Data Warehousing

Lecture 8 – Graph DBs and Graph Data Modelling

CITS3401
CITS5504

Dr. Sirui Li

Computer Science and Software Engineering

School of Maths, Physics and Computing

Acknowledgement: The lecture slides are adopted from online sources.

Lecture Outline

- **What is a Graph**
- Graph Databases vs. Relational
- Graph Data Modelling
    - From Scratch
    - From an existing relational DB
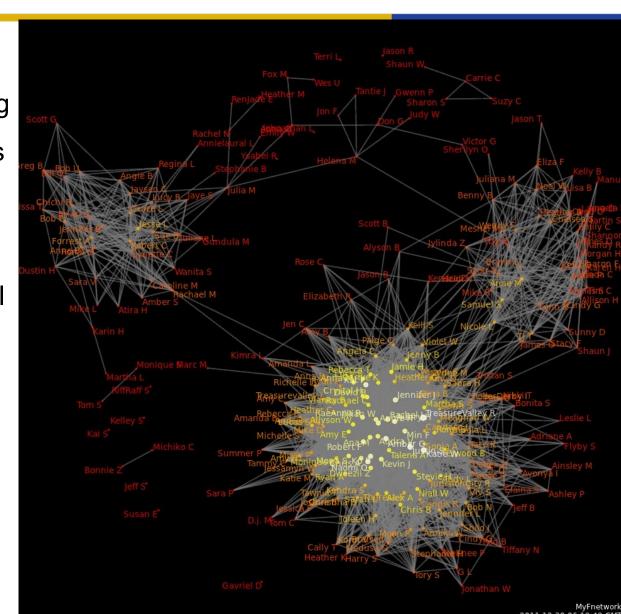
What is a graph?

- A graph is a collection of **vertices** and **edges,** also known as **nodes** and **relationships.**

- We can model all sorts of scenarios using graphs – social networks, natural language, scientific papers, etc.
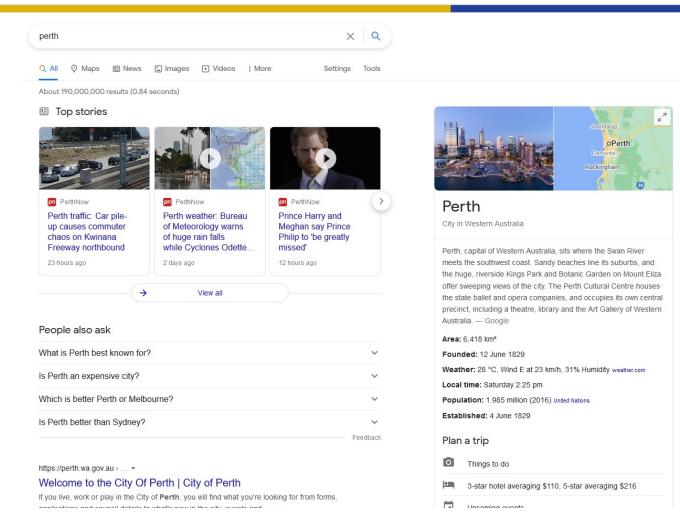
Facebook's social network represents friendship among a set of users. It helps users connect with friends or find new friends based on interests, location, or mutual connections.

MyFnetwork
2011-12-30 06:19:49 GMT

Examples of graphs in use today

Google's search functionality is made possible via a knowledge graph.

Labels and Relationships

- Nodes can have **multiple labels**.

- We can use labels to group nodes – this way, we can ask the database to find all nodes labelled "User", or perhaps "User" and also "Admin".

- Relationships in a graph **naturally form paths**.

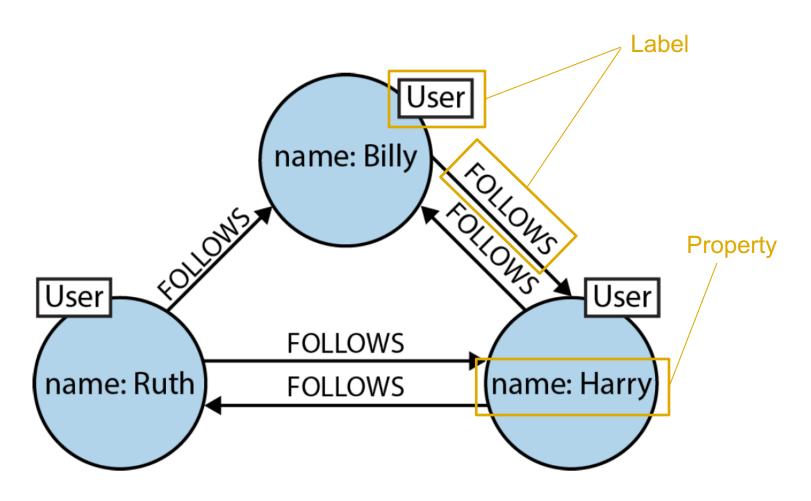- This makes graph databases **extremely efficient** for querying, particularly when the data is heavily connected.

