API ASSET JANUS

Technologies for Big Data Management

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Project overview

Asset management prototype tool based on **JanusGraph** database, able to run **CRUD operations** with focus on **search functionalities** over digital twin properties.

JanusGraph | Features

JanusGraph is a **graph-oriented** database:

- Uses graph structures with **nodes**, **edges** and **properties**
- **Graph Theory** concepts are applicable
- **Query language** is **Gremlin**, which chains together traversal operators to form **path-like expressions**
  - **e.g.** "*from node A traverse to node B and return its outgoing nodes*"
- Storage and index backends are **pluggable**
  - In our case, JanusGraph + Cassandra for storage

JanusGraph | Storage backend solutions

- JanusGraph is distributed with 3 supporting backends: **Apache Cassandra, Apache HBase and Oracle Berkeley DB**.
- The choice of backend solution falls according to specific implementation needs (e.g. **Availability over Consistency** and vice versa).
- In our case we chose **Cassandra** but, since our project is a prototype implementation we didn’t have any strict constraints to be met.

JanusGraph | Guarantees*

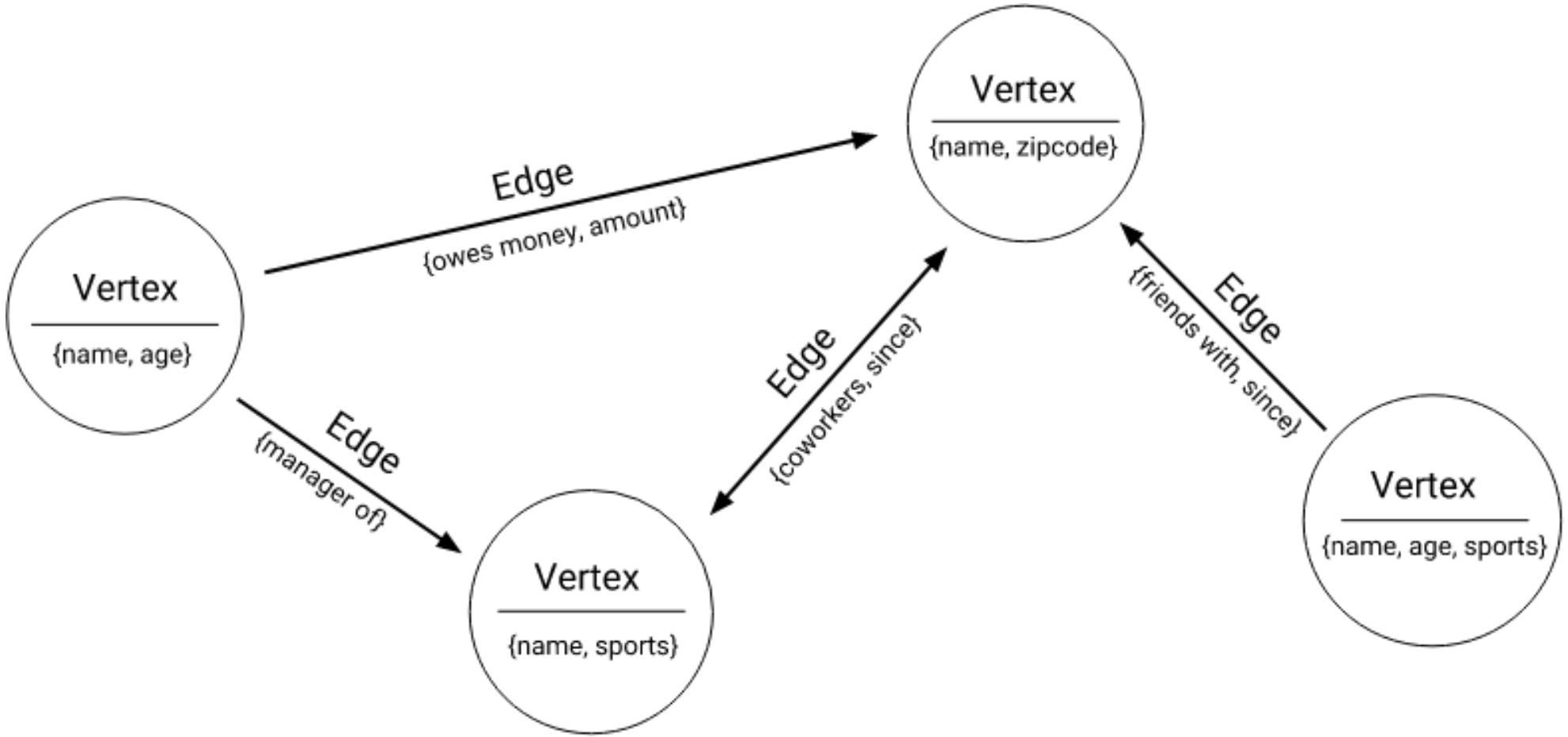
- When used with Cassandra, JanusGraph transactions are **not** ACID
  - simulating them is **costly** in terms of overhead
- Cassandra values **availability** and **partition tolerance** over **consistency** (CAP Theorem)
- Cassandra is an **eventually consistent** storage system
  - Tradeoff to achieve **high availability**
  - Involves some read and write **latencies**

