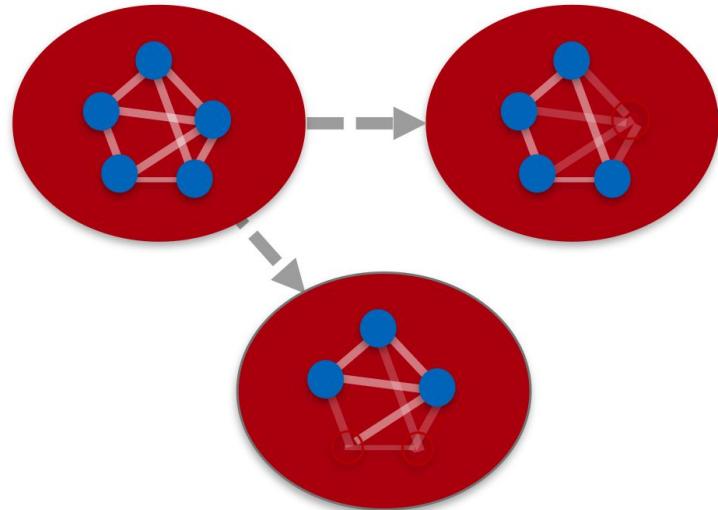
# Neo4j Database: ACID

Transactional consistency - all updates either succeed or fail.

*ACID Consistency*

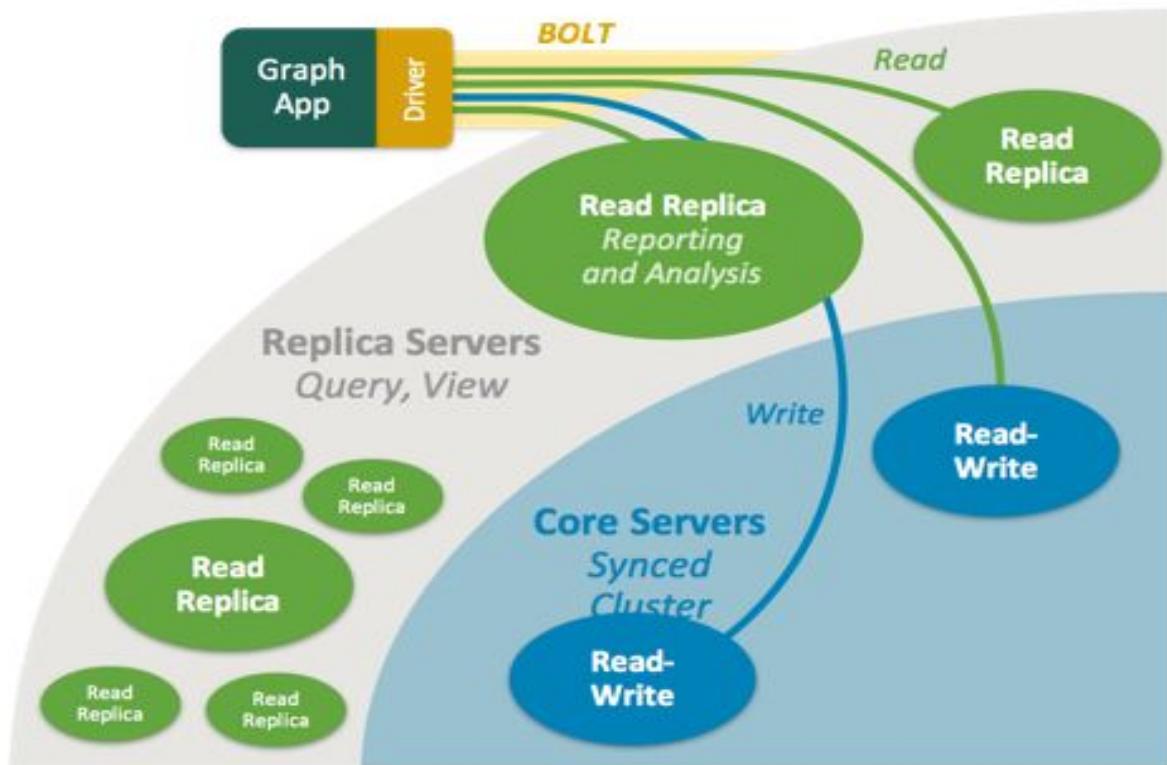


*Non-ACID Graph DBMSs (NoSQL)*



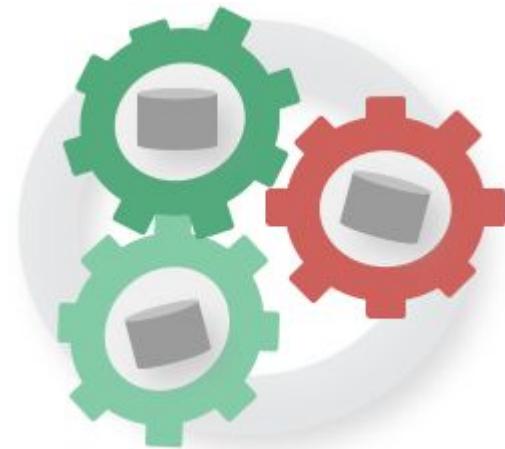
# Clusters

ACID across locations.



# Graph engine

- Interpret Cypher statements
- Store and retrieve data
- Kernel-level access to filesystem
- Scalable
- Performant



# Language and driver support

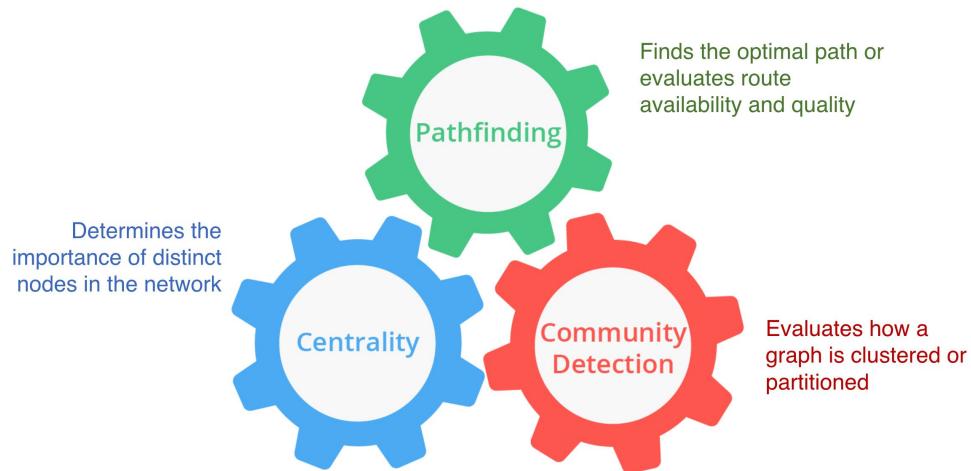
- Cypher to access the database
- Open source Cypher
- You can write server-side extensions to access the database
- Out-of-the-box drivers to access the database via **bolt** protocol:
  - Java
  - JavaScript
  - Python
  - C#
  - Go
- Neo4j community contributions for other languages

# Libraries

Out-of-the-box:

- Awesome Procedures on Cypher (APOC)
- Graph Algorithms
- GraphQL

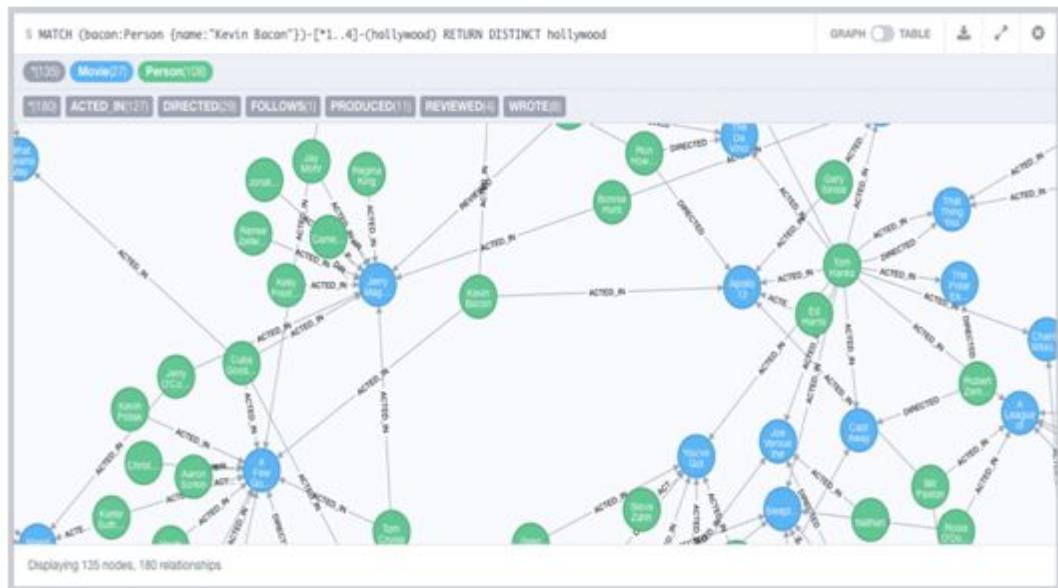
Neo4j community has contributed many specialized libraries also.



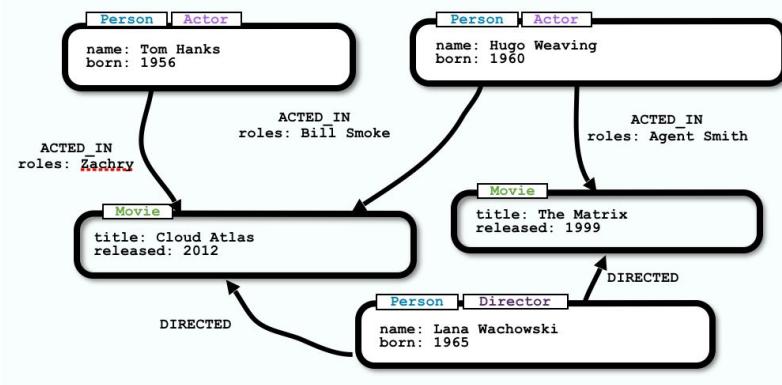
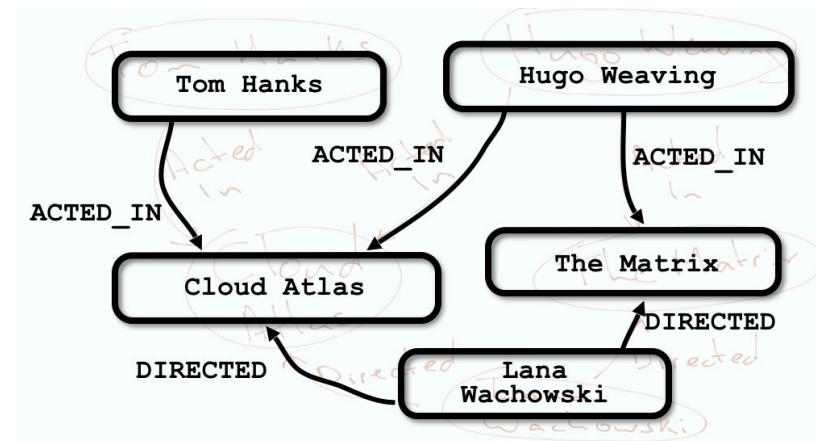
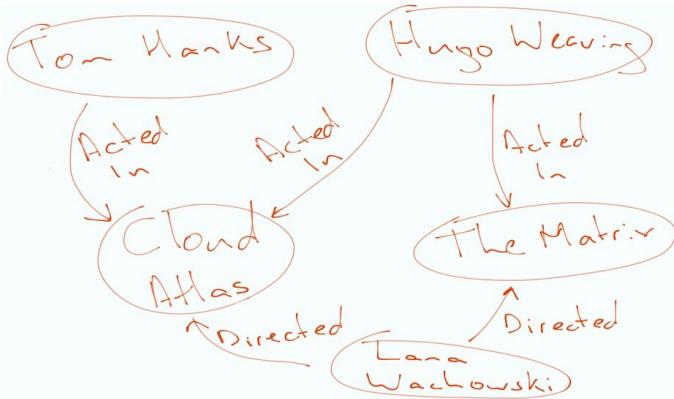
# Tools

- Neo4j Desktop
- Neo4j Browser
- Neo4j Bloom
- Neo4j ETL Tool

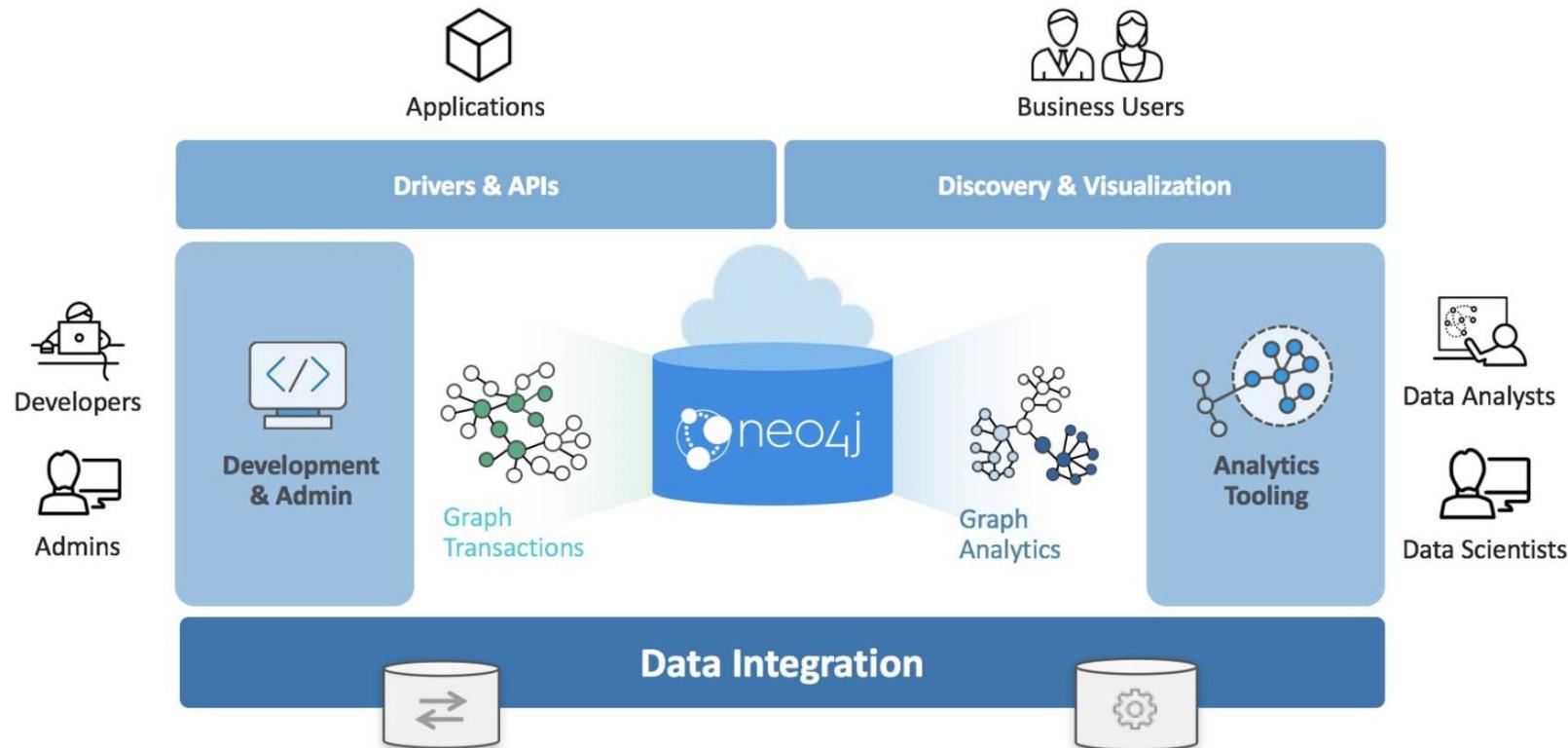
Neo4j community has contributed many specialized tools also.



# Whiteboard modeling



# Neo4j Graph Platform architecture





# Check your understanding

# Question 1

What are some of the benefits provided by the Neo4j Graph Platform?

Select the correct answers.

- Database clustering
- ACID
- Index free adjacency
- Optimized graph engine

# Answer 1

What are some of the benefits provided by the Neo4j Graph Platform?

Select the correct answers.

- ✓ Database clustering
- ✓ ACID
- ✓ Index free adjacency
- ✓ Optimized graph engine

# Question 2

What libraries are included with Neo4j Graph Platform?

Select the correct answers.

- APOC
- JGraph
- GRAPH ALGORITHMS
- GraphQL

# Answer 2

What libraries are included with Neo4j Graph Platform?

Select the correct answers.

- APOC
- JGraph
- GRAPH ALGORITHMS
- GraphQL

# Question 3

What are some of the language drivers that come with Neo4j out of the box?

Select the correct answers.

- Java
- Ruby
- Python
- JavaScript

# Answer 3

What are some of the language drivers that come with Neo4j out of the box?

Select the correct answers.

- Java
- Ruby
- Python
- JavaScript

# Summary

You should be able to:

- Describe the components and benefits of the Neo4j Graph Platform.

# Setting Up Your Development Environment

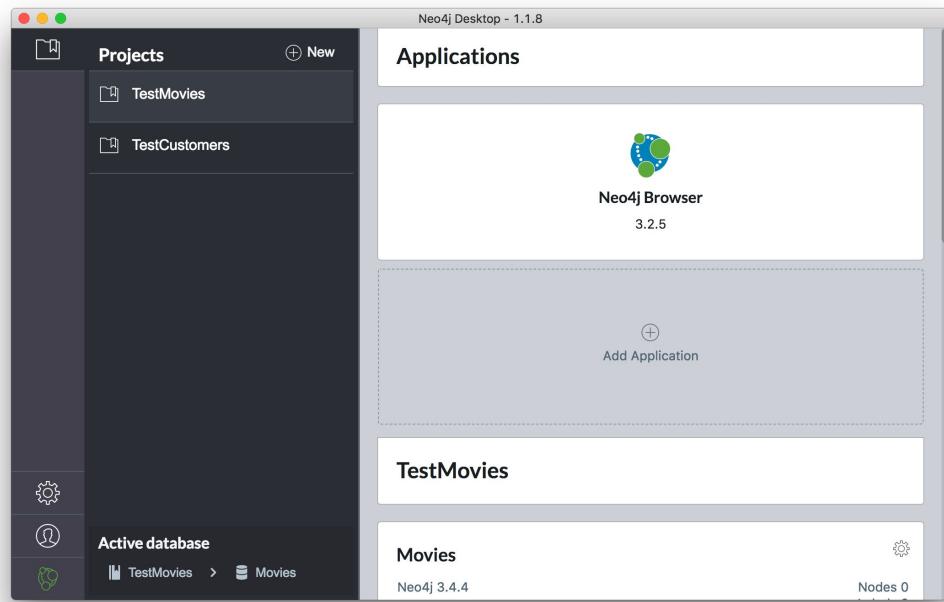
# Overview

At the end of this module, you should be able to:

- Determine the development environment that is best for you:
  - Install and start using the Neo4j Desktop.
  - Create a Neo4j Sandbox for learning Neo4j.
- Start using Neo4j Browser.

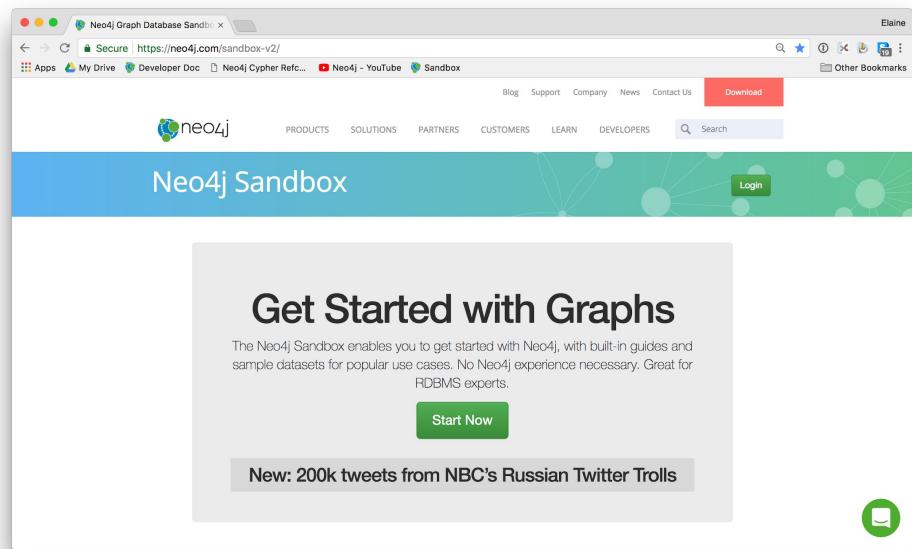
# Neo4j Desktop

- Create local databases
- Manage multiple projects
- Manage Database Server
- Start Neo4j Browser instances
- Install plugins (libraries) for use with a project
- OS X, Linux, Windows



# Neo4j Sandbox

- Web browser access to Neo4j Database Server and Neo4j Database in the cloud
- Comes with a blank or pre-populated database
- Temporary access
- Save Cypher scripts for use in other sandboxes or Neo4j projects
- Instance lives for up to ten days
- No need to install Neo4j on your machine



# **Setting up your development environment**

## **If using Neo4j Sandbox:**

1. Start a Neo4j Sandbox (use latest Neo4j release).
  - a. Has a blank database that is started.
2. Click the link to access Neo4j Browser.

## **If using Neo4j Desktop:**

1. Install Neo4j Desktop.
2. In a project, create a local graph (database).
3. Start the database.
4. Click the Neo4j Browser application.

# Guided Exercise: Getting Started with Neo4j Desktop

Note: You must either install Neo4j Desktop or create a Neo4j Sandbox to perform the hands-on exercises.

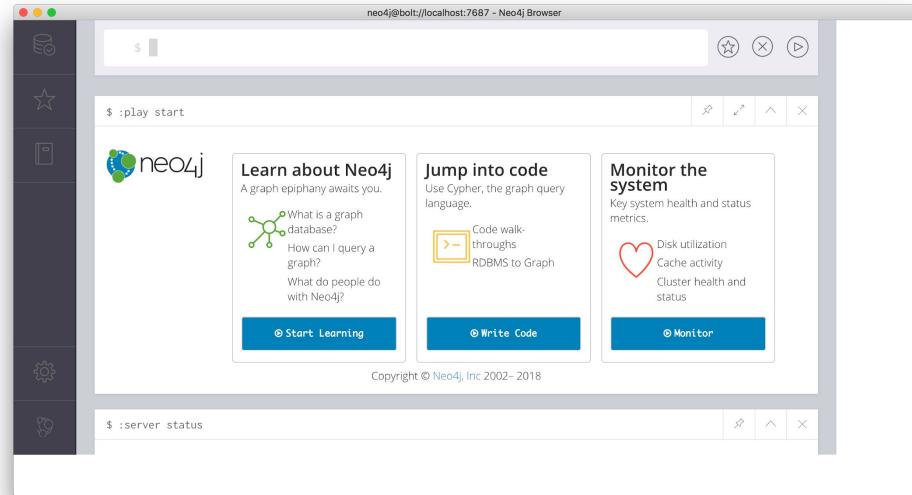


# Guided Exercise: Creating a Neo4j Sandbox

Note: You must either install Neo4j Desktop or create a Neo4j Sandbox to perform the hands-on exercises.

# Neo4j Browser

- Web browser access to Neo4j Database Server and Neo4j Database
- Access local database (Neo4j Desktop) or database in the cloud (Sandbox)
- Access the database with commands or Cypher statements



# Guided Exercise: Getting Started with Neo4j Browser

Note: You must have created a Neo4j Database locally or a Neo4j Sandbox to begin using Neo4j Browser. In this exercise, you will populate the database used for the hands-on exercises.



# Check your understanding

# Question 1

What development environment should you use if you want to develop a graph-enabled application using a local Neo4j Database?

Select the correct answer.

- Neo4j Desktop
- Neo4j Sandbox

# Answer 1

What development environment should you use if you want to develop a graph-enabled application using a local Neo4j Database?

Select the correct answer.

