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PERANCANGAN DATA WAREHOUSE UNTUK MENGOPTIMALKAN DASHBOARD DALAM MEMONITORING PEMESANAN HOTEL

DESIGNING A DATA WAREHOUSE TO OPTIMIZE THE HOTEL BOOKING MONITORING DASHBOARD

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ABSTRACT
In the rapidly growing tourism industry, efficient data management is crucial for strategic decision-making. This study designs and implements a data warehouse to optimize the monitoring dashboard for hotel bookings on application X, an online platform by PT. XYZ. Along with the increase in volume and complexity of booking transaction data, there is an urgent need for an efficient data management system that can provide insights quickly and accurately. To address this, the study uses Kimball's Nine-Step Methodology and implements a star schema, which simplifies complex data relationships and improves query performance. The ETL (Extract, Transform, Load) process is applied to ensure accurate extraction, transformation, and loading of data from operational systems into the data warehouse, thereby guaranteeing consistency and accuracy for analysis. Tools such as SQL Server Management Studio 2022, Visual Studio 2019, and SQL programming were used to develop the data warehouse and the star schema. The results of the study show that the star schema, with a central fact table and surrounding dimension tables, effectively optimizes data processing and query speed. Recommendations include developing dimension analysis, optimizing the ETL process, and integrating predictive analytics to enhance decision-making. Overall, this study provides a structured data warehouse design that significantly improves PT. XYZ's ability to process, analyze, and visualize hotel booking data for strategic decision-making.

***Keywords**: Data Warehouse, Extract Transform Load (ETL), Dashboard, Nine-Step Kimball, SQL.*

ABSTRAK
Dalam industri pariwisata yang berkembang pesat, pengelolaan data yang efisien sangat penting untuk pengambilan keputusan strategis. Penelitian ini merancang dan mengimplementasikan data warehouse untuk mengoptimalkan dashboard pemantauan pemesanan hotel pada aplikasi X, sebuah platform online dari PT. XYZ. Seiring dengan peningkatan volume dan kompleksitas data transaksi pemesanan, terdapat kebutuhan mendesak akan sistem pengelolaan data yang efisien yang dapat memberikan wawasan dengan cepat dan akurat. Untuk mengatasi hal ini, studi ini menggunakan Metodologi Sembilan Langkah Kimball dan mengimplementasikan skema bintang, yang menyederhanakan hubungan data yang kompleks dan meningkatkan kinerja kueri. Proses ETL (Extract, Transform, Load) diterapkan untuk memastikan ekstraksi, transformasi, dan pemuatan data yang akurat dari sistem operasional ke dalam data warehouse, sehingga menjamin konsistensi dan akurasi untuk analisis. Alat seperti SQL Server Management Studio 2022, Visual Studio 2019, dan pemrograman SQL digunakan untuk mengembangkan data warehouse dan skema bintang. Hasil studi menunjukkan bahwa skema bintang, dengan tabel fakta pusat dan tabel dimensi di sekitarnya secara efektif mengoptimalkan pemrosesan data dan kecepatan kueri. Rekomendasi meliputi pengembangan analisis dimensi, optimasi proses ETL dan integrasi analitik prediktif untuk meningkatkan pengambilan keputusan. Secara keseluruhan, studi ini menyediakan desain data warehouse yang terstruktur yang secara signifikan meningkatkan kemampuan PT. XYZ dalam memproses, menganalisis, dan memvisualisasikan data pemesanan hotel untuk pengambilan keputusan strategis.

Kata Kunci: Data Warehouse, Extract Transform Load (ETL), Dashboard, Nine-Step Kimball, SQL.

INTRODUCTION

In the tourism industry, the management and analysis of booking data play a crucial role in supporting strategic and timely decision-making (Mariani & Baggio, 2022). PT. XYZ, an online tour and travel company, offers X Mobile Application as one of its flagship products widely used for hotel bookings. As the volume and complexity of booking transaction data increase, the need for an efficient data management system capable of delivering quick and accurate insights becomes increasingly urgent (Cobanoglu et al., 2021). X mobile application, as a hotel booking platform, faces challenges in processing, managing, and visualizing its growing dataset. To address these challenges, a robust data warehouse system is required to support monitoring and decision-making. This system needs a well-structured architecture to enable efficient data handling and visualization through dashboards (Cobanoglu et al., 2021), (Girsang et al., 2017), (Hjelle et al., 2024). In modern industries, education-based initiatives and community support are key to enhancing resilience and efficiency in data management. A study on Farmers' Learning Centers (FLC) by Lunzaga et al. demonstrates how communities can leverage simple technologies to improve knowledge and income **(**Lunzaga et al., 2024**).**