***Guarantees made by JanusGraph depend on the storage backend**

JanusGraph | Schema and Data Modeling

- Each graph has a schema defined **explicitly** or **implicitly**
  - keys can be defined for **vertex/edge labels** and **property keys**
- A schema can be **evolved** over time:
  - it does **not** slow down query answering
  - it does **not** require database downtime
- Schemas allow to set property and connection **constraints:**
  - bound properties to specific vertex/edge labels
  - define which vertex labels can be connected by an edge

JanusGraph | Schema and Data Modeling



JanusGraph | Gremlin Query Language

- Gremlin is a graph traversal language used to **retrieve and modify** data
  - functional language
  - path-oriented language

- Gremlin is part of the **Apache TinkerPop** project
  - every Gremlin traversal is composed of a sequence of steps
  - a step perform an **atomic operation** on the data stream

e.g.

```
g.V().hasLabel('airport') // Find vertices that are airports
```

JanusGraph | Transactions

- Almost every interactions with JanusGraph is associated with transactions.
- Transactions are **safe for concurrent use** by multiple threads.
- Transactions are **not necessarily ACID** due to the underlying storage systems like Cassandra and HBase that do not provide such characteristics.

JanusGraph | Transactions

- Each thread **automatically opens** its own transaction
- Transactions are handled via ***commit()*** and ***rollback()*** methods
- **Thread-independent transactions** are also supported
  - multiple threads work on the same transaction
  - useful for concurrent algorithms or nested transactions
- JanusGraph automatically tries to rerun **failed transactions**
  - the number of attempts and delays are configurable

JanusGraph | Indexes

- Indexes are used to improve queries performance.
- JanusGraph currently supports:
  - Two types of indexes **graph indexes** and **vertex indexes**.
    - **composite indexes**
    - **mixed indexes**

JanusGraph | Graph Indexes

- Indexes are used to **speed up** the **random access** to the entire database.
- The goal is to get at the starting point of a query as **efficiently as possible** without having to first search the entire graph.
- Graph indexes should be established for **property keys** or **combination keys** that will be used regularly in the queries.

JanusGraph | Vertex Indexes

- Vertex indexes are associated with **vertices**.
- Typically used when the number of **incident edges** on a given vertex becomes significantly large such that it can impact on performance.
- While graph indexes are usually created at graph schema creation, vertex indexes are created as the need arises.

JanusGraph | Composite Indexes

- Composite indexes can be used to speed up queries where an **exact match** with the value for the given property key is sufficient.

```
g.V().has('type','class_room')
```

- For example the query above could take advantage of a composite index as we are only looking for exact matches where the value associated with ***type*** key is the value ***class_room***.

```
mgmt = graph.openManagement()  // Open a new management transaction
idx = mgmt.buildIndex('typeIndex',Vertex.class)
key = mgmt.getPropertyKey('type')  // Create a composite index for the type key for use with vertices
idx.addKey(key).buildCompositeIndex()
```

JanusGraph | Mixed indexes

- For queries that require more than a simple test for equality, like text predicates such as *textContains*, the creation of **mixed indexes is needed**.
- To use them an **indexing backend** is needed. The ones supported by JanusGraph are:
  - **Apache Solr**
  - **Apache Lucene**
  - **Elasticsearch**

Technical implementation | Objectives

Implement an asset management tool using **JanusGraph** able to:

- Run **CRUD operations**
- Run complex **search operations**
- Interact with a storage backend to **persist data**
- Expose **REST API endpoints**