- Neo4j Desktop
- Neo4j Sandbox

# Question 2

What development environment should you use if you want develop a graph-enabled application using a temporary, cloud-based Neo4j Database?

Select the correct answer.

- Neo4j Desktop
- Neo4j Sandbox

# Answer 2

What development environment should you use if you want develop a graph-enabled application using a temporary, cloud-based Neo4j Database?

Select the correct answer.

- Neo4j Desktop
- Neo4j Sandbox

# Question 3

Which Neo4j Browser command do you use to view a browser guide for the Movie graph?

Select the correct answer.

- MATCH (Movie Graph)
- :MATCH (Movie Graph)
- play Movie Graph
- :play Movie Graph

# Answer 3

Which Neo4j Browser command do you use to view a browser guide for the Movie graph?

Select the correct answer.

- MATCH (Movie Graph)
- :MATCH (Movie Graph)
- play Movie Graph
- :play Movie Graph

# Summary

You should be able to:

- Determine the development environment that is best for you:
  - Install and start using the Neo4j Desktop.
  - Create a Neo4j Sandbox for learning Neo4j.
- Start using Neo4j Browser.

# Introduction to Cypher

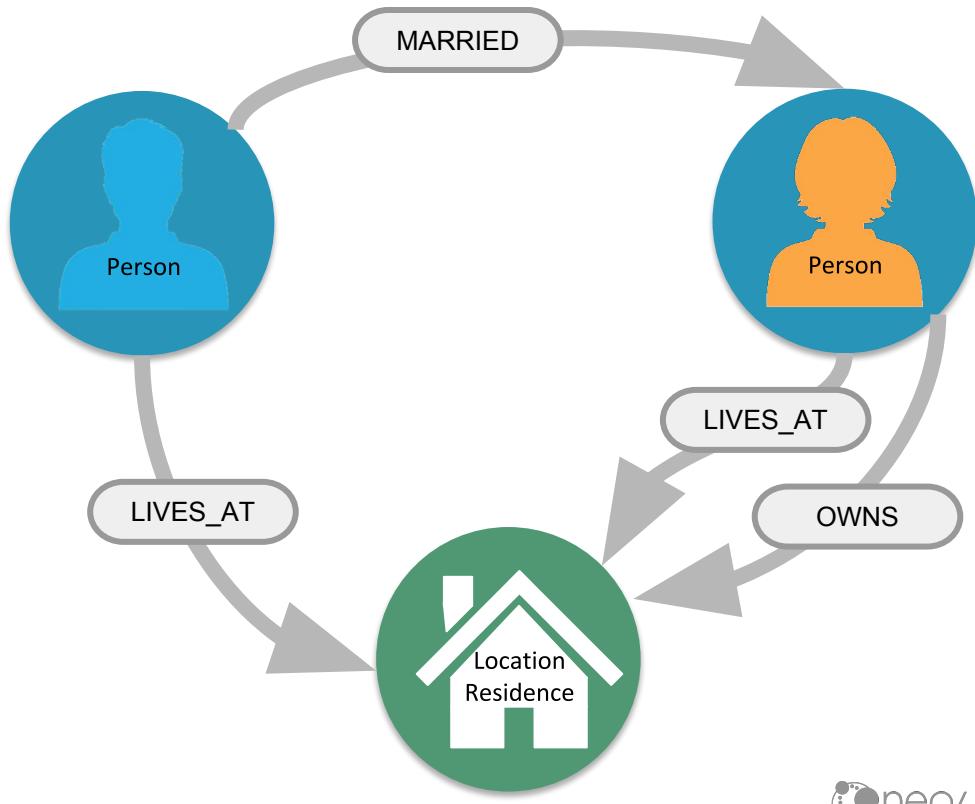
# Overview

At the end of this module, you should be able to write Cypher statements to:

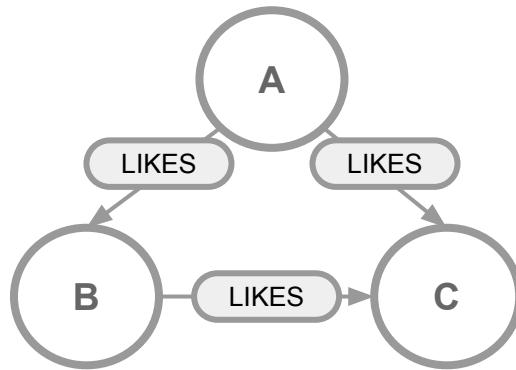
- Retrieve nodes from the graph.
- Filter nodes retrieved using labels and property values of nodes.
- Retrieve property values from nodes in the graph.
- Filter nodes retrieved using relationships.

# What is Cypher?

- Declarative query language
- Focuses on **what**, not how to retrieve
- Uses keywords such as **MATCH, WHERE, CREATE**
- Runs in the database server for the graph
- ASCII art to represent nodes and relationships



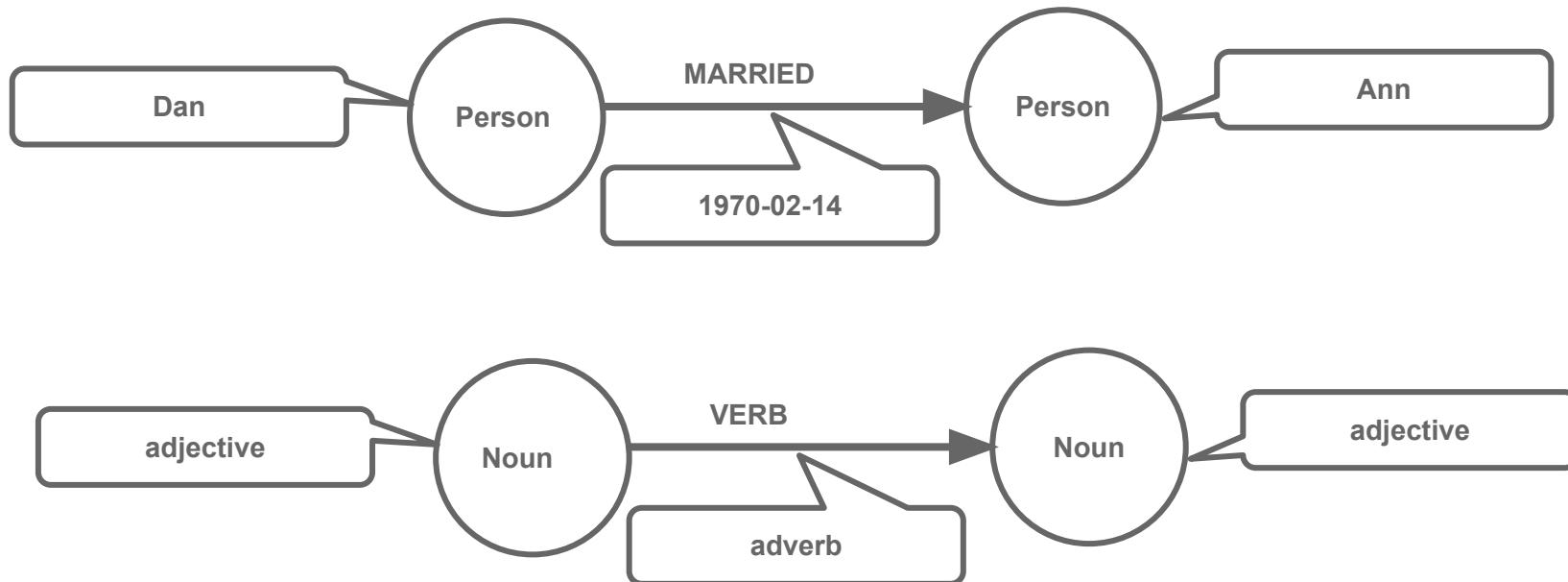
# Cypher is ASCII Art



```
(A) - [ :LIKES ] -> (B) , (A) - [ :LIKES ] -> (C) , (B) - [ :LIKES ] -> (C)
```

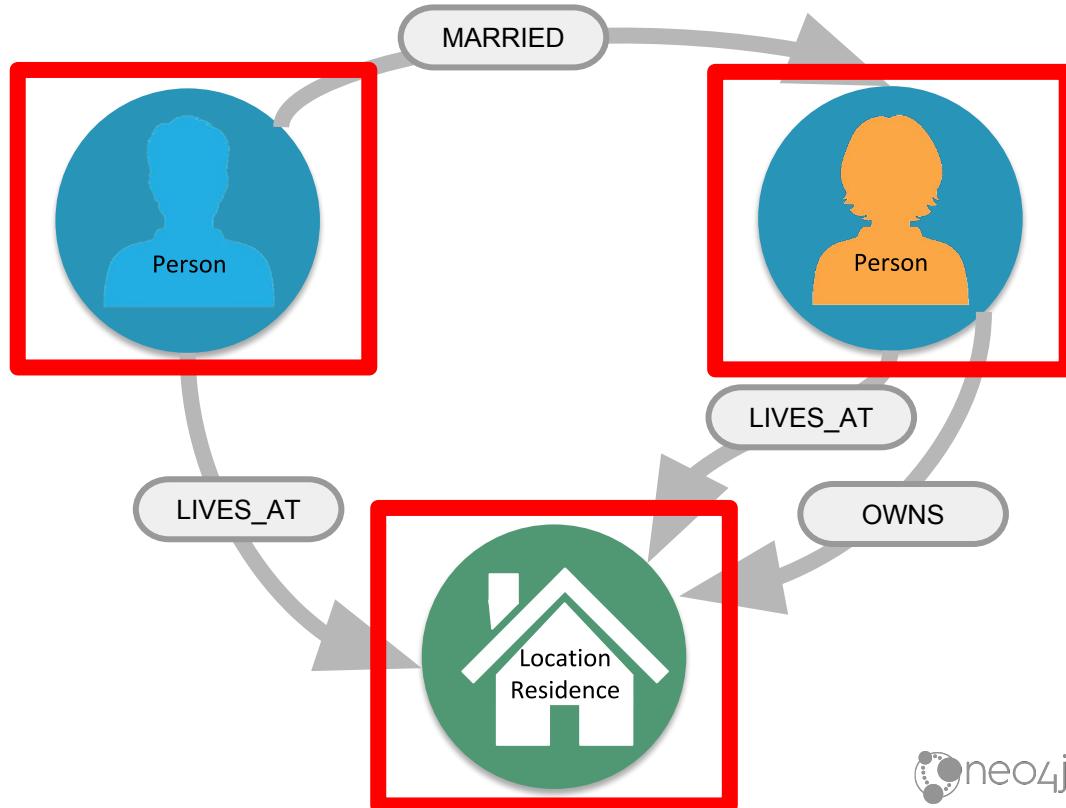
```
(A) - [ :LIKES ] -> (B) - [ :LIKES ] -> (C) <- [ :LIKES ] - (A)
```

# Cypher is readable



# Nodes

( )  
(p)  
(l)  
(n)



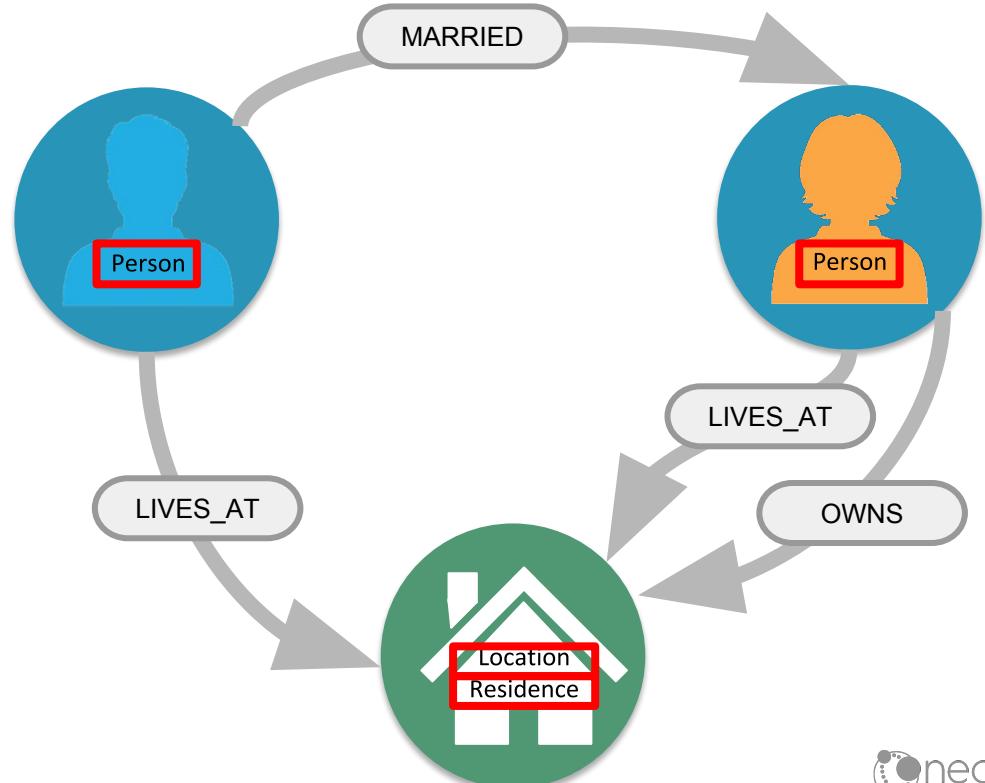
# Labels

```
(:Person)  
(p:Person)  
(:Location)  
(l:Location)  
(n:Residence)  
(x:Location:Residence)
```

 Database Information

 Node Labels

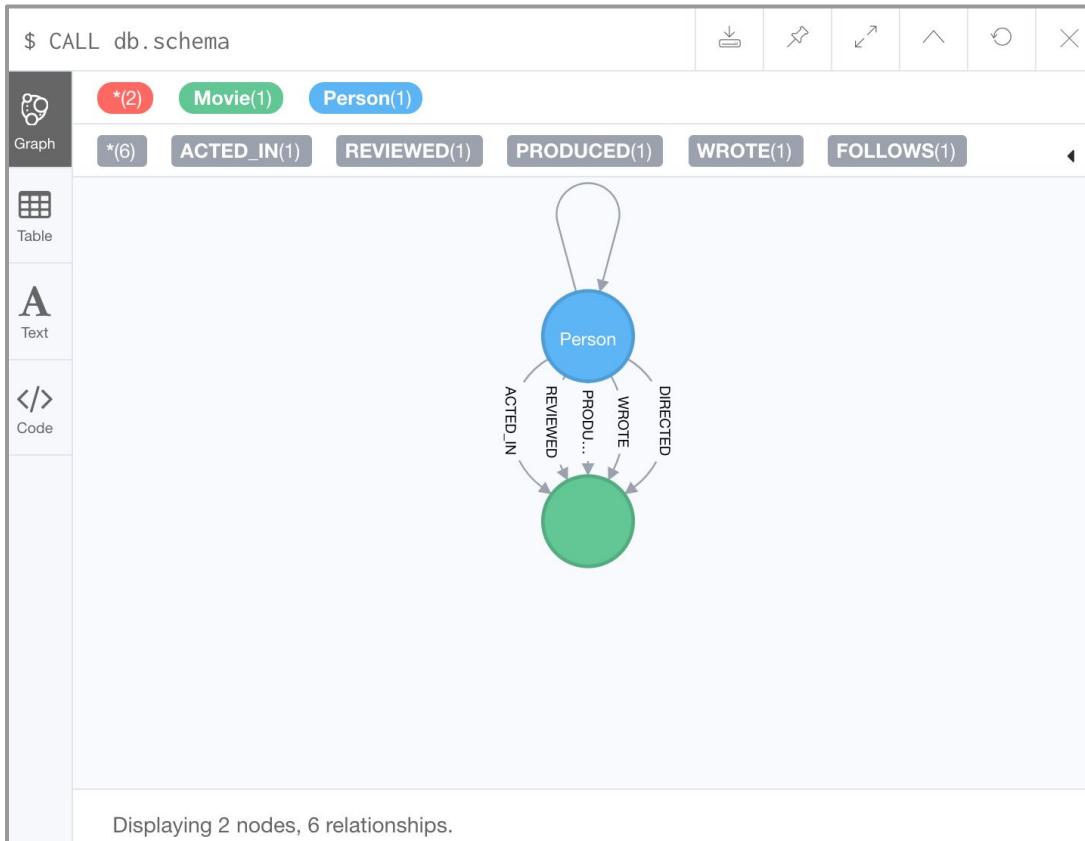
\*(171) Movie Person



# Comments in Cypher

```
()          // anonymous node not be referenced later in the query  
(p)        // variable p, a reference to a node used later  
(:Person)   // anonymous node of type Person  
(p:Person)  // p, a reference to a node of type Person  
(p:Actor:Director) // p, a reference to a node of types Actor and Director
```

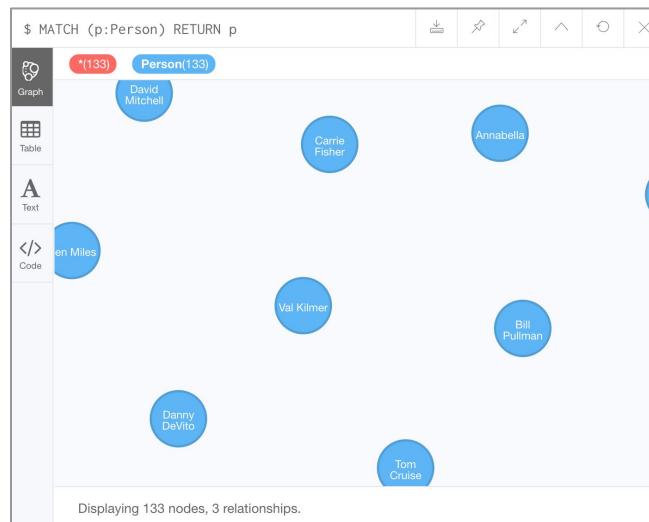
# Examining the data model



# Using MATCH to retrieve nodes

```
MATCH (n) // returns all nodes in the graph  
RETURN n
```

```
MATCH (p:Person) // returns all Person nodes in the graph  
RETURN p
```



# Viewing nodes as table data

The screenshot shows the Neo4j browser interface with the following details:

- Query:** \$ MATCH (p:Person) RETURN p
- Result:** Three nodes are listed, each represented by a JSON object:
  - Keanu Reeves:** {"name": "Keanu Reeves", "born": 1964}
  - Carrie-Anne Moss:** {"name": "Carrie-Anne Moss", "born": 1967}
  - Laurence Fishburne:** {"name": "Laurence Fishburne", "born": 1961}
- UI Elements:** On the left, there is a sidebar with four tabs: Graph (selected), Table (highlighted with a red box), Text, and Code. Above the results, there is a toolbar with icons for copy, export, and other operations.

# Exercise 1: Retrieving Nodes

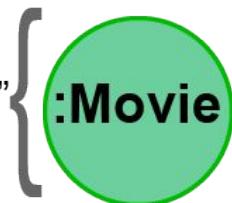
In Neo4j Browser:

:play intro-neo4j-exercises

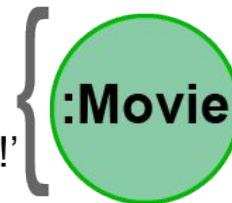
Then follow instructions for Exercise 1.

# Properties

**title:** "Something's Gotta Give"  
**released:** 2003



**title:** 'V for Vendetta'  
**released:** 2006  
**tagline:** 'Freedom! Forever!'



**title:** 'The Matrix Reloaded'  
**released:** 2003  
**tagline:** 'Free your mind'

# Examining property keys

```
CALL db.propertyKeys
```

```
$ CALL db.propertyKeys
```



# Retrieving nodes filtered by a property value - 1

Find all *people* born in 1970, returning the nodes:

```
MATCH (p:Person {born: 1970})  
RETURN p
```

\$ MATCH (p:Person {born: 1970}) RETURN p

Graph Table Text Code

(\*) (4) Person(4)

Ethan Hawke  
Brooke Langton  
River Phoenix  
Jay Mohr

# Retrieving nodes filtered by a property value - 2

Find all movies released in 2003 with the tagline,  
*Free your mind*, returning the nodes:

```
MATCH (m:Movie {released: 2003, tagline: 'Free your mind'})  
RETURN m
```



The screenshot shows the Neo4j browser interface with the following details:

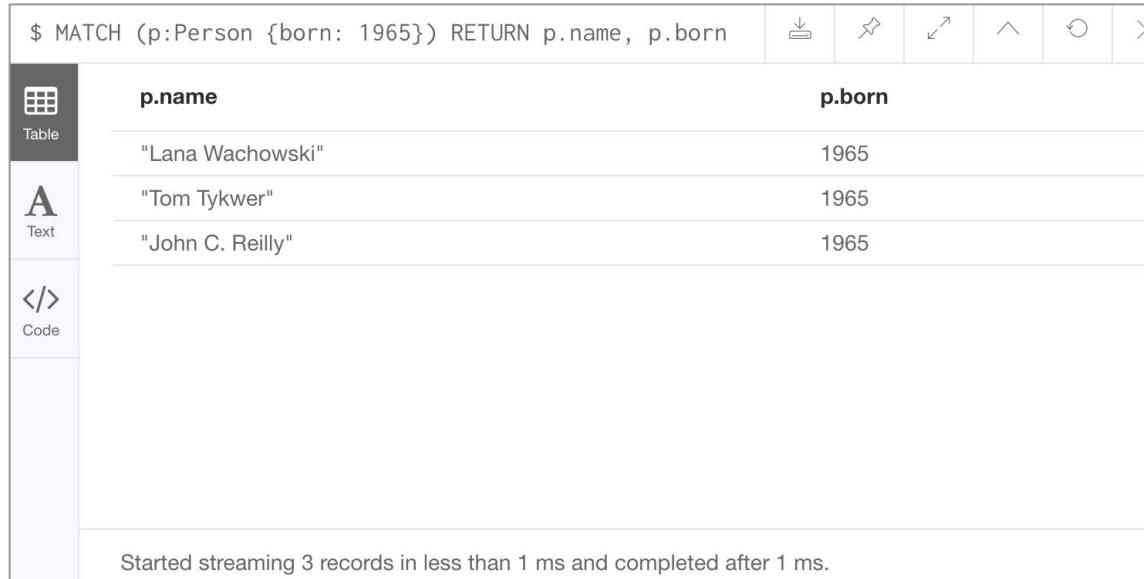
- Query:** \$ MATCH (m:Movie {released: 2003, tagline: "Free your mind"}) RETURN m
- Graph View:** Shows a node labeled "m" with properties.
- Table View:** Shows the following JSON result row:
- Text View:** Shows the JSON result in a code block:
- Code View:** Shows the Cypher query used.
- Status Bar:** Started streaming 1 records after 1 ms and completed after 2 ms.

```
{  
    "title": "The Matrix Reloaded",  
    "tagline": "Free your mind",  
    "released": 2003  
}
```

# Returning property values

Find all people born in 1965 and return their names:

```
MATCH (p:Person {born: 1965})  
RETURN p.name, p.born
```



The screenshot shows the Neo4j browser interface with a query results table. On the left, there are three navigation tabs: 'Table' (selected), 'Text', and 'Code'. The main area displays the results of the following Cypher query:

```
$ MATCH (p:Person {born: 1965}) RETURN p.name, p.born
```

The results are presented in a table with two columns: 'p.name' and 'p.born'. The data rows are:

p.name	p.born
"Lana Wachowski"	1965
"Tom Tykwer"	1965
"John C. Reilly"	1965

At the bottom of the results panel, a message states: "Started streaming 3 records in less than 1 ms and completed after 1 ms."

