Neo4j: Graph Database

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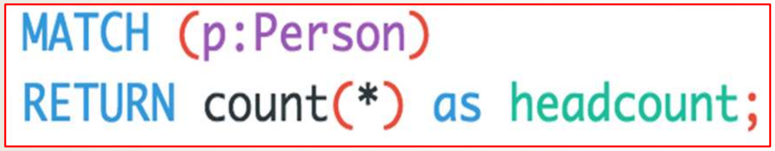
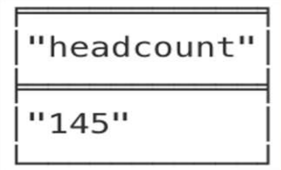
CS411: Database Systems

Aggregation

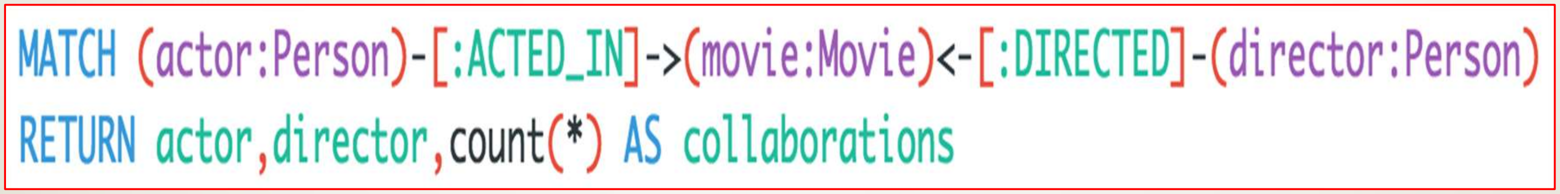
common aggregation functions are supported:
count, sum, avg, min, and max



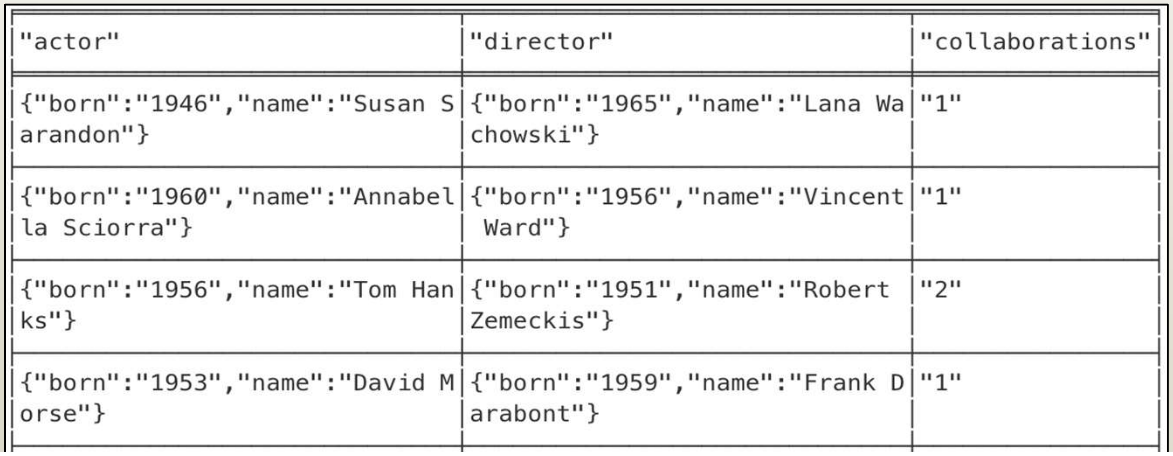
```
MATCH (p:Person)
RETURN count(*) as headcount;
```



```
│"headcount"│
╞═══════════╡
│"145"      │
└───────────┘
```



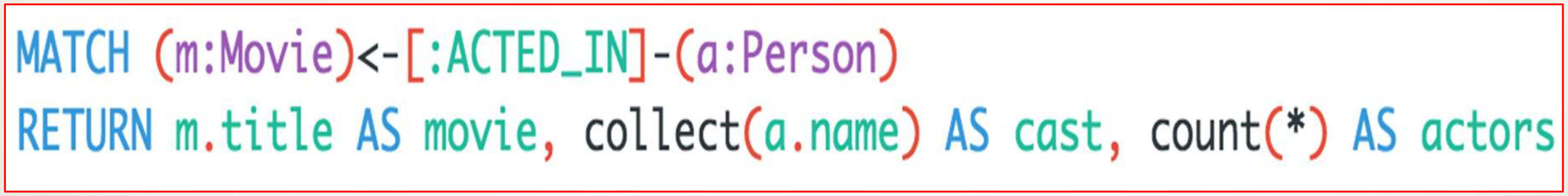
```
MATCH (actor:Person)-[:ACTED_IN]->(movie:Movie)<-[:DIRECTED]-(director:Person)
RETURN actor,director,count(*) AS collaborations
```