Technical implementation | Technologies

- **JanusGraph**
  - as distributed **graph database**;
- **Apache Cassandra**
  - as **storage backend** for JanusGraph;
- **Java + Spring Boot**
  - run **Gremlin queries**
  - expose **REST APIs**

Technical implementation | Cassandra

- NOSQL column-oriented database
- Uses the **Cassandra Query Language (CQL)**
- **Distributed** and **scalable**
- Guarantees **high reliability** and **performance**

Technical implementation | Spring Boot

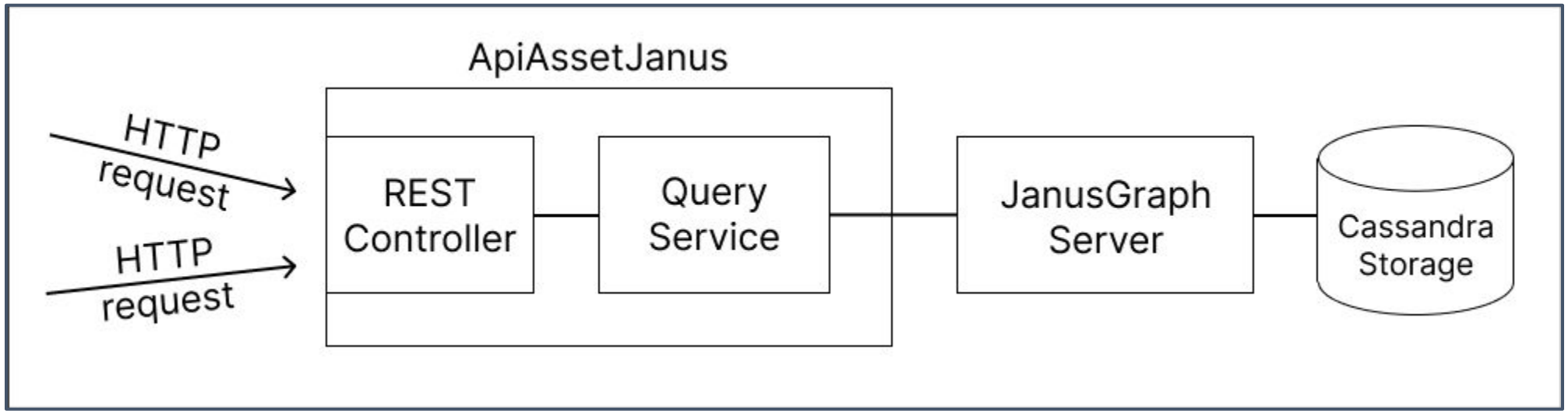
- Java framework to develop **web applications** and microservices
- Popular framework because it is focused on **speed**, **simplicity** and **productivity**, with a lot of the out of the box solutions
- It has been used in the project to develop **REST APIs**

Technical implementation | Steps

1. Installation of **JanusGraph** and **Cassandra**
2. Setting up JanusGraph to work with Cassandra
3. Creation of a Java application with the needed **dependencies**
4. **Code implementation** following an iterative approach
    a. **Writing** queries and REST APIs
    b. **Testing** with Postman

Technical implementation | Architecture

- **RESTController**: handles the incoming requests to the **QueryService**
- **QueryService:**
  - implements the code for executing queries
  - speaks directly to the JanusGraph server



Technical implementation | Queries

Gremlin-Java is considered the **reference implementation** of Gremlin

- allows interaction with a **Gremlin Server** (e.g. JanusGraph Server)
- implements Gremlin within the **Java** language (**same syntax**)
- allows **application-code** and **database-code** to be written in Java

```
public List<Map<Object, Object>> getVerticesByLabel(String label) {
        return this.g.V().hasLabel(label).elementMap().toList();
}
```

Achieved results

- Our software is capable of interacting with JanusGraph to
  - Run **CRUD operations**
  - Run complex **search operations**
  - Interact with a storage backend to **persist data**
  - Expose **REST API endpoints**

https://github.com/TBDM-Project/JanusGraph-API-example

Possible future improvements

- Implementation of an **index backend**
  - Improve search performance
  - One can add full-text search, geo search, …
  - e.g. **Elasticsearch**
- Improve the tool to work in a **real-world environment**

Thank you
for your attention!