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Issue Article

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THE STUDY OF COMBINING SQL AND NOSQL DATABASES IN A HETEROGENEOUS SYSTEM FOR THE DEVELOPMENT OF A PROJECT MANAGEMENT DATABASE

Abstract: *The article presents a study of combining SQL and NoSQL databases in a heterogeneous system in order to develop a database for project management. The paper analyzes the features of both types of databases and examines their interaction in the context of effective project management. The proposed approach involves the use of SQL for structured data, such as information about tasks, deadlines and performers, and NoSQL for storing unstructured data – various documents for project management.*

Key words: *databases, heterogeneous system, project management.*

Language: *English*

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Introduction

In the modern world, project management plays an important role, as it allows you to effectively plan, organize and control the fulfillment of tasks, optimize available resources, as well as identify and analyze risks, manage them to achieve the desired results. Tracking and analyzing project data, managing resources, and ensuring communication between participants all require a reliable and scalable database. In this context, choosing between SQL and NoSQL technologies for data storage and management is an important decision. SQL databases provide a reliable way to store structured data, while NoSQL databases have the flexibility and ability to work with unstructured data. However, in real-world projects, a combination of both of these technologies is often required to provide a full range of functionality for a better organization. This article explores the technology of combining SQL and NoSQL databases in a single heterogeneous system, with an emphasis on application in the field of project management. The purpose of this work is to research and develop a prototype of a heterogeneous database system for project management and project documentation storage based on PostgreSQL and MongoDB databases.

Literature review

In 1980-1990, active work began on the creation of heterogeneous systems for industrial applications. During this period, companies began to offer their own solutions to solve this problem. Among such solutions, DATAPLEX, IMDAS and others stood out[4]. These systems offered integration of various types of databases, allowing efficient storage and management of a variety of data, which became increasingly important with the increase in the volume of information in the corporate environment.

Currently, one of the key elements of Amazon's heterogeneous systems is their Amazon Web Services

(AWS) cloud platform, which provides a wide range of cloud services such as computing power, data storage, databases, analytics, artificial intelligence, machine learning and more. Amazon's heterogeneous systems are a complex combination of various technologies, platforms and innovations that provide high performance, scalability and reliability for various aspects of the company's business[11].

Methodology

The first and most important step in our methodology is the selection of a DBMS for the projected heterogeneous database system, which will serve as the basis for our research. This choice has a critical impact on the subsequent process of developing and evaluating a system for combining SQL and NoSQL databases. PostgreSQL was chosen as the SQL DBMS. PostgreSQL is an open source object–relational database system that uses and extends the SQL language in combination with many features that allow you to securely store and scale complex data workloads[8]. The main advantages of PostgreSQL include high extensibility[6]: in this DBMS there is support for user objects and their behavior, including data types, operations, functions, indexes and domains. For this reason, PostgreSQL can be called a really flexible tool. In addition, this DBMS provides the ability to create, store and extract complex data structures. It is also worth noting that PostgreSQL supports nested and composite constructs that are not supported by some existing standard relational databases. MongoDB, a NoSQL database management system that is gaining increasing popularity in the market and stands out among competitors for its ability to scale on demand, was chosen as a non-relational DBMS. The advantages of MongoDB include flexibility, scalability, availability and high performance.

Design of a relational model

When designing a database for project management, it is necessary to take into account many aspects related to project management. It should be borne in mind that the system being developed can be used by teams that may be part of various departments in certain companies, as well as just ordinary people who have collaborated in a team to develop a product.

It is necessary to identify the criteria based on which the relational database will be designed.

– Each customer can have 0, 1 or more projects.

– Each project can have only one customer or not at all.

– Each team member can complete 0, 1 or more projects within his team at the same time.

After the analysis, we will identify the main entities, objects in the database, for the system being developed.

– Project: project name, brief description, project customer, start date, end date.

– Project team: the name of the team, the department to which the team belongs in the company.

– Department: the name of the department, the company in which this department exists.

– Company: the name of the company, its bank details.

– Employee: first name, last name, position, work format (full/part-time, for example), date of hiring, the team to which he belongs.