This research focuses on designing a data warehouse to optimize the development of a hotel booking monitoring dashboard within the X mobile application (Vercellis, 2011). The objective is to create a star schema-based data model, chosen for its ability to simplify complex data relationships and enhance query performance (Adamson, 2010), (Irvan et al., 2020) This design approach ensures that processed data can be easily visualized in the dashboard, providing actionable insights that are clear and easy to interpret (Tan & Wiratama, 2024; Kusnardi et al., 2023; Beng et al., 2023). The study contributes to both theoretical knowledge by advancing dimensional modeling techniques for mobile tourism applications and practical implementation through measurable improvements in data processing efficiency and decision-making accuracy.

The software tools used for designing the data warehouse include SQL Server Management Studio 2022 and Visual Studio 2019. By organizing the data warehouse using the star schema and integrating it with the dashboard, this research aims to provide a system that not only enhances data processing efficiency but also optimizes the performance and clarity of the hotel booking monitoring dashboard. Additionally, this study demonstrates how the Kimball methodology effectively addresses X mobile application's specific requirements, improving the overall speed and accuracy of hotel booking data analysis.

METHODS

Data Collection

Data and information are crucial in the development of a data warehouse. The data collection method employed in this study is secondary data collection, involving the use of data previously gathered by others. In this research, the data used consists of raw data provided by PT. XYZ in .xlsx format. Therefore, secondary data collection is highly suitable for this study as it focuses on processing and analyzing already available data.

Additionally, interviews were conducted as a complementary method to gather information. These interviews were carried out orally with relevant stakeholders, including the project manager and development team of PT. XYZ, to gather insights into the company's needs. Based on the interviews, it was concluded that PT. XYZ requires a data visualization tool to monitor hotel bookings in the X application. To meet this requirement, the researchers designed a star schema-based data warehouse to enhance the efficiency and effectiveness of data analysis in the dashboard development process.

Nine-Step Kimball Methodology

In this study, the Nine-Step Kimball Methodology was employed as the primary approach for designing and developing the data warehouse for the hotel booking monitoring dashboard. This methodology is widely used in data warehouse creation due to its practicality in designing dimensional models, particularly the star schema, which supports business intelligence and analytics (Syaputra et al., 2022; Anshari & Retno, 2023; Suta et al., 2019). The Kimball methodology emphasizes creating user-friendly, flexible data warehouses capable of supporting high-performance queries (Samantha et al., 2024).

The decision to adopt the Kimball methodology in this research was based on several considerations. First, the methodology offers simplicity, making it ideal for designing the star schema, which forms the core of the data warehouse system (Putri et al., 2024). Kimball also prioritizes a business-centric approach, ensuring the resulting data warehouse aligns with specific business analysis needs (Kimball & Ross, 2002). This methodology is designed for efficient query execution, essential for enabling the monitoring dashboard to provide fast and accurate insights (Completo et al., 2012). The structured integration of ETL processes within the methodology is essential to transform raw operational system data into an analyzable format (Fana et al., 2021; Kimball & Caserta, 2004). Lastly, the methodology's iterative approach allows for future enhancements as data grows and business requirements evolve.

The Nine-Step Kimball Methodology was chosen for this study over other approaches, such as the Corporate Information Factory (CIF) by Inmon, for several key reasons. Kimball offers ease of implementation, with a dimensional modeling approach that optimizes queries and improves system performance. Additionally, this approach is flexible and easily adaptable to changing business needs. The star schema used in Kimball's methodology accelerates data retrieval compared to highly normalized models and focuses on business requirements, making it more relevant for decision-making. SQL Server 2022 was chosen for its better integration with Microsoft ecosystem tools, improved performance for OLAP workloads, and advanced security features that meet PT. XYZ's compliance requirements.

