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Sales Information System Using FP-Growth Algorithm Based on Consumer Purchasing Patterns

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ABSTRACT

The advancement of technology has driven businesses to innovate digitally to improve operational efficiency and effectiveness, including in the food and beverage industry. Two Much Coffee & Roastery is one of the cafes that still operates in a semi-digital manner, recording transactions manually using Microsoft Excel. The cafe faces challenges in optimizing sales strategies, particularly in implementing cross-selling strategies, as there is no system that provides automatic product recommendations. This study aims to implement data mining techniques using the FP-Growth algorithm to identify consumer purchasing patterns from historical transaction data. The algorithm was applied with a minimum support of 0.01 and a lift of 1.0, resulting in 30 association rules. These rules were integrated into a web-based system used by the cashier to support cross-selling strategies. The system not only records transactions but also provides product recommendations based on previous purchasing patterns, which is expected to effectively and efficiently increase the cafe's sales.

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I. INTRODUCTION

The rapid advancement of technology in various fields has brought about innovations that have transformed the way businesses operate and interact with customers. This development is evident across all industrial sectors, including the food and beverage industry. This industry has begun adopting technology to improve sales within business operations. One segment of the food and beverage industry that has been influenced by this technological development is the cafe. In facing intense business competition, cafe business owners need to design various marketing strategies to maintain the sustainability of their business [1]. Some marketing strategies that can be implemented include improving service quality and conducting promotions. Promotions are carried out to encourage repeat purchases, introduce new products, and attract new customers.

Two Much Coffee & Roastery is one of the cafes that has been operating for a long time. This cafe offers a variety of menu items to customers daily, ranging from various beverages, including coffee and non-coffee drinks such as milk, chocolate, and tea, to main dishes such as rice and noodles, as well as snacks such as French fries. Despite having a diverse menu, the cafe has experienced difficulties in optimizing its sales strategy to continuously improve sales. Previous studies have shown that data mining techniques, particularly association rule mining using the Apriori and FP-

Growth algorithms, are effective in identifying consumer purchasing patterns and supporting marketing strategies [1], [2]. The results of these studies indicate that transaction data can be analyzed to generate product bundling recommendations and promotional strategies that help increase sales. One marketing strategy that can be applied by the cafe is a method known as cross selling, which is considered one of the easiest methods to increase sales [3]. Cross selling is a marketing strategy in which the seller offers or promotes additional products with the aim of attracting customer interest to complement their purchase with other products [4]. However, a new challenge arises when the cafe needs to determine which products are most suitable to offer to customers as part of the cross-selling strategy, especially when such decisions must be based on historical transaction data rather than intuition alone.

Based on these challenges, the implementation of technology in the form of an information system with data mining can help the cafe. Data mining is the process of extracting data to discover hidden relationships, patterns, and trends within large datasets using various techniques or methods [5]. Data mining can be performed on the cafe's historical transaction data. The data mining technique to be used is association rules with the FP-Growth algorithm. Several previous studies have demonstrated that the FP-Growth algorithm is effective for product recommendation and sales strategy optimization, as it produces strong association rules and improves recommendation accuracy compared to Apriori [6], [7]. The FP-Growth algorithm is an improvement over the previous Apriori algorithm, addressing several of Apriori's shortcomings [8]. In addition, one of the advantages of the FP-Growth algorithm is its ability to efficiently handle and process large transaction datasets [9]. This algorithm can be used to identify consumer purchasing patterns by finding products or menu items that are frequently bought together in a single transaction. In addition, the implementation of recommendation systems based on FP-Growth has been proven to significantly increase sales performance in food related businesses [10]. By implementing this data mining technique, it is expected to generate appropriate product recommendations for cross selling by the cashier. The results of this algorithm implementation will also be integrated into a web-based information system that can be utilized by the cashier to enhance the effectiveness and efficiency of sales strategies through cross selling.

However, most previous studies primarily focus on analyzing transaction data and presenting association rule results in the form of tables or reports, without directly integrating the analytical outcomes into an operational information system. Therefore, this research extends previous work by implementing the results of the FP-Growth analysis directly into a web-based information system that can be accessed and utilized by the café [11]-[13]. Unlike prior studies that emphasize analytical outputs, this study develops an interactive system that enables cashiers to obtain real-time menu recommendations based on historical sales data. Consequently, the generated recommendations are not only accurate and relevant but can also be directly applied in the daily operational activities of the cafe to support cross-selling strategies [14]-[15].

II. METHODOLOGY

A. Problem Identification

The research begins with problem identification in the cafe. This stage aims to understand the challenges and issues faced by the cafe, so that the focus can be directed toward relevant aspects and the formulation of precise research questions. Thus, the resulting solutions can align with the defined problem statements.

B. Literature Review

Alongside problem identification, a literature review is conducted to gain deeper insights into the challenges faced by the cafe. The literature review is carried out by collecting references such as journals, books, and previous studies to understand the context and theoretical foundations that can support problem-solving in the research. These two stages are conducted simultaneously so that the identified problems can be connected with relevant theories and findings from previous studies.

C. System Requirements Analysis

This stage aims to identify the requirements that must be fulfilled by the information system to be developed. The requirements are identified based on the problems faced by the cafe. Through this stage, the resulting information system is expected to provide an appropriate and accurate solution to address the identified problems.