– Position: the title of the position.

– Work format: the name of the work format.

– Customer: name of the customer, contact details.

Design of a non-relational model

The following documents will be stored in the non-relational database: project plan, communication plan, risk register, project requirements.

– The project plan. The collection contains documents that will contain the name of the project and a list of tasks that need to be implemented. The task description will include the following fields: ID, name, description, start date for completion and date for completion of the task. The task will also have a priority, a completion status, and an employee field indicating which team member needs to complete the task.

– Communication plan. The collection includes documents containing the name of the project, team members, the customer and ways of communication between them.

– Risk register. The collection contains documents that contain the name of the project and a list of risks that the project may be exposed to. The list of risks will include the risk identifier, name, description of the risk, the probability of its occurrence, its impact on the project and a plan to prevent the occurrence of risk.

– Project requirements. The collection includes documents, each of which contains the requirement ID, its name, description and priority.

SQL and NoSQL integration

Due to various factors, different types of databases can often be used in projects. There may be several reasons for this approach: adding a new database for load balancing, optimal data storage, or resource utilization.

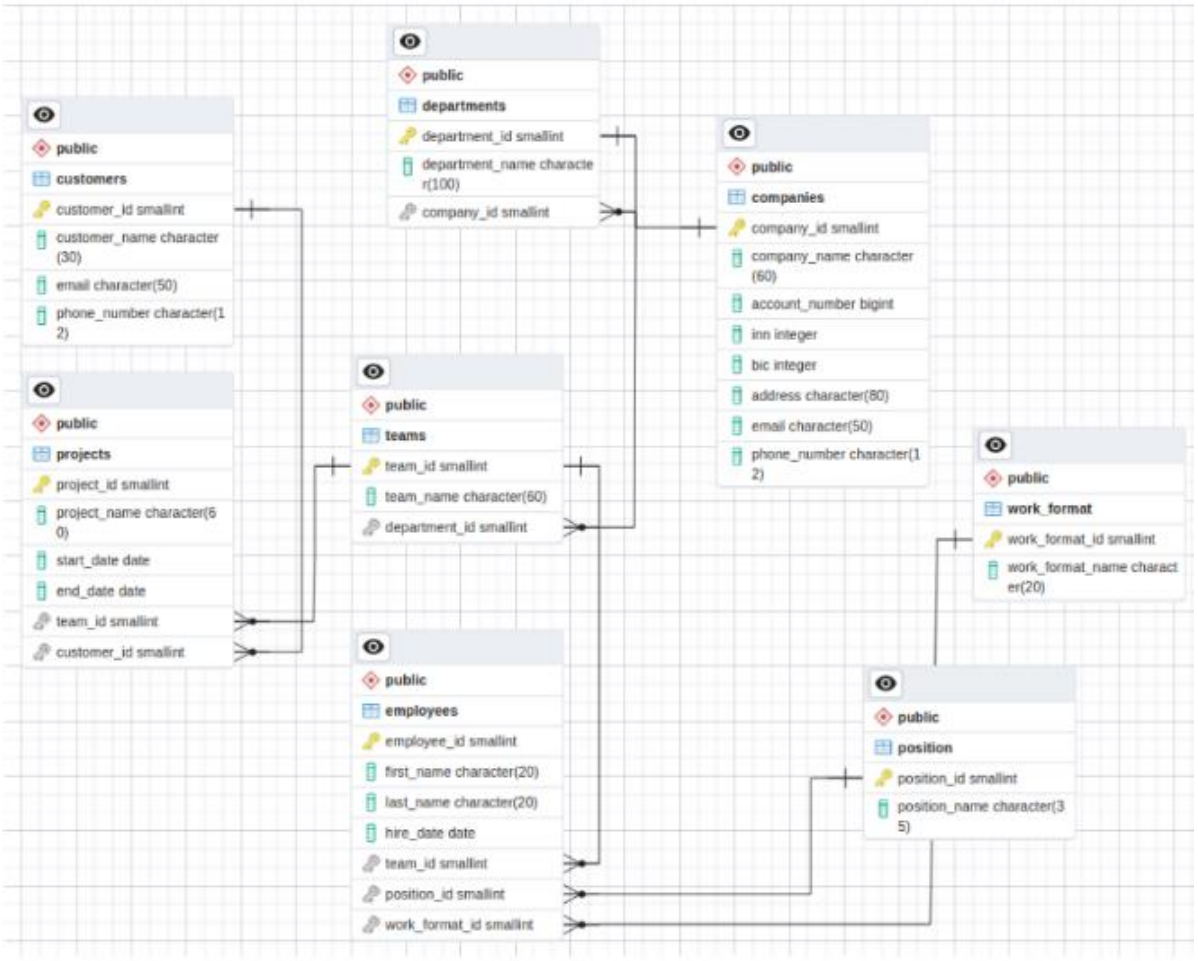

Figure 1. The scheme of the developed relational model.

To access external data (accessing from one database to another), shells (wrappers) of external data (Foreign Data Wrappers) are used[3]. An external data wrapper is a library designed to interact with an external source and load data from it. NoSQL repositories or third-party Postgres servers can act as external sources.

There are currently many external data wrappers (FDWs) available that allow the PostgreSQL server to work with various remote data stores.

Among the many external data wrappers for NoSQL databases, you can also find FDW for MongoDB. The MongoDB data wrapper performs the function of connecting between the MongoDB server and PostgreSQL, translating PostgreSQL statements into queries that are understandable to the MongoDB database. The SELECT, INSERT, DELETE and UPDATE operators are supported for this connection. In Fig.3.2 shows the scheme of interaction between PostgreSQL and MongoDB via FDW.

To set up a connection between PostgreSQL and MongoDB to send requests, you will need to install the mongo_fdw extension[5]. The following libraries are required to compile mongo_fdw:

– libbson;

– libmongoc;

– json-c.