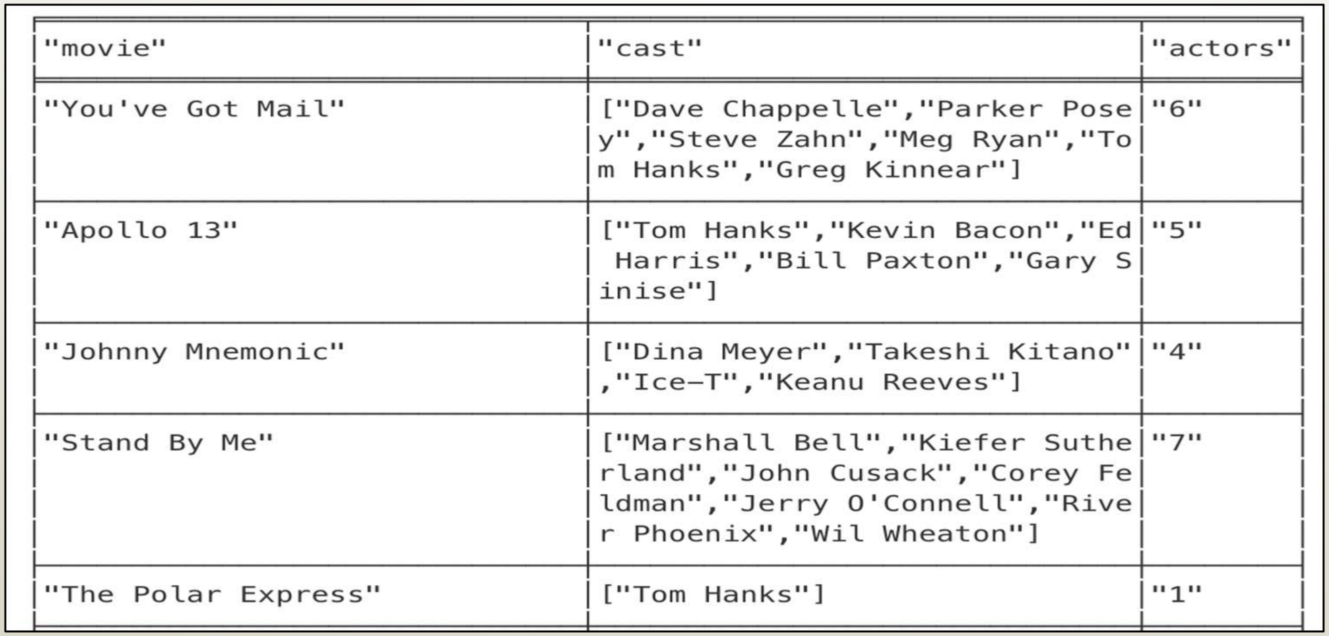
```
│"actor"                          │"director"                       │"collaborations"│
╞═════════════════════════════════╪═════════════════════════════════╪════════════════╡
│{"born":"1946","name":"Susan S   │{"born":"1965","name":"Lana Wa   │"1"             │
│arandon"}                        │chowski"}                        │                │
├─────────────────────────────────┼─────────────────────────────────┼────────────────┤
│{"born":"1960","name":"Annabel   │{"born":"1956","name":"Vincent   │"1"             │
│la Sciorra"}                     │ Ward"}                          │                │
├─────────────────────────────────┼─────────────────────────────────┼────────────────┤
│{"born":"1956","name":"Tom Han   │{"born":"1951","name":"Robert    │"2"             │
│ks"}                             │Zemeckis"}                       │                │
├─────────────────────────────────┼─────────────────────────────────┼────────────────┤
│{"born":"1953","name":"David M   │{"born":"1959","name":"Frank D   │"1"             │
│orse"}                           │arabont"}                        │                │
├─────────────────────────────────┼─────────────────────────────────┼────────────────┤
```

COLLECT

- ***Collect()*** function collects all aggregated values into a list



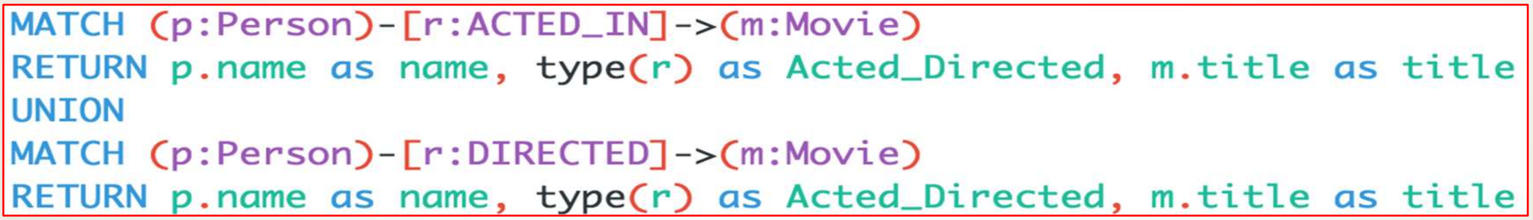
```
MATCH (m:Movie)<-[:ACTED_IN]-(a:Person)
RETURN m.title AS movie, collect(a.name) AS cast, count(*) AS actors
```



"movie"	"cast"	"actors"
"You've Got Mail"	["Dave Chappelle","Parker Posey","Steve Zahn","Meg Ryan","Tom Hanks","Greg Kinnear"]	"6"
"Apollo 13"	["Tom Hanks","Kevin Bacon","Ed Harris","Bill Paxton","Gary Sinise"]	"5"
"Johnny Mnemonic"	["Dina Meyer","Takeshi Kitano","Ice-T","Keanu Reeves"]	"4"
"Stand By Me"	["Marshall Bell","Kiefer Sutherland","John Cusack","Corey Feldman","Jerry O'Connell","River Phoenix","Wil Wheaton"]	"7"
"The Polar Express"	["Tom Hanks"]	"1"

