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Business Intelligence Implementation for Hotel Room Reservation Data Analysis

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ABSTRACT

The growth of the hotel industry in Indonesia is driven by increasing mobility for business and tourism purposes. However, this growth presents new challenges in hotel management, particularly in analyzing customer behavior, optimizing room availability, and making strategic decisions. Manual management of reservations and customer data is considered ineffective. This study implements Business Intelligence (BI) for analyzing hotel reservation data from 2022–2024 using OLAP and data mining techniques. BI enables the analysis of room popularity, active customer identification, payment method trends, and customer profiles. Additionally, this study applies clustering for room segmentation and forecasting methods to predict future income and reservation trends. Data is processed using ETL into a star schema-based data warehouse, visualized through Power BI dashboards. Results show that BI provides valuable insights into customer behavior, room occupancy trends, and financial performance, supporting management in improving operational efficiency and revenue.

Keyword: Business Intelligence, Hotel Reservation, Data Warehouse, OLAP, Data Mining, Power BI, Forecasting

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1. INTRODUCTION

Indonesia is known as a multicultural country with a wide diversity of cultural groups, languages, religions, and ethnicities. Based on data obtained from the website of the Central Bureau of Statistics (BPS) on March 17, 2025, Indonesia's population in 2024 reached 281,603.8 thousand people (BPS, 2024). Currently, Indonesia's population growth continues to increase, and along with this, the mobility of its people is also rising, especially for business, tourism, or other activities. This directly impacts the increasing demand for accommodation, including hotels. At present, hotels in Indonesia are growing rapidly and are spread across all regions of the country, offering various classes to meet this demand.

To face these challenges, hotels need data-driven planning and decision-making through the use of Business Intelligence (BI). Relying on manual methods to manage guest

data, room bookings, and the use of hotel facilities can lead to inefficiencies and delays in making strategic decisions. Therefore, the utilization of information technology, particularly Business Intelligence, becomes a suitable solution to improve the quality of hotel management.

In the hospitality context, Business Intelligence can be used to answer various strategic questions, such as: which room types are most frequently booked in the past three months, who are the most frequent customers, and how are occupancy or room density trends changing over time. In addition, BI can help analyze the average length of stay by room type, the most commonly used payment methods, and the occupations of customers who most often stay at the hotel. From a financial perspective, BI can calculate the hotel's total revenue from room bookings within a specific period and identify whether there are customers booking more than one room in a single transaction.

Through such analyses, hotel management can gain deeper insights into customer behavior and characteristics, improve room allocation efficiency, design more targeted promotional strategies, and optimize revenue. The implementation of Business Intelligence will assist hotels in making faster, more accurate, data-driven decisions and visualizing clear information to enhance competitiveness in the increasingly competitive hospitality industry. This research aims to implement BI to analyze hotel reservation data from 2022–2024 using OLAP and data mining.

2. METHODS

This study uses a quantitative descriptive approach through CRISP-DM methodology integrated with the traditional BI architecture which consists of three main layers: data source layer; data movement, storage, and processing layer; and data visualisation and reporting layer. The process includes:

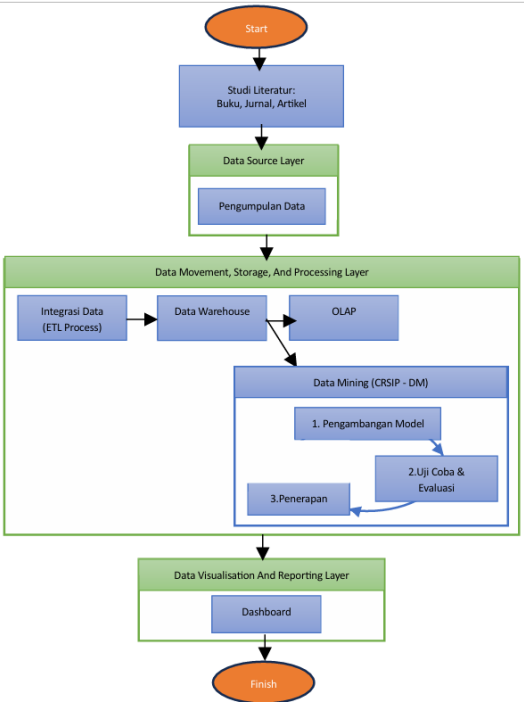

Figure 1. Methods

2.1 Data Source Layer

The data source layer is the layer contains the data to be used in this research. The data can come from ERP systems, SQL databases, flat files, CRM systems, and othe sources. Enterprise Resource Planning (ERP) is a concept for managing company resources in the form of an integrated software system designed to serve and support various functions within the company [8].

2.2 Data Movement, Storage, and Processing Layer

Data movement, storage, and processing layer is the layer that involves processing the collected data and storing the processed data into a database. The collected data will be processed through several stages, including the ETL process in jupyter notebook. This layer includes several stages: ETL is the process of extracting, transforming, and loading data. The extract process involves retrieving data from the data source through several steps, including importing libraries, creating a database connection, retrieving data, and displaying the data. The transform process involves modifying the data with the aim of shaping it into a star schema. Transform is the process of converting data that was originally in operational form so that it can be used as a data warehouse format [9]. This includes steps such as data validation, data cleaning, data merging, data type conversion, derivation, creating new tables, and performing aggregation.

Data validation aims to check the data types that will be used in the research. Data cleaning can be performed by removing duplicate data, data with null values, and handling missing values. Data merging is carried out during the transformation process by combining tables from the source database to meet business requirements. Data type conversion is done to change the data types to facilitate easier analysis. Derivation is performed when adding new tables or columns. Aggregation is conducted to analyze data mathematically according to business needs in order to obtain the desired results. The load process involves transferring data from the staging area into a database known as the data warehouse.

Data warehouse is a centralized storage used to store data from various sources that have undergone the ETL process. The data in the data warehouse is ready to be processed for OLAP and data mining analysis. The development of the data warehouse in this study uses the Kimball model, which consists of nine steps for building a data warehouse (Mahendra et al., 2023): Choose the process, this step involves selecting a business process that aligns with the objective of providing information as a solution to the user. Choose the grain, this step aims to define the level of detail (grain) represented in the fact table, ensuring that the fact table columns function accurately and appropriately. Identify and comfort the dimensions this step involves creating dimension tables that support the fact table, containing relevant descriptive information. Choose the facts in this step, fact tables are selected that will be useful for dashboard visualization and analysis. Store pre-Calculations in the fact table, this step includes checking or reviewing the fact table to ensure it is ready for calculations. Round out the dimension tables, this step included detailed identification of the dimension tables, focusing on the columns they contain and their specific functions. Choose the duration of the database, this step determines the time span of the data to be stored in the data warehouse. Determine to track slowly changing dimensions (SCD), this step involves tracking changes in dimension data or creating new columns in the existing dimension tables to manage historical changes. Decide the physical

design, this final step involves implementing the fact and dimension tables based on the previous eight steps, resulting in a well-structured and effective data warehouse.

OLAP is the process of analyzing data ti find information stored in the database using operations such as roll-up, drill-down, slice and dice, and pivot. OLAP is used for multidimensional analysis. Drill down, one of the operations in OLAP analysis used to provide a more detailed view of data by moving from a higher level to a lower level. Example: from province-level data to city-level data. Roll up an OLAP operation used to summarize or aggregate data from a lower level to a higher level. Example: from city-level data to province-level data. Slice an OLAP operation used to analyze a single part of the data from a dimension table. Example: viewing hotel reservation data only for the month of March. Dice similar to the slice operation, but differs in that dice retrieves a smaller, more specific subset of data. Example: viewing hotel reservation data for the month of March specifically for the family room type. Pivot an OLAP operation used to change the data display perspective, allowing users to rotate the data axes for different views.

Data mining is the process of analyzing large-scale data using statistical techniques, artificial intelligence, and mathematical methods to discover trends, patterns, correlations, predictions, and business rules. At this layer, the CRISP-DM methodology is used to analyze the data within the data warehouse using data mining techniques. Some steps in the CRISP-DM process for analyzing questions in the business requirements are implemented within the ETL process, while others are implemented separately or outside the ETL process. The CRISP-DM stages that are separate from ETL include model building, testing and evaluation, and deployment. Data mining (K-Means Clustering, Exponential Smoothing) is used for segmentation and forecasting. Model building in this stage, the user selects a data mining model and applies it to the previously processed dataset. Testing and evaluation, this stage involves assessing and evaluating the accuracy of the selected data mining model. The purpose of this evaluation is to determine how well the chosen model meets the user's intended business objectives. Deployment, this is the final stage, where the data mining model is implemented to fulfill the defined business objectives.

2.3 Data Visualization And Reporting Layer

The visualization used can make it easier for users to describe the presentation of data so that it looks attractive and interactive [1]. The processed data is visualized through Power BI dashboards to support business decisions. The overall architecture includes fact and dimension tables focusing on customer, reservation, payment, and room data.

3. RESULTS AND DISCUSSION

The data used in this research is adopted from a hotel reservation ERP system available on GitHub. The ERP obtained by the researcher is a hotel room reservation website built with Laravel, featuring two types of users: admin and customer. This ERP includes a database that serves as the data source for the analysis of Business Intelligence implementation. The researcher obtained an SQL file from the hotel reservation ERP system available on GitHub. The following is an image of the database:

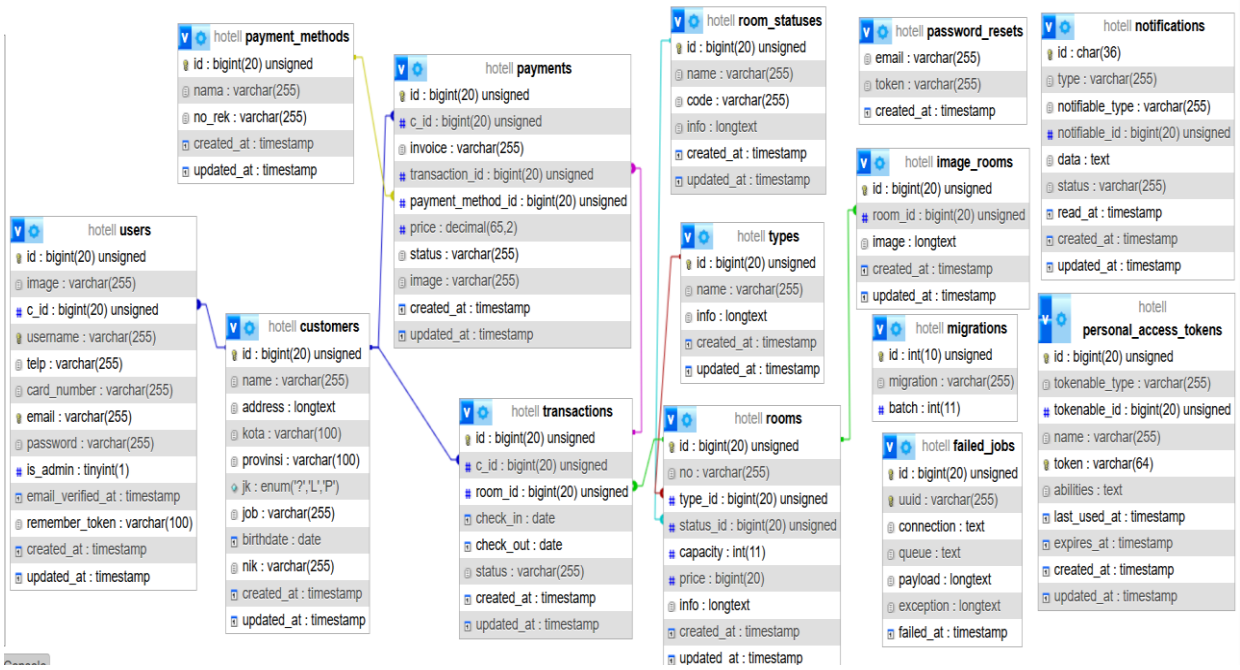

Figure 2. Database Source ERP

The data used in this reserach is stored in a MySQL database consisting of 14 tables, but only 7 tables are used in this research, as shown in Figure 2. The structure of this database originates from an ERP system available on GitHub. Each table contains dummy data spanning three years, from 2022 to 2024, which was generated both manually and automatically to realistically simulate hotel operational activities, including customer data, room data, transaction data, and payment data. The following is an explanation of the tables:

3.1 Customers Table

The customers table is used to store hotel customer data. Table 1 below shows the details of the customers table:

Table 1. Customers

No	Field	Data Type	Description
1	id	Int(20)	Contains the customer ID
2	name	Varchar(255)	Contains the customer name
3	adddress	Long text	Contains the customer address
4	kota	Varchar(100)	Contains the customer city
5	provinsi	Varchar(100)	Contains the customer province
6	jk	Enum (‘P’,’L’)	Contains the customer gender
7	job	Varchar(255)	Contains the customer occupation
8	birthdate	Date	Contains the customer date of birth
9	nik	Varchar(255)	Contains the customer national ID number (NIK)

3.2 Payment Table

The payment table is used to store hotel room reservation payment data from customers. Table 2 below shows the details of the payments table:

Table 2 Payments

No	Field	Data Type	Description
1	id	Int (20)	Contains the payment ID
2	c_id	Int (20)	Contains the customer ID
3	invoice	Varchar (255)	Contains the invoice
4	transaction_id	Int (20)	Contains the transaction ID
5	payment_method_id	Int (20)	Contains the payment method ID
6	price	decimal	Contains the amount
7	status	Varchar(255)	Contains the status