# Specifying aliases

```
MATCH (p:Person {born: 1965})  
RETURN p.name AS name, p.born AS 'birth year'
```

```
$ MATCH (p:Person {born: 1965}) RETURN p.name AS name, p.born AS `birth year`
```



Table



Text



Code

**name**

"Lana Wachowski"

**birth year**

1965

"Tom Tykwer"

1965

"John C. Reilly"

1965

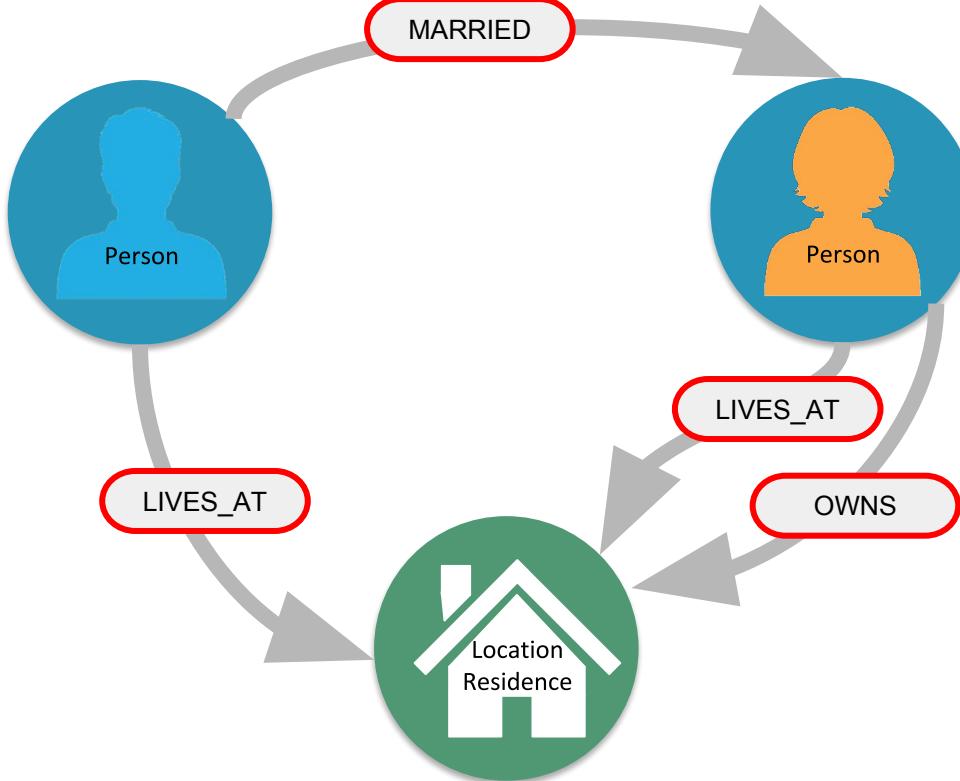
# Exercise 2: Filtering queries using property values

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 2.

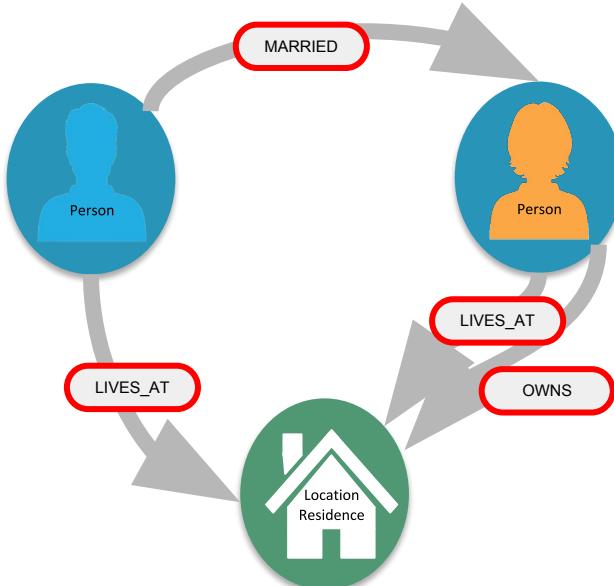
# Relationships



# ASCII art for nodes and relationships

```
()          // a node  
()--()      // 2 nodes have some type of relationship  
()-->()    // the first node has a relationship to the second node  
()<--()    // the second node has a relationship to the first node
```

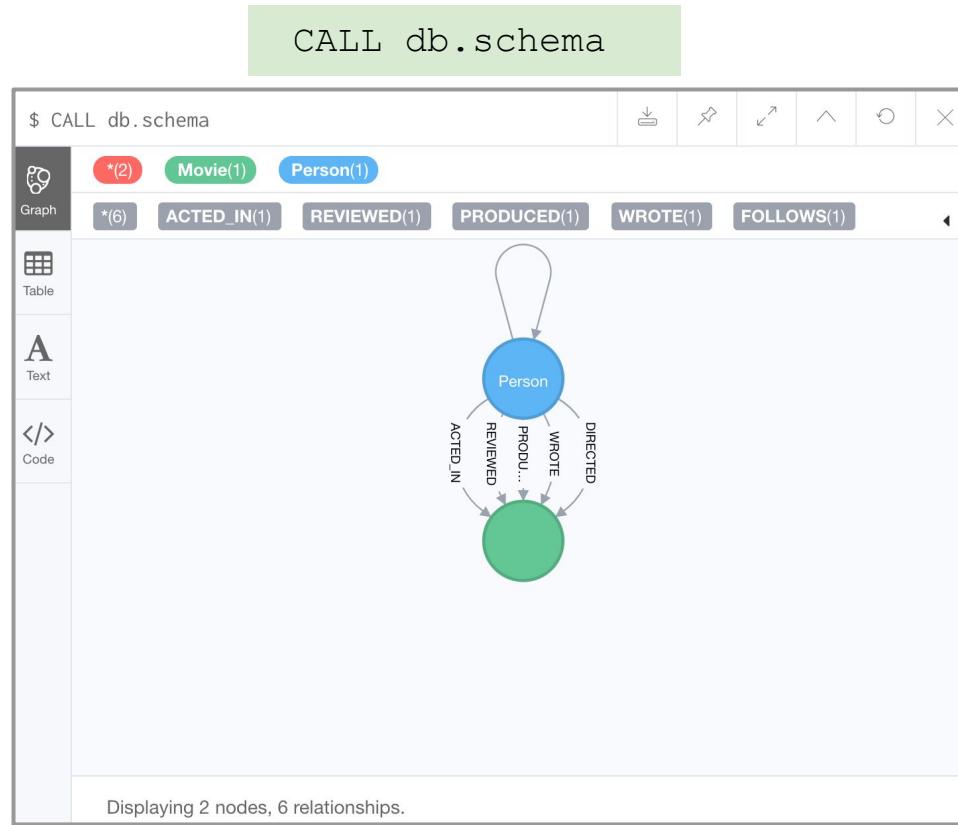
# Querying using relationships



```
MATCH (p:Person) -[:LIVES_AT]->(h:Residence)  
RETURN p.name, h.address
```

```
MATCH (p:Person) --(h:Residence) // any relationship  
RETURN p.name, h.address
```

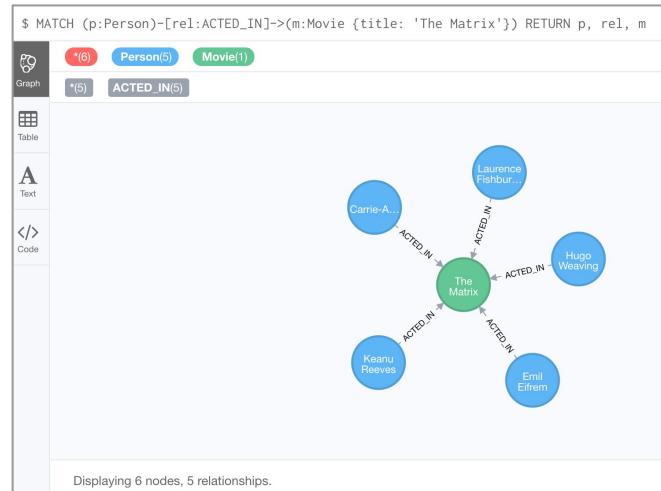
# Examining relationships



# Using a relationship in a query

Find all people who acted in the movie, *The Matrix*, returning the nodes and relationships found:

```
MATCH (p:Person)-[rel:ACTED_IN]->(m:Movie {title: 'The Matrix'})  
RETURN p, rel, m
```



# Querying by multiple relationships

Find all movies that *Tom Hanks* acted in or directed and return the title of the move:

```
MATCH (p:Person {name: 'Tom Hanks'})-[:ACTED_IN | :DIRECTED]->(m:Movie)  
RETURN p.name, m.title
```

\$ MATCH (p:Person {name: 'Tom Hanks'})-[:ACTED\_IN | :DIRECTED]->(m:Movie) RETURN p.name, m.title

The screenshot shows the Neo4j browser interface with a query results table. The table has two columns: 'p.name' and 'm.title'. The 'p.name' column contains 13 entries, each with the value "'Tom Hanks'". The 'm.title' column contains 13 corresponding movie titles: "Apollo 13", "Cast Away", "The Polar Express", "A League of Their Own", "Charlie Wilson's War", "Cloud Atlas", "The Da Vinci Code", "The Green Mile", "You've Got Mail", "That Thing You Do", "Joe Versus the Volcano", and "Sleepless in Seattle". The table is displayed in a light green background area.

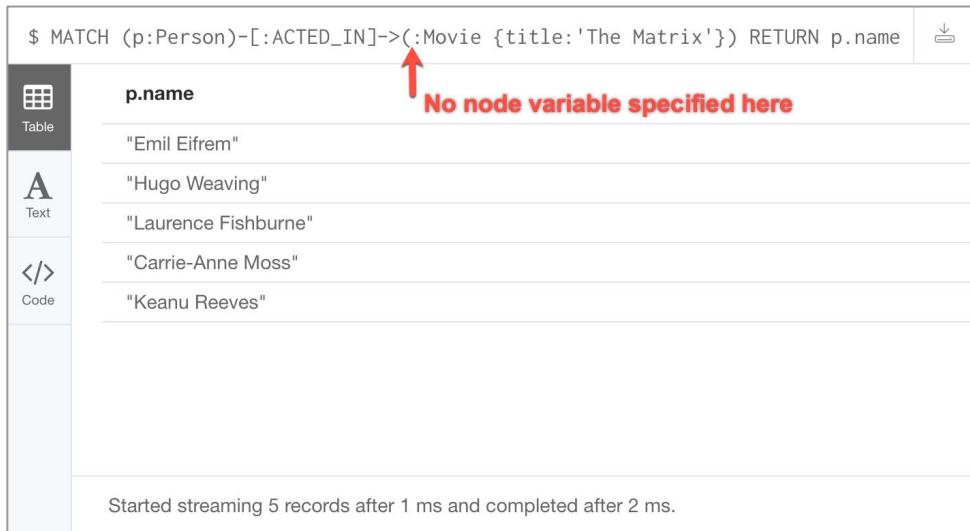
p.name	m.title
"Tom Hanks"	"Apollo 13"
"Tom Hanks"	"Cast Away"
"Tom Hanks"	"The Polar Express"
"Tom Hanks"	"A League of Their Own"
"Tom Hanks"	"Charlie Wilson's War"
"Tom Hanks"	"Cloud Atlas"
"Tom Hanks"	"The Da Vinci Code"
"Tom Hanks"	"The Green Mile"
"Tom Hanks"	"You've Got Mail"
"Tom Hanks"	"That Thing You Do"
"Tom Hanks"	"That Thing You Do"
"Tom Hanks"	"Joe Versus the Volcano"
"Tom Hanks"	"Sleepless in Seattle"

Started streaming 13 records after 1 ms and completed after 1 ms.

# Using anonymous nodes in a query

Find all people who acted in the movie, *The Matrix* and return their names:

```
MATCH (p:Person)-[:ACTED_IN]->(:Movie {title: 'The Matrix'})  
RETURN p.name
```



The screenshot shows the Neo4j browser interface. On the left, there's a sidebar with icons for Table, Text, and Code. The Text tab is selected, displaying the query: \$ MATCH (p:Person)-[:ACTED\_IN]->(:Movie {title:'The Matrix'}) RETURN p.name. A red arrow points from the text "No node variable specified here" to the colon in the pattern (:Movie). The main area shows a table with one column labeled "p.name" containing five rows: "Emil Eifrem", "Hugo Weaving", "Laurence Fishburne", "Carrie-Anne Moss", and "Keanu Reeves". At the bottom, a status message says "Started streaming 5 records after 1 ms and completed after 2 ms."

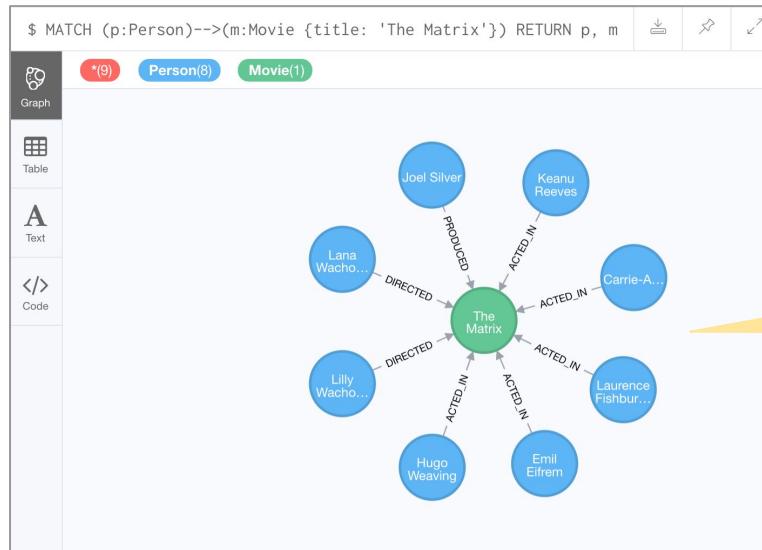
p.name
"Emil Eifrem"
"Hugo Weaving"
"Laurence Fishburne"
"Carrie-Anne Moss"
"Keanu Reeves"

Started streaming 5 records after 1 ms and completed after 2 ms.

# Using an anonymous relationship for a query

Find all people who have any type of relationship to the movie, *The Matrix* and return the nodes:

```
MATCH (p:Person) -->(m:Movie {title: 'The Matrix'})  
RETURN p, m
```

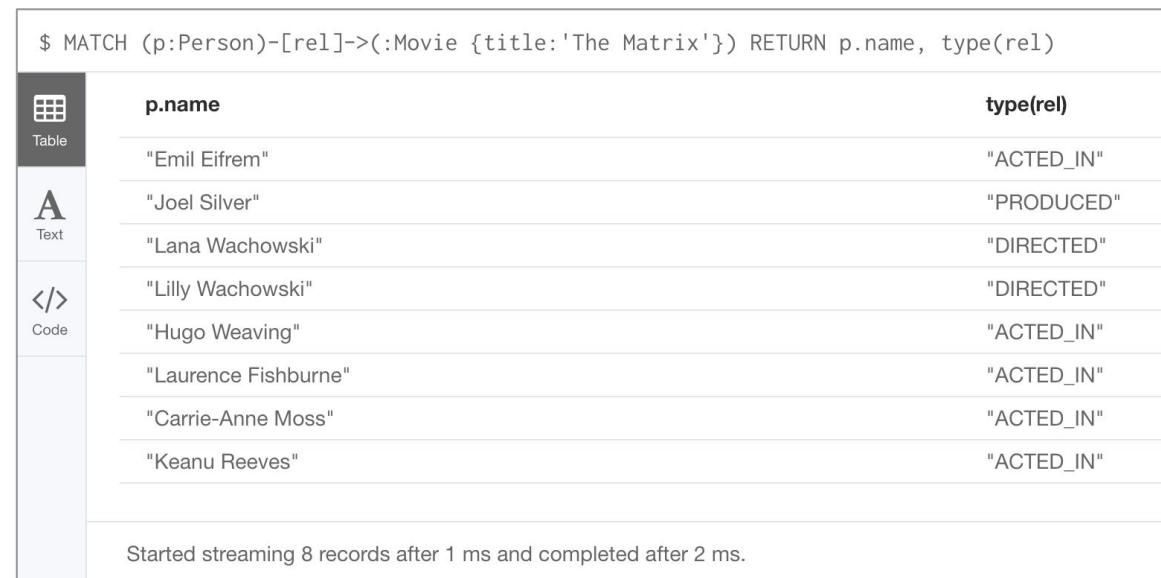


Connect result  
nodes enabled in  
Neo4j Browser

# Retrieving relationship types

Find all people who have any type of relationship to the movie, *The Matrix* and return the name of the person and their relationship type:

```
MATCH (p:Person)-[rel]->(:Movie {title:'The Matrix'})  
RETURN p.name, type(rel)
```



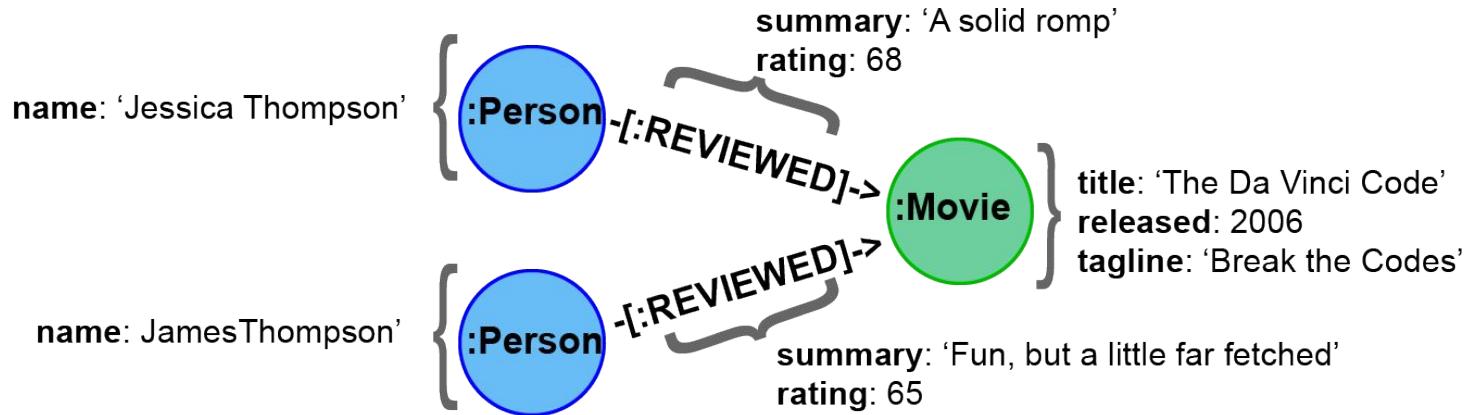
The screenshot shows the Neo4j browser interface with a query results table. The table has two columns: 'p.name' and 'type(rel)'. The data rows are:

p.name	type(rel)
"Emil Eifrem"	"ACTED_IN"
"Joel Silver"	"PRODUCED"
"Lana Wachowski"	"DIRECTED"
"Lilly Wachowski"	"DIRECTED"
"Hugo Weaving"	"ACTED_IN"
"Laurence Fishburne"	"ACTED_IN"
"Carrie-Anne Moss"	"ACTED_IN"
"Keanu Reeves"	"ACTED_IN"

Started streaming 8 records after 1 ms and completed after 2 ms.

The sidebar on the left shows navigation icons: Table, Text, and Code, with 'Text' currently selected.

# Retrieving properties for a relationship - 1



# Retrieving properties for a relationship - 2

Find all people who gave the movie, *The Da Vinci Code*, a rating of 65, returning their names:

```
MATCH (p:Person)-[:REVIEWED {rating: 65}]->(:Movie {title: 'The Da Vinci Code'})  
RETURN p.name
```

```
$ MATCH (p:Person)-[:REVIEWED {rating: 65}]->(:Movie {title: 'The Da Vinci Code'}) RETURN p.name
```

p.name

"James Thompson"

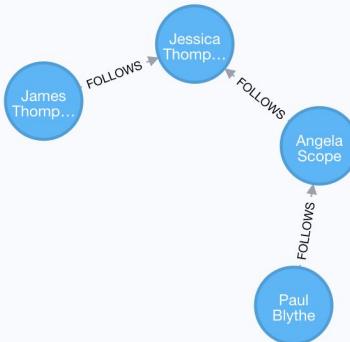


Table



Text

# Using patterns for queries - 1



Find all people who follow *Angela Scope*, returning the nodes:

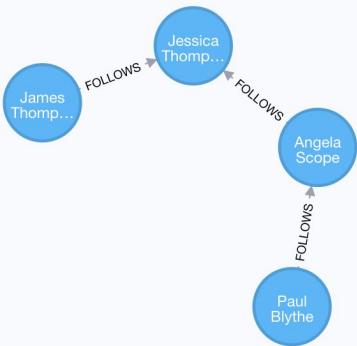
```
MATCH (p:Person) -[:FOLLOWERS]->(:Person {name:'Angela Scope'})  
RETURN p
```

\$ MATCH (p:Person)-[:FOLLOWERS]->(:Person {name:'Angela Scope'}) RETURN p

*	(1)	Person(1)
Graph		
Table		
A Text		

Paul Blythe

# Using patterns for queries - 2



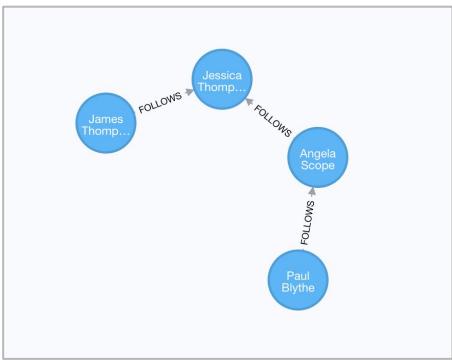
Find all people who *Angela Scope* follows, returning the nodes:

```
MATCH (p:Person)<-[:FOLLOWS]-(:Person {name:'Angela Scope'})  
RETURN p
```

```
$ MATCH (p:Person)<-[:FOLLOWS]-(:Person {name:'Angela Scope'}) RETURN p
```



# Querying by any direction of the relationship



Find all people who follow *Angela Scope* or who *Angela Scope* follows, returning the nodes:

```
MATCH (p1:Person) - [:FOLLOWS] - (p2:Person {name:'Angela Scope'})  
RETURN p1, p2
```

```
$ MATCH (p1:Person)-[:FOLLOWS]-(p2:Person {name:'Angela Scope'}) RETURN p1, p2
```



Graph

\*(3)

Person(3)



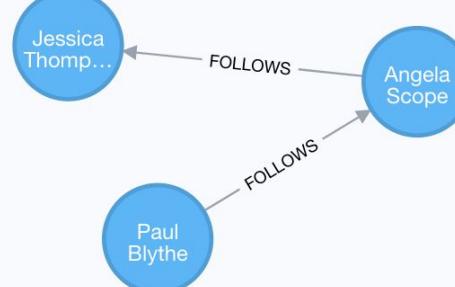
Table



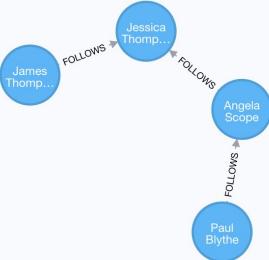
Text



</>



# Traversing relationships - 1



Find all people who follow anybody who follows *Jessica Thompson* returning the people as nodes:

```
MATCH (p:Person) - [:FOLLOWS] -> (:Person) - [:FOLLOWS] ->
      (:Person {name:'Jessica Thompson'})
RETURN p
```

```
$ MATCH (p:Person)-[:FOLLOWS]->(:Person)-[:FOLLOWS]->(:Person {name:'Jessica Thompson'}) RETURN p
```



\*(1)

Person(1)

Graph

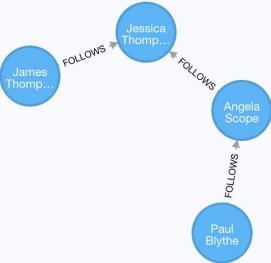


Table

A



# Traversing relationships - 2



Find the path that includes all people who follow anybody who follows *Jessica Thompson* returning the path:

```
MATCH path = (:Person) - [:FOLLOWERS] -> (:Person) - [:FOLLOWERS] -> (:Person {name:'Jessica Thompson'})  
RETURN path
```

\$ MATCH path = (:Person)-[:FOLLOWERS]->(:Person)-[:FOLLOWERS]->(:Person {name:'Jessica T...'}  
Graph Person(3)  
Table (2) FOLLOWERS(2)  
Text  
Code

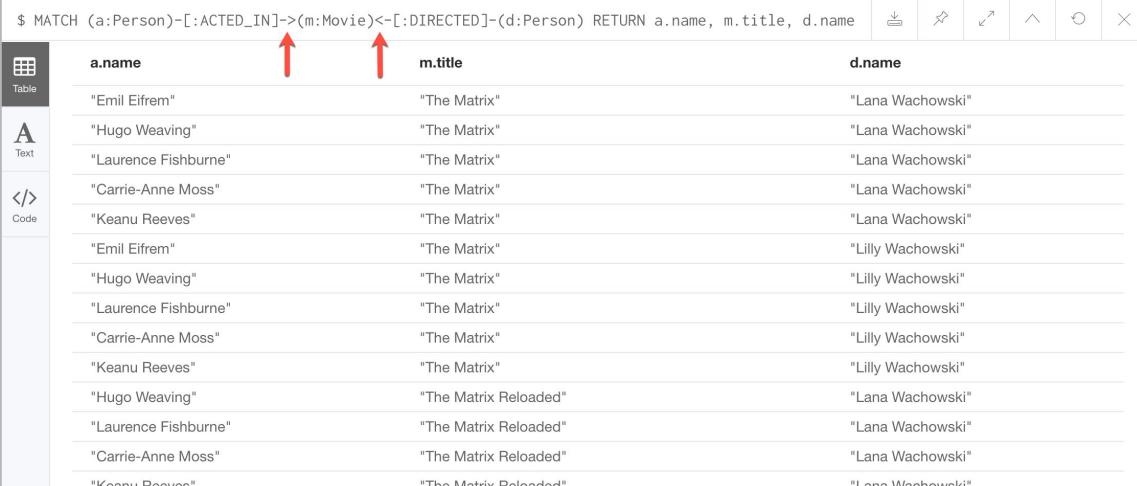
Displaying 3 nodes, 2 relationships.