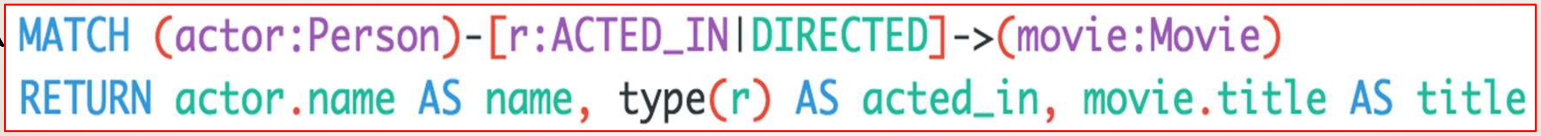
Composing Statements: UNION

- UNION combines the results of two statements that have the same result structure

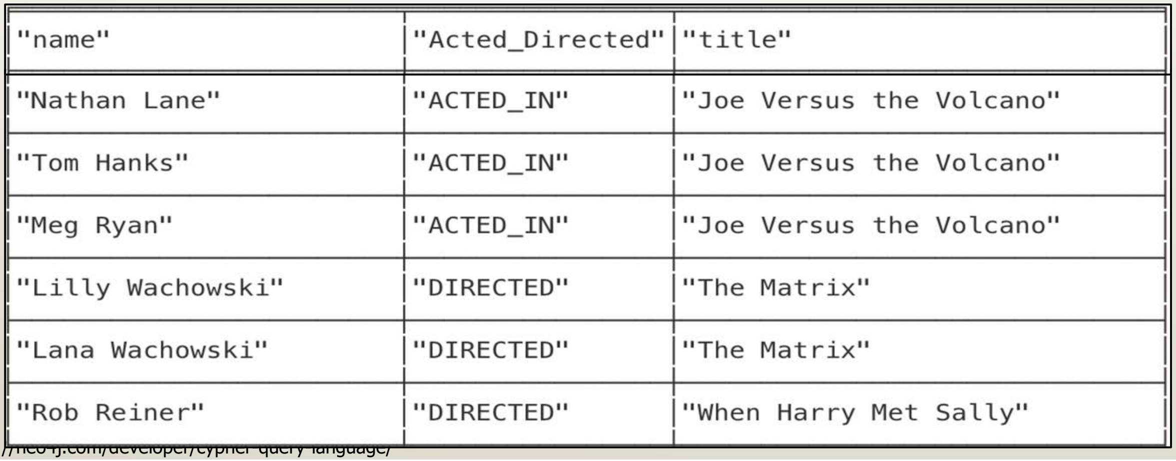


```
MATCH (p:Person)-[r:ACTED_IN]->(m:Movie)
RETURN p.name as name, type(r) as Acted_Directed, m.title as title
UNION
MATCH (p:Person)-[r:DIRECTED]->(m:Movie)
RETURN p.name as name, type(r) as Acted_Directed, m.title as title
```

Equivalent Query



```
MATCH (actor:Person)-[r:ACTED_IN|DIRECTED]->(movie:Movie)
RETURN actor.name AS name, type(r) AS acted_in, movie.title AS title
```



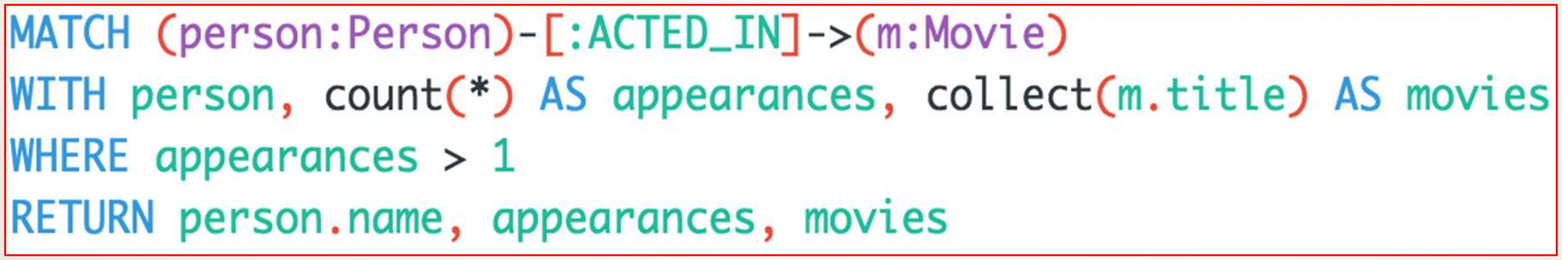
```
"name"                   "Acted_Directed"  "title"
"Nathan Lane"            "ACTED_IN"        "Joe Versus the Volcano"
"Tom Hanks"              "ACTED_IN"        "Joe Versus the Volcano"
"Meg Ryan"               "ACTED_IN"        "Joe Versus the Volcano"
"Lilly Wachowski"        "DIRECTED"        "The Matrix"
"Lana Wachowski"         "DIRECTED"        "The Matrix"
"Rob Reiner"             "DIRECTED"        "When Harry Met Sally"
```