D. Data Mining

The next stage of this research is data mining. The cafe has agreed to provide sales transaction data for the period from January 2023 to July 2024, consisting of approximately 17,000 transaction records. The data first undergoes preprocessing, including data cleaning, validation of active menu items, and transformation into a transactional format suitable for analysis. Next, the FP-Growth algorithm is implemented on the prepared data to uncover relationships between items in the sales transactions. In this study, the minimum support parameter is set to 0.01 to identify item combinations that appear in at least 1% of the total transactions, while the minimum lift threshold is set to 1.0 to ensure that the generated rules indicate a meaningful association between items. This process generates frequent itemset based on the predetermined minimum support value, which are then used to form association rules with the specified minimum lift threshold. The final result of the data mining stage is a set of association rules that indicate items frequently purchased together.

The generated association rules are then stored in the system database and integrated into the web-based information system. During the ordering process, when the cashier selects one or more menu items, the system automatically checks the selected items against the stored association rules. If a rule matches the selected item as an antecedent, the system retrieves the corresponding consequent item and displays it as a product recommendation for cross selling. This mechanism allows the recommendation process to run automatically and in real time during transactions. Through this workflow, the results of the data mining process are directly applied within the information system to support decision-making and enhance the effectiveness of cross-selling strategies.

E. System Design

The following stage is system design. This design includes the creation of Unified Modeling Language (UML) diagrams such as use case, activity, sequence, and class diagrams. These diagrams assist in understanding the system to be developed. In addition, user interface design is also carried out to serve as a reference in the development of the user interface.

F. Code Implementation

The next stage is code implementation, which serves as the main phase. At this stage, the information system begins to be developed through program coding. The development of the system refers to the previously designed specifications to meet user requirements.

G. System Testing

The developed information system must undergo testing before being applied in the cafe environment. The system is tested using the black-box testing method to ensure that all functionalities operate according to the requirements. If no issues are found, the system proceeds to the next stage. Conversely, if bugs or shortcomings are identified, the system is revised to align with the requirements.

H. System Deployment

The final stage of information system development is system deployment. At this stage, the successfully developed system is deployed in the cafe environment. This is carried out to ensure that the cafe can utilize the system to meet its operational needs.

III. Result and Discussion

A. Use Case Diagram

Fig. 1 presents a use case diagram that illustrates all interactions between the actors and the system.

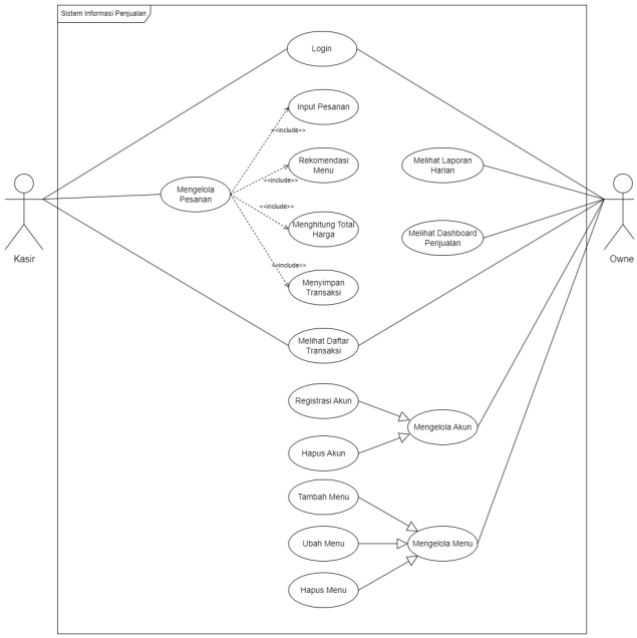

Fig. 1. Use Case Diagram

B. Activity Diagram

The Activity Diagram explains the flow and sequence of activities performed by the actors and the system being developed. Fig. 2 represents the ordering activity diagram that illustrates the flow of the ordering process in the information system.

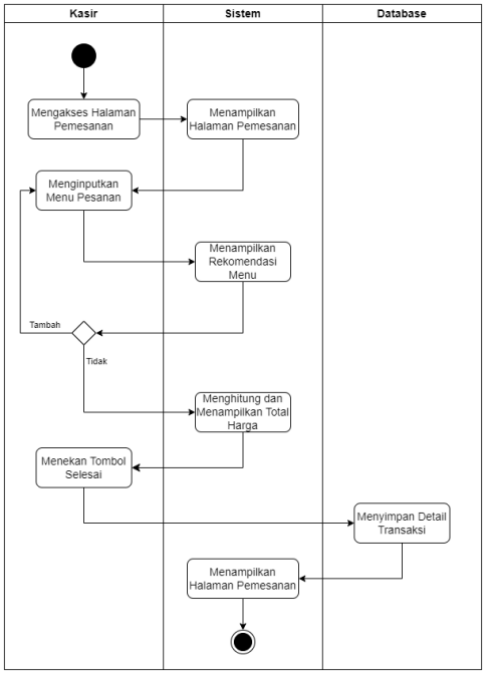

Fig. 2. Ordering Activity Diagram

Fig. 3 represents the add menu activity diagram that illustrates the flow of the process of adding a menu item into the cafe information system.