Sub-graph

# Using relationship direction to optimize a query

Find all people that acted in a movie and the directors for that same movie, returning the name of the actor, the movie title, and the name of the director:

```
MATCH (a:Person) - [:ACTED_IN] -> (m:Movie) <- [:DIRECTED] - (d:Person)  
RETURN a.name, m.title, d.name
```



	a.name	m.title	d.name
Table	"Emil Eifrem"	"The Matrix"	"Lana Wachowski"
A	"Hugo Weaving"	"The Matrix"	"Lana Wachowski"
Text	"Laurence Fishburne"	"The Matrix"	"Lana Wachowski"
	"Carrie-Anne Moss"	"The Matrix"	"Lana Wachowski"
	"Keanu Reeves"	"The Matrix"	"Lana Wachowski"
Code	"Emil Eifrem"	"The Matrix"	"Lily Wachowski"
	"Hugo Weaving"	"The Matrix"	"Lily Wachowski"
	"Laurence Fishburne"	"The Matrix"	"Lily Wachowski"
	"Carrie-Anne Moss"	"The Matrix"	"Lily Wachowski"
	"Keanu Reeves"	"The Matrix"	"Lily Wachowski"
	"Hugo Weaving"	"The Matrix Reloaded"	"Lana Wachowski"
	"Laurence Fishburne"	"The Matrix Reloaded"	"Lana Wachowski"
	"Carrie-Anne Moss"	"The Matrix Reloaded"	"Lana Wachowski"
	"Keanu Reeves"	"The Matrix Reloaded"	"Lana Wachowski"

# Cypher style recommendations - 1

Here are the **Neo4j-recommended** Cypher coding standards that we use in this training:

- Node labels are CamelCase and case-sensitive (examples: *Person*, *NetworkAddress*).
- Property keys, variables, parameters, aliases, and functions are camelCase case-sensitive (examples: *businessAddress*, *title*).
- Relationship types are in upper-case and can use the underscore. (examples: *ACTED\_IN*, *FOLLOWS*).
- Cypher keywords are upper-case (examples: MATCH, RETURN).

# Cypher style recommendations - 2

Here are the **Neo4j-recommended** Cypher coding standards that we use in this training:

- String constants are in single quotes (with exceptions).
- Specify variables only when needed for use later in the Cypher statement.
- Place named nodes and relationships (that use variables) before anonymous nodes and relationships in your MATCH clauses when possible.
- Specify anonymous relationships with -->, --, or <--

```
MATCH (:Person {name: 'Diane Keaton'})-[movRel:ACTED_IN]-->
(:Movie {title:"Something's Gotta Give"})
RETURN movRel.roles
```

# Exercise 3: Filtering queries using relationships

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 3.



# Check your understanding

# Question 1

Suppose you have a graph that contains nodes representing customers and other business entities for your application. The node label in the database for a customer is *Customer*. Each *Customer* node has a property named *email* that contains the customer's email address. What Cypher query do you execute to return the email addresses for all customers in the graph?

Select the correct answer.

- MATCH (n) RETURN n.Customer.email
- MATCH (c:Customer) RETURN c.email
- MATCH (Customer) RETURN email
- MATCH (c) RETURN Customer.email

# Answer 1

Suppose you have a graph that contains nodes representing customers and other business entities for your application. The node label in the database for a customer is *Customer*. Each *Customer* node has a property named *email* that contains the customer's email address. What Cypher query do you execute to return the email addresses for all customers in the graph?

Select the correct answer.

- MATCH (n) RETURN n.Customer.email
- MATCH (c:Customer) RETURN c.email
- MATCH (Customer) RETURN email
- MATCH (c) RETURN Customer.email

# Question 2

Suppose you have a graph that contains *Customer* and *Product* nodes. A *Customer* node can have a *BOUGHT* relationship with a *Product* node. *Customer* nodes can have other relationships with *Product* nodes. A *Customer* node has a property named *customerName*. A *Product* node has a property named *productName*. What Cypher query do you execute to return all of the products (by name) bought by customer 'ABCCO'.

Select the correct answer.

- MATCH (c:Customer {customerName: 'ABCCO'}) RETURN c.BOUGHT.productName
- MATCH (:Customer 'ABCCO') - [:BOUGHT] -> (p:Product) RETURN p.productName
- MATCH (p:Product) -> [:BOUGHT\_BY] -> (:Customer 'ABCCO') RETURN p.productName
- MATCH (:Customer {customerName: 'ABCCO'}) - [:BOUGHT] -> (p:Product) RETURN p.productName

# Answer 2

Suppose you have a graph that contains *Customer* and *Product* nodes. A *Customer* node can have a *BOUGHT* relationship with a *Product* node. *Customer* nodes can have other relationships with *Product* nodes. A *Customer* node has a property named *customerName*. A *Product* node has a property named *productName*. What Cypher query do you execute to return all of the products (by name) bought by customer 'ABCCO'.

Select the correct answer.

- MATCH (c:Customer {customerName: 'ABCCO'}) RETURN c.BOUGHT.productName
- MATCH (:Customer 'ABCCO') -[:BOUGHT]→(p:Product) RETURN p.productName
- MATCH (p:Product)←[:BOUGHT\_BY] - (:Customer 'ABCCO') RETURN p.productName
- MATCH (:Customer {customerName: 'ABCCO'}) -[:BOUGHT]→(p:Product) RETURN p.productName

# Question 3

When must you use a variable in a MATCH clause?

Select the correct answer.

- When you want to query the graph using a node label.
- When you specify a property value to match the query.
- When you want to use the node or relationship to return a result.
- When the query involves two types of nodes.

# Answer 3

When must you use a variable in a MATCH clause?

Select the correct answer.

- When you want to query the graph using a node label.
- When you specify a property value to match the query.
- When you want to use the node or relationship to return a result.
- When the query involves two types of nodes.

# Summary

You should be able to write Cypher statements to:

- Retrieve nodes from the graph.
- Filter nodes retrieved using labels and property values of nodes.
- Retrieve property values from nodes in the graph.
- Filter nodes retrieved using relationships.

# Getting More Out of Queries

# Overview

At the end of this module, you should be able to write Cypher statements to:

- Filter queries using the WHERE clause
- Control query processing
- Control what results are returned
- Work with Cypher lists and dates

# Filtering queries using WHERE

Previously you retrieved nodes as follows:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie {released: 2008})  
RETURN p, m
```

A more flexible syntax for the same query is:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)  
WHERE m.released = 2008  
RETURN p, m
```

Testing more than equality:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)  
WHERE m.released = 2008 OR m.released = 2009  
RETURN p, m
```

# Specifying ranges in WHERE clauses

This query to find all people who acted in movies released between 2003 and 2004:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)  
WHERE m.released >= 2003 AND m.released <= 2004  
RETURN p.name, m.title, m.released
```

Is the same as:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)  
WHERE 2003 <= m.released <= 2004  
RETURN p.name, m.title, m.released
```

	p.name	m.title	m.released
Table	"Carrie-Anne Moss"	"The Matrix Reloaded"	2003
A	"Laurence Fishburne"	"The Matrix Reloaded"	2003
Text	"Keanu Reeves"	"The Matrix Reloaded"	2003
C	"Hugo Weaving"	"The Matrix Reloaded"	2003
Code	"Laurence Fishburne"	"The Matrix Revolutions"	2003
	"Hugo Weaving"	"The Matrix Revolutions"	2003
	"Keanu Reeves"	"The Matrix Revolutions"	2003
	"Carrie-Anne Moss"	"The Matrix Revolutions"	2003
	"Jack Nicholson"	"Something's Gotta Give"	2003
	"Diane Keaton"	"Something's Gotta Give"	2003
	"Keanu Reeves"	"Something's Gotta Give"	2003
	"Tom Hanks"	"The Polar Express"	2004

Started streaming 12 records after 1 ms and completed after 8 ms.

# Testing labels

These queries:

```
MATCH (p:Person)  
RETURN p.name
```

```
MATCH (p:Person)-[:ACTED_IN]->(:Movie {title: 'The  
Matrix'})  
RETURN p.name
```

Can be rewritten as:

```
MATCH (p)  
WHERE p:Person  
RETURN p.name
```

```
MATCH (p)-[:ACTED_IN]->(m)  
WHERE p:Person AND m:Movie AND m.title='The Matrix'  
RETURN p.name
```

# Testing the existence of a property

Find all movies that *Jack Nicholson* acted in that have a tagline, returning the title and tagline of the movie:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name='Jack Nicholson' AND exists(m.tagline)
RETURN m.title, m.tagline
```

```
$ MATCH (p:Person)-[:ACTED_IN]->(m:Movie) WHERE p.name='Jack Nicholson' AND exists(m.tagline) RETURN m.title, m.tagline
```



Table

A  
Text

</>  
Code

# Testing strings

Find all actors whose name begins with *Michael*:

```
MATCH (p:Person)-[:ACTED_IN]->()
WHERE p.name STARTS WITH 'Michael'
RETURN p.name
```

```
$ MATCH (p:Person)-[:ACTED_IN]->() WHERE p.name STARTS WITH 'Michael' RETURN p.name
```



p.name

"Michael Clarke Duncan"

"Michael Sheen"

```
MATCH (p:Person)-[:ACTED_IN]->()
WHERE toLower(p.name) STARTS WITH 'michael'
RETURN p.name
```

# Testing with regular expressions

Find people whose name starts with *Tom*:

```
MATCH (p:Person)
WHERE p.name =~ 'Tom.*'
RETURN p.name
```

```
$ MATCH (p:Person) WHERE p.name =~ 'Tom.*' RETURN p.name
```

	Table
	Text
	Code

p.name

"Tom Cruise"

"Tom Skerritt"

"Tom Hanks"

"Tom Tykwer"

# Testing with patterns - 1

Find all people who wrote movies returning their names and the title of the movie they wrote:

```
MATCH (p:Person)-[:WROTE]->(m:Movie)  
RETURN p.name, m.title
```

\$ MATCH (p:Person)-[:WROTE]->(m:Movie) RETURN p.name, m.title	
p.name	m.title
"Aaron Sorkin"	"A Few Good Men"
"Jim Cash"	"Top Gun"
"Cameron Crowe"	"Jerry Maguire"
"Nora Ephron"	"When Harry Met Sally"
"David Mitchell"	"Cloud Atlas"
"Lilly Wachowski"	"V for Vendetta"
"Lana Wachowski"	"V for Vendetta"
"Lana Wachowski"	"Speed Racer"
"Lilly Wachowski"	"Speed Racer"
"Nancy Meyers"	"Something's Gotta Give"

Started streaming 10 records in less than 1 ms and completed after 1 ms.

# Testing with patterns - 2

Find the people who wrote movies, but did not direct them, returning their names and the title of the movie:

```
MATCH (p:Person)-[:WROTE]->(m:Movie)  
WHERE NOT exists( (p)-[:DIRECTED]->() )  
RETURN p.name, m.title
```

```
$ MATCH (p:Person)-[:WROTE]->(m:Movie) WHERE NOT exists( (p)-[:DIRECTED]->() ) RETURN p.name, m.tit...
```



Table

**p.name**

"Aaron Sorkin"

**m.title**

"A Few Good Men"



Text

"Jim Cash"

"Top Gun"



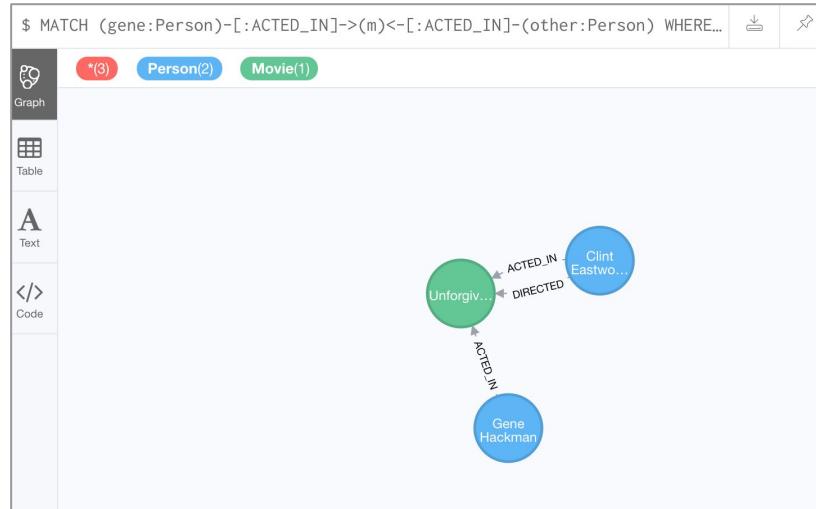
"David Mitchell"

"Cloud Atlas"

# Testing with patterns - 3

Find *Gene Hackman* and the movies that he acted in with another person who also directed the movie, returning the nodes found:

```
MATCH (gene:Person)-[:ACTED_IN]->(m:Movie)<-[ :ACTED_IN]-(other:Person)  
WHERE gene.name= 'Gene Hackman' AND exists( (other)-[:DIRECTED]->() )  
RETURN gene, other, m
```



# Testing with list values - 1

Find all people born in 1965 and 1970:

```
MATCH (p:Person)
WHERE p.born IN [1965, 1970]
RETURN p.name as name, p.born as yearBorn
```

```
$ MATCH (p:Person) WHERE p.born IN [1965, 1970] RETURN p.name as name, p.born as yearBorn
```



Table



Text



Code

name	yearBorn
"Lana Wachowski"	1965
"Jay Mohr"	1970
"River Phoenix"	1970
"Ethan Hawke"	1970
"Brooke Langton"	1970
"Tom Tykwer"	1965
"John C. Reilly"	1965

Started streaming 7 records after 1 ms and completed after 2 ms.

# Testing with list values - 2

Find the actor who played *Neo* in the movie, *The Matrix*:

```
MATCH (p:Person)-[r:ACTED_IN]->(m:Movie)
WHERE 'Neo' IN r.roles AND m.title='The Matrix'
RETURN p.name
```

```
$ MATCH (p:Person)-[r:ACTED_IN]->(m:Movie) WHERE "Neo" IN r.roles and m.title="The Matrix" RETURN p.name
```



Table

p.name

"Keanu Reeves"

A

# **Exercise 4: Filtering queries using the WHERE clause**

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 4.



# Controlling query processing

- Multiple MATCH clauses
- Path variables
- Varying length paths
- Finding the shortest path
- Optional pattern matching
- Collecting results into lists
- Counting results
- Using the WITH clause to control processing

# Specifying multiple MATCH patterns

This query to find people who either acted or directed a movie released in 2000 is specified with two MATCH patterns:

```
MATCH  (a:Person)-[:ACTED_IN]->(m:Movie),  
      (m:Movie)<-[:DIRECTED]-(d:Person)  
WHERE m.released = 2000  
RETURN a.name, m.title, d.name
```

A best practice is to use a single MATCH pattern if possible:

```
MATCH  (a:Person)-[:ACTED_IN]->(m:Movie)<-[:DIRECTED]-(d:Person)  
WHERE m.released = 2000  
RETURN a.name, m.title, d.name
```

# Example 1: Using two MATCH patterns

Find the actors who acted in the same movies as *Keanu Reeves*, but not when *Hugo Weaving* acted in the same movie:

```
MATCH (keanu:Person)-[:ACTED_IN]->(movie:Movie)<-[ACTED_IN]-(n:Person), (hugo:Person)
WHERE keanu.name='Keanu Reeves' AND hugo.name='Hugo Weaving' AND
      NOT (hugo)-[:ACTED_IN]->(movie)
RETURN n.name
```

The screenshot shows the Neo4j Browser interface. A warning message is displayed in a modal window:

⚠️ 1 MATCH (keanu:Person)-[:ACTED\_IN]->(movie:Movie)<-[ACTED\_IN]-(n:Person),  
This query builds a cartesian product between disconnected patterns.  
If it matches multiple disconnected patterns, this will build a cartesian product  
between all those parts. This may produce a large  
amount of data and slow down query processing.  
While occasionally intended, it may often be  
possible to reformulate the query that avoids the  
use of this cross product, perhaps by adding a  
relationship between the different parts or by  
using OPTIONAL MATCH (identifier is: (hugo))

The screenshot shows the results of the query in the Neo4j Browser. The results are listed in a table under the "Text" tab:

n.name
"Jack Nicholson"
"Diane Keaton"
"Ice-T"
"Takeshi Kitano"
"Dina Meyer"
"Brooke Langton"
"Gene Hackman"
"Orlando Jones"
"Al Pacino"
"Charlize Theron"

At the bottom of the results pane, a message states: "Started streaming 10 records in less than 1 ms and completed in less than 1 ms."

# Example 2: Using two MATCH patterns

Retrieve the movies that *Meg Ryan* acted in and their respective directors, as well as the other actors that acted in these movies:

```
MATCH (meg:Person)-[:ACTED_IN]->(m:Movie)<-[DIRECTED]-(d:Person),  
      (other:Person)-[:ACTED_IN]->(m)  
WHERE meg.name = 'Meg Ryan'  
RETURN m.title AS movie, d.name AS director, other.name AS `co-actors`
```

\$ MATCH (meg:Person)-[:ACTED\_IN]->(m:Movie)<-[DIRECTED]-(d:Person), (other:Person)-[:ACTED\_IN]->(m... 

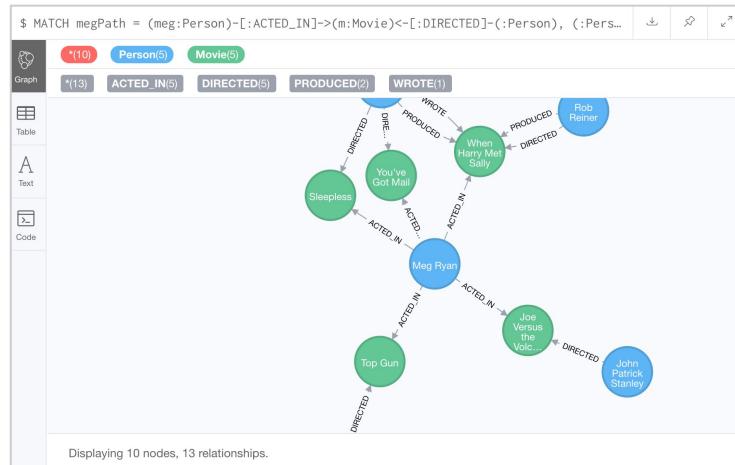
movie	director	co-actors
"Joe Versus the Volcano"	"John Patrick Stanley"	"Tom Hanks"
"Joe Versus the Volcano"	"John Patrick Stanley"	"Nathan Lane"
"When Harry Met Sally"	"Rob Reiner"	"Bruno Kirby"
"When Harry Met Sally"	"Rob Reiner"	"Carrie Fisher"
"When Harry Met Sally"	"Rob Reiner"	"Billy Crystal"
"Sleepless in Seattle"	"Nora Ephron"	"Rosie O'Donnell"
"Sleepless in Seattle"	"Nora Ephron"	"Tom Hanks"
"Sleepless in Seattle"	"Nora Ephron"	"Bill Pullman"
"Sleepless in Seattle"	"Nora Ephron"	"Victor Garber"
"Sleepless in Seattle"	"Nora Ephron"	"Rita Wilson"
"You've Got Mail"	"Nora Ephron"	"Dave Chappelle"
"You've Got Mail"	"Nora Ephron"	"Steve Zahn"
"You've Got Mail"	"Nora Ephron"	"Greg Kinnear"
"You've Got Mail"	"Nora Ephron"	"Parker Posey"
"You've Got Mail"	"Nora Ephron"	"Tom Hanks"
"Top Gun"	"Tony Scott"	"Tom Skerritt"

Started streaming 20 records in less than 1 ms and completed after 2 ms.

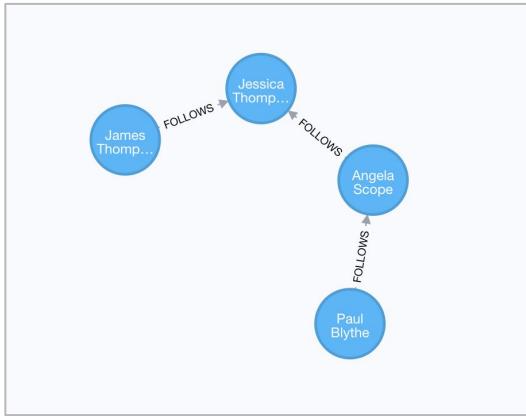
# Setting path variables

Path variables allow you to reuse path/pattern in a query or return the path. Here us the previous query where the path is returned.

```
MATCH megPath =  
  (meg:Person) - [:ACTED_IN] -> (m:Movie) <- [:DIRECTED] - (:Person),  
    (:Person) - [:ACTED_IN] -> (m)  
  WHERE meg.name = 'Meg Ryan'  
  RETURN megPath
```



# Specifying varying length paths



Find all people who are exactly two hops away from *Paul Blythe*:

```
MATCH (follower:Person)-[:FOLLOWERS*2]->(p:Person)  
WHERE follower.name = 'Paul Blythe'  
RETURN p
```

\$ MATCH (follower:Person)-[:FOLLOWERS\*2]->(p:Person) WHERE follower.name = 'Paul Blythe' RETURN p

Graph	Table	Text

\*(1) Person(1)

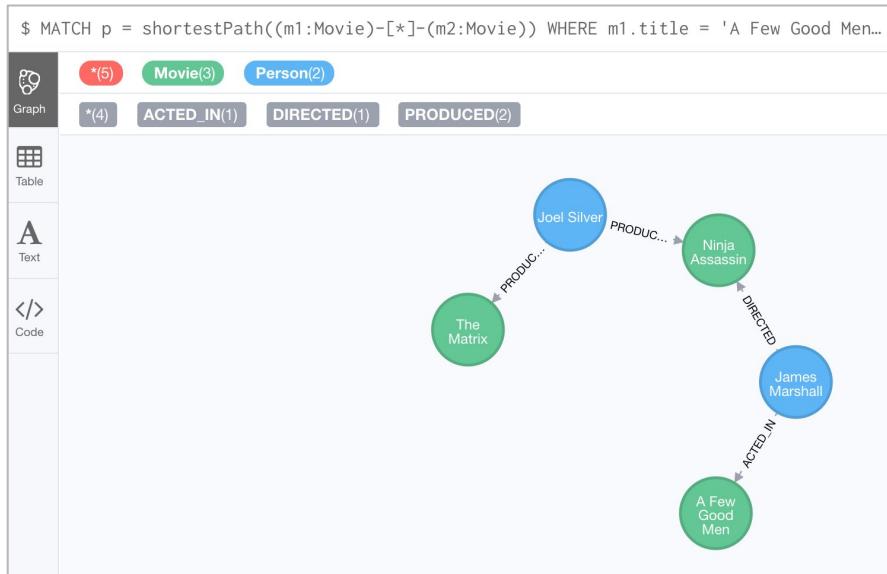
row	name
1	Jessica Thompson

# Finding the shortest path

Find the shortest path between the movies *The Matrix* and *A Few Good Men*:

```
MATCH p = shortestPath((m1:Movie)-[*]-(m2:Movie))  
WHERE m1.title = 'A Few Good Men' AND  
      m2.title = 'The Matrix'  
RETURN p
```

Specifying \* for the relationship means we use any relationship type for determining the path.