Property graph model

- The most common form of graph model is the **property graph model**, whereby:

  - The graph contains **nodes** and **relationships.**

  - A node may have zero or more **properties** (key-value pairs).

  - Nodes can be labelled with one or more **labels.**

  - Relationships can be **named** and **directed**, and always have a start and end node.

  - Relationships can also contain **properties**.

Example: Twitter

*No relationship properties are shown here. An example might be the date in which the person followed another person.

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Graph vs Relational: The Irony of RDBMS

- RDBMS were originally designed to **codify** paper forms and tabular structures.

- Relational databases are excellent for storing **tabular data**, but are not ideal for storing data where relationships are involved, despite their name!

Relational Database Example

User

UserID	User	Email	Address
1	Alice	alice@example.org	1 Duck St, ...
2	Bob	bob@example.org	1 Duck St, ...
3	...	...	37 Rabbit Lane...
4	Zach	zach@example.org	49 Rabbit Lane...

Product

ProductID	Description	Handling
321	Strawberry ice cream	freezer
765	Potatoes	null
...	...	...
987	Dried spaghetti	null

Order

OrderID	UserID
1234	1
5678	1
...	...
9001	99

LineItem

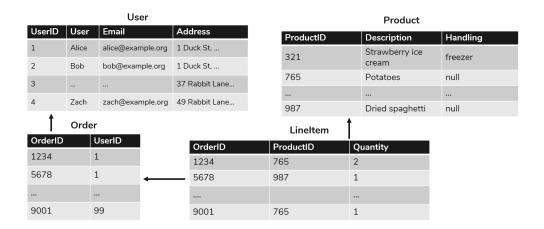| OrderID	ProductID	Quantity
1234	765	2
5678	987	1
....		...
9001	765	1
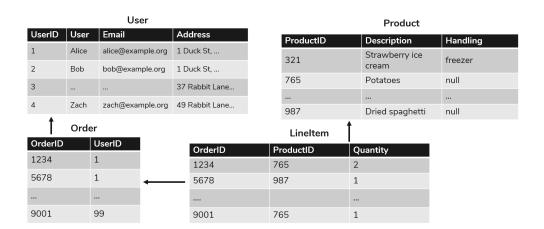
Relational Database Example

- "Which items did a customer buy?"

- "Which customers bought this product?"

- "Which customers buying *this* product also bought *that* product?"

User

UserID	User	Email	Address
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…	…
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LineItem

OrderID	ProductID	Quantity
1234	765	2
5678	987	1
….		…
9001	765	1

Relational Database Example

- Queries across multiple tables are
  - inefficient yet doable
  - prohibitively slow

- RDBMs schemas are **inflexible**, and can't keep up with dynamic and uncertain variables.

- Relational databases **aren't effective at handling data relationships**, especially when those relationships are added or adjusted on an ad hoc basis.

User

UserID	User	Email	Address
1	Alice	alice@example.org	1 Duck St, ...
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5678	987	1
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9001	765	1

"I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail".
- Abraham Maslow (The Psychology of Science, 1966)

How the Graph Model differs from the Relational Model
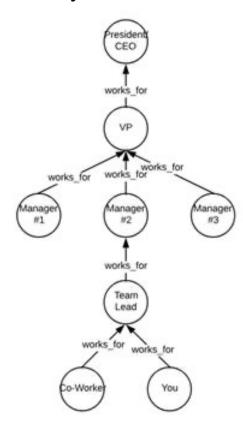
- There are **no nulls**. Non-existing value entries (properties) are just not present.

- It describes the relationships in more detail.

  - For example, we know that an employee SOLD an order rather than having a foreign key relationship between the Orders and Employees tables.

  - We could also choose to add more **metadata** about that relationship, should we wish.

- Either model can be more normalized.

  - For example, addresses have been denormalized in several of the tables, but could have been in a separate table.

  - In a future version of our graph model, we might also choose to separate addresses from the Order (or Supplier or Employee) entities and create separate Address nodes.

