Use Case: Route Finding

Source: Neo Technology, Inc.
Use Case: Logistics

Source: Neo Technology, Inc.
Use Case: Social Network

Source: Neo Technology, Inc.
Use Case: Recommendations

Source: Neo Technology, Inc.
Use Case: Access Control

Source: Neo Technology, Inc.
Graph Database: Example

Source: Neo Technology, Inc.
Graph Database: Definitions

- “A graph database is a database whose data model conforms to some form of graph (...) structure. The graph data model usually consists of nodes (...) and (...) edges (...), where the nodes represent concepts (...) and the edges represent relationships (...) between these concepts (...). ...”  
  *Encyclopedia of Database Systems (Springer)*

- “A graph database management system (henceforth, a graph database) is an online database management system with Create, Read, Update, and delete (CRUD) methods that expose a graph data model ...”
  *Robinson/Webber/Eifrem*

- “A graph database is any storage system that provides index-free adjacency.“
  *Rodriquez*
Relational vs. Graph (Cont.)

Source: Neo Technology, Inc.
Relational vs. Graph (Cont.)

Source: Neo Technology, Inc.
Example: Social Network “path exists” Performance

- a sample social graph with ~1,000 persons
- average 50 friends per person
- pathExists(a,b) limited to depth 4
- caches warmed up to eliminate disk I/O

<table>
<thead>
<tr>
<th># persons</th>
<th>query time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relational DBMS</td>
<td>1,000</td>
</tr>
<tr>
<td>Neo4j</td>
<td>1,000</td>
</tr>
<tr>
<td>Neo4j</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Source: Neo Technology, Inc.
Graph Databases ...

Are good for ...

- Highly connected data (social networks)
- Recommendations (e-commerce)
- Path Finding (how do I know you?)
- A* (Least Cost path)
- ...

If you’ve ever ...

- Joined more than 7 tables together
- Modeled a graph in a table
- Tried to write some crazy stored procedure with multiple recursive self and inner joins

... you should use a graph database
Graph Databases – Topics of Interest

- Graph Data Models
- Graph Query Languages
- Graph Indexing
- Graph Storage
• Edlich, S., Friedland, A., Hampe, J., Brauer, B., Brückner, M. *NoSQL Einstieg in die Welt nichtrelationaler Web 2.0 Datenbanken*, Carl Hanser Verlag, 2011 (2nd ed.)

Graph Databases

✓ Introduction

• Graph Data Models

• Graph Query Languages

• Graph Indexing

• Graph Storage

• Graph Database Management Systems

• Conclusion & Outlook
Graph Data Models

Orthogonal graph characteristics

- Directed vs. undirected
- Simple vs. multi
- Weighted vs. unweighted
- Unlabeled vs. edge-labeled vs. vertex-labeled
- ...

Property Graph Model

- Most popular graph data model in graph databases today (Tinkerpop, InfiniteGraph, InfoGrid, Neo4j etc.)
- Directed labeled multigraph
- Edge properties: key/value pairs
Property Graph Data Model

• **Nodes**
  – Entities

• **Relationships**
  – Connect entities and structure domain

• **Properties**
  – Attributes and metadata

• **(Labels)**
  – Group nodes by role
Property Graph Data Model: Nodes

Source: Neo Technology, Inc.
Property Graph Data Model: Relationships

Source: Neo Technology, Inc.
Property Graph Data Model: Relationships

- Nodes can have more than one relationship.
- Self relationships are allowed.

Source: Neo Technology, Inc.
Property Graph Data Model: Labels

Source: Neo Technology, Inc.
Property Graph Data Model

Source: Neo Technology, Inc.
Graph Data Modeling

- Easy to design and model direct representation of the model – "Whiteboard Friendliness"

Source: Neo Technology, Inc.
Graph Data Modeling (Cont.)

Source: Neo Technology, Inc.
Graph Data Modeling (Cont.)

Source: Neo Technology, Inc.
Graph Data Modeling: Best Practice

• Nodes for Things
• Relationships for Structure
• Represent Complex value types as nodes

• Iterative and incremental development
• Test-driven data model development
Graph Data Modelling: Cross-Domain Models

Source: Robinson/Webber/Eifrem: 2013
Graph Data Modelling: Cross-Domain Models

Source: Robinson/Webber/Eifrem: 2013
Most graph databases are schema-less
However, first graph databases started to introduce schema constructs ...

Example: Neo4j 2.0
- Necessary requirement: Labels
- Unique Constraints:
  - Unique constraints do not mean that all nodes have to have a unique value for the properties — nodes without the property are not subject to this rule.
  - CREATE CONSTRAINT / DROP CONSTRAINT

```
CREATE CONSTRAINT ON (book:Book) ASSERT book.isbn IS UNIQUE
```
Graph Data Models

• Further graph data model approaches
  – Hypergraphs with hyperedges (e.g. HyperGraphDB, sonesGraphDB)
  – ...

• Related approaches
  – RDF
    • Triples (subject, predicate, object)
    • Standardized (W3C)
    • Optimized for reasoning
    • However, e.g. AllegroGraph: RDF store and graph database
  – ...

• Further reading for graph data models:
  – Edlich, S., Friedland, A., Hampe, J., Brauer, B., Brückner, M.
    NoSQL Einstieg in die Welt nichtrelationaler Web 2.0 Datenbanken,
    Carl Hanser Verlag, 2011 (2nd ed.)
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