# Specifying optional pattern matching

Find all people whose name starts with *James*, additionally return people who have reviewed a movie:

```
MATCH (p:Person)
WHERE p.name STARTS WITH 'James'
OPTIONAL MATCH (p)-[r:REVIEWED]->(m:Movie)
RETURN p.name, type(r), m.title
```

\$ MATCH (p:Person) WHERE p.name STARTS WITH 'James' OPTIONAL MATCH (p)-[r:REVIEWED]->(m:Movie) RETU...

	p.name	type(r)	m.title
Table	"James Marshall"	null	null
A	"James L. Brooks"	null	null
	"James Cromwell"	null	null
Code	"James Thompson"	"REVIEWED"	"The Replacements"
	"James Thompson"	"REVIEWED"	"The Da Vinci Code"

Nulls are returned for the missing parts of the pattern. Similar to an outer join in SQL.

# Aggregation in Cypher

- Different from SQL - no need to specify a grouping key.
- As soon as you use an aggregation function, all non-aggregated result columns automatically become grouping keys.
- Implicit grouping based upon fields in the RETURN clause.

```
// implicitly groups by a.name and d.name
MATCH (a)-[:ACTED_IN]->(m)<-[DIRECTED]-(d)
RETURN a.name, d.name, count(*)
```

\$ MATCH (a)-[:ACTED\_IN]->(m)<-[DIRECTED]-(d) RETURN a.name, d.name, count(\*)

The screenshot shows the Neo4j browser interface with a query results table. The table has three columns: 'a.name', 'd.name', and 'count(\*)'. The data consists of 175 records, each showing a combination of an actor's name and a director's name, along with a count of 1, indicating they have exactly one co-occurrence in the dataset. The table includes standard browser navigation controls like back, forward, and search at the top.

a.name	d.name	count(*)
"Lori Petty"	"Penny Marshall"	1
"Emile Hirsch"	"Lana Wachowski"	1
"Val Kilmer"	"Tony Scott"	1
"Gene Hackman"	"Howard Deutch"	1
"Rick Yune"	"James Marshall"	1
"Audrey Tautou"	"Ron Howard"	1
"Halle Berry"	"Tom Tykwer"	1
"Cuba Gooding Jr."	"James L. Brooks"	1
"Kevin Bacon"	"Rob Reiner"	1
"Tom Hanks"	"Ron Howard"	2
"Laurence Fishburne"	"Lana Wachowski"	3
"Hugo Weaving"	"Lana Wachowski"	4
"Jay Mohr"	"Cameron Crowe"	1
"Hugo Weaving"	"James Marshall"	1
"Philip Seymour Hoffman"	"Mike Nichols"	1
"Werner Herzog"	"Vincent Ward"	1

Started streaming 175 records after 8 ms and completed after 8 ms.

# Collecting results

Find the movies that Tom Cruise acted in and return them as a list:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name = 'Tom Cruise'
RETURN collect(m.title) AS `movies for Tom Cruise`
```

```
$ MATCH (p:Person)-[:ACTED_IN]->(m:Movie) WHERE p.name = 'Tom Cruise' RETURN collect(m.title) AS `mo...
```



Table



Text

**movies for Tom Cruise**

```
["Jerry Maguire", "Top Gun", "A Few Good Men"]
```

# Counting results

Find all of the actors and directors who worked on a movie, return the count of the number paths found between actors and directors and collect the movies as a list:

```
MATCH (actor:Person)-[:ACTED_IN]->(m:Movie)<-[:DIRECTED]-(director:Person)  
RETURN actor.name, director.name, count(m) AS collaborations,  
collect(m.title) AS movies
```

Table

A Text

</> Code

actor.name	director.name	collaborations	movies
"Lori Petty"	"Penny Marshall"	1	[{"A League of Their Own"]}
"Emile Hirsch"	"Lana Wachowski"	1	[{"Speed Racer"]}
"Val Kilmer"	"Tony Scott"	1	[{"Top Gun"]}
"Gene Hackman"	"Howard Deutch"	1	[{"The Replacements"]}
"Rick Yune"	"James Marshall"	1	[{"Ninja Assassin"]}
"Audrey Tautou"	"Ron Howard"	1	[{"The Da Vinci Code"]}
"Halle Berry"	"Tom Tykwer"	1	[{"Cloud Atlas"]}
"Cuba Gooding Jr."	"James L. Brooks"	1	[{"As Good as It Gets"]}
"Kevin Bacon"	"Rob Reiner"	1	[{"A Few Good Men"]}
"Tom Hanks"	"Ron Howard"	2	[{"The Da Vinci Code", "Apollo 13"]}
"Laurence Fishburne"	"Lana Wachowski"	3	[{"The Matrix", "The Matrix Reloaded", "The Matrix Revolutions"}]
"Hugo Weaving"	"Lana Wachowski"	4	[{"The Matrix", "The Matrix Reloaded", "The Matrix Revolutions", "Cloud Atlas"]}
"Jay Mohr"	"Cameron Crowe"	1	[{"Jerry Maguire"]}
"Hugo Weaving"	"James Marshall"	1	[{"V for Vendetta"]}
"Philip Seymour Hoffman"	"Mike Nichols"	1	[{"Charlie Wilson's War"]}
"Werner Herzog"	"Vincent Ward"	1	[{"What Dreams May Come"]}

Started streaming 175 records after 14 ms and completed after 14 ms.

# Additional processing using WITH - 1

Use the WITH clause to perform intermediate processing or data flow operations.

Find all actors who acted in two or three movies, return the list of movies:

```
MATCH (a:Person) - [:ACTED_IN] -> (m:Movie)
WITH a, count(a) AS numMovies, collect(m.title) as movies
WHERE numMovies > 1 AND numMovies < 4
RETURN a.name, numMovies, movies
```

\$ MATCH (a:Person)-[:ACTED\_IN]->(m:Movie) WITH a, count(a) AS numMovies, collect(m.title) as movies...

A	a.name	numMovies	movies
Text	"Bill Paxton"	3	[{"Apollo 13", "Twister", "A League of Their Own"}]
	"Rosie O'Donnell"	2	[{"Sleepless in Seattle", "A League of Their Own"}]
	"Oliver Platt"	2	[{"Frost/Nixon", "Bicentennial Man"}]
	"Helen Hunt"	3	[{"As Good as It Gets", "Twister", "Cast Away"}]
	"Gary Sinise"	2	[{"The Green Mile", "Apollo 13"}]
	"Nathan Lane"	2	[{"Joe Versus the Volcano", "The Birdcage"}]
	"Gene Hackman"	3	[{"The Replacements", "The Birdcage", "Unforgiven"}]
	"Kiefer Sutherland"	2	[{"A Few Good Men", "Stand By Me"}]
	"Carrie-Anne Moss"	3	[{"The Matrix", "The Matrix Reloaded", "The Matrix Revolutions"}]
	"James Cromwell"	2	[{"Snow Falling on Cedars", "The Green Mile"}]
	"Danny DeVito"	2	[{"Hoffa", "One Flew Over the Cuckoo's Nest"}]
	"Sam Rockwell"	2	[{"The Green Mile", "Frost/Nixon"}]
	"Rain"	2	[{"Speed Racer", "Ninja Assassin"}]
	"Rick Yune"	2	[{"Snow Falling on Cedars", "Ninja Assassin"}]
	"Max von Sydow"	2	[{"What Dreams May Come", "Snow Falling on Cedars"}]
	"Zach Grenier"	2	[{"RescueDawn", "Twister"}]

Started streaming 29 records after 4 ms and completed after 7 ms.

# Additional processing using WITH - 2

Find all actors who have acted in at least five movies, and find (optionally) the movies they directed and return the person and those movies.:

```
MATCH (p:Person)
WITH p, size((p)-[:ACTED_IN]->(:Movie)) AS movies
WHERE movies >= 5
OPTIONAL MATCH (p)-[:DIRECTED]->(m:Movie)
RETURN p.name, m.title
```

\$ MATCH (p:Person) WITH p, size((p)-[:ACTED\_IN]->(:Movie)) AS mo...⬇️↗️↖️↗️⟳⟳

TableTextCode

	p.name	m.title
"Keanu Reeves"		null
"Hugo Weaving"		null
"Jack Nicholson"		null
"Meg Ryan"		null
"Tom Hanks"		"That Thing You Do"

# Exercise 5: Controlling query processing

In Neo4j Browser:

:play intro-neo4j-exercises

Then follow instructions for Exercise 5.

# Controlling how results are returned

- Eliminating duplication
- Ordering results
- Limiting the number of results

# Eliminating duplication - 1

Here is a query where the movie *That Thing You Do* is repeated in the list because Tom Hanks both acted in and directed the movie:

```
MATCH (p:Person)-[:DIRECTED | :ACTED_IN]->(m:Movie)  
WHERE p.name = 'Tom Hanks'  
RETURN m.released, collect(m.title) AS movies
```

\$ MATCH (p:Person)-[:DIRECTED | :ACTED\_IN]->(m:Movie) WHERE p.name = 'Tom Hanks' RETURN m.released,...

The screenshot shows the Neo4j browser interface with a sidebar on the left containing icons for Table, Text, and Code. The main area displays a table with two columns: 'm.released' and 'movies'. The table lists 12 rows of data, each corresponding to a specific year and a list of movie titles. Notably, the year 1996 appears twice, each associated with a different set of titles, demonstrating the presence of duplicates in the results.

m.released	movies
2012	[ "Cloud Atlas" ]
2006	[ "The Da Vinci Code" ]
2000	[ "Cast Away" ]
1993	[ "Sleepless in Seattle" ]
1996	[ "That Thing You Do", "That Thing You Do" ]
1990	[ "Joe Versus the Volcano" ]
1999	[ "The Green Mile" ]
1998	[ "You've Got Mail" ]
2007	[ "Charlie Wilson's War" ]
1992	[ "A League of Their Own" ]
1995	[ "Apollo 13" ]
2004	[ "The Polar Express" ]

Started streaming 12 records after 2 ms and completed after 2 ms.

# Eliminating duplication - 2

We can eliminate the duplication in this query by specifying the DISTINCT keyword as follows:

```
MATCH (p:Person)-[:DIRECTED | :ACTED_IN]->(m:Movie)
WHERE p.name = 'Tom Hanks'
RETURN m.released, collect(DISTINCT m.title) AS movies
```

\$ MATCH (p:Person)-[:DIRECTED | :ACTED\_IN]->(m:Movie) WHERE p.name = 'Tom Hanks' RETURN m.released,...

	m.released	movies
Table	2012	["Cloud Atlas"]
A	2006	["The Da Vinci Code"]
Text	2000	["Cast Away"]
	1993	["Sleepless in Seattle"]
</>	1996	["That Thing You Do"]
Code	1990	["Joe Versus the Volcano"]
	1999	["The Green Mile"]
	1998	["You've Got Mail"]
	2007	["Charlie Wilson's War"]
	1992	["A League of Their Own"]
	1995	["Apollo 13"]
	2004	["The Polar Express"]

Started streaming 12 records after 1 ms and completed after 1 ms.

# Using WITH and DISTINCT to eliminate duplication

We can also eliminate the duplication in this query by specifying WITH DISTINCT as follows:

```
MATCH (p:Person)-[:DIRECTED | :ACTED_IN]->(m:Movie)
WHERE p.name = 'Tom Hanks'
WITH DISTINCT m
RETURN m.released, m.title
```

\$ MATCH (p:Person)-[:DIRECTED | :ACTED\_IN]->(m:Movie) WHERE p.name = 'Tom Hanks' WITH distinct m RE...

The screenshot shows the Neo4j browser interface with a table results panel. On the left, there are three navigation tabs: 'Table' (selected), 'Text', and 'Code'. The table has two columns: 'm.released' and 'm.title'. The data consists of 12 rows, each representing a movie directed or acted in by Tom Hanks. The movies and their release years are:

m.released	m.title
2004	"The Polar Express"
1995	"Apollo 13"
1990	"Joe Versus the Volcano"
1992	"A League of Their Own"
1999	"The Green Mile"
1996	"That Thing You Do"
1998	"You've Got Mail"
2000	"Cast Away"
2012	"Cloud Atlas"
1993	"Sleepless in Seattle"
2007	"Charlie Wilson's War"
2006	"The Da Vinci Code"

At the bottom of the table panel, it says: "Started streaming 12 records after 1 ms and completed after 1 ms."

# Ordering results

You can return results in order based upon the property value:

```
MATCH (p:Person)-[:DIRECTED | :ACTED_IN]->(m:Movie)
WHERE p.name = 'Tom Hanks'
RETURN m.released, collect(DISTINCT m.title) AS movies
ORDER BY m.released DESC
```

```
$ MATCH (p:Person)-[:DIRECTED | :ACTED_IN]->(m:Movie) WHERE p.name = 'Tom Hanks' RETURN m.released,...
```

Table

A  
Text

</>  
Code

m.released	movies
2012	[ "Cloud Atlas" ]
2007	[ "Charlie Wilson's War" ]
2006	[ "The Da Vinci Code" ]
2004	[ "The Polar Express" ]
2000	[ "Cast Away" ]
1999	[ "The Green Mile" ]
1998	[ "You've Got Mail" ]
1996	[ "That Thing You Do" ]
1995	[ "Apollo 13" ]
1993	[ "Sleepless in Seattle" ]
1992	[ "A League of Their Own" ]
1990	[ "Joe Versus the Volcano" ]

Started streaming 12 records after 2 ms and completed after 2 ms.

# Limiting results

What are the titles of the ten most recently released movies:

```
MATCH (m:Movie)  
RETURN m.title as title, m.released as year ORDER BY m.released  
DESC LIMIT 10
```

\$ MATCH (m:Movie) RETURN m.title as title, m.r...		↓	↗	↖	↗	↖	↗	↖	↗	↖	↗	↖
	title	year										
	"Cloud Atlas"	2012										
	"Ninja Assassin"	2009										
	"Frost/Nixon"	2008										
	"Speed Racer"	2008										
	"Charlie Wilson's War"	2007										
	"V for Vendetta"	2006										
	"The Da Vinci Code"	2006										
	"RescueDawn"	2006										
	"The Polar Express"	2004										
	"The Matrix Reloaded"	2003										

Started streaming 10 records after 1 ms and completed after 2 ms.

# Controlling number of results using WITH

Retrieve the actors who have acted in exactly five movies, returning the list of movies:

```
MATCH (a:Person)-[:ACTED_IN]->(m:Movie)
WITH a, count(*) AS numMovies, collect(m.title) as movies
WHERE numMovies = 5
RETURN a.name, numMovies, movies
```

```
$ MATCH (a:Person)-[:ACTED_IN]->(m:Movie) WITH a, count(*) AS numMovies, collect(m.title) as movies...
```



a.name	numMovies	movies
"Jack Nicholson"	5	["A Few Good Men", "As Good as It Gets", "Hoffa", "One Flew Over the Cuckoo's Nest", "Something's Gotta Give"]
"Hugo Weaving"	5	["The Matrix", "The Matrix Reloaded", "The Matrix Revolutions", "Cloud Atlas", "V for Vendetta"]
"Meg Ryan"	5	["Top Gun", "You've Got Mail", "Sleepless in Seattle", "Joe Versus the Volcano", "When Harry Met Sally"]

</>

Code

# Exercise 6: Controlling results returned

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 6.

# Working with Cypher data

Properties do not have types, but the values of the properties can contain data of any types:

- String                'Tom Cruise'
- Numeric              2012
- Date                  2018-12-15
- Spatial                {x: 12.0, y: 56.0, z: 1000.0}
- List                    ['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']
- Map                    [Q1: 395, Q2: 200, Q3: 604, Q3: 509]

# Lists

Retrieve all actors and their movies, returning each movie, its cast, and the size of the cast, ordered by the size of the cast:

```
MATCH (a:Person) - [:ACTED_IN] -> (m:Movie)
WITH m, count(m) AS numCast, collect(a.name) as cast
RETURN m.title, cast, numCast ORDER BY size(cast)
```

\$ MATCH (a:Person)-[:ACTED\_IN]->(m:Movie) WITH m, count(m) AS numCast, collect(a.name) as cast ORDER BY size(cast)

Table	m.title	cast	numCast
	"The Polar Express"	["Tom Hanks"]	1
	"Cast Away"	["Helen Hunt", "Tom Hanks"]	2
	"One Flew Over the Cuckoo's Nest"	["Jack Nicholson", "Danny DeVito"]	2
	"Bicentennial Man"	["Robin Williams", "Oliver Platt"]	2
	"Joe Versus the Volcano"	["Nathan Lane", "Meg Ryan", "Tom Hanks"]	3
	"The Devil's Advocate"	["Keanu Reeves", "Al Pacino", "Charlize Theron"]	3
	"The Birdcage"	["Nathan Lane", "Gene Hackman", "Robin Williams"]	3

# Unwinding lists

Just as you can create lists, you can take them apart as separate data values:

```
WITH [1, 2, 3] AS list  
UNWIND list AS row  
RETURN list, row
```

```
$ WITH [1, 2, 3] AS list UNWIND list AS row RETURN list, row
```

	list	row
Table	[1, 2, 3]	1
A	[1, 2, 3]	2
	[1, 2, 3]	3

# Dates

Find all actors in the graph that have a value for *born* and calculate their ages as of today:

```
MATCH (actor:Person)-[:ACTED_IN]->(:Movie)
WHERE exists(actor.born)
// calculate the age
with DISTINCT actor, date().year - actor.born as age
RETURN actor.name, age as `age today`
ORDER BY actor.born DESC
```



The screenshot shows the Neo4j browser interface with a table results window. The table has two columns: 'actor.name' and 'age today'. The data is as follows:

actor.name	age today
"Jonathan Lipnicki"	22
"Emile Hirsch"	33
"Rain"	36
"Natalie Portman"	37
"Christina Ricci"	38
"Emil Eifrem"	40
"Liv Tyler"	41
"Audrey Tautou"	42
"Charlize Theron"	43
"Jerry O'Connell"	44
"Christian Bale"	44
"Dave Chappelle"	45
"Wil Wheaton"	46
"Noah Wyle"	47
"Regina King"	47
"Corey Feldman"	47

Started streaming 101 records after 10 ms and completed after 10 ms.

# Exercise 7: Working with Cypher data

In Neo4j Browser:

:play intro-neo4j-exercises

Then follow instructions for Exercise 7.



# Check your understanding

# Question 1

Suppose you want to add a WHERE clause at the end of this statement to filter the results retrieved.

```
MATCH (p:Person) - [rel] -> (m:Movie) <- [:PRODUCED] - (:Person)
```

What variables, can you test in the WHERE clause:

Select the correct answers.

- p
- rel
- m
- PRODUCED

# Answer 1

Suppose you want to add a WHERE clause at the end of this statement to filter the results retrieved.

```
MATCH (p:Person) - [rel] -> (m:Movie) <- [:PRODUCED] - (:Person)
```

What variables, can you test in the WHERE clause:

Select the correct answers.

- p
- rel
- m
- PRODUCED

# Question 2

Suppose you want to retrieve all movies that have a *released* property value that is 2000, 2002, 2004, 2006, or 2008. Here is an incomplete Cypher example to return the *title* property values of all movies released in these years.

```
MATCH (m:Movie)
WHERE m.released XX [2000, 2002, 2004, 2006, 2008]
RETURN m.title
```

What keyword do you specify for **XX**?

Select the correct answer.

- CONTAINS
- IN
- IS
- EQUALS

# Answer 2

Suppose you want to retrieve all movies that have a *released* property value that is 2000, 2002, 2004, 2006, or 2008. Here is an incomplete Cypher example to return the *title* property values of all movies released in these years.

```
MATCH (m:Movie)
WHERE m.released XX [2000, 2002, 2004, 2006, 2008]
RETURN m.title
```

What keyword do you specify for **XX**?

Select the correct answer.

- CONTAINS
- IN
- IS
- EQUALS

# Question 3

Given this Cypher query:

```
MATCH (a:Person)-[:ACTED_IN]->(m:Movie)
WITH m, count(m) AS numMovies, collect(m.title) as movies
WHERE numMovies > 1 AND numMovies < 4
RETURN //??
```

What variables or aliases can be used to return values?

Select the correct answers.

- a
- m
- numMovies
- movies

# Answer 3

Given this Cypher query:

```
MATCH (a:Person)-[:ACTED_IN]->(m:Movie)
WITH m, count(m) AS numMovies, collect(m.title) as movies
WHERE numMovies > 1 AND numMovies < 4
RETURN //??
```

What variables or aliases can be used to return values?

Select the correct answers.

- a
- m
- numMovies
- movies

# Summary

At the end of this module, you should be able to write Cypher statements to:

- Filter queries using the WHERE clause
- Control query processing
- Control what results are returned
- Work with Cypher lists and dates

# Creating Nodes and Relationships

# Overview

At the end of this module, you should be able to write Cypher statements to:

- Create a node:
  - Add and remove node labels.
  - Add and remove node properties.
  - Update properties.
- Create a relationship:
  - Add and remove properties for a relationship.
- Delete a node.
- Delete a relationship.
- Merge data in a graph:
  - Creating nodes.
  - Creating relationships.

# Creating a node

Create a node of type *Movie* with the *title* property set to *Batman Begins*:

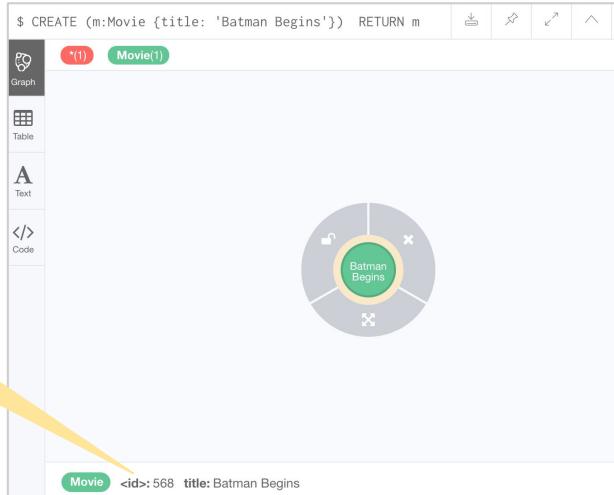
```
CREATE (:Movie {title: 'Batman Begins'})
```

Create a node of type *Movie* and *Action* with the *title* property set to *Batman Begins*:

```
CREATE (:Movie:Action {title: 'Batman Begins'})
```

Create a node of type *Movie* with the *title* property set to *Batman Begins* and return the node:

```
CREATE (:Movie {title: 'Batman Begins'})  
RETURN m
```



# Creating multiple nodes

Create some *Person* nodes for actors and the director for the movie, *Batman Begins*:

```
CREATE (:Person {name: 'Michael Caine', born: 1933}),  
       (:Person {name: 'Liam Neeson', born: 1952}),  
       (:Person {name: 'Katie Holmes', born: 1978}),  
       (:Person {name: 'Benjamin Melniker', born: 1913})
```

```
$ CREATE (:Person {name: 'Michael Caine', born: 1933}), (:Person {name: 'Liam Nees...
```



Table