- **No nulls!**

Recursive Queries

Given a list of employees and managers in a company, how we would determine a person's reporting hierarchy?

```
g.V().
   repeat(
     out('works_for')
   ).path().next()
```



```sql
WITH RECURSIVE org AS (
    SELECT employee_id,
           manager_employee_id,
           employee_name,
           1 AS level
    FROM org_chart
  UNION
    SELECT m.employee_id,
           e.manager_employee_id,
           e.employee_name,
           m.level+1 AS level
    FROM org_chart AS e
      INNER JOIN org AS m ON
e.manager_employee_id = m.employee_id
  )

SELECT employee_id,
manager_employee_id, employee_name,
FROM org
ORDER BY level ASC;
```

Summary – Relational DB vs. Graph DB

- Because relational DBs were originally designed to codify tabular forms, they are not ideal for storing heavily related data.

- Graph DBs, on the other hand, excel when dealing with **highly connected data**.

- Graph DBs do **not need to store null values**, and we can add **new properties** or node types (labels) **on the fly**.

- They are also much better at handling **recursive queries** and **queries across multiple entities**.

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Intro to Graph Data Modelling
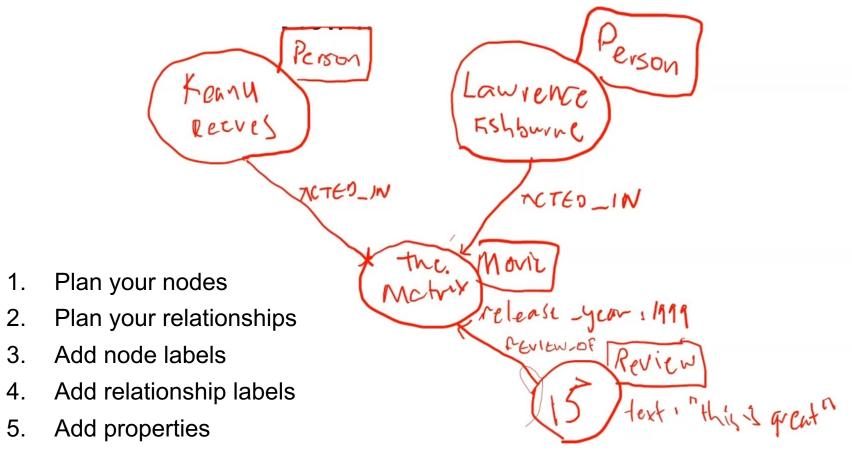
- **Data modelling** aims to bring specific facets of an unruly domain into a space where they can be **structured** and **manipulated**.

- Graph representations are one way to model data, and are excellent when modelling **highly-interconnected** data.

- Unlike relational database modelling, we do not need to deviate from **natural language representations** when modelling graphs.

Planning out a graph DB
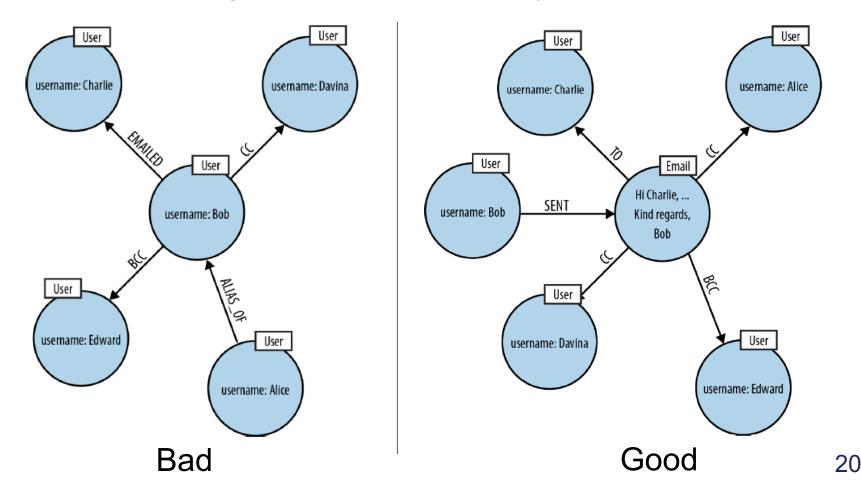
Graph data modelling is whiteboard-friendly. Let's plan a graph model for a few movies…

