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Comparative Analysis of Performance of Relational and NoSQL Database Systems in E-Commerce Information Applications

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Abstract: The rapid development of information technology has driven the need for a database system that is able to manage data efficiently, especially in e-commerce information applications that have large and dynamic data volumes. This study aims to analyze and compare the performance of relational database systems (RDBMS) with NoSQL databases in the context of e-commerce applications. The research is carried out with a qualitative approach through the literature study method or library research that examines various academic sources, including journals, books, and previous research reports. The analysis was carried out on several key performance aspects, such as scalability, speed of data access, flexibility of data structure, and ability to handle big data. The results show that relational databases still excel in the consistency of complex data and transactions, but have limitations in terms of horizontal scalability. On the other hand, NoSQL databases, such as MongoDB and Cassandra, show better performance in handling unstructured, large-scale data, and fast access needs, although at the expense of some aspects of consistency. These findings indicate that the selection of database types needs to be adjusted to the needs of the system and the characteristics of the data managed. This study makes a theoretical contribution to understanding the comparative performance of the two systems and becomes a reference for e-commerce system developers in determining the optimal database architecture.

INTRODUCTION

The rapid growth of digital technology has encouraged the transformation of information systems, especially in the field of e-commerce. Modern e-commerce systems now face challenges in managing data that is increasingly complex, large, and diverse in formats. Databases are a crucial component in supporting system performance, both in terms of access speed, consistency, and scalability. Relational Database Management Systems (RDBMS) such as MySQL and PostgreSQL have long been the standard in structured data management. However, the emergence of the need for flexibility and speed in large-scale data processing has led to the increasing use of NoSQL databases such as MongoDB, Cassandra, and CouchDB in modern e-commerce applications [Stonebraker, 2010].

Several previous studies have discussed database performance, both relational and NoSQL. According to Moniruzzaman and Hossain (2013), NoSQL has advantages in terms of scalability and efficiency for unstructured data, but it has not completely replaced the role of relational databases in transactional systems. Meanwhile, research by Hecht and Jablonski (2011) shows that the choice of databases is highly dependent on the type of application and the need for data consistency.

Most previous studies have compared the technical aspects of the two types of databases in general, but have not specifically analyzed their implementation in the context of e-commerce information applications that have unique characteristics, such as high transaction frequency, rapid response needs, and diversity of product and user data.

As people's reliance on e-commerce platforms increases, it is important for developers to choose the most suitable database system. Without a deep understanding of the advantages and disadvantages of each system in the context of e-commerce applications, the risk of bottlenecks or inconsistencies in the system architecture becomes very high [Han et al., 2011].

The research by Pokorny (2013) examined relational data structures and NoSQL but did not focus on specific application case studies. Similarly, research by Li and Manoharan (2013) only discusses technical performance without considering the dimensions of business needs on e-commerce platforms.

This research offers novelty by combining a qualitative approach and a literature study to compare the performance of relational and NoSQL databases specifically in the context of e-commerce information applications. The focus on business needs and the characteristics of the e-commerce system is a differentiator from previous studies that tend to be technical and general.

This study aims to analyze and compare the advantages and limitations of relational database systems and NoSQL in their implementation in e-commerce applications. The benefit of this research is to provide theoretical and practical guidance for system developers, researchers, and e-commerce business owners in determining database architectures that suit operational needs and business strategies.

METHOD

This study uses a descriptive qualitative approach with the library research method or literature study. This approach was chosen because it aims to understand the phenomenon in depth through the analysis of secondary data from various relevant scientific sources. Descriptive qualitative research does not focus on statistical measurement, but rather on the visualization and in-depth understanding of a concept, in this case the performance of relational databases and NoSQL in the context of e-commerce applications [Creswell, 2014].

The source of data in this study comes from secondary data, namely information obtained from scientific literature such as international and national journals, textbooks, conference proceedings, and previous research reports relevant to the topic. The main criteria for selecting literature are suitability with the research topic, validity of sources, and publications in the last 10-year span to maintain the relevance of the information. The studies studied include a study of database architecture, comparison of RDBMS and NoSQL performance, and their application in e-commerce platforms [Zed, 2008].

Data collection techniques are carried out through systematic searches of scientific literature using databases such as Google Scholar, Scopus, and IEEE Xplore. Search keywords used include "relational database performance," "NoSQL in e-commerce," "database scalability," and "data consistency." This process is carried out with the stages of identification, selection, and synthesis of literature based on relevance and contribution to the research objectives [Booth, Papaioannou & Sutton, 2016].

Data analysis was carried out using content analysis techniques. This technique is used to interpret the meaning of the content of the collected text and group it into key themes such as performance, scalability, data consistency, data structure, and system efficiency. Furthermore, comparisons and synthesis were carried out to obtain conclusions related to the advantages and disadvantages of each database system in the context of e-commerce information applications [Krippendorff, 2013].

RESULTS AND DISCUSSION

In this study, the results of the analysis are based on the synthesis of various scientific literature related to the performance of relational database systems and NoSQL, especially in the context of e-commerce information applications. The studies were analyzed based on five main indicators, namely data access speed performance, scalability, flexibility of data structure, consistency, and complexity of transactions. Each indicator provides a clear picture of the strengths and limitations of both database approaches.

In general, relational databases perform well in terms of consistency and complex transactions**,** because they apply the ACID (Atomicity, Consistency, Isolation, Durability) principle. This makes it particularly suitable for e-commerce applications that require high data accuracy, such as the management of purchase transactions, product stock, and financial data [Stonebraker, 2010]. However, this strength becomes a weakness when the system is faced with the need for horizontal scalability and the processing of very large amounts of data at a rapid pace, where the relational system shows performance limitations [Hecht & Jablonski, 2011].