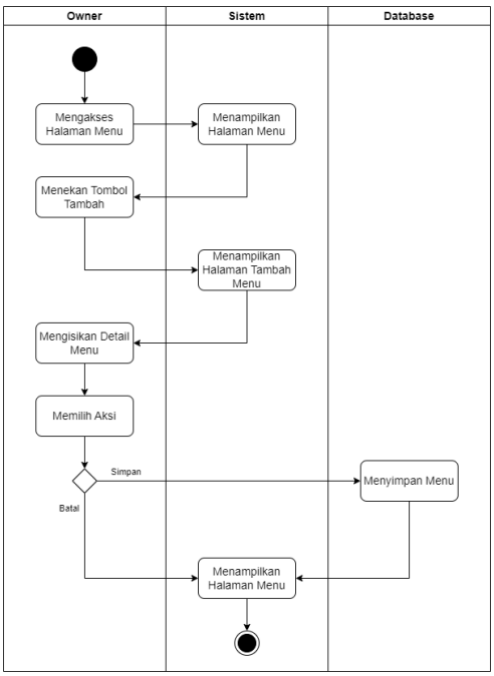

Fig. 3. Add Menu Activity Diagram

Fig. 4 represents the edit menu activity diagram that illustrates the flow of the process of modifying menu data in the cafe information system.

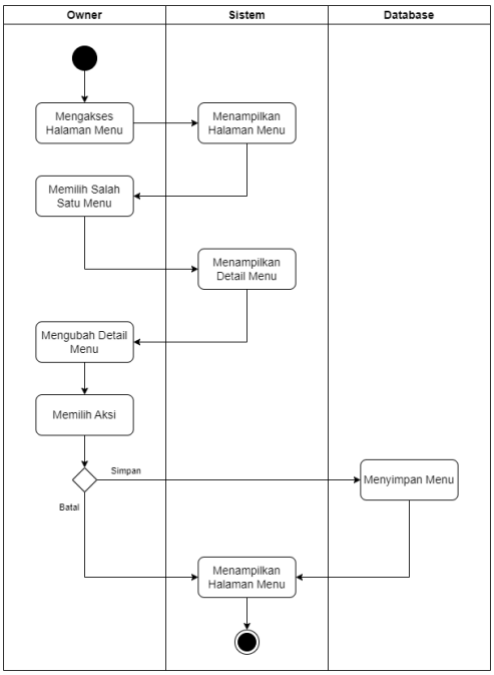

Fig. 4. Edit Menu Activity Diagram

Fig. 5 represents the delete menu activity diagram that illustrates the flow of the process of deleting menu data in the cafe information system.

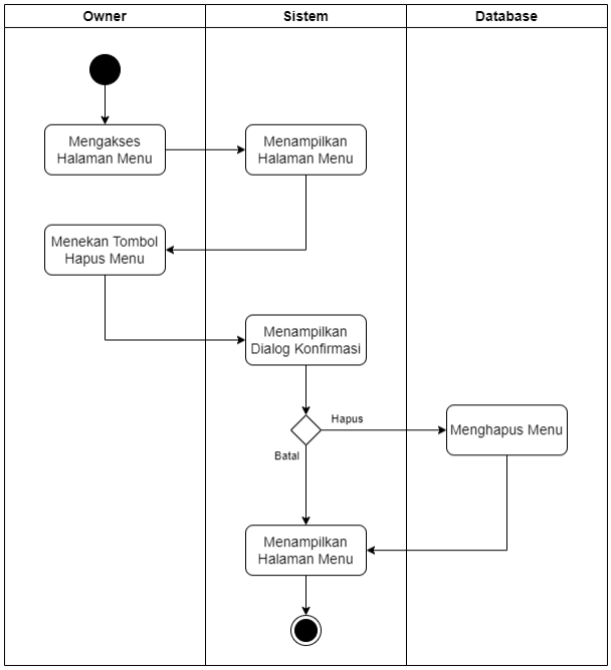

Fig. 5. Delete Menu Activity Diagram

Fig. 6 shows the view transactions activity diagram, outlining the sequence of steps involved in accessing and displaying transaction records within the system.

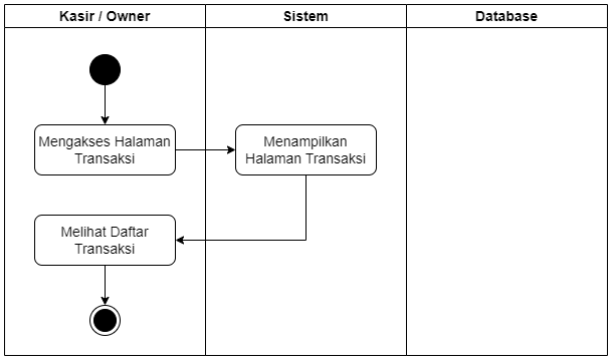

Fig. 6. View Transactions Activity Diagram

Fig. 7 depicts the view dashboard activity diagram, presenting the workflow of how users navigate to and obtain sales dashboard information.

