·         What were the decisions taken in the modelling?

·         Why were these decisions taken?

·         What were the consequences of these decisions?

In the BookStore database that have been implemented in Neo4j, there are 7 different kinds of nodes and 7 different kinds of relationships that connect these nodes together.

Most of the nodes has a unique auto created UUID instead of using the normal id that Neo4j is auto generating it.

**Node IDs have a semantic and give the offset of that node or relationship within the store file. Consider the following example: Let’s say when deleting a node that has a reference in MongoDB (or any other third-party database), and if we forget the reference in Mongo to that now-deleted node.**

**After the original node is deleted, there’s a free space in the node file, so when  creating a new (likely unrelated) node, it now uses the same previously-used Node ID. The dangling reference now points to something semantically completely different, which can cause huge problems in database.**

**So instead of relying on the semantic-driven ID, it is possible and better to store** [**UUID**](http://searchsoa.techtarget.com/definition/UUID) **property , place an index on that and then reference the UUID. Then, even when deleting the node in the future, and forgetting about the reference from a third-party system, it will end up with an error message instead of a dangling reference.**

The Customer is a node which stores the following information about customers:

name, email, password, customerNo as UUID is connected to two different nodes using two kinds of relationships.

It has Lives\_In relationship connecting it to the Address node which stores street, zip, and town for each customer.

The decision of having the address as a node and not having it embedded in the customer node is to avoid redundancy in the database. For sure Queries have been taken into consideration as well,

For instance, if a customer has changed his address it is also possible to execute this process in an easy way if the address is a separate node.

 The customer node has another relationship called PURCHASED to the order node which stores only date and orderNo as UUID, while the other properties that must be contained in an order (price, qty, and ISBN of an book) are stored in the relationship PURCHASED between the customer and the order nodes.

So, it is easier to check how many books a customer has bought in a single order by counting the number of purchased relationships between a specific customer and a specific order.

In addition it is easier to check the number of books a customer has bought in a single order through the graph since simply the number of purchased relationships is the number of books.

The decision of having the price in an order and not having a reference to it in the Book node which stores all the information about  books including the price, is that a book may be on a discount or a different price when it has been ordered by an customer and when this customer wants to return the book so he will get back the same amount of money as when he bought the book.

Using a relationship called CONTAINED the order node is connected to the Book node, which is the main and the most important node, which stores information about books, each book has ISBN, pages, copies, price, currency, language and title.

Author is a separate node, as it is an important node and a lot of information about authors can be necessary to store, name, email and UUID, the author node is connected to the book node using WROTE relationship.

A book can have more than one author so having it as separate node avoid redundancy.

In the same way a separate node has been created to store Characters of a book which in this case has only one attributes called type.

The character node in connected to the book node using PRESENTED\_IN relationship.

A book has one more relationship called IS\_a which connect the book node with the Category node which stores only the name of a category.

This node is recursive, it has a relationship of type PARENT to itself.

·         What were the difficult and easy parts of the exercise?

The most time-consuming queries in the exercise was everything related to the recursive node (Category), it just took some more time to understand how to execute queries on a recursive node.

It was also a bit strange that group by is not provided on everything in Neo4j as it is only possible to do group by on aggregate functions, so all the exercised that was possible to solve them using group by in relational database and Mongodb has been solved in a different way here in Neo4j.

On the other hand it was interesting to play around the data in Neo4j and execute queries and see results in colourful graphs bedside tables.

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In the world of databases, it is essential to find the right tools for the right job. Thus, the “one size fits all” proposition of large relational systems was replaced by conscious decisions about choosing the tools that fit each concrete use case.

With the advent of the NoSQL movement, the “one-size-fits-all” proposition of large relational systems was replaced by conscious decisions about finding the right tool for the job.

In this section we are going to compare graph database, neo4j in particular, to its sibling namely MongoDB.  Mongo is an aggregate oriented database system, which means that it groups the data based on particular criterion (document that has key-value pairs) this approach forms one dedicated view of the data. In terms of scalability, this approach allows developers to spread the data across a network of machines (the shards) where each shard has its share of the dataset, that is only possible because the aggregation framework focuses on only one aggregate at a time. The problem in this approach comes to the view first when we want to connect the document together, or when we have a graph structure where all data is connected. There is of course a work around this, since we are allowed to embed documents inside other documents, but then we compromise the fact that we will end up with redundant data. Another possible solution is to reference by foreign keys, then we can embed an aggregate’s identifier, typically an id, that references another aggregate. The same principle as in relational databases. However, this approach is prohibitively expensive since we want to join aggregates at the application level. In other words, the more joins we have the slower it will be. Indexing the foreign key will help in this case by making the aggregation perform faster. The problem introduced here is important when we want to update the data, then we should follow all the references and update manually using a manually implemented transaction that we block any access to the data until the update is done. Neo4j supports complex related data with as much depth as needed and the update scenario is much convenient since neo4j supports transactions that conform to ACID standards. One thing to point out though, the transaction is not supported through the bowser application, it requires an implementation of the Driver provided from neo4j. using the driver means calling neo4J REST API or Bolt by opening a session with the transaction API and doing whatever job we want then neo4j will manage the successful scenario or the rollback scenario. It is still possible to achieve atomic queries in the browser in one statement but it is not as convenient as the transaction api. Relational database will have a point over Nosql in this scenario.