The libbson and libmongoc libraries are necessary for the correct operation of mongo_fdw, since this extension uses the C language driver to function.

To install the mongo_fdw extension, you will need to clone the github repository[9] to the desired directory on your PC. Next, you need to build and compile the necessary libraries. For this purpose, you will need to run the script autogen.sh from the given repository.

After executing the script autogen.sh you need to configure the environment variables. The PKG_CONFIG_PATH environment variable should point to the mongo-c source directory:

"export PKG_CONFIG_PATH=$YOUR_MONGO_FDW_SOURCE_DIR/mongo-c-driver/src/libmongoc/src:$YOUR_MONGO_FDW_SOURCE_DIR/mongo-c-driver/src/libbson/src"

The LD_LIBRARY_PATH environment variable must include the path to the mongo-c installation directory containing the files libmongoc-1.0.so and libbson-1.0.so:

"export LD_LIBRARY_PATH=/home/mongo-c/lib64:$LD_LIBRARY_PATH"

After the steps are completed, you need to compile the solution and install the mongo_fdw extension using the make and make install commands.

Experiments and results

The developed system has been tested for performance.

PostgreSQL has materialized views [9] that allow you to materialize queries and update them on demand. Using such views allows you to speed up access to data: the results of queries are saved, and therefore there is no need to execute them over and over again.

Accessing third-party data through the external data wrapper can be quite slow because they are on other systems. Therefore, by implementing materialized views to external tables, we can make access to external data much faster.

To test performance, several experiments were conducted, where the execution time of data sampling from the materialized view and from an external table was measured. Confidence intervals for evaluating the stability and accuracy of performance testing results were also calculated.

To calculate the confidence intervals, we determined the reliability level $\gamma = 95\%$, which shows how confident we are that the test results have a certain accuracy.

For the sample of data from the external table, the confidence interval was in the range from 0.94 to 9.23, for the sample of data from the materialized representation – from 0 to 0.48. A comparison of the intervals for the sample of data from the external table and the materialized representation showed that they do not overlap, which indicates statistically significant differences in the mean values of the samples. Thus, it can be concluded that using a materialized representation in a heterogeneous one allows you to increase the data sampling rate several times.

Conclusion

This paper describes the process of designing and testing a heterogeneous database system for project management and project documentation storage based on PostgreSQL and MongoDB databases.

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