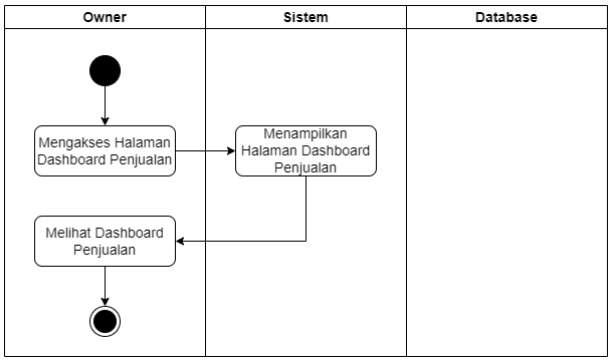

Fig. 7. View Dashboard Activity Diagram

C. *Sequence Diagram*

The sequence diagram provides an overview of the detailed interactions between objects within a system. Fig. 8 represents the ordering sequence diagram that illustrates the interaction between objects in the cafe information system.

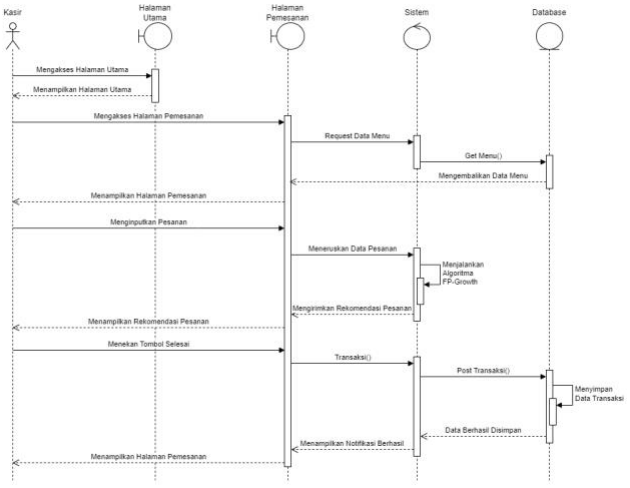

Fig. 8. Ordering Sequence Diagram

Fig. 9 represents the add menu sequence diagram that illustrates the interaction between objects in the process of adding a menu item in the cafe information system.

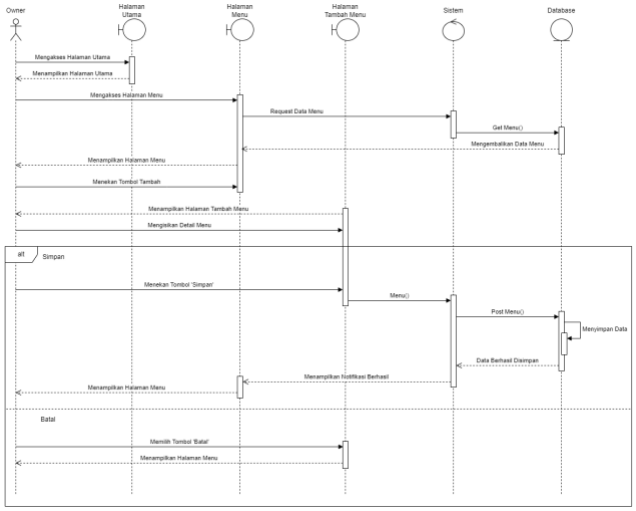

Fig. 9. Add Menu Sequence Diagram

Fig. 10 represents the edit menu sequence diagram that illustrates the interaction between objects in the process of modifying a menu item in the cafe information system.

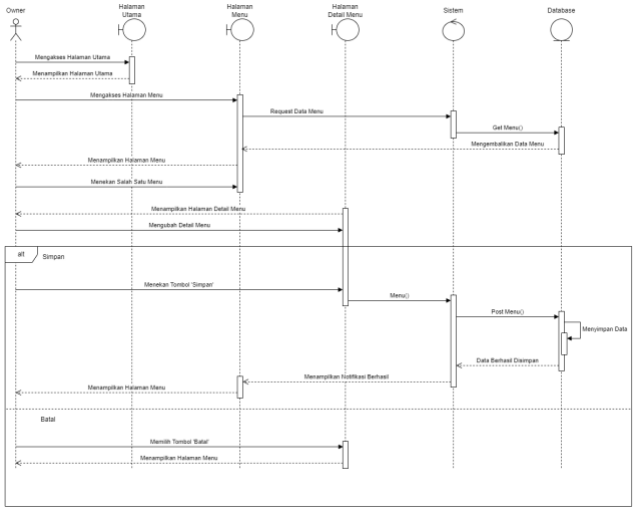

Fig. 10. Edit Menu Sequence Diagram

Fig. 11 represents the delete menu sequence diagram that illustrates the interaction between objects in the process of deleting a menu item in the cafe information system.

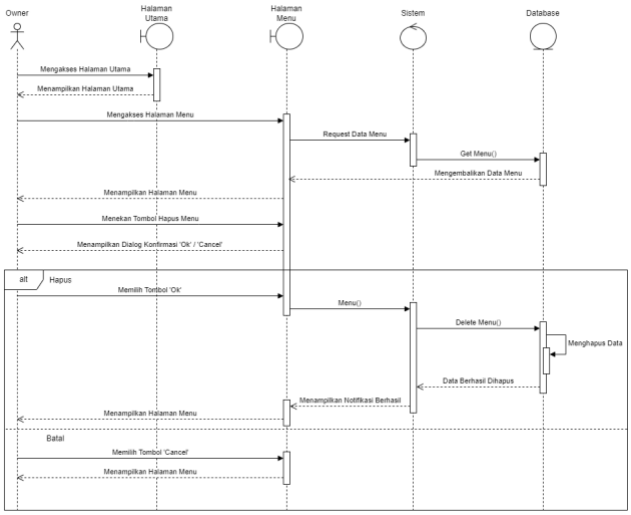

Fig. 11. Delete Menu Sequence Diagram

Fig. 12 illustrates the view transactions sequence diagram, detailing the interactions between objects during the process of retrieving and showing transaction data.