The figure above shows the key differences between RDBMS, Mongo, and Neo4j :

First, mongodb can handle big size data and it is very good at that specially when it comes to multimedia files, but the downside comes to the picture when we have a depth in the data such that it has to link many documents either with referencing or documenting.

Another point for mongo is its flexibility regarding the schema less model. Even when we apply a restricted schema to mongo, it is still considered more flexible than SQL since it can still handle the data with some extra attribute. Mongo, however, is bad at linking because as described in the first part of this document, it needs to perform many aggregations to view the data in the desired form. Moreover, mongo has a limit of embedding documents inside other documents, which might be an issue if we go with embedding instead of referencing.

the graph paradigm to store data:  neo4j is very strong in storing and retrieving highly-related data as shown in the diagram above. And even though there are many relationships between the data, a graph database will remain very performant during data retrieval, even with millions of nodes. That means you can add or delete nodes and property of nodes without affecting already stored nodes. Because of that, a graph database responds well in an agile environment where course changes over product are very common

Neo4j, is vey good in data that requires many links, data with a high depth, it is much better, in terms of speed, than SQL in performing queries against such a data set.

RDBMS on the other hand, can handle data with a high depth, but the performance is much slower than neo4j. RDBMS is not the best choice for large data, large text multimedia data with unknown shape since the schema in SQL for example cannot handle undefined attributes.

General comparison between RDBMS and Graph

RDBMS has a predefined schema, and all the data must match the schema exactly, when we have a record that has columns with fields that are not applicable, we can mark them as nullable values in the schema. Thus, the application must check for null values and handle exceptions in such a case. Graph on the other hand, consists of nodes instead of tables, and each node is on its own, which means that we do not have to work with null values, just leave out or add properties when needed. In RDBMS, the foreign key paradigm approach is applied to link tables. To get data from a related table, we must perform a join query. In case the data is spread among multiple tables we need to perform multiple joins. The more joins there are in a query, the more the performance suffers exponentially

Graph databases besides the nodes have relationships, first-class citizens of the database, which directionally point from one node to another node. Relationships in a graph database are just as important as nodes and are separate from them. Therefore, there is no data duplication. The cypher query is optimized for relationships too. The query targets a pattern that is matched by the database. Querying nodes related to other nodes is easy and take more time to execute, but the increase in wait time doesn't compare to a multi-joined in relational databases

When to choose a Relational databases:

1 Relational databases will beat a graph database if, this example is from the book store assignment , a sum of the total price for an order has to be calculated or the average age of customers.

 Relational databases are not very good at retrieving nested data.

Example from the assignment: the foreign key CustomerId in the order table points to a primary key CustomerId in a customer's table. The foreign key orderNo and bookISBN points to order and a book. We need several complicated and costly joins just to find out what book a customer bought. But it gets even more complex if you want to ask the database which customers bought a certain book, and to find out which customers bought this book who also bought that book, like Amazon does for finding customer trends.

RDSMS is not good at highly related data

Example from facebook:

 If we want to find friends of friends at minimum level 5 depth and compare the performance between SQL and neo4j.this Query will break SQL off because it just took too long, when Neo4j produced the results much faster. regardless of the complication of the query

Question 12 is an example of how recursive queries looks like in neo4j vs SQL

Where in neo4j this is enough to do the same job, with no need of any temporary table to save the result from each result and then join it with the next and so on

The main difference between mongodb and neo4j for this exercise was to manage transactions, where it has to be done using many helper functions and following some complicated procedures to do the job, since mongo update works on the document level, it does not support atomic update across multiple documents. In neo4j this scenario was manageable with less effort since we could write multiple commands in the same query and if one fails none of them will be applied.

To be fair with this, managing rollbacks in neo4j was so difficult and we could not figure out whether it can be done in the browser or not.

The writebulk function in mongodb supports multiple statements within one scope, but it does not support rollback in case if one of the queries fails.

Summary :

Graph databases are flexible and performant with highly related data

Relational databases are great for reporting and transactional queries

Document databases are great to store object

All databases have their place, and it always depends on the use case to select the right tools

The best implementation of this exercise will be in SQL since there is not much depth level in the data, and the shape of the data is well known in advance. Moreover, managing transactions in NoSQL databases is not optimal yet.