```
Added 4 labels, created 4 nodes, set 8 properties, completed after 1 ms.
```

</>

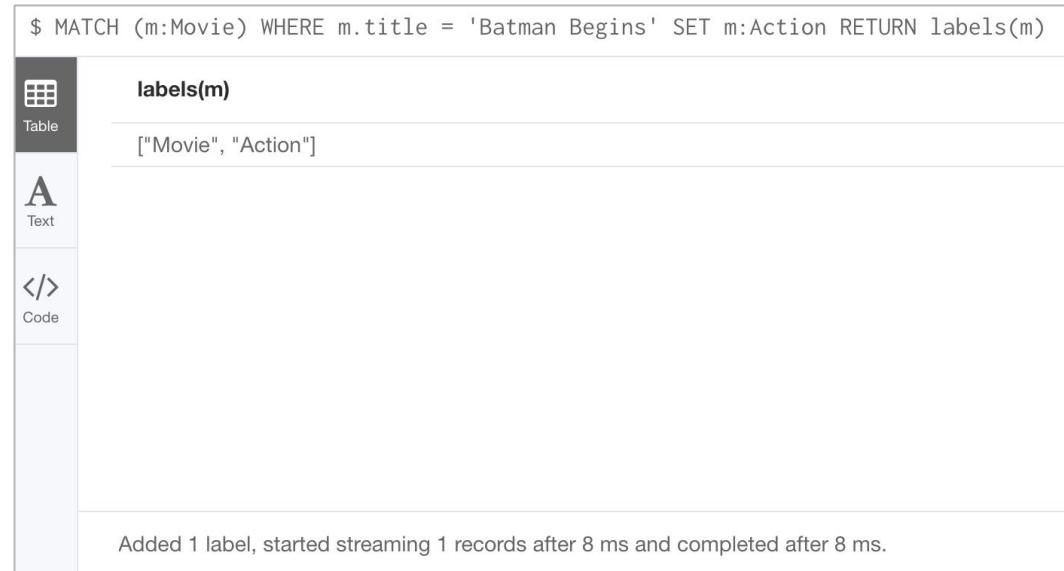
**Important:** The graph engine will create a node with the same properties of a node that already exists. You can prevent this from happening in one of two ways:

1. You can use `MERGE` rather than `CREATE` when creating the node.
2. You can add constraints to your graph.

# Adding a label to a node

Add the *Action* label to the movie, *Batman Begins*, return all labels for this node:

```
MATCH (m:Movie)  
WHERE m.title = 'Batman Begins'  
SET m:Action  
RETURN labels(m)
```



The screenshot shows the Neo4j browser interface with the following details:

- Query:** \$ MATCH (m:Movie) WHERE m.title = 'Batman Begins' SET m:Action RETURN labels(m)
- Labels:** labels(m)  
["Movie", "Action"]
- Panel Tabs:** Table (selected), Text, Code.
- Message:** Added 1 label, started streaming 1 records after 8 ms and completed after 8 ms.

# Removing a label from a node

Remove the *Action* label to the movie, *Batman Begins*, return all labels for this node:

```
MATCH (m:Movie:Action)  
WHERE m.title = 'Batman Begins'  
REMOVE m:Action  
RETURN labels(m)
```

```
$ MATCH (m:Movie:Action) WHERE m.title = 'Batman Begins' REMOVE m:Action RETURN labe...
```



Table

labels(m)

["Movie"]



Text



Code

Removed 1 label, started streaming 1 records after 22 ms and completed after 22 ms.

# Adding or updating properties for a node

- If property does not exist for the node, it is added with the specified value.
- If property exists for the node, it is updated with the specified value

Add the properties *released* and *lengthInMinutes* to the movie *Batman Begins*:

```
MATCH (m:Movie)
WHERE m.title = 'Batman Begins'
SET m.released = 2005, m.lengthInMinutes = 140
RETURN m
```

The screenshot shows the Neo4j browser interface. On the left, there is a sidebar with icons for Graph, Table (selected), Text, and Code. The main area displays a query in the Text tab:

```
$ MATCH (m:Movie) WHERE m.title = 'Batman Begins' SET m.released = 2005, m.lengthInMinutes = 140 .
```

Below the query, the results are shown in the Table tab. A single row is present, labeled 'm', containing the following JSON object:

```
{
  "title": "Batman Begins",
  "lengthInMinutes": 140,
  "released": 2005
}
```

At the bottom of the results panel, a status message reads: "Set 2 properties, started streaming 1 records after 6 ms and completed after 6 ms."

# Adding properties to a node - JSON style

Add or update all properties: *title*, *released*, *lengthInMinutes*, *videoFormat*, and *grossMillions* for the movie *Batman Begins*:

```
MATCH (m:Movie)
WHERE m.title = 'Batman Begins'
SET m = {title: 'Batman Begins',
          released: 2005,
          lengthInMinutes: 140,
          videoFormat: 'DVD',
          grossMillions: 206.5}
RETURN m
```

The screenshot shows the Neo4j browser interface. On the left, there is a sidebar with four tabs: Graph (selected), Table, Text, and Code. The Text tab is active, displaying the Cypher query:

```
$ MATCH (m:Movie) WHERE m.title = 'Batman Begins' SET m = {title: 'Batman Begins', released: 200...
```

The results pane shows a single row for node 'm'. The properties are listed in JSON format:

```
{
    "lengthInMinutes": 140,
    "grossMillions": 206.5,
    "title": "Batman Begins",
    "videoFormat": "DVD",
    "released": 2005
}
```

At the bottom of the results pane, a message states: "Set 5 properties, started streaming 1 records after 1 ms and completed after 1 ms."

# Adding or updating properties for a node - JSON style

Add the *awards* property and update the *grossMillions* for the movie *Batman Begins*:

```
MATCH (m:Movie)
WHERE m.title = 'Batman Begins'
SET m += { grossMillions: 300,
           awards: 66}
RETURN m
```

The screenshot shows the Neo4j browser interface. On the left, there is a sidebar with tabs: Graph (selected), Table, Text, and Code. The main area displays a query in the code tab:

```
$ MATCH (m:Movie) WHERE m.title = 'Batman Begins' SET m += { grossMillions: 300, awa...
```

Below the code, the results are shown in a table tab. It lists one row for the movie "Batman Begins" with the following details:

Movie	<id>	awards	grossMillions	lengthInMinutes	released	title	videoFormat
Batman Begins	2088	66	300	140	2005	Batman Begins	DVD

The node for "Batman Begins" is highlighted with a green circle and has a yellow border. It is connected to other nodes represented by small icons.

# Removing properties from a node

Properties can be removed in one of two ways:

- Set the property value to null
- Use the REMOVE keyword

Remove the grossMillions and videoFormat properties:

```
MATCH (m:Movie)
WHERE m.title = 'Batman Begins'
SET m.grossMillions = null
REMOVE m.videoFormat
RETURN m
```



The screenshot shows the Neo4j browser interface with a query in the top panel:

```
$ MATCH (m:Movie) WHERE m.title = 'Batman Begins' SET m.grossMillions = null REMOVE m.videoFormat ...
```

The results pane displays a node labeled "m" with the following properties:

```
{
  "title": "Batman Begins",
  "lengthInMinutes": 140,
  "released": 2005
}
```

Below the results, a status message reads: "Set 2 properties, started streaming 1 records after 2 ms and completed after 2 ms."

# Exercise 8: Creating nodes

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 8.



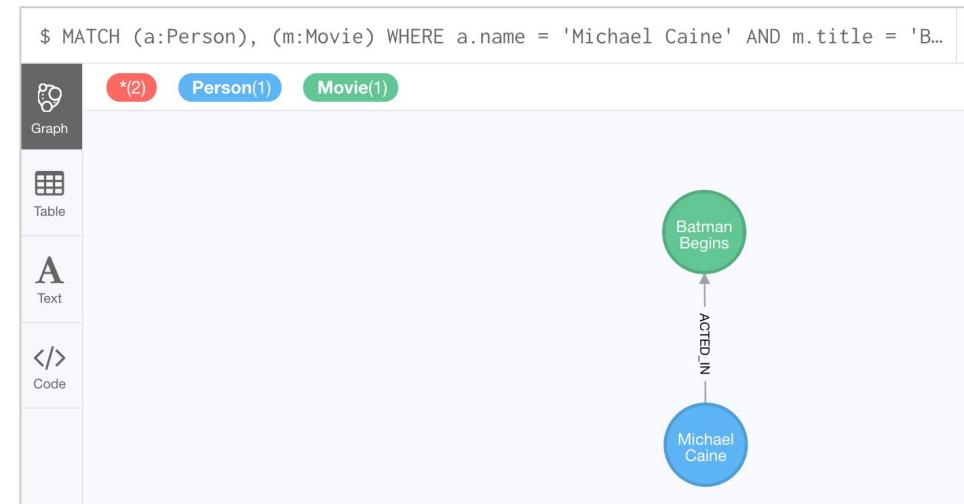
# Creating a relationship

You create a relationship by:

1. Finding the “from node”.
2. Finding the “to node”.
3. Using CREATE to add the directed relationship between the nodes.

Create the `:ACTED_IN` relationship between the *Person*, *Michael Caine* and the *Movie*, *Batman Begins*:

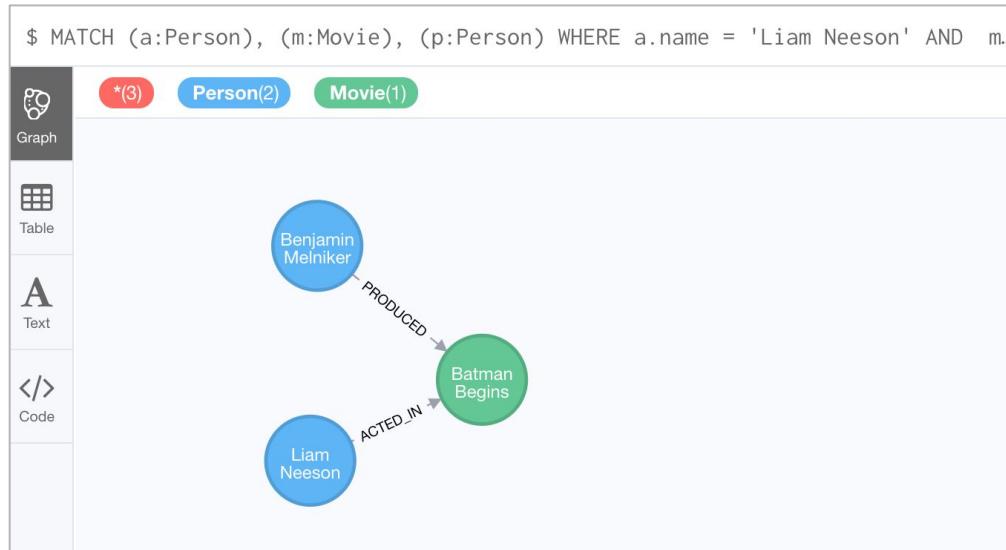
```
MATCH (a:Person), (m:Movie)
WHERE a.name = 'Michael Caine' AND
      m.title = 'Batman Begins'
CREATE (a) - [:ACTED_IN] -> (m)
RETURN a, m
```



# Creating multiple relationships

Create the `:ACTED_IN` relationship between the *Person*, *Liam Neeson* and the *Movie*, *Batman Begins* and the `:PRODUCED` relationship between the *Person*, *Benjamin Melniker* and same movie.

```
MATCH (a:Person), (m:Movie), (p:Person)
WHERE a.name = 'Liam Neeson' AND
      m.title = 'Batman Begins' AND
      p.name = 'Benjamin Melniker'
CREATE (a) - [:ACTED_IN] -> (m) <- [:PRODUCED] - (p)
RETURN a, m, p
```

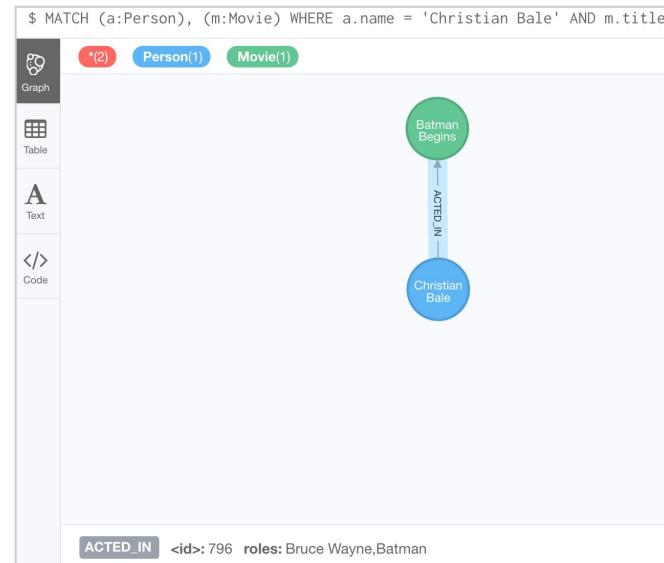


# Adding properties to relationships

Same technique you use for creating and updating node properties.

Add the *roles* property to the `:ACTED_IN` relationship from Christian Bale to *Batman Begins*:

```
MATCH (a:Person), (m:Movie)
WHERE a.name = 'Christian Bale' AND
      m.title = 'Batman Begins' AND
      NOT exists((a)-[:ACTED_IN]->(m))
CREATE (a)-[rel:ACTED_IN]->(m)
SET rel.roles = ['Bruce Wayne', 'Batman']
RETURN a, m
```



# Removing properties from relationships

Same technique you use for removing node properties.

Remove the *roles* property from the  
:ACTED\_IN relationship from Christian  
Bale to *Batman Begins*:

```
MATCH (a:Person)-[rel:ACTED_IN]->(m:Movie)
WHERE a.name = 'Christian Bale' AND
      m.title = 'Batman Begins'
REMOVE rel.roles
RETURN a, rel, m
```



# Exercise 9: Creating relationships

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 9.



# Deleting a relationship

Batman Begins relationships:

```
$ MATCH (a:Person)-[rel]->(m:Movie) WHERE m.title = 'Batman Begins' RETURN a, rel, m
```

Graph

\*(6) Person(4) Movie(1)

\*(4) ACTED\_IN(3) PRODUCED(1)

Displaying 5 nodes, 4 relationships.

Delete the :ACTED\_IN relationship between *Christian Bale* and *Batman Begins*:

```
MATCH (a:Person) - [rel:ACTED_IN] -> (m:Movie)  
WHERE a.name = 'Christian Bale' AND  
m.title = 'Batman Begins'  
DELETE rel  
RETURN a, m
```

```
$ MATCH (a:Person)-[rel:ACTED_IN]->(m:Movie) WHERE a.name = 'Christian Bale' AND m.t...
```

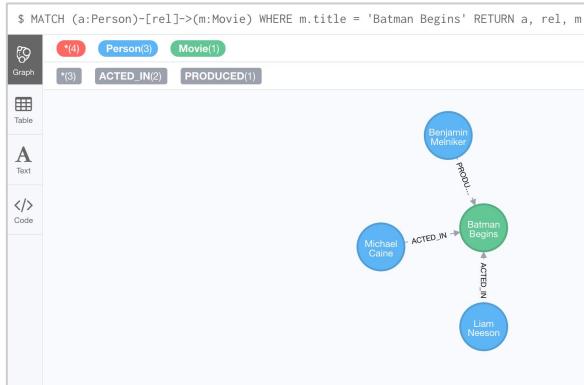
Graph

\*(2) Person(1) Movie(1)

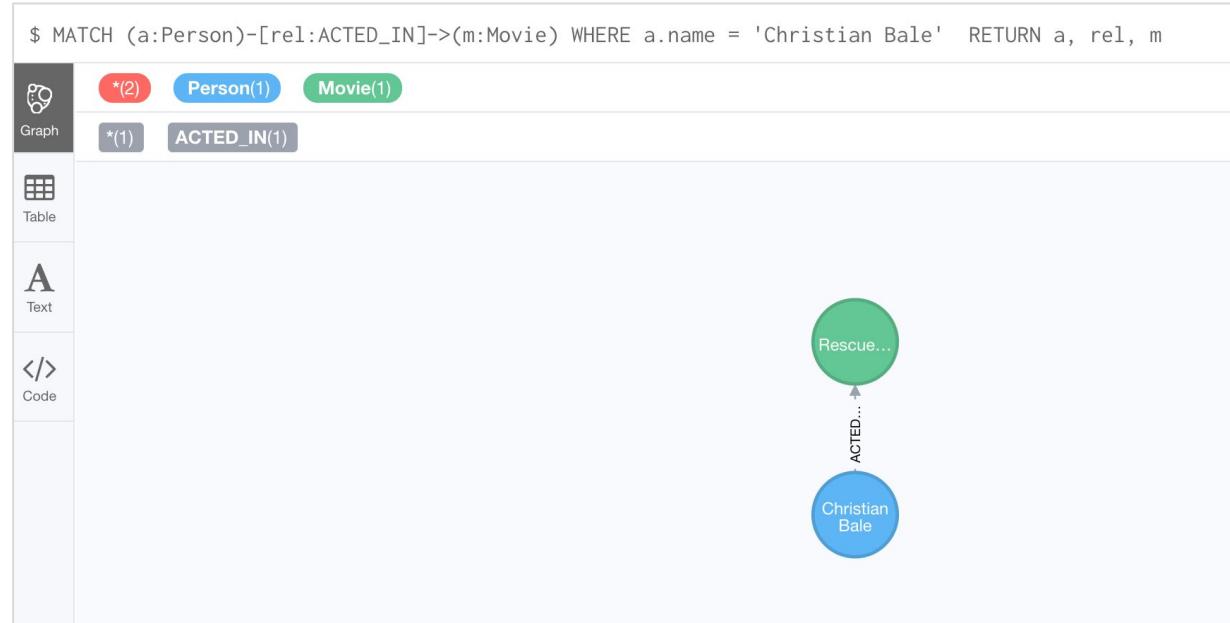
neo4j

# After deleting the relationship from Christian Bale to Batman Begins

Batman Begins relationships:

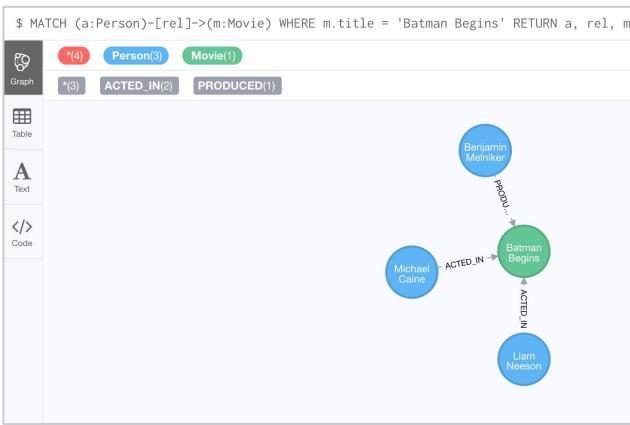


Christian Bale relationships:



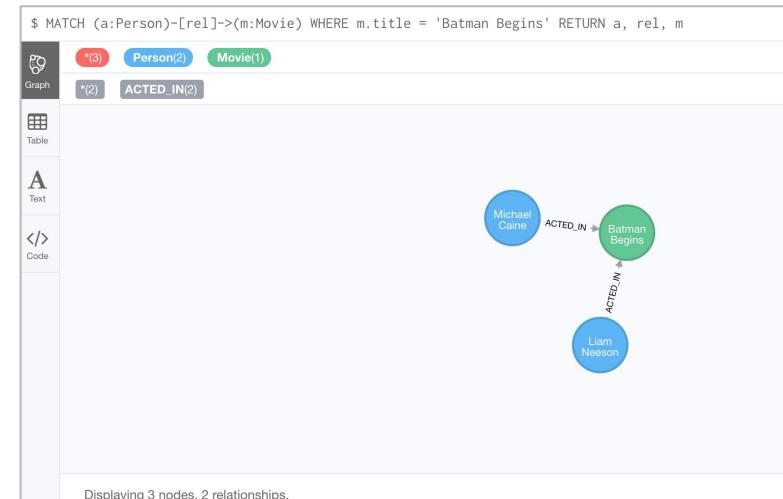
# Deleting a relationship and a node - 1

Batman Begins relationships:



Delete the `:PRODUCED` relationship between *Benjamin Melniker* and *Batman Begins*, as well as the *Benjamin Melniker* node:

```
MATCH (p:Person) - [rel:PRODUCED] -> (:Movie)
WHERE p.name = 'Benjamin Melniker'
DELETE rel, p
```



# Deleting a relationship and a node - 2

Batman Begins relationships:



Attempt to delete *Liam Neeson* and not his relationships to any other nodes:

```
MATCH (p:Person)  
WHERE p.name = 'Liam Neeson'  
DELETE p
```

```
$ MATCH (p:Person) WHERE p.name = 'Liam Neeson' DELETE p
```

Error

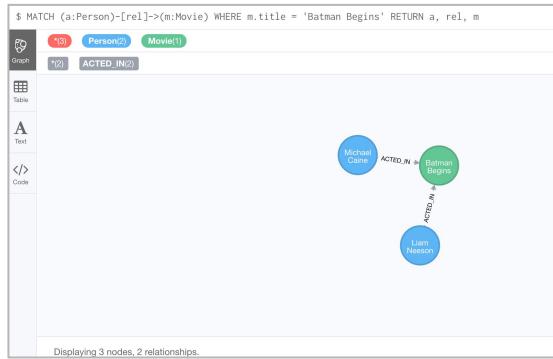
Neo.ClientError.Schema.ConstraintValidationFailed

Neo.ClientError.Schema.ConstraintValidationFailed: Cannot delete node<1899>, because it still has relationships. To delete this node, you must first delete its relationships.

⚠ Neo.ClientError.Schema.ConstraintValidationFailed: Cannot delete node<1899>, because it still has relationships. To delete this node, you must first...

# Deleting a relationship and a node - 3

Batman Begins relationships:

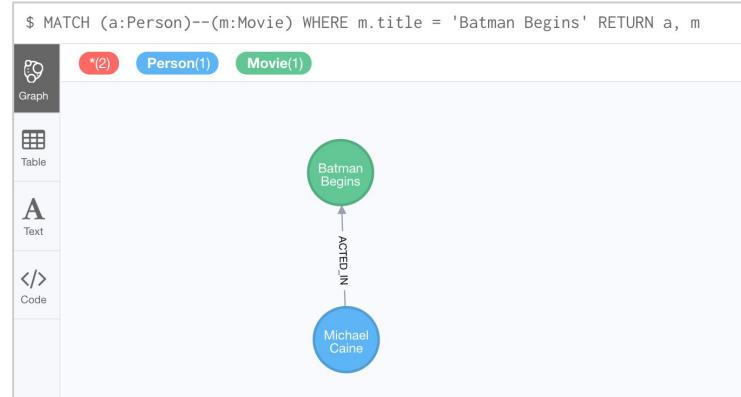


Delete *Liam Neeson* and his relationships to any other nodes:

```
MATCH (p:Person)  
WHERE p.name = 'Liam Neeson'  
DETACH DELETE p
```

The screenshot shows the Neo4j browser interface with the following details:

- Query: `$ MATCH (p:Person) WHERE p.name = 'Liam Neeson' DETACH DELETE p`
- UI elements:
  - Table icon
- Message: "Deleted 1 node, deleted 1 relationship, completed after 10 ms."



# Exercise 10: Deleting nodes and relationships

In Neo4j Browser:

:play intro-neo4j-exercises

Then follow instructions for Exercise 10.

# Merging data in a graph

- Create a node with a different label (You do not want to add a label to an existing node.).
- Create a node with a different set of properties (You do not want to update a node with existing properties.).
- Create a unique relationship between two nodes.

# Using MERGE to create nodes

Current *Michael Caine Person*\_node:

```
$ MATCH (a:Person {name: 'Michael Caine', born: 1933}) RETURN a
```

a

```
{  
  "name": "Michael Caine",  
  "born": 1933  
}
```

Add a *Michael Caine Actor* node with a value of 1933 for *born* using MERGE. The Actor node is not found so a new node is created:

```
MERGE (a:Actor {name: 'Michael Caine'})  
SET a.born=1933  
RETURN a
```

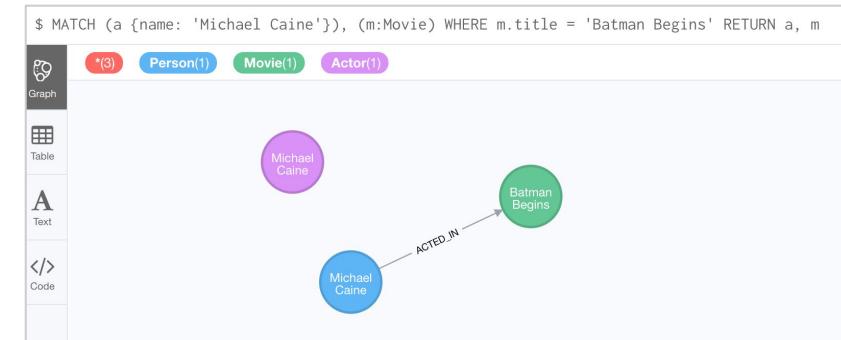
```
$ MERGE (a:Actor {name: 'Michael Caine'}) SET a.born=1933 RETURN a
```

a