Source: https://neo4j.com/developer/cypher-query-language/

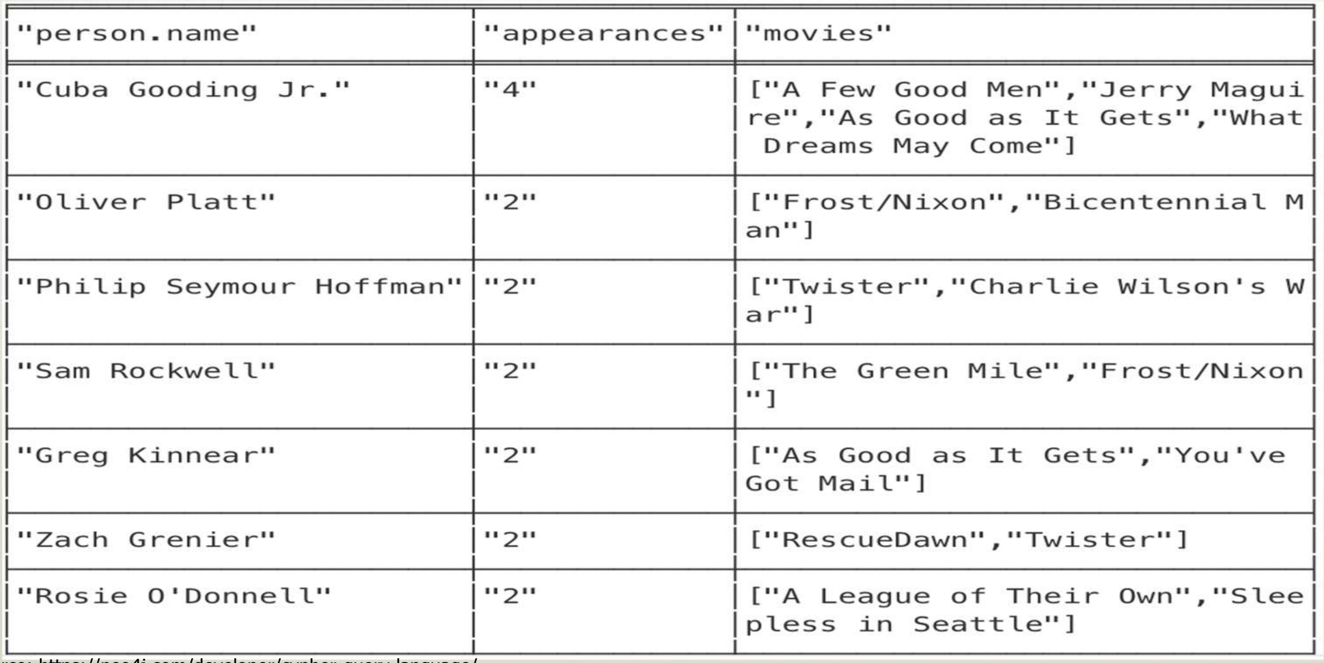
Composing Statements: WITH

- WITH clause combines individual parts of a query and declare which data flows from one to the other.
- WITH is like RETURN with the difference that it doesn’t finish a query but prepares the input for the next part.

WITH Example



```
MATCH (person:Person)-[:ACTED_IN]->(m:Movie)
WITH person, count(*) AS appearances, collect(m.title) AS movies
WHERE appearances > 1
RETURN person.name, appearances, movies
```

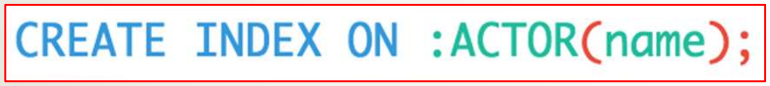


"person.name"	"appearances"	"movies"
"Cuba Gooding Jr."	"4"	["A Few Good Men","Jerry Maguire","As Good as It Gets","What Dreams May Come"]
"Oliver Platt"	"2"	["Frost/Nixon","Bicentennial Man"]
"Philip Seymour Hoffman"	"2"	["Twister","Charlie Wilson's War"]
"Sam Rockwell"	"2"	["The Green Mile","Frost/Nixon"]
"Greg Kinnear"	"2"	["As Good as It Gets","You've Got Mail"]
"Zach Grenier"	"2"	["RescueDawn","Twister"]
"Rosie O'Donnell"	"2"	["A League of Their Own","Sleepless in Seattle"]

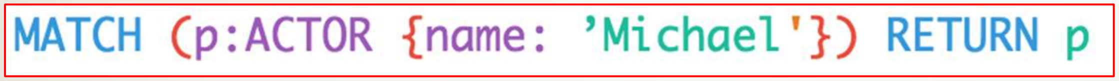
Source: https://neo4j.com/developer/cypher-query-language/

Indexing and Constraints

- Goal of indexing: find the starting point in the graph as fast as possible



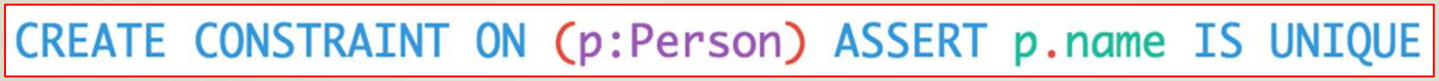
```
CREATE INDEX ON :ACTOR(name);
```



```
MATCH (p:ACTOR {name: ’Michael'}) RETURN p
```

Interested in DB Tuning?
http://neo4j.com/docs/developer-manual/current/cypher/query-tuning/using/

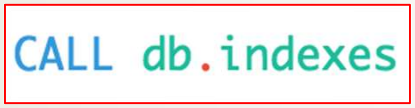
- Unique constraints guarantee uniqueness of a certain property on nodes with a specific label.