1. Plan your nodes
2. Plan your relationships
3. Add node labels
4. Add relationship labels
5. Add properties

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Pitfalls to avoid
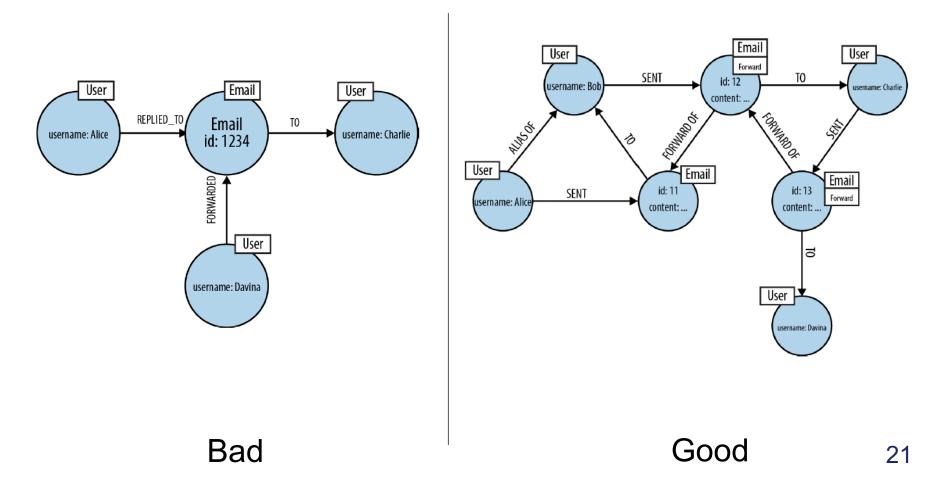
It's important to make sure that your graph model **facilitates the types of queries** that you are interested in.

Bad

Good

20
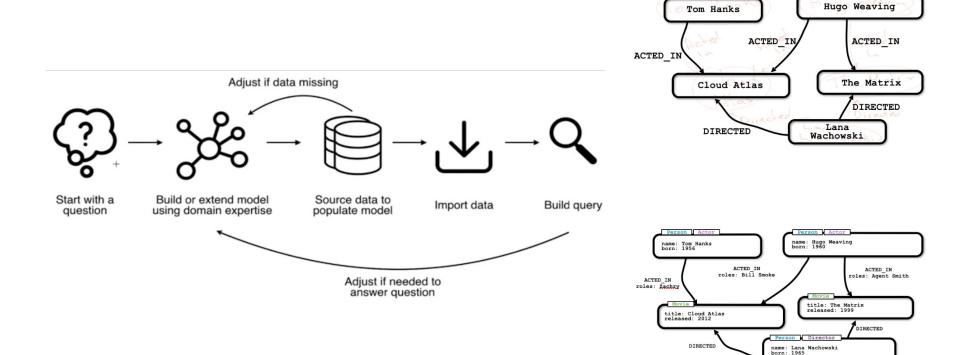
It's also important to **think ahead** and ensure that your graph can evolve with new types of nodes/relationships.

Bad   Good

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Graph Data Modelling & Implementation

Arrows: Neo4j Graph Modelling Tool

https://neo4j.com/developer/guide-data-modeling/
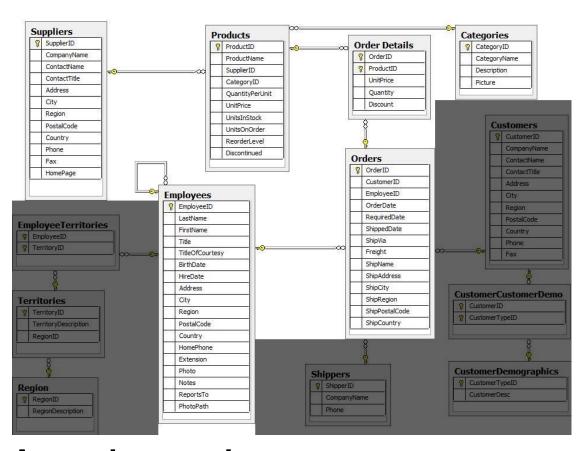
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The Popular Northwind Dataset for SQL

Northwind - a product sale system

- customers,
- products,
- customer orders,
- warehouse stock,
- shipping,
- suppliers,
- employees, and
- sales territories.
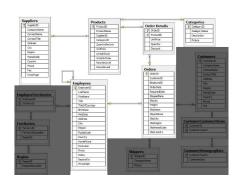
A *row* is a *node*
A *table name* is a *label name*
A *join or foreign key* is a *relationship*
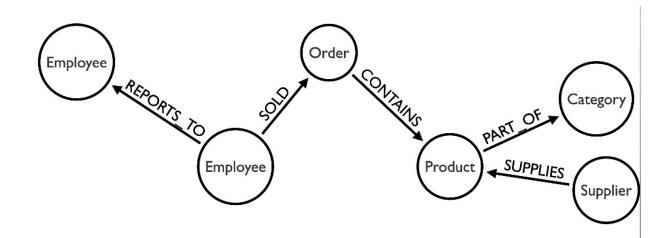
https://neo4j.com/developer/guide-importing-data-and-etl/