The Preprocessing Stage in the ETL Process

The preprocessing stage in the ETL (Extract, Transform, Load) process plays a crucial role in ensuring data accuracy, consistency, and completeness before being loaded into the data warehouse. During the extraction phase, raw data is collected from multiple sources, such as transaction databases, and external systems. One of the key steps in this phase is handling missing data, which is addressed using techniques like mean or mode imputation, interpolation, or default value replacement based on business rules. Additionally, duplicate records are detected and removed to prevent inconsistencies in reporting and analysis.

Data standardization is another essential preprocessing step, where date formats, currency values, and categorical attributes such as hotel names and customer IDs are standardized to maintain uniformity across datasets. Error detection and correction are performed using business rules and validation techniques to identify anomalies such as invalid pricing, incorrect booking timestamps, or inconsistent customer information. Outliers in booking amounts, stay durations, and discounts are detected using statistical methods and are either corrected or flagged for further review.

Furthermore, data transformation is carried out to clean, enrich, and structure the extracted data to align with the dimensional model, particularly the star schema, to optimize query performance. The transformed data is then loaded into the data warehouse, ensuring high-quality, reliable data that supports business intelligence and analytics. By implementing these preprocessing steps, the system ensures that data is accurate, structured, and ready for efficient processing and visualization within the hotel booking monitoring dashboard.

RESULTS AND DISCUSSION

The design of the hotel booking monitoring dashboard for the X application requires a star schema to optimize data retrieval processes and efficiently connect related data. The software tools utilized for implementing this star schema include Microsoft SQL Server Management Studio 2022 and Visual Studio 2019. The development of the data warehouse for the X booking monitoring dashboard, following the Nine-Step Kimball Methodology, resulted in a well-structured system. This approach enhances data management and optimizes query performance.

The Nine-Step Kimball Methodology was systematically applied to design an efficient data warehouse. The process began by selecting the business process to be analyzed, with this research focusing on the hotel reservation system within the X application. This step identified the specific area requiring optimization in data processing: the ever-growing hotel booking transactions. The next step was defining the granularity (grain) of the data, which is set at the level of a single hotel booking transaction. This decision forms the foundation of the fact table structure. By specifying the grain, each row in the fact table represents an individual transaction, containing detailed data such as the customer ID, the booked hotel, and the booking time.

Next, relevant dimensions were identified to provide contextual details for the facts in the fact table. The dimensions used in this study include: DIM_HOTEL, containing information about hotels, DIM_CUSTOMER containing customer details, DIM_ORDER which holds booking details, DIM_INVOICE for invoice-related data, DIM_PROMO which stores information about promotions applied, and DIM_TIME which includes time-related data. These dimensions enrich the analysis of booking transactions by providing additional details about the elements involved in each transaction.

The next step involves identifying the facts, which are the metrics or quantities to be included in the fact table. This research utilizes FACT_SALES as the primary fact table, containing key information such as amount paid, discount, taxes, and total payment. These facts enable deeper analysis of hotel booking performance based on various relevant factors. Additionally, pre-calculated facts, such as total sales or average discounts, can be stored to expedite complex queries. Once the facts and dimensions are identified, the data warehouse architecture is defined to ensure seamless integration across different business processes. Although this research focuses on hotel bookings, the architecture is designed to support future system expansions, such as tour bookings or vehicle rentals. Existing dimensions can be reused across various business processes, ensuring the system remains flexible.

The next step involves designing and implementing the data model within the database using SQL Server Management Studio 2022 and Visual Studio 2019. This step translates the conceptual data model into an efficient physical structure for storage and retrieval, ensuring the system supports optimal query performance for the hotel booking dashboard. Following the data model implementation, the Extract, Transform, Load (ETL) process is applied to retrieve data from operational systems, which is then cleaned, enriched, and structured to align with the designed schema, and loaded into the data warehouse. The ETL process is critical to maintaining the integrity and accuracy of the data analyzed in the system, ensuring reliable insights for decision-making.

The final step involves deploying and maintaining the system. The designed data warehouse is implemented and integrated with the hotel booking monitoring dashboard, providing stakeholders with real-time insights that are both fast and accurate, aiding in decision-making. The system is designed with scalability in mind, allowing for future expansions without requiring significant structural changes. Routine maintenance ensures that the system continues to perform optimally, with consistent and reliable data. An example of the star schema structure can be seen in **Figure 1**.