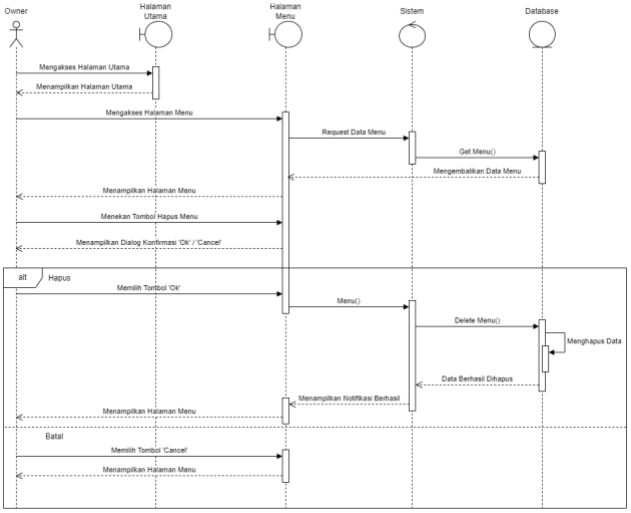

Fig. 12. View Transactions Sequence Diagram

Fig. 13 presents the view dashboard sequence diagram, highlighting the object interactions that occur when generating and displaying overall sales information on the dashboard.

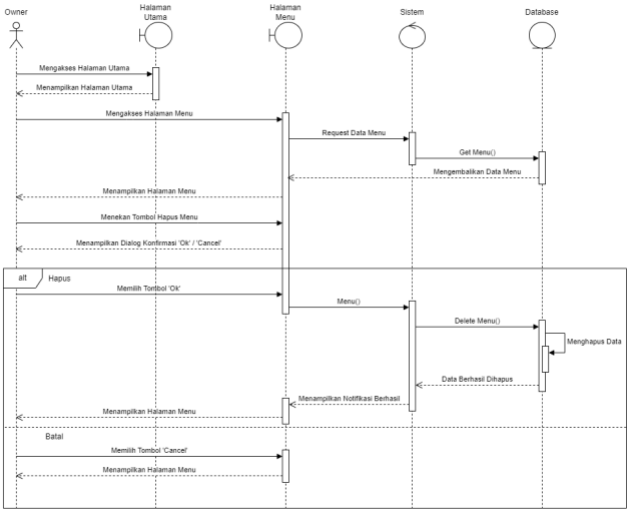

Fig. 13. View Dashboard Sequence Diagram

D. Class Diagram

The Class Diagram serves to represent the structure of classes and objects that compose the system, while also illustrating the relationships among these elements. Fig. 14 represents the Class Diagram of the cafe information system.

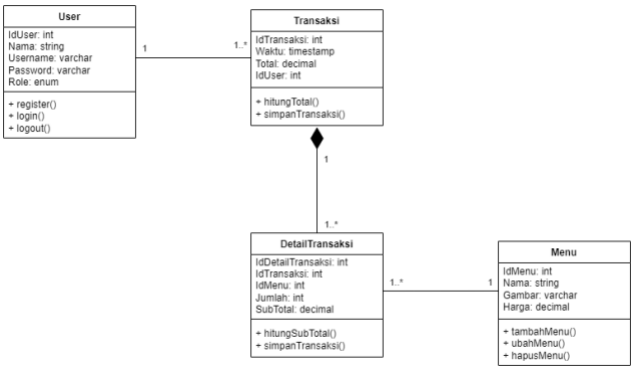

Fig. 14. Class Diagram

E. Data Mining

The initial stage in the data mining process begins with data selection and preprocessing. In the selection stage, transaction data from Two Much Coffee & Roastery, which consists of time, total, and product columns, is added with two additional columns, namely id_transaksi and id_user. Then, preprocessing is carried out to ensure that only relevant data is used, including filling in missing values and matching menu items with the latest prices through a dictionary. Each transaction is processed to separate menu items and recalculate the total price based on active menu items, so that only valid transactions are used for further analysis.

The validated transaction data is then transformed to facilitate the data mining process. The data is arranged into two DataFrames, namely transaksi and detail_transaksi, which are then stored in an Excel file to be uploaded into the system database. The detail_transaksi data is filtered so that it only includes transactions with more than one menu, since only this type of transaction is needed in Market Basket Analysis. After that, the data is converted into a binary format using TransactionEncoder to prepare it for the application of the FP-Growth algorithm.

The data mining stage is carried out using the FP-Growth algorithm, which is known to be efficient in handling large datasets because it uses the FP-Tree data structure. In this process, the algorithm identifies frequent itemsets, which are combinations of menu items that often appear together in one transaction. With a minimum support value of 0.01, 84 frequent itemsets are obtained, most of which consist of two-item combinations. The results of these frequent itemsets become the basis for forming association rules in understanding consumer purchasing patterns.