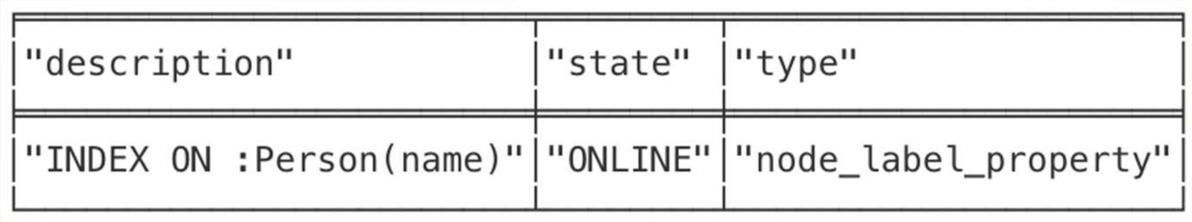
```
CREATE CONSTRAINT ON (p:Person) ASSERT p.name IS UNIQUE
```

Index Management

- Listing database indexes

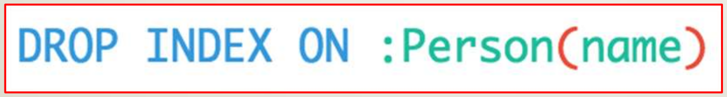


```
CALL db.indexes
```



```
╒═══════════════════════════╤══════════╤═════════════════════╕
│"description"              │"state"   │"type"               │
╞═══════════════════════════╪══════════╪═════════════════════╡
│"INDEX ON :Person(name)"   │"ONLINE"  │"node_label_property"│
└───────────────────────────┴──────────┴─────────────────────┘
```

- Dropping an Index



```
DROP INDEX ON :Person(name)
```

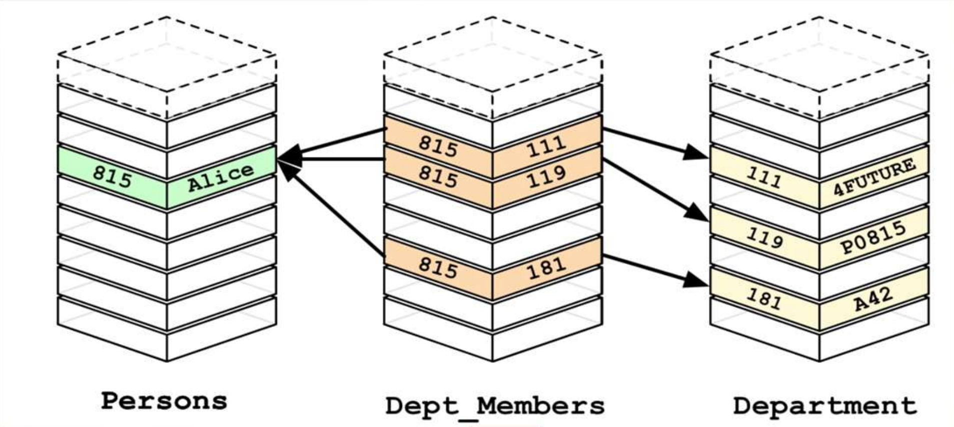
From Relational to Graph Databases

- Graph databases store relationships and connections as first-class entities: “Property Graph Model”

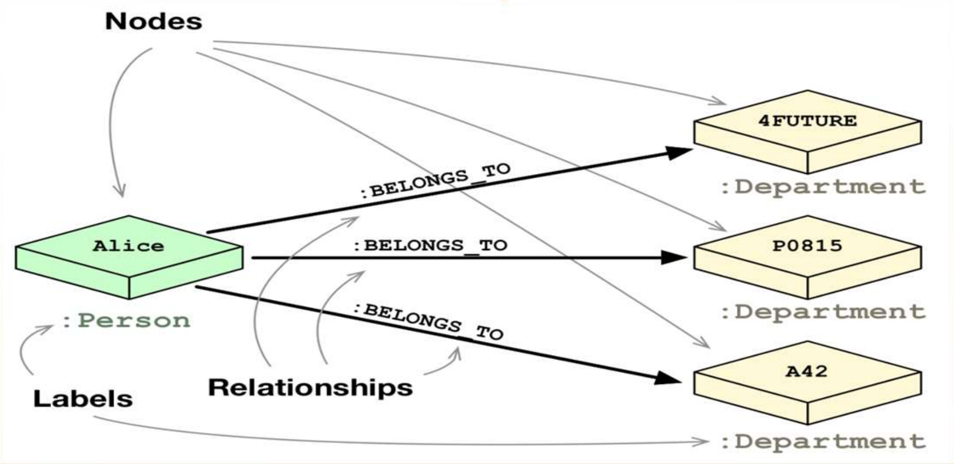
RDBMS	Graph Databases
Tables	Set of Nodes/Relationships
Rows	Nodes
Columns and data	Data properties and values
Constraints	Relationships
Joins	Traversals