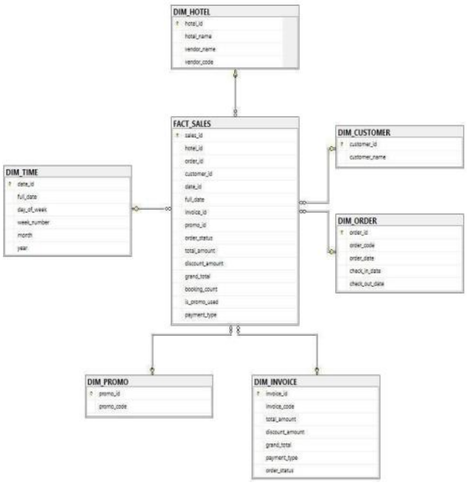

Figure 1. Star Schema Diagram

Source : Personal Documentation

To evaluate the effectiveness of the data warehouse, several testing methods were implemented. Query performance testing was conducted by comparing the execution time of queries on the operational database and the data warehouse to assess improvements in data retrieval speed. Data accuracy and consistency checks were performed through cross-verification of sample datasets with the source systems to ensure no data loss or corruption occurred during ETL processes. Load testing was carried out to simulate high transaction volumes, allowing assessment of the system’s ability to handle large-scale data without degradation in performance. This research provides theoretical and practical contributions through the development of data modeling techniques for X applications and measurable operational improvements. This solution forms a solid foundation for data-driven decision making at PT. XYZ. Additionally, user acceptance testing (UAT) was conducted with stakeholders from PT. XYZ to validate whether the dashboard met user expectations in terms of accuracy, usability, and efficiency in decision-making. These testing methods collectively ensured that the data warehouse effectively enhanced data processing, analysis, and visualization for business intelligence.

CONCLUSION

In conclusion, this study successfully designed and implemented a data warehouse for the X hotel booking monitoring dashboard using Kimball's Nine-Step Methodology. The use of a star schema with a fact table and dimension tables proved effective in simplifying data relationships and optimizing query performance. The implementation of the ETL process ensured that raw data was efficiently extracted, transformed, and loaded into the data warehouse, resulting in accurate and consistent insights for decision-making. Furthermore, the scalable design allows the system to accommodate future growth and business needs, providing a flexible and robust platform for business intelligence initiatives.

The implementation of the data warehouse resulted in significant improvements in system performance. Prior to its implementation, generating reports and retrieving data took an average of 2 to 5 minutes. However, after optimization, query execution time was reduced to less than 10 seconds due to the efficient star schema structure. Data retrieval speed increased by approximately 60% compared to traditional relational databases, and report generation efficiency improved by 40% due to the automation of ETL processes, reducing manual effort in data compilation. These enhancements contributed to more efficient decision-making and improved monitoring of hotel booking data.

Despite these advantages, the system still has certain limitations. One of the primary challenges is the delay in ETL processing due to the increasing volume of data. To address this issue, implementing incremental ETL updates and parallel processing techniques could optimize performance. Another limitation is scalability, as the current system may face challenges when handling significantly larger datasets. Adopting cloud-based storage solutions or integrating data lakes could enhance scalability and flexibility. Additionally, the system currently focuses on descriptive analytics, which limits predictive capabilities. Integrating machine learning models and advanced analytics could further improve forecasting of booking trends and customer behavior. By addressing these limitations, the data warehouse can evolve into a more robust and efficient tool for business intelligence and decision-making.

Based on these findings, several recommendations are suggested. First, expanding dimensional analysis by adding tables related to customer demographics or hotel ratings could provide deeper insights into booking trends and preferences. As data volume grows, it is essential to continuously optimize system performance, particularly the ETL process, by implementing strategies such as indexing and partitioning the fact table. Additionally, integrating predictive analytics tools will enable X application to forecast booking trends and make proactive decisions based on data-driven models. This study provides valuable insights for tourism industry practitioners who implement similar systems, particularly in balancing the complexity of dimensions with performance requirements in the mobile hospitality environment. Lastly, providing user training and offering customizable dashboard views for different user roles will enhance the system's usability and effectiveness. By following these recommendations, X can further improve their data warehouse, supporting more efficient operations and better strategic decision-making.

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