Rows to Nodes, Table names to labels

Each row on the **Orders** table becomes a node in with *Order* as the label.
Each row on the **Products** table becomes a node with *Product* as the label.
Each row on the **Suppliers** table becomes a node with *Supplier* as the label.
Each row on the **Categories** table becomes a node with *Category* as the label.
Each row on the **Employees** table becomes a node with *Employee* as the label.

Schema-level graph

Rows to Nodes, Table names to labels
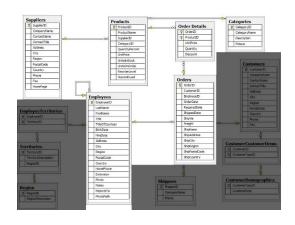
Join between **Suppliers** and **Products** becomes a relationship named SUPPLIES (where supplier supplies product).
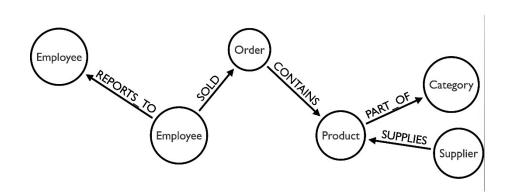
Join between **Products** and **Categories** becomes a relationship named PART_OF (where product is part of a category).

Join between **Employees** and **Orders** becomes a relationship named SOLD (where employee sold an order).

Join between **Employees** and *itself* (unary relationship) becomes a relationship named REPORTS_TO (where employees have a manager).

Join with join table (Order Details) between **Orders** and **Products** becomes a relationship named CONTAINS with properties of `unitPrice`, `quantity`, and `discount` (where order contains a product).

Importing the Data using Cypher

```
// Create orders
LOAD CSV WITH HEADERS FROM 'file:///orders.csv' AS row
MERGE (order:Order {orderID: row.OrderID})
  ON CREATE SET order.shipName = row.ShipName;

// Create products
LOAD CSV WITH HEADERS FROM 'file:///products.csv' AS row
MERGE (product:Product {productID: row.ProductID})
  ON CREATE SET product.productName = row.ProductName, product.unitPrice = toFloat(row.UnitPrice);

// Create suppliers
LOAD CSV WITH HEADERS FROM 'file:///suppliers.csv' AS row
MERGE (supplier:Supplier {supplierID: row.SupplierID})
  ON CREATE SET supplier.companyName = row.CompanyName;

// Create employees
LOAD CSV WITH HEADERS FROM 'file:///employees.csv' AS row
MERGE (e:Employee {employeeID:row.EmployeeID})
  ON CREATE SET e.firstName = row.FirstName, e.lastName = row.LastName, e.title = row.Title;

// Create categories
LOAD CSV WITH HEADERS FROM 'file:///categories.csv' AS row
MERGE (c:Category {categoryID: row.CategoryID})
  ON CREATE SET c.categoryName = row.CategoryName, c.description = row.Description;
```
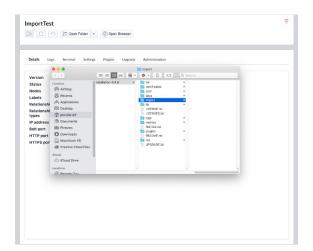
With Neo4j Desktop, we can place CSV files in the local database import directory.
Use the file:/// prefix in our Cypher statements to locate the files.

https://neo4j.com/developer/desktop-csv-import/#csv-location

Summary

- We have shown how to model a graph database model using a whiteboard, and discussed some pitfalls when modelling a graph database.

- Next week we will cover Cypher in much more detail and show how to query the database.

- We will also look at the process of converting an existing CSV (tabular) dataset to a graph database.

Reading

1. What is knowledge graph:
    https://www.youtube.com/watch?v=y7sXDpffzQQ
2. Property graph:
    https://docs.oracle.com/en/database/oracle/property-graph/22.2/spgdg/what-are-property-graphs.html
3. Importing data from a relational database into Neo4j:

https://neo4j.com/docs/getting-started/appendix/tutorials/guide-import-relational-and-etl/