The association rules are then calculated based on the obtained frequent itemsets, using Lift as a measure of the strength of the association between items, and setting the minimum Lift value at 1.0. The results show significant purchasing patterns, where some menu items tend to be purchased together. These generated association rules can then be utilized in a recommendation system to support cross-selling strategies at Two Much Coffee & Roastery, in order to increase sales and improve service efficiency. Here are some examples of the generated association rules.

TABLE I. ASSOCIATION RULES RESULT

Antecedents	Consequents	Support	Confidence	Lift
Java Liqueur	Dublin Coffee	0.013118	0.167043	2.108029
Dublin Coffee	Java Liqueur	0.013118	0.165548	2.108029
Classic Tea	Cappuccino	0.012232	0.172070	2.074030
Cappuccino	Classic Tea	0.012232	0.147436	2.074030
Ricebowl Katsu	Classic Tea	0.011700	0.129666	1.824055
Classic Tea	Ricebowl Katsu	0.011700	0.164589	1.824055
Classic Tea	Americano	0.010991	0.154613	1.473268
Americano	Classic Tea	0.010991	0.104730	1.473268
Chocolate	Matcha	0.019855	0.146789	1.269995
Matcha	Chocolate	0.019855	0.171779	1.269995

Fig. 15. Association Rules Result

The generated association rules reveal meaningful information for the cafe. For example, the strong relationship between Java Liqueur and Dublin Coffee (lift 2.108), as well as between Classic Tea and Cappuccino (lift 2.074), indicates that customers tend to purchase certain beverages together, suggesting complementary consumption behavior. Similarly, the association between Ricebowl Katsu and Classic Tea (lift 1.824) reflects a natural pairing between main dishes and drinks, which can be strategically utilized for menu bundling and cross-selling. These findings demonstrate that transaction data can provide actionable insights for designing more effective sales strategies. It should be emphasized that this study focuses on the implementation and integration of FP-Growth results into a web based information system, rather than conducting comparative system performance evaluation. Therefore, the presented association rules serve as the analytical foundation for the real time recommendation mechanism embedded within the system.

F. Information System Results

Figs. 16 to 29 show the results of the cafe information system for Two Much Coffee & Roastery, which was developed using HTML, CSS, JavaScript, and Flask Python. The cross-selling recommendations generated from the association rules are displayed on the Ordering Page of the information system. When the cashier selects menu items during the transaction process, the system automatically presents relevant recommended products based on the stored association rules. These recommendations appear alongside the selected items, allowing the cashier to directly offer additional products to customers as part of the cross-selling strategy.

Fig. 16. Landing Page

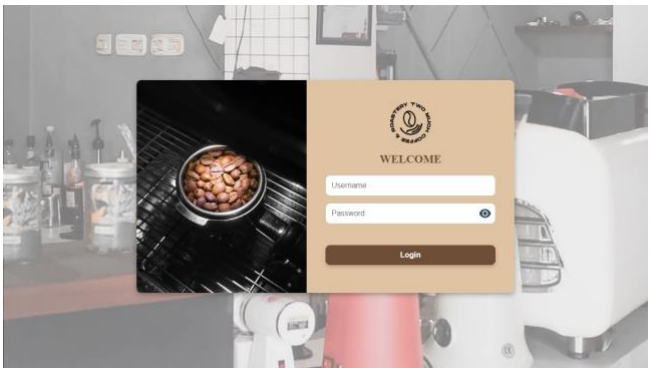

Fig. 17. Login Page

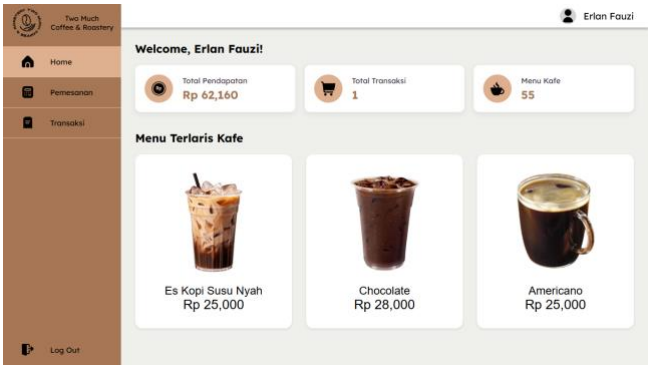

Fig. 18. Home (Cashier)