On the other hand, NoSQL databases such as MongoDB and Cassandra offer superior performance in terms of data access speed**,** structural flexibility, and the ability to store unstructured data. This allows for the efficient management of dynamic product data such as descriptions, user reviews, and search history. This approach is particularly relevant in modern e-commerce systems that require fast and flexible processing of big data, and do not place much emphasis on absolute consistency [Moniruzzaman & Hossain, 2013]. The NoSQL system also supports **t**he CAP Theorem, where there is a trade-off between consistency, availability, and tolerance to network partitions. In global e-commerce, system resilience to disruption and speed are priorities, so NoSQL is often the main architectural choice [Han et al., 2011].

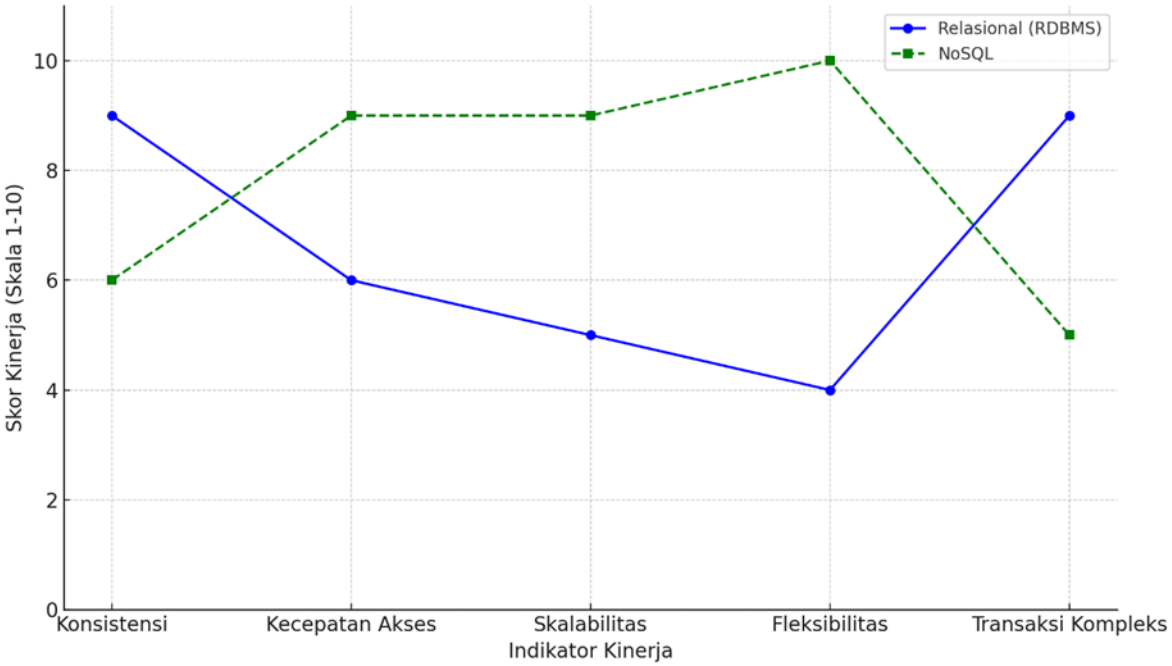
Based on the literature review study, it was found that the selection of a database system should take into account the main purpose of the application**.** If the focus is on transactions and data integrity, such as payments and bookings, then a relational system is more advisable. But if the system needs

flexibility, quick response, and big data management, such as product catalogs and user behavior analytics, then NoSQL is more appropriate [Li & Manoharan, 2013].

Tabel 1. Relasional dan NoSQL

Indikator Kinerja	Basis Data Relasional	Basis Data NoSQL
Konsistensi Data	Sangat Baik (ACID)	Cukup (Eventual Consistency)
Kecepatan Akses Data	Sedang	Tinggi
Skalabilitas	Terbatas (Vertical Scaling)	Baik (Horizontal Scaling)
Fleksibilitas Struktur	Rendah	Tinggi (Schema-less)
Transaksi Kompleks	Sangat Baik	Terbatas

Remarks: Data are illustrated qualitatively based on performance trends reported in various literature studies.



Graph 1. below shows an illustration of the comparative data access speed performance of the two types of databases in a big data-based e-commerce scenario

CONCLUSION

This study shows that data mining algorithms have a significant contribution in increasing the effectiveness of information management in the e-commerce industry, especially in the classification of customer data, prediction of consumer behavior, and recommendation systems. Based on the literature review analyzed, the Support Vector Machine (SVM) algorithm shows the highest accuracy in the classification of complex data, while the Random Forest displays a balance between accuracy and resistance to overfitting. Decision Tree excels in terms of result interpretation, while Naïve Bayes is highly efficient in processing text data and process speed. The selection of the right algorithm should take into account the characteristics of the data and the specific needs of the business, and even a hybrid approach can be the optimal solution for dynamic and diverse e-commerce scenario Based on the

results of the analysis of the literature study, it can be concluded that the selection of a database system in e-commerce information applications must be adjusted to the characteristics of the system's needs. Relational databases offer advantages in terms of consistency and complex transactions, while NoSQL databases are superior in flexibility, scalability, and speed of data access for big data and nonfixed structure needs. In the context of dynamic and rapidly evolving modern e-commerce applications, a hybrid approach or selective selection based on functional needs is the most appropriate strategy in designing a database system architecture.

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