3.3 Transactions Table

The transaction table is used to store data related to the room reservation transaction process by customers. Table 3 below shows the details of the transactions table:

Table 3 Transactions

No	Field	Data Type	Description
1	id	Int (20)	Contains the transaction ID
2	c_id	Int (20)	Contains the customer ID
3	room_id	Int (20)	Contains the room ID
4	check_in	Date	Contains the check-in date
5	check_out	Date	Contains the check-out date

3.4 Payment Method Table

The payment_method table is used to store the room reservation payment methods, which can be either cash or bank transfer. It includes several bank account numbers from various banks that can be chosen according to the customer's preferences. Table 4 below shows the details of the payment_methods table:

Table 4 Payment_methods

No	Field	Data Type	Description
1	Id	Int	Contains the payment method ID
2	Nama	varchar	Contains the name of the payment method
3	No_rek	varchar	Contains the bank account number for each payment method

3.5 Users Table

The users table is user to store customer and admin accounts. Table 5 below shows the details of the users table:

Table 5 Users

No	Field	Data Type	Description
1	id	Int (20)	Contains the account ID
2	c_id	Int (20)	Contains the customer ID
3	username	Varchar (255)	Contains the customer's username
4	telp	Varchar (255)	Contains the user's phone number
5	card_number	Varchar (255)	Contains the user's card number
6	email	Varchar (255)	Contains the user's email
7	password	Varchar (255)	Contains the user's password
8	is_admin	Tinyint (1)	Contains the role ID

3.6 Room_statuses Table

The room_statuses table is used to store room status information based on customer needs, such as checkout, house use, and others. Table 6 below shows the details of the room_statuses table:

Table 6 Room_statuses

No	Field	Data Type	Description
1	id	Int (20)	Contains the room status ID
2	name	Varchar (255)	Contains the room status name
3	code	Varchar (255)	Contains the room status code
4	info	Longtext	Contains the description of the room status

3.7 Rooms Table

The rooms table is used to store data about the rooms provided by the hotel. Table 7 below shows the details of the rooms table:

Table 7 Rooms

No	Field	Data Type	Description
1	id	Int (20)	Contains the room ID
2	no	Int (20)	Contains the room number
3	type_id	Int (20)	Contains the room type ID
4	status_id	Int (20)	Contains the room status ID
5	capacity	Int (11)	Contains the total room capacity per unit
6	price	Int (20)	Contains the room rental price
7	info	Longtext	Contains the room information

3.8 Types Table

The types table is used to store room types such as double room, single room, and others. Table 8 below shows the details of the types table:

Table 8 Rooms

No	Field	Data Type	Description
1	id	Int (20)	Contains the type ID
2	name	Varchar (255)	Contains the room type name
3	info	Longtext	Contains detailed room information

CONCLUSION

After undergoing a series of research processes and the implementation of a Business Intelligence (BI) system in processing hotel room reservation data, several key conclusions have been drawn as follows:The implementation of Business Intelligence (BI) using OLAP (Online Analytical Processing) analysis enables the identification of the most frequently booked rooms, frequent guests, reservation trends, commonly used payment methods, as well as the dominant occupations and regions of origin of customers at Hotel XYZ. This is achieved through the development of a data warehouse and the application of the ETL (Extract, Transform, Load) process using the Python programming language in Jupyter Notebook. Data originally stored in the hotel room reservation ERP system is transformed into a dimensional structure (fact and dimension tables), and then loaded into a dedicated database for further analysis using Power BI.

The implementation of Business Intelligence (BI) with data mining analysis enables room segmentation, hotel revenue prediction, and room booking forecasts for the next 12 months at Hotel XYZ. This is done through the development of a data warehouse and the application of the ETL (Extract, Transform, Load) process using Python in Jupyter Notebook, followed by data mining analysis using the CRISP-DM methodology.

Business Intelligence (BI) provides informative insights into reservation analysis and room segmentation at Hotel XYZ in the form of interactive dashboards using Microsoft Power BI.Based on the results of the analysis and the implementation of the system, the author provides the following suggestion: for future development of this topic, it would be beneficial to explore the use of other Business Intelligence (BI) analysis tools beyond Jupyter Notebook and Microsoft Power BI. Additionally, it is recommended to develop the system in the form of a user-friendly website, so that when data is entered into the website, it can be automatically analyzed with predefined outputs.

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