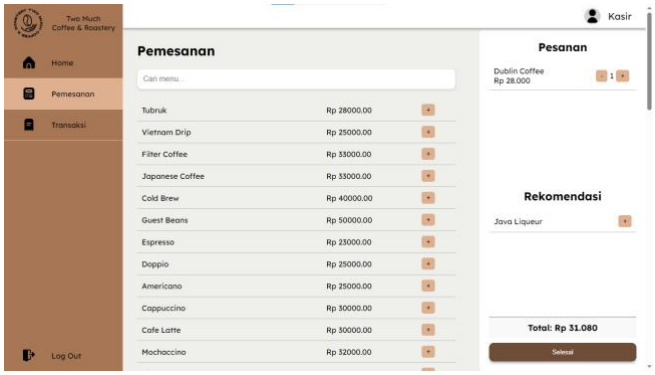

Fig. 19. Ordering Page

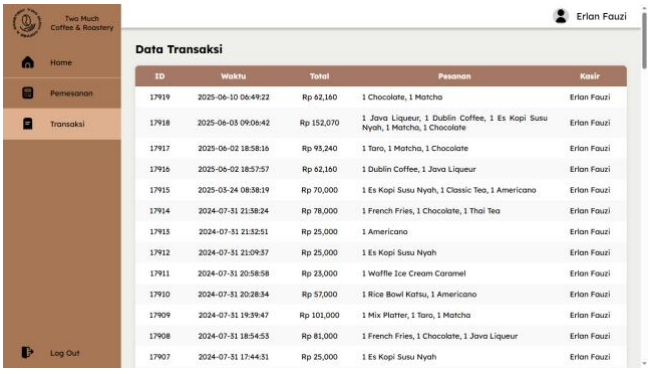

Fig. 20. Transaction Page (Cashier)

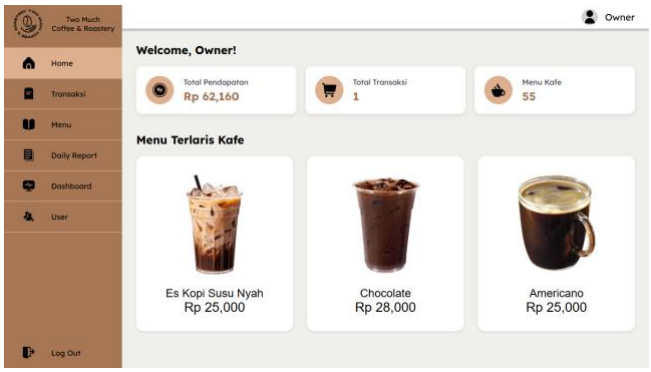

Fig. 21. Home (Owner)

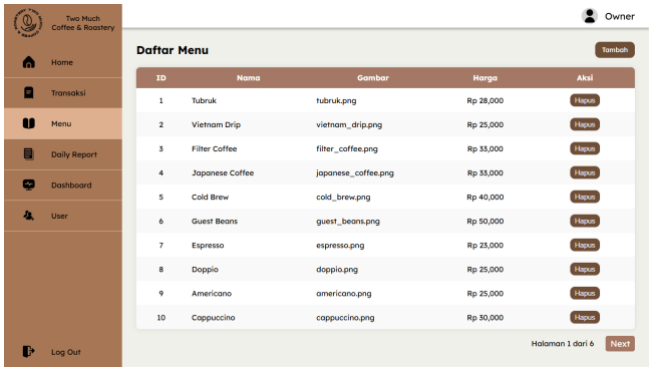

Fig. 22. Menu Page

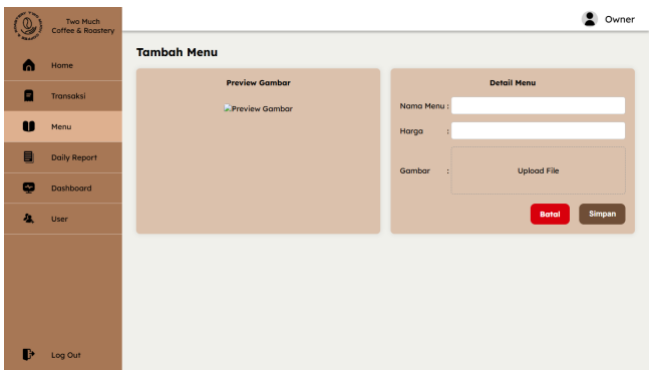

Fig. 23. Add Menu Page

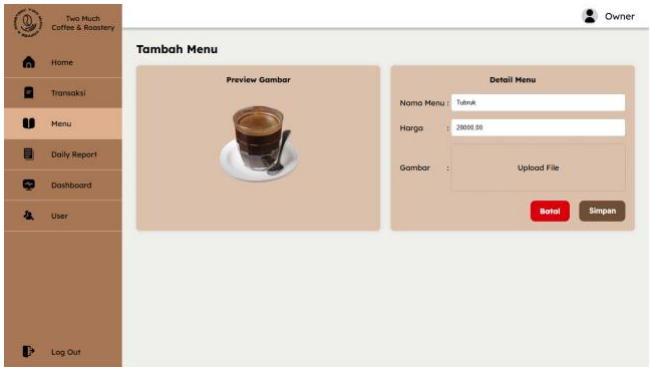

Fig. 24. Detail Menu Page

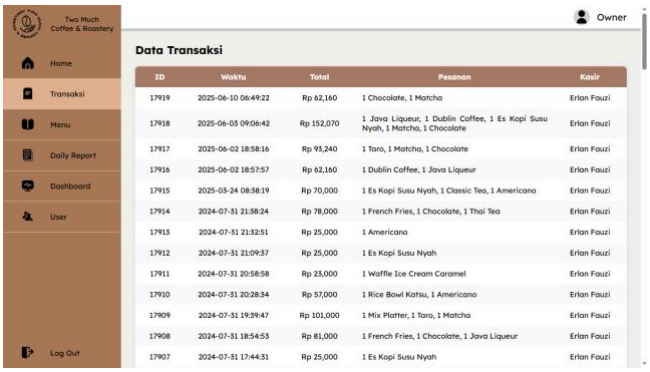

Fig. 25. Transaction Page (Owner)