From Relational to Graph Databases

Relational Model

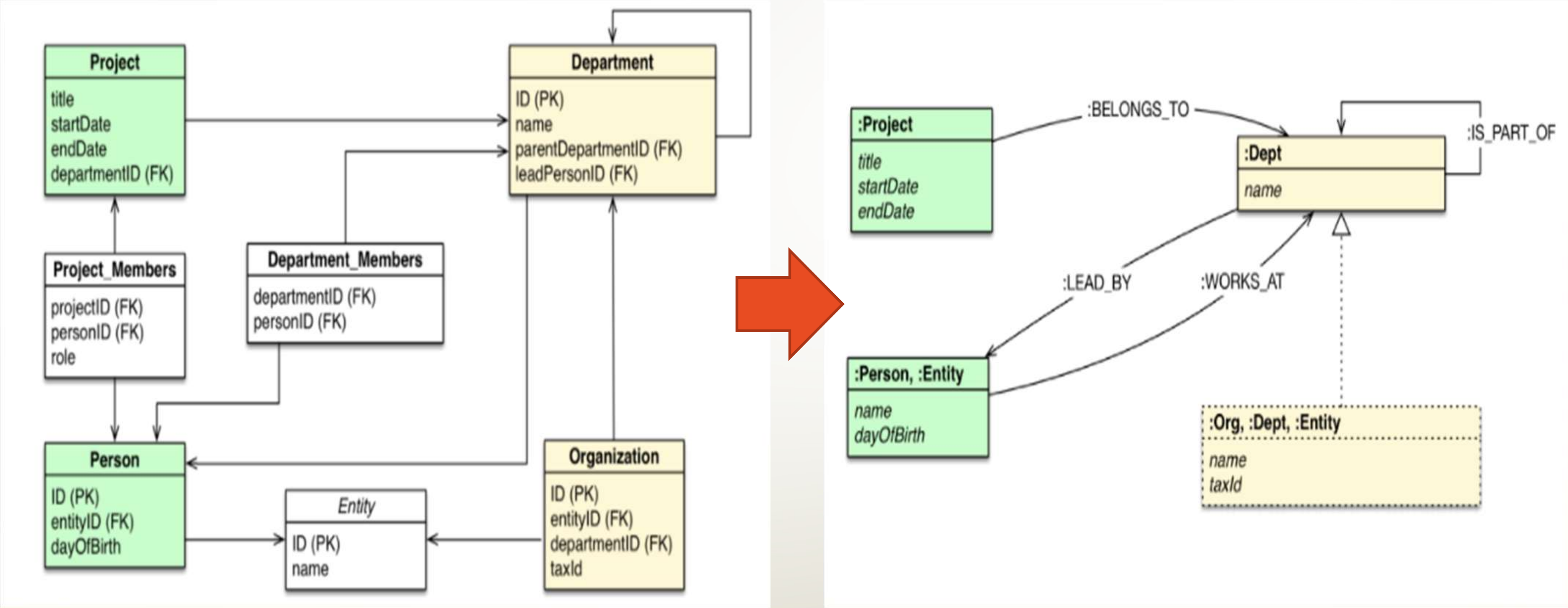


Graph Model



Source: https://neo4j.com/developer/graph-db-vs-rdbms/#_from_relational_to_graph_databases

DB=>Graph Data Model Transformation



Project
title
startDate
endDate
departmentID (FK)

Department
ID (PK)
name
parentDepartmentID (FK)
leadPersonID (FK)

Project_Members
projectID (FK)
personID (FK)
role

Department_Members
departmentID (FK)
personID (FK)

Person
ID (PK)
entityID (FK)
dayOfBirth

Entity
ID (PK)
name

Organization
ID (PK)
entityID (FK)
departmentID (FK)
taxId

:Project
title
startDate
endDate

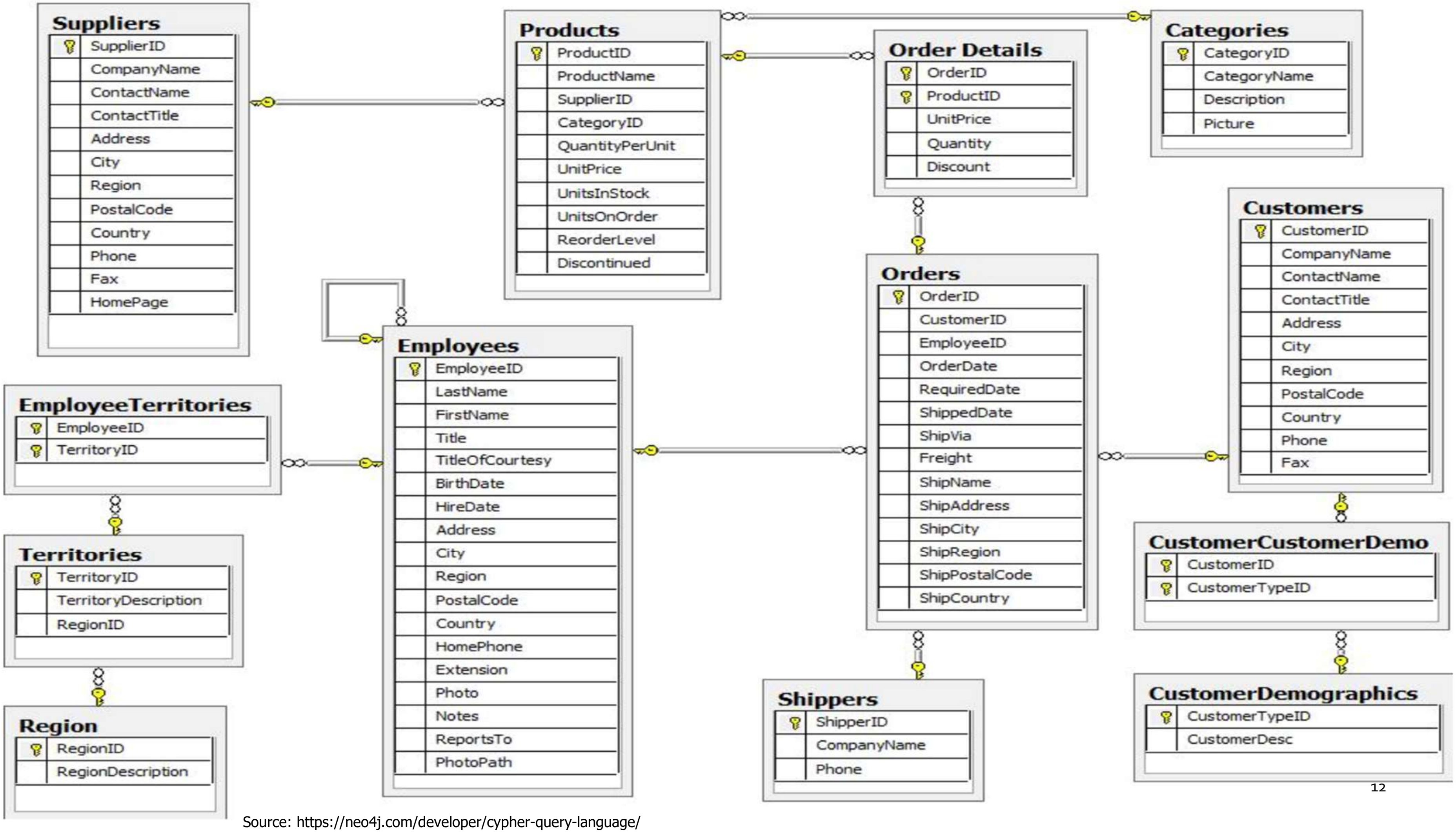
:Dept
name

:Person, :Entity
name
dayOfBirth

:Org, :Dept, :Entity
name
taxId

Source: https://neo4j.com/developer/graph-db-vs-rdbms/#_from_relational_to_graph_databases

Northwind Example



Suppliers
- 🔑 SupplierID
- CompanyName
- ContactName
- ContactTitle
- Address
- City
- Region
- PostalCode
- Country
- Phone
- Fax
- HomePage

Products
- 🔑 ProductID
- ProductName
- SupplierID
- CategoryID
- QuantityPerUnit
- UnitPrice
- UnitsInStock
- UnitsOnOrder
- ReorderLevel
- Discontinued

Order Details
- 🔑 OrderID
- 🔑 ProductID
- UnitPrice
- Quantity
- Discount

Categories
- 🔑 CategoryID
- CategoryName
- Description
- Picture

Customers
- 🔑 CustomerID
- CompanyName
- ContactName
- ContactTitle
- Address
- City
- Region
- PostalCode
- Country
- Phone
- Fax

Orders
- 🔑 OrderID
- CustomerID
- EmployeeID
- OrderDate
- RequiredDate
- ShippedDate
- ShipVia
- Freight
- ShipName
- ShipAddress
- ShipCity
- ShipRegion
- ShipPostalCode
- ShipCountry

Employees
- 🔑 EmployeeID
- LastName
- FirstName
- Title
- TitleOfCourtesy
- BirthDate
- HireDate
- Address
- City
- Region
- PostalCode
- Country
- HomePhone
- Extension
- Photo
- Notes
- ReportsTo
- PhotoPath

EmployeeTerritories
- 🔑 EmployeeID
- 🔑 TerritoryID

Territories
- 🔑 TerritoryID
- TerritoryDescription
- RegionID

Region
- 🔑 RegionID
- RegionDescription

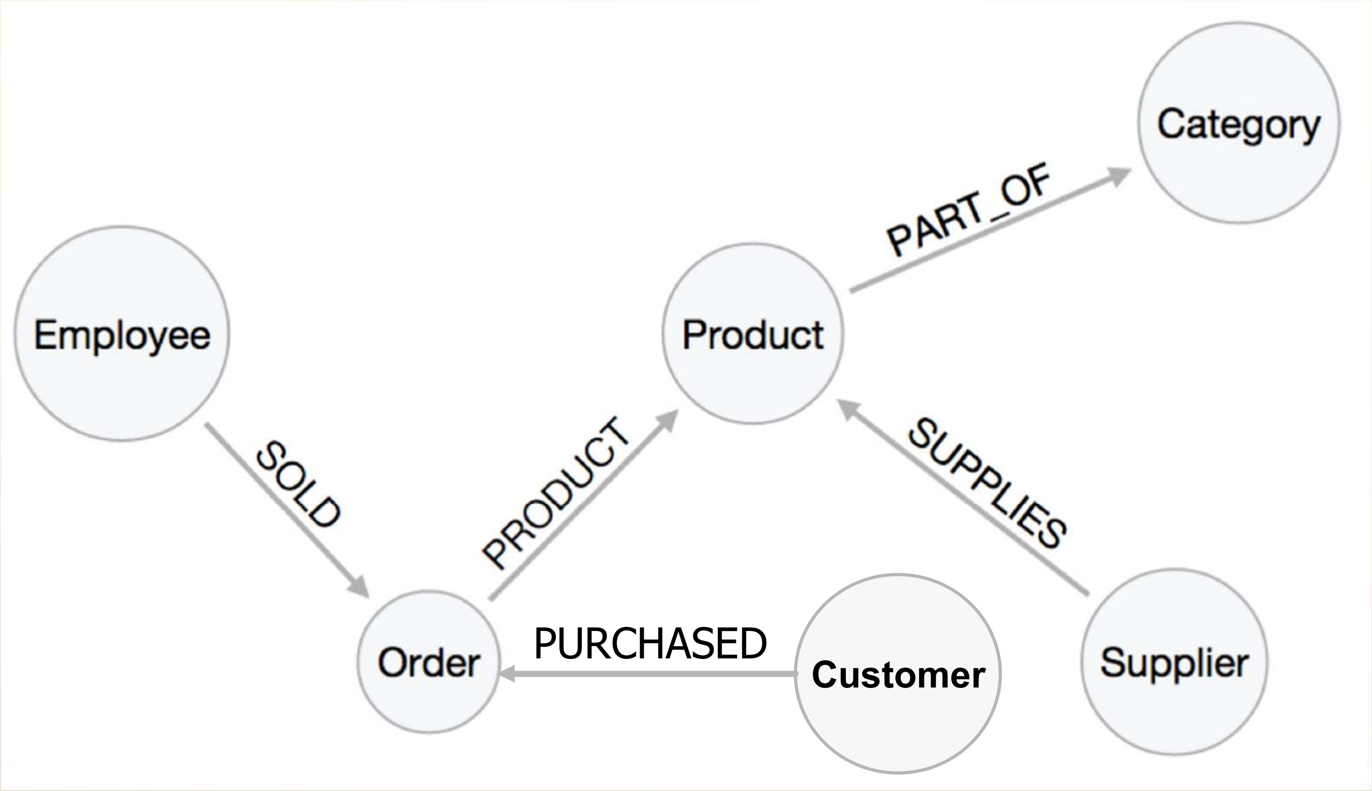
Shippers
- 🔑 ShipperID
- CompanyName
- Phone

CustomerCustomerDemo
- 🔑 CustomerID
- 🔑 CustomerTypeID

CustomerDemographics
- 🔑 CustomerTypeID
- CustomerDesc

Source: https://neo4j.com/developer/cypher-query-language/

Northwind: Graph Model



Source: https://neo4j.com/developer/cypher-query-language/

Querying Northwind DB: SQL vs. Neo4J

- Select everything from the products table

SQL

```
SELECT p.*
FROM products as p;
```

Cypher

```
MATCH (p:Product)
RETURN p;
```

Source: https://neo4j.com/developer/cypher-query-language/

SQL vs. Neo4J: Projection

- Select Product Name and Price from products table

SQL

```
SELECT p.ProductName, p.UnitPrice
FROM products as p
ORDER BY p.UnitPrice DESC
 LIMIT 10;
```

Cypher

```
MATCH (p:Product)
RETURN p.productName, p.unitPrice
ORDER BY p.unitPrice DESC
LIMIT 10;
```

Source: https://neo4j.com/developer/cypher-query-language/

SQL vs. Neo4J: Filtering

- Select Product Name and Price for “Chocolate”

SQL

```
SELECT p.ProductName, p.UnitPrice
FROM products AS p
WHERE p.ProductName = 'Chocolate';
```

Cypher

```
MATCH (p:Product)
WHERE p.productName = "Chocolate"
RETURN p.productName, p.unitPrice;
```

OR

```
MATCH (p:Product {productName:"Chocolate"})
RETURN p.productName, p.unitPrice;
```

Source: https://neo4j.com/developer/cypher-query-language/

SQL vs. Neo4J: Filtering

- List expensive products that starts with C.

SQL

```
SELECT p.ProductName, p.UnitPrice
FROM products AS p
WHERE p.ProductName LIKE 'C%'
AND p.UnitPrice > 100;
```

Cypher

```
MATCH (p:Product)
WHERE p.productName STARTS WITH "C"
AND p.unitPrice > 100
RETURN p.productName, p.unitPrice;
```

Source: https://neo4j.com/developer/cypher-query-language/

SQL vs. Neo4J: Joining vs. Traversing

- Who bought Chocolate?

SQL

```
SELECT DISTINCT c.CompanyName
FROM customers AS c JOIN orders AS o ON (c.CustomerID =
o.CustomerID)
JOIN order_details AS od ON (o.OrderID = od.OrderID)
JOIN products AS p ON (od.ProductID = p.ProductID)
WHERE p.ProductName = 'Chocolate';
```

Cypher

```
MATCH (p:Product {productName:"Chocolate"})<-
[:PRODUCT]-(:Order)<-[:PURCHASED]-(c:Customer)
RETURN distinct c.companyName;
```

Source: https://neo4j.com/developer/cypher-query-language/

SQL vs. Neo4J: Aggregation

- Find top-selling employees

SQL

```
SELECT e.EmployeeID, count(*) AS Count
FROM Employee AS e JOIN Order AS o ON
(o.EmployeeID = e.EmployeeID)
GROUP BY e.EmployeeID
ORDER BY Count DESC;
```

Cypher

```
MATCH (:Order)<-[:SOLD]-(e:Employee)
RETURN e.name, count(*) AS cnt
ORDER BY cnt DESC;
```

Source: https://neo4j.com/developer/cypher-query-language/

Summary

- Graph databases store relationships and connections as first-class entities
- Graph databases have good performance when dealing with connected data
- Cypher is a declarative pattern-matching graph query language
- Querying connected data is easier with Cypher

Neo4j Resources

1. Neo4j Tutorial: https://www.tutorialspoint.com/neo4j/index.htm
2. Video Tutorials: https://neo4j.com/blog/neo4j-video-tutorials/?_ga=2.57983406.580712586.1555337212-902296776.1553382068
3. GraphGists are teaching tools which allow you to explore how data in a particular domain would be modeled as a graph and see some example queries of that graph data
   - https://neo4j.com/graphgists/
4. Awesome user-defined procedures: https://github.com/neo4j-contrib/neo4j-apoc-procedures