```
{  
  "name": "Michael Caine",  
  "born": 1933  
}
```

**Important:** Only specify properties that will have unique keys when you merge.

Resulting *Michael Caine* nodes:



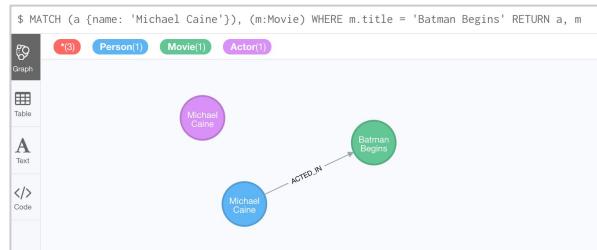
# Using MERGE to create relationships

Add the relationship(s) from all *Person* nodes with a *name* property that ends with *Caine* to the *Movie* node, *Batman Begins*:

```
MATCH (p:Person), (m:Movie)
WHERE m.title = 'Batman Begins' AND
p.name ENDS WITH 'Caine'
MERGE (p) - [:ACTED_IN] -> (m)
RETURN p, m
```

# Specifying creation behavior for the merge

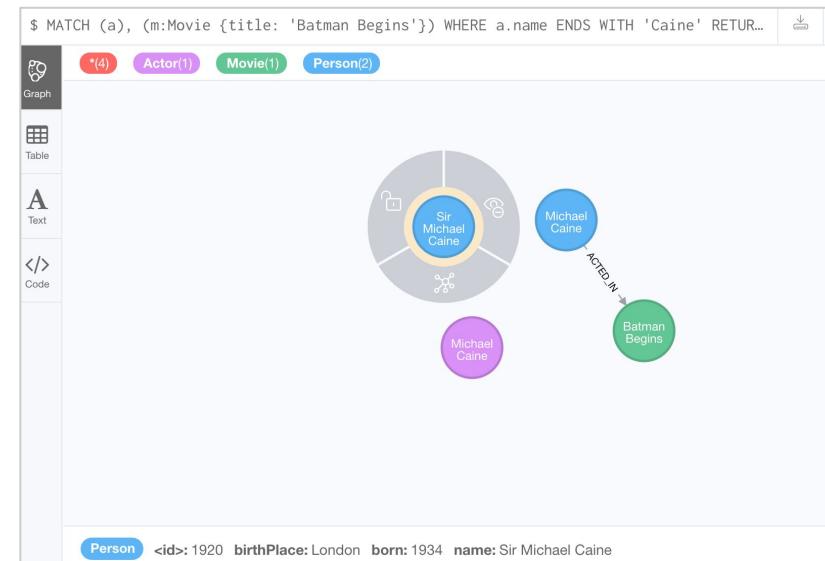
Current *Michael Caine* nodes:



Add a *Sir Michael Caine* Person node with a *born* value of 1934 for *born* using MERGE and also set the *birthPlace* property:

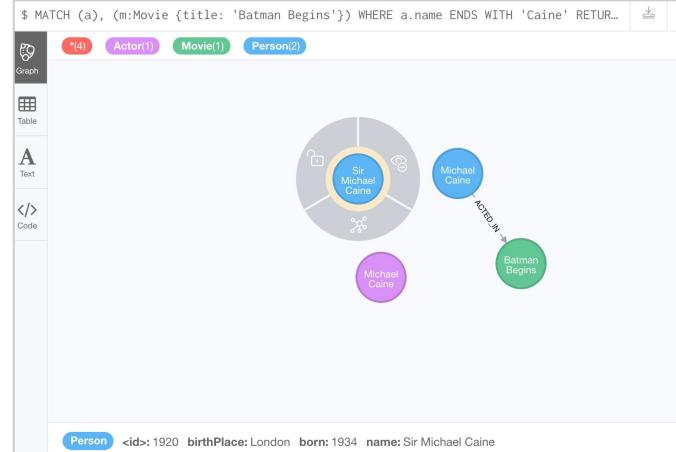
```
MERGE (a:Person {name: 'Sir Michael Caine'})  
ON CREATE SET a.born = 1934,  
a.birthPlace = 'London'  
RETURN a
```

Resulting *Michael Caine* nodes:



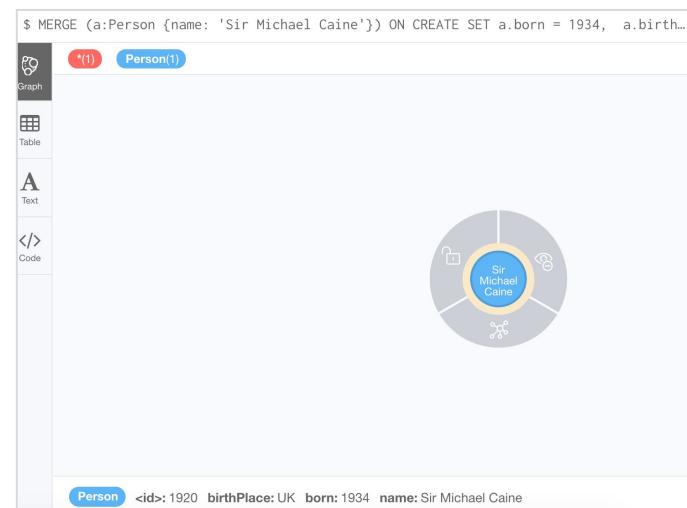
# Specifying match behavior for the merge

Current *Michael Caine* nodes:



Add or update the *Michael Caine Person* node:

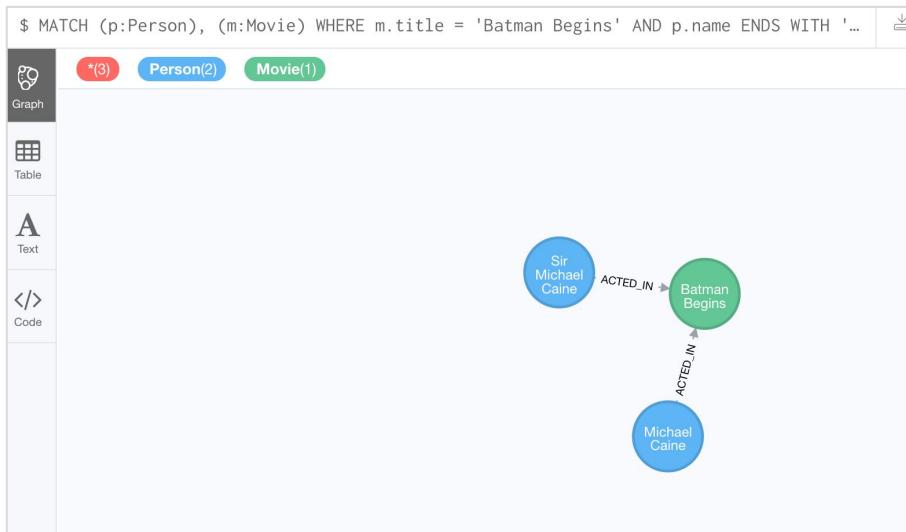
```
MERGE (a:Person {name: 'Sir Michael Caine'})  
ON CREATE SET a.born = 1934,  
a.birthPlace = 'UK'  
ON MATCH SET a.birthPlace = 'UK'  
RETURN a
```



# Using MERGE to create relationships

Make sure that all *Person* nodes with a person whose name ends with *Caine* are connected to the *Movie* node, *Batman Begins*.

```
MATCH (p:Person), (m:Movie)
WHERE m.title = 'Batman Begins' AND p.name ENDS WITH 'Caine'
MERGE (p)-[:ACTED_IN]->(m)
RETURN p, m
```



# Exercise 11: Merging data in the graph

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 11.



# Check your understanding

# Question 1

What Cypher clauses can you use to create a node?

Select the correct answers.

- CREATE
- CREATE NODE
- MERGE
- ADD

# Answer 1

What Cypher clauses can you use to create a node?

Select the correct answers.

- CREATE
- CREATE NODE
- MERGE
- ADD

# Question 2

Suppose that you have retrieved a node, `s` with a property, `color`:

What Cypher clause do you add here to delete the `color` property from this node?

Select the correct answers.

- DELETE `s.color`
- SET `s.color=null`
- REMOVE `s.color`
- SET `s.color=?`

# Answer 2

Suppose that you have retrieved a node, `s` with a property, `color`:

What Cypher clause do you add here to delete the `color` property from this node?

Select the correct answers.

- DELETE `s.color`
- SET `s.color=null`
- REMOVE `s.color`
- SET `s.color=?`

# Question 3

Suppose you retrieve a node,  $n$  in the graph that is related to other nodes. What Cypher clause do you write to delete this node and its relationships in the graph?

Select the correct answers.

- DELETE n
- DELETE n WITH RELATIONSHIPS
- REMOVE n
- DETACH DELETE n

# Answer 3

Suppose you retrieve a node,  $n$  in the graph that is related to other nodes. What Cypher clause do you write to delete this node and its relationships in the graph?

Select the correct answers.

- DELETE n
- DELETE n WITH RELATIONSHIPS
- REMOVE n
- DETACH DELETE n

# Summary

You should be able to write Cypher statements to:

- Create a node:
  - Add and remove node labels.
  - Add and remove node properties.
  - Update properties.
- Create a relationship:
  - Add and remove properties for a relationship.
- Delete a node.
- Delete a relationship.
- Merge data in a graph:
  - Creating nodes.
  - Creating relationships.

# Getting More Out of Neo4j

v 1.0



# Overview

At the end of this module, you should be able to:

- Use parameters in your Cypher statements.
- Analyze Cypher execution.
- Monitor queries.
- Manage constraints and node keys for the graph.
- Import data into a graph from CSV files.
- Manage indexes for the graph.
- Access Neo4j resources.

# Cypher parameters

\$ MATCH (p:Person)-[:ACTED\_IN]->(m:Movie) WHERE m.title='Cloud Atlas' RETURN p, m

\*(6) Person(5) Movie(1)

We do not want this value to be hard-coded in the query.

Displaying 6 nodes, 5 relationships.

# Using Cypher parameters - 1

1. Set values for parameters in your Neo4j Browser session before you run the query.

```
$ :param actorName => 'Tom Hanks'  
{  
    "actorName": "Tom Hanks"  
}
```

See `:help param` for usage of the `:param` command.

2. Specify parameters using '\$' in your Cypher query.

Successfully set your parameters.

```
MATCH (p:Person) - [:ACTED_IN] -> (m:Movie)  
WHERE p.name = $actorName  
RETURN m.released, m.title ORDER BY m.released DESC
```

# Using Cypher parameters - 2

When this query runs, \$actorName has a value *Tom Hanks*:

	\$ MATCH (p:Person)-[:ACTED_IN]->(m:Movie) WHERE p.name = \$actorName RETURN m.released, m.title ...	
Table	m.released	m.title
Text	2012	"Cloud Atlas"
	2007	"Charlie Wilson's War"
	2006	"The Da Vinci Code"
	2004	"The Polar Express"
	2000	"Cast Away"
	1999	"The Green Mile"
	1998	"You've Got Mail"
	1996	"That Thing You Do"
	1995	"Apollo 13"
	1994	"Forrest Gump"
	1993	"Sleepless in Seattle"
	1992	"A League of Their Own"
	1990	"Joe Versus the Volcano"

# Using Cypher parameters - 3

Change the value of the parameter, \$actorName to *Tom Cruise*:

```
:param actorName => 'Tom Cruise'
```

Re-run the same query:

\$ MATCH (p:Person)-[:ACTED_IN]->(m:Movie) WHERE p.name = \$actorName RETURN m.released, m.title 0...	 Table
<b>m.released</b>	<b>m.title</b>
2000	"Jerry Maguire"
1992	"A Few Good Men"
1986	"Top Gun"

# Setting and viewing Cypher parameters - JSON style

```
$ :params {actorName: 'Tom Cruise', movieName: 'Top Gun'}  
{  
  "actorName": "Tom Cruise",  
  "movieName": "Top Gun"  
}  
  
See :help param for usage of the :param command.
```

Successfully set your parameters.

```
$ :params  
{  
  "actorName": "Tom Cruise",  
  "movieName": "Top Gun"  
}
```

See `:help param` for usage of the `:param` command.

# Exercise 12: Using Cypher parameters

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 12.

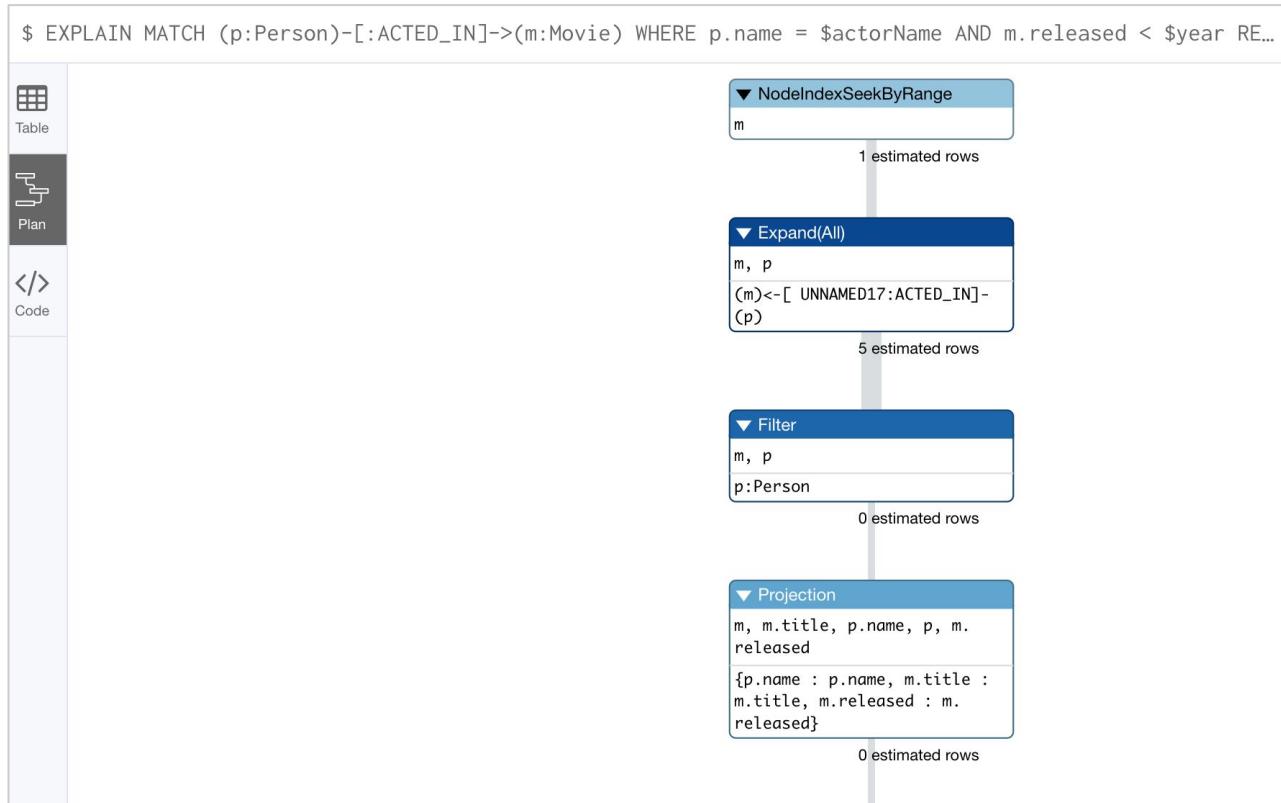
# Analyzing Cypher queries - EXPLAIN - 1

- Provides information about the query plan.
- Does not execute the Cypher statement.

Here is an example where we have set the `$actorName` and `$year` parameters for our session and we execute this Cypher statement to produce the query plan:

```
EXPLAIN MATCH (p:Person) - [:ACTED_IN] -> (m:Movie)
WHERE p.name = $actorName AND
      m.released < $year
RETURN p.name, m.title, m.released
```

# Analyzing Cypher queries - EXPLAIN - 2



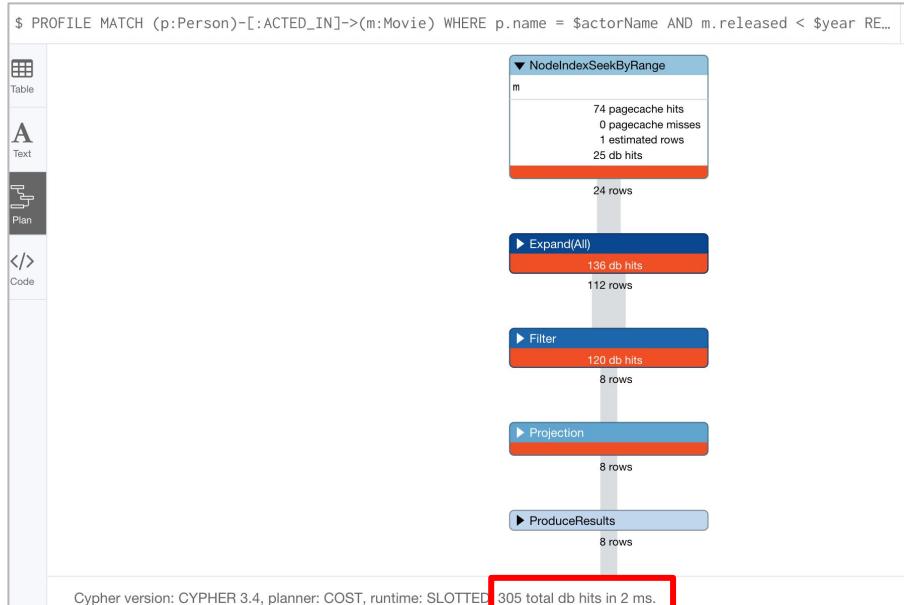
# Analyzing Cypher queries - PROFILE - 1

- Provides information about the query plan.
- Executes the Cypher statement.
- Provides information about db hits.

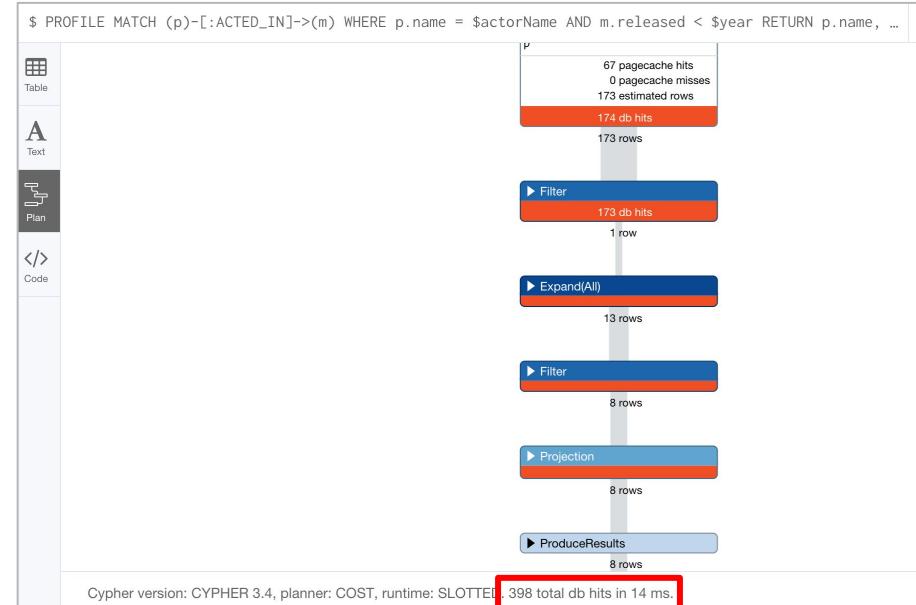
```
PROFILE MATCH (p:Person) -[:ACTED_IN]->(m:Movie)
WHERE p.name = $actorName AND
      m.released < $year
RETURN p.name, m.title, m.released
```

# Analyzing Cypher queries - PROFILE - 2

Profile query where node labels are specified:



Profile query where node labels not are specified:



# Monitoring queries

There are two reasons why a Cypher query may take a long time:

1. The query returns a lot of data. The query completes execution in the graph engine, but it takes a long time to create the result stream to return to the client.

```
MATCH (a) -- (b) -- (c) -- (d) -- (e) -- (f) RETURN a
```

You should avoid these type of queries! You cannot monitor them.

2. The query takes a long time to execute in the graph engine.

```
MATCH (a), (b), (c), (d), (e) RETURN count(id(a))
```

You can monitor and kill these types of queries.

# Viewing running queries

If your query is taking a long time to execute you first have to determine if it is running in the graph engine:

1. Open a new Neo4j Browser session.
2. Execute the `:queries` command.

\$ :queries					✖	
Database URI	User	Query	Params	Meta	Elapsed time	Kill
bolt://localhost:7687	neo4j	CALL dbms.listQueries	{}	{}	30 ms	⊖

No other queries running, except for the :queries command.

Found 1 query running on one server

AUTO-REFRESH  OFF

# Handling “rogue” queries

If your query is taking a long time to execute and you cannot monitor it, your options are to:

1. Close the Neo4j Browser session that is stuck and start a new Neo4j Browser session.
2. If that doesn't work:
  - a. On Neo4j Desktop, restart the database.
  - b. In Neo4j Sandbox, shut down the sandbox (ouch!). You need to re-create the Sandbox.

# Viewing long-running queries

\$ :queries							X
Database URI	User	Query	Params	Meta	Elapsed time	Kill	
bolt://localhost:7687	neo4j	CALL dbms.listQueries	{}	{}	0 ms	⊖	
bolt://localhost:7687	neo4j	match (a), (b), (c), (d), (e) return count (id(a))	{}	{}	55526 ms	⊖	
Long-running query							
Found 2 queries running on one server				AUTO-REFRESH	ON		

# Killing long-running queries

\$ :queries						
Database URI	User	Query	Params	Meta	Elapsed time	Kill
bolt://localhost:7687	neo4j	match (a), (b), (c), (d), (e) return count (id(a))	{}	{}	135525 ms	
bolt://localhost:7687	neo4j	CALL dbms.listQueries	{}	{}	0 ms	

Monitoring session

Found 2 queries running on one server

AUTO-REFRESH

```
$ match (a), (b), (c), (d), (e) return count (id(a))
```

Error

**Neo.TransientError.Transaction.Terminated**

Neo.TransientError.Transaction.Terminated: The transaction has been terminated. Retry your operation in a new transaction, and you should see a successful result. Explicitly terminated by the user.

⚠ Neo.TransientError.Transaction.Terminated: The transaction has been terminated. Retry your operation in a new transa...

# Exercise 13: Analyzing and monitoring queries

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 13.



# Managing constraints and node keys

Automatically control the data that is added to the graph:

- **Uniqueness:** Unique values for node properties
- **Existence:** Required properties for nodes or relationships

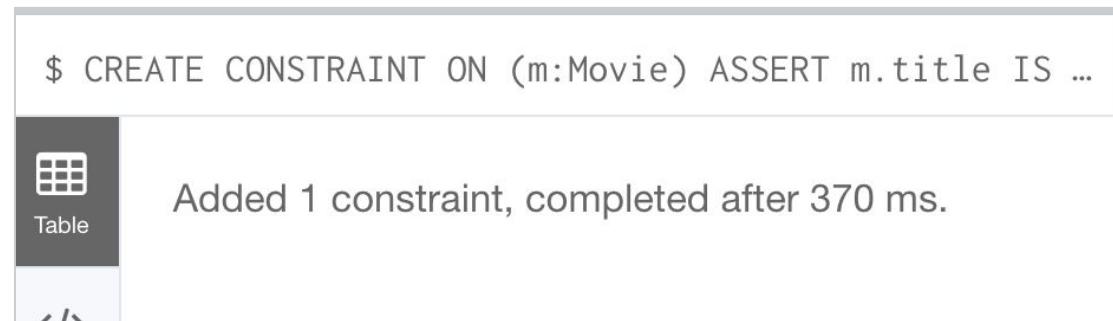
## Note:

- You can write additional code in your Cypher statements to assert values, but it is much easier to let the graph engine do it for you.
- You can also write server-side extensions which are beyond the scope of this training.

# Ensuring that a property value for a node is unique

Ensure that the *title* for a node of type *Movie* is unique:

```
CREATE CONSTRAINT ON (m:Movie) ASSERT m.title IS UNIQUE
```



- This statement will fail if there are any *Movie* nodes in the graph that have the same value for the *title* property.
- This statement will succeed if there are any *Movie* nodes in the graph that do not have the *title* property.

# Ensuring uniqueness using the constraint

After creating the constraint, we attempt to create a *Movie* with the *title*, *The Matrix*:

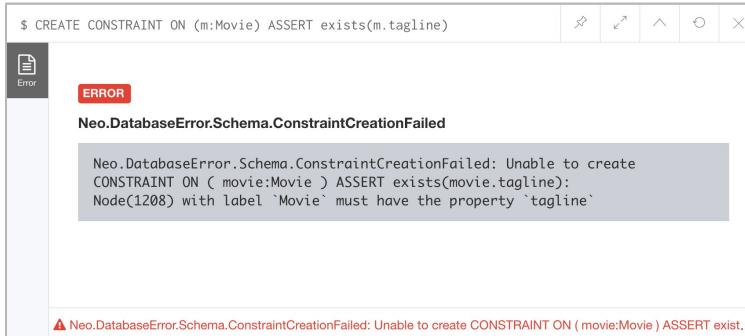
```
CREATE (:Movie {title: 'The Matrix'})
```

The screenshot shows the Neo4j browser interface. A green header bar contains the query: `CREATE (:Movie {title: 'The Matrix'})`. Below the header is a toolbar with icons for back, forward, search, and close. On the left, there's a sidebar with a file icon and the word "Error". The main content area has a red "ERROR" button. Below it, the error message `Neo.ClientError.Schema.ConstraintValidationFailed` is displayed. A detailed error message in a gray box states: `Neo.ClientError.Schema.ConstraintValidationFailed: Node(874) already exists with label `Movie` and property `title` = 'The Matrix'`. At the bottom, a red warning icon is followed by the full error message: `⚠ Neo.ClientError.Schema.ConstraintValidationFailed: Node(874) already exists with label `Movie` ...`.

# Ensuring that properties exist

You can create a constraint that will ensure that when a node or relationship is created or updated, a particular property must have a value:

```
CREATE CONSTRAINT ON (m:Movie) ASSERT exists(m.tagline)
```



This statement failed because the *Movie* node for the movie, *Something's Gotta Give* does not have a value for the *tagline* property.

The screenshot shows the Neo4j browser interface with a successful query result. The query entered is: \$ MATCH (m:Movie) WHERE m.title STARTS WITH 'Something' RETURN m. The result is a single node labeled 'm' with the following properties: { "title": "Something's Gotta Give", "released": 2003 }.

# Creating an exists constraint on a relationship

We know that in the *Movie* graph, all `:REVIEWED` relationships currently have a property, `rating`. We can create an existence constraint on that property as follows:

```
CREATE CONSTRAINT ON () - [rel:REVIEWED] - () ASSERT exists(rel.rating)
```

```
$ CREATE CONSTRAINT ON ()-[rel:REVIEWED]-() ASSERT exists(rel.rating)
```



Table



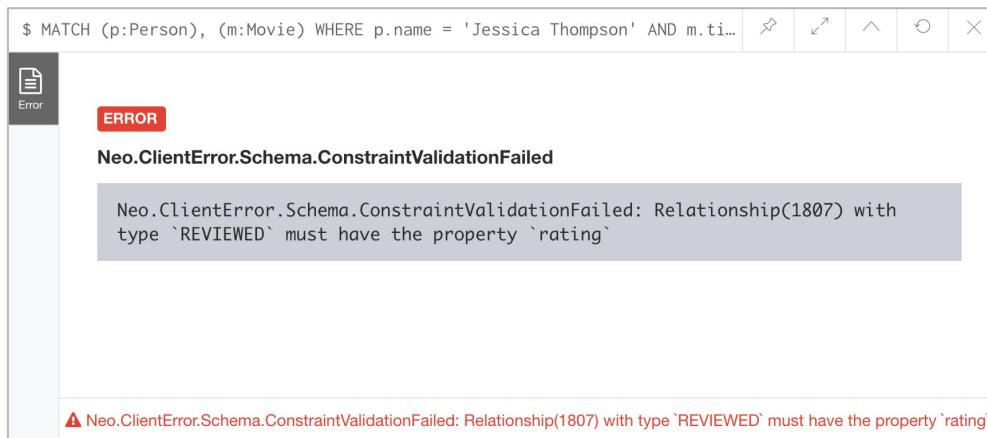
Code

Added 1 constraint, completed after 2 ms.

# Using the exists constraint on a relationship

After creating this constraint, if we attempt to create a `:REVIEWED` relationship without setting the `rating` property:

```
MATCH (p:Person), (m:Movie)
WHERE p.name = 'Jessica Thompson' AND
      m.title = 'The Matrix'
MERGE (p) - [:REVIEWED {summary: 'Great movie!'}] -> (m)
```



The screenshot shows the Neo4j browser interface with an error message. The query in the top bar is:

```
$ MATCH (p:Person), (m:Movie) WHERE p.name = 'Jessica Thompson' AND m.ti...
```

The error message is displayed in a red box:

**ERROR**  
**Neo.ClientError.Schema.ConstraintValidationFailed**

The detailed error message is:

```
Neo.ClientError.Schema.ConstraintValidationFailed: Relationship(1807) with type 'REVIEWED' must have the property 'rating'
```

At the bottom of the browser window, there is a red warning message:

⚠ Neo.ClientError.Schema.ConstraintValidationFailed: Relationship(1807) with type 'REVIEWED' must have the property 'rating'

# Retrieving constraints defined for the graph

```
CALL db.constraints()
```

```
$ CALL db.constraints()
```

	Table
	Text

## description

"CONSTRAINT ON ( movie:Movie ) ASSERT movie.title IS UNIQUE"

"CONSTRAINT ON ()-[ reviewed:REVIEWED ]-() ASSERT exists(reviewed.rating)"

**Note:** Adding the method notation for this CALL statement enables you to use the call for returning results that may be used later in the Cypher statement.

# Dropping constraints

```
DROP CONSTRAINT ON ()-[rel:REVIEWED]-() ASSERT exists(rel.rating)
```

```
$ DROP CONSTRAINT ON ()-[rel:REVIEWED]-() ASSERT exists(rel.rating)
```



Table

Removed 1 constraint, completed after 1 ms.

# Creating node keys - 1

- Unique constraint for a set of properties for a node
- Is implemented as an index in the graph

Suppose that in our *Movie* graph, we will not allow a *Person* node to be created where both the *name* and *born* properties are the same. We can create a constraint that will be a node key to ensure that this uniqueness for the set of properties is asserted:

```
CREATE CONSTRAINT ON (p:Person) ASSERT (p.name, p.born) IS NODE KEY
```

We attempt to create the constraint, but it fails because there is a *Person* node in the graph that does not have the *born* property set:

The screenshot shows the Neo4j browser interface. A modal dialog box is open with the following details:

- Header: \$ CREATE CONSTRAINT ON (p:Person) ASSERT (p.name, p.born) IS NODE KEY
- Status: Error
- Message: Neo.DatabaseError.Schema.ConstraintCreationFailed
- Details: Neo.DatabaseError.Schema.ConstraintCreationFailed: Unable to create CONSTRAINT ON ( person:Person ) ASSERT exists(person.name, person.born): Node(1183) with label `Person` must have the properties `name, born`
- Footer: ▲ Neo.DatabaseError.Schema.ConstraintCreationFailed: Unable to create CONSTRAINT ON ( person:Person ) ASSERT exists.

# Creating node keys - 2

We then ensure that all *Person* nodes have a value for the *born* property:

```
MATCH (p:Person)  
WHERE NOT exists(p.born)  
SET p.born = 0
```

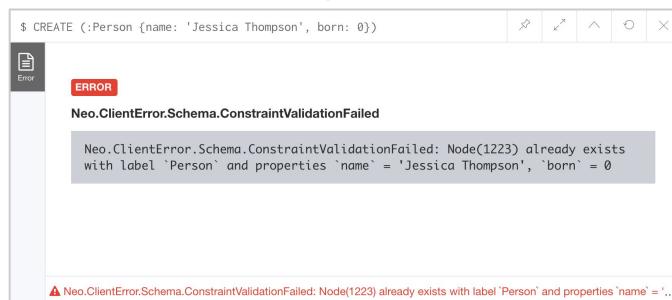
The creation of the node key will now be successful:

```
$ CREATE CONSTRAINT ON (p:Person) ASSERT (p.name, p.born) IS NODE KEY
```



Added 1 constraint, completed after 251 ms.

Any subsequent attempt to create or modify an existing *Person* node with *name* or *born* values that violate the uniqueness constraint as a node key will fail:



# Exercise 14: Managing constraints and node keys

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 14.



# Indexes in Neo4j

- Neo4j supports two types of indexes on a node of a specific type:
  - single property
  - composite properties
- Indexes store redundant data that points to nodes with the specific property value or values.
- Unlike SQL, there is no such thing as a primary key in Neo4j. You can have multiple properties on nodes that must be unique.
- Add indexes before you create relationships between nodes.
- Creating an index on a property does not guarantee uniqueness.
  - But uniqueness and node key constraints are indexes that guarantee uniqueness.

# When indexes are used

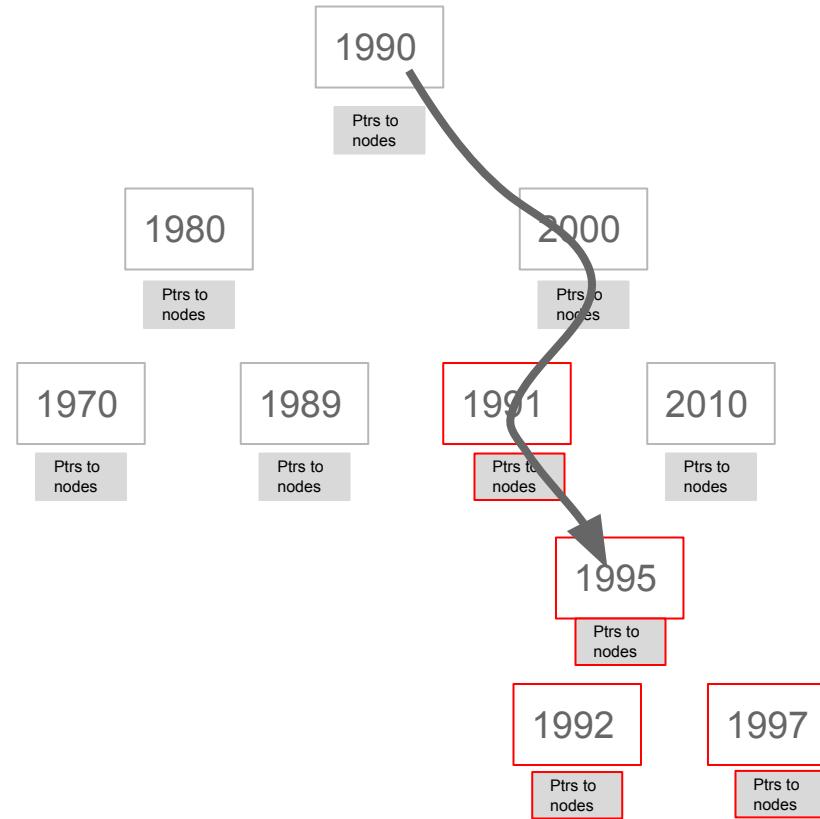
Single property indexes are used to determine the starting point for graph traversal using:

- Equality checks =
- Range comparisons >, >=, <, <=
- List membership IN
- String comparisons STARTS WITH, ENDS WITH, CONTAINS
- Existence checks exists()
- Spatial distance searches distance()
- Spatial bounding searches point()

**Note:** Composite indexes are only used for equality checks and list membership.

# Indexes for range queries

```
MATCH (m:Movie)  
WHERE 1990 < m.released < 2000  
SET m.videoFormat = 'DVD'
```



# Creating a single-property index

Create a single-property index on the *released* property of all nodes of type *Movie*:

```
CREATE INDEX ON :Movie(released)
```

```
$ CREATE INDEX ON :Movie(released)
```



Table

Added 1 index, completed after 4 ms.

# Creating a composite index - 1

Suppose first that we added the property, *videoFormat* to every *Movie* node and set its value, based upon the released date of the movie as follows:

```
MATCH (m:Movie)
WHERE m.released >= 2000
SET m.videoFormat = 'DVD';
MATCH (m:Movie)
WHERE m.released < 2000
SET m.videoFormat = 'VHS'
```

```
$ MATCH (m:Movie) WHERE m.released >= 2000 SET m.videoFormat = 'DVD'; MATCH (m:Movie) WHERE m.releas...
```



^

```
$ MATCH (m:Movie) WHERE m.released >= 2000 SET m.videoFormat = 'DVD'
```



```
$ MATCH (m:Movie) WHERE m.released < 2000 SET m.videoFormat = 'VHS'
```



All *Movie* nodes in the graph now have both a *released* and *videoFormat* property.



# Creating a composite index - 2

Create a composite index for every *Movie* node that uses the *videoFormat* and *released* properties:

```
CREATE INDEX ON :Movie(released, videoFormat)
```

```
$ CREATE INDEX ON :Movie(released, videoFormat)
```



Added 1 index, completed after 2 ms.

**Note:** You can create a composite index with many properties.

# Retrieving indexes

```
CALL db.indexes()
```

\$ CALL db.indexes()					
description	label	properties	state	type	provider
"INDEX ON :Movie(released)"	"Movie"	["released"]	"ONLINE"	"node_label_property"	{ "version": "2.0", "key": "lucene+native" }
"INDEX ON :Movie(released, videoFormat)"	"Movie"	["released", "videoFormat"]	"ONLINE"	"node_label_property"	{ "version": "2.0", "key": "lucene+native" }
"INDEX ON :Person(name, born)"	"Person"	["name", "born"]	"ONLINE"	"node_unique_property"	{ "version": "2.0", "key": "lucene+native" }
"INDEX ON :Movie(title)"	"Movie"	["title"]	"ONLINE"	"node_unique_property"	{ "version": "2.0", "key": "lucene+native" }

# Dropping indexes

```
DROP INDEX ON :Movie(released, videoFormat)
```

```
$ DROP INDEX ON :Movie(released, videoFormat)
```



Table

Removed 1 index, completed after 8 ms.

# Exercise 15: Managing indexes

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 15.

# Importing data

CSV import is commonly used to import data into a graph where you can:

- Load data from a URL (http(s) or file).
- Process data as a stream of records.
- Create or update the graph with the data being loaded.
- Use transactions during the load.
- Transform and convert values from the load stream.
- Load up to 10M nodes and relationships.

# Steps for importing data

1. Determine the number of lines that will be loaded.
  - Is the load possible without special processing to handle transactions?
2. Examine the data and see if it may need to be reformatted.
  - Does data need alterations based upon your data requirements?
3. Make sure reformatting you will do is correct.
  - Examine final formatting of data before loading it.
4. Load the data and create nodes in the graph.
5. Load the data and create the relationships in the graph.

# Importing normalized data - 1

Example CSV file, **movies\_to\_load.csv**:

```
id,title,country,year,summary
1,Wall Street,USA,1987, Every dream has a price.
2,The American President,USA,1995, Why can't the most powerful man in the world have the one thing he wants most?
3,The Shawshank Redemption,USA,1994, Fear can hold you prisoner. Hope can set you free.
```

1. Determine the number of lines that will be loaded:

```
LOAD CSV WITH HEADERS
FROM 'http://data.neo4j.com/intro-neo4j/movies_to_load.csv'
AS line
RETURN count(*)
```

\$ LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/intro-neo4j/movies_to_load.csv" AS line RETURN count(*)	
count(*)	
3	

# Importing normalized data - 2

2. Examine the data and see if it may need to be reformatted:

```
LOAD CSV WITH HEADERS  
FROM 'https://data.neo4j.com/intro-neo4j/movies_to_load.csv'  
AS line  
RETURN * LIMIT 1
```

The screenshot shows the Neo4j browser interface with a query result table. The table has one row labeled 'line'. The 'Text' column displays a JSON object:

```
{  
    "summary": " Every dream has a  
price.",  
    "country": "USA",  
    "id": "1",  
    "title": "Wall Street",  
    "year": "1987"  
}
```

Two annotations highlight specific issues:

- A yellow callout points to the 'summary' field with the text: "We need to trim leading spaces for the *tagline* property value".
- A yellow callout points to the 'year' field with the text: "We need to convert to integer for the released property value".

At the bottom of the browser, a status message reads: "Started streaming 1 records after 245 ms and completed after 346 ms."

# Importing normalized data - 3

## 3. Format the data prior to loading:

```
LOAD CSV WITH HEADERS  
FROM 'http://data.neo4j.com/intro-neo4j/movies_to_load.csv'  
AS line  
RETURN line.id, line.title, toInteger(line.year), trim(line.summary)
```

\$ LOAD CSV WITH HEADERS FROM 'http://data.neo4j.com/intro-neo4j/movies\_to\_load.csv' ...

Table	line.id	line.title	toInteger(line.year)	lTrim(line.summary)	↓	↗	↖	↖	⟳	×
A Text	"1"	"Wall Street"	1987	"Every dream has a price."						
	"2"	"The American President"	1995	"Why can't the most powerful man in the world have the one thing he wants most?"						
</> Code	"3"	"The Shawshank Redemption"	1994	"Fear can hold you prisoner. Hope can set you free."						

# Importing normalized data - 4

4. Load the data and create the nodes in the graph:

```
LOAD CSV WITH HEADERS  
FROM 'https://data.neo4j.com/intro-neo4j/movies_to_load.csv'  
AS line  
CREATE (movie:Movie { movieId: line.id,  
                      title: line.title,  
                      released: toInteger(line.year) ,  
                      tagline: trim(line.summary) })
```

```
$ LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/intro-neo4j/movies_to_load.csv" AS line CREATE (movie:Movie {...
```



Added 3 labels, created 3 nodes, set 12 properties, completed after 289 ms.

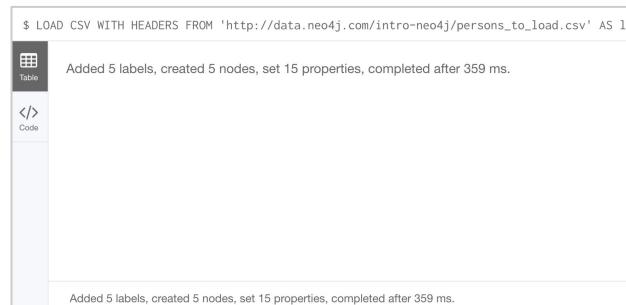
# Importing the Person data

Example CSV file, `persons_to_load.csv`:

```
Id,name,birthyear  
1,Charlie Sheen, 1965  
2,Oliver Stone, 1946  
3,Michael Douglas, 1944  
4,Martin Sheen, 1940  
5,Morgan Freeman, 1937
```

```
LOAD CSV WITH HEADERS  
FROM 'https://data.neo4j.com/intro-neo4j/persons_to_load.csv'  
AS line  
MERGE (actor:Person { personId: line.Id })  
ON CREATE SET actor.name = line.name,  
        actor.born = toInteger(trim(line.birthyear))
```

We use MERGE to ensure that we will not create any duplicate nodes



The screenshot shows the Neo4j Browser interface with a query results table. The table has two rows, both of which are identical: "Added 5 labels, created 5 nodes, set 15 properties, completed after 359 ms.". This indicates that the import process successfully loaded all five rows from the CSV file into the database.

Table
Added 5 labels, created 5 nodes, set 15 properties, completed after 359 ms.
Code
Added 5 labels, created 5 nodes, set 15 properties, completed after 359 ms.

# Creating the relationships

Example CSV file, **roles\_to\_load.csv**:

```
personId,movieId,role
1,1,Bud Fox
4,1,Carl Fox
3,1,Gordon Gekko
4,2,A.J. MacInerney
3,2,President Andrew
Shepherd
5,3,Ellis Boyd 'Red' Redding
```

```
LOAD CSV WITH HEADERS
FROM 'https://data.neo4j.com/intro-neo4j/roles_to_load.csv'
AS line
MATCH (movie:Movie { movieId: line.movieId })
MATCH (person:Person { personId: line.personId })
CREATE (person)-[:ACTED_IN { roles: [line.role] }]->(movie)
```

```
$ LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/intro-neo4j/roles_to_load.csv" AS line MATCH (movie:Movie { m...
```



Set 6 properties, created 6 relationships, completed after 323 ms.

# Importing denormalized data

Example CSV file, `movie_actor_roles_to_load.csv`:

```
title;released;summary;actor;birthyear;characters
Back to the Future;1985;17 year old Marty McFly got home early last night. 30 years early.;Michael J. Fox;1961;Marty McFly
Back to the Future;1985;17 year old Marty McFly got home early last night. 30 years early.;Christopher Lloyd;1938;Dr. Emmet Brown
```

```
LOAD CSV WITH HEADERS
FROM 'https://data.neo4j.com/intro-neo4j/movie_actor_roles_to_load.csv'
AS line FIELDTERMINATOR ';'
MERGE (movie:Movie { title: line.title })
ON CREATE SET movie.released = toInteger(line.released),
        movie.tagline = line.summary
MERGE (actor:Person { name: line.actor })
ON CREATE SET actor.born = toInteger(line.birthyear)
MERGE (actor)-[r:ACTED_IN]->(movie)
ON CREATE SET r.roles = split(line.characters,',')
```

```
$ LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/intro-neo4j/movie_actor_roles_to_load.csv" AS line FIELDTERMI...
```



Added 3 labels, created 3 nodes, set 9 properties, created 2 relationships, completed after 302 ms.

# Importing a large dataset

< very large dataset that is greater than 10K rows>

```
PERIODIC COMMIT LOAD CSV . . .
```

**Benefit:** The graph engine will automatically commit data to avoid memory issues.

# Exercise 16: Importing data

In Neo4j Browser:

```
:play intro-neo4j-exercises
```

Then follow instructions for Exercise 16.

# Accessing Neo4j resources

There are many ways that you can learn more about Neo4j. A good starting point for learning about the resources available to you is the **Neo4j Learning Resources** page at <https://neo4j.com/developer/resources/>.

A background image of a human brain in profile, colored in shades of pink, red, and blue. Overlaid on the brain is a network graph consisting of numerous small, dark grey circular nodes connected by thin grey lines, representing a complex system or web of connections.

# Check your understanding

# Question 1

What Cypher keyword can you use to prefix any Cypher statement to examine how many db hits occurred when the statement executed?

Select the correct answer.

- ANALYZE
- EXPLAIN
- PROFILE
- MONITOR

# Answer 1

What Cypher keyword can you use to prefix any Cypher statement to examine how many db hits occurred when the statement executed?

Select the correct answer.

- ANALYZE
- EXPLAIN
- PROFILE
- MONITOR

# Question 2

What types of constraints can you define for a graph that are asserted when a node or relationship is created or updated?

Select the correct answers.

- unique values for a property of a node
- unique values for a property of a relationship
- a node must have a certain set of properties with values
- a relationship must have a certain set of properties with values

# Answer 2

What types of constraints can you define for a graph that are asserted when a node or relationship is created or updated?

Select the correct answers.

- unique values for a property of a node
- unique values for a property of a relationship
- a node must have a certain set of properties with values
- a relationship must have a certain set of properties with values

# Question 3

In general, what is the maximum number of nodes or relationships that you can easily create using LOAD CSV?

Select the correct answer.

- 1K
- 10K
- 1M
- 10M

# Answer 3

In general, what is the maximum number of nodes or relationships that you can easily create using LOAD CSV?

Select the correct answer.

- 1K
- 10K
- 1M
- 10M

# Summary

You should be able to:

- Use parameters in your Cypher statements.
- Analyze Cypher execution.
- Monitor queries.
- Manage constraints and node keys for the graph.
- Import data into a graph from CSV files.
- Manage indexes for the graph.
- Access Neo4j resources.

# **Course feedback**

We value your feedback!

Please fill out the feedback form and receive a

**Certificate of Completion**

[bit.ly/neo-survey](https://bit.ly/neo-survey)