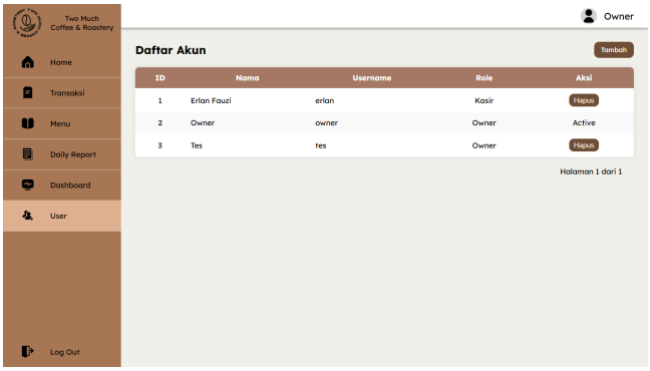

Fig. 26. User Page

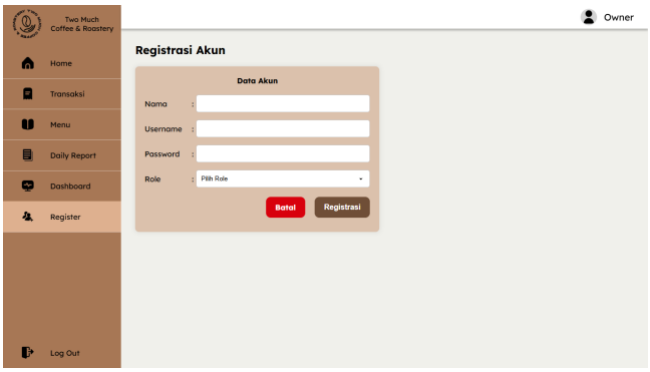

Fig. 27. Account Registration Page

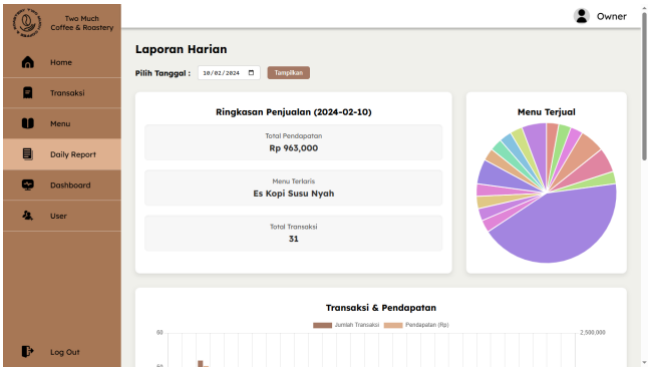

Fig. 28. Daily Report Page

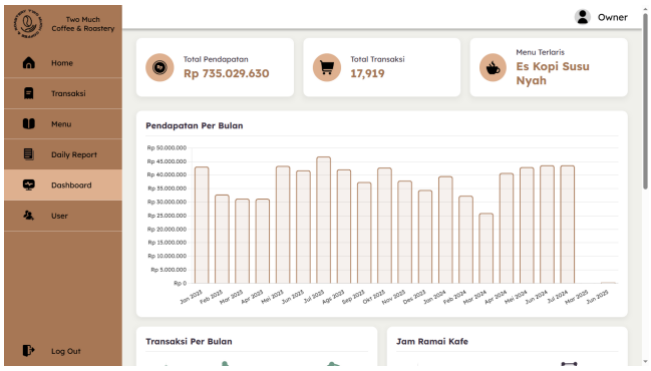

Fig. 29. Dashboard Page

G. *Black Box Testing*

Fig. 30 shows the results of black box testing on the cafe information system that includes various features.

TABLE II. BLACK BOX TESTING

Feature	Scenario	Expected Result	Status
Login	1. Access the Website 2. Click the Login Page Button 3. Enter Username and Password 4. Click the Login Button	The user successfully logs in with their account and accesses the main page of the website.	Success
Home Page	1. Accessing the Main Page after Login	The user can view the information provided on the main page of the website.	Success
Manage Orders	1. Select the Ordering Page 2. Search and Add Menu Items to the Cart 3. Add Recommended Menu Items to the Cart 4. Click the Finish Button	The cashier successfully inputs the customer's order into the cart, offers the recommended menu items generated by the system, and saves the order into the transaction data.	Success
View Transaction Data	1. Select the Transaction Page 2. Click the Next or Previous Button	The user can view all transaction data stored in the database.	Success
View Menu	1. Select the Menu Page 2. Click the Next or Previous Button	The owner can view all the menu items sold by the cafe.	Success
Add New Menu	1. Select the Menu Page 2. Click the "Add" Button 3. Enter Menu Details 4. Click the Save Button	The owner successfully adds the new menu details into the database.	Success
Edit Menu Details	1. Select the Menu Page 2. Click on a Menu Item 3. Modify Menu Details 4. Click the Save Button	The owner successfully updates the details of a menu item.	Success

Feature	Scenario	Expected Result	Status
Delete Menu	1. Select the Menu Page 2. Click the "Delete" Button 3. Confirm Menu Deletion	The owner successfully deletes a menu item from the database.	Success
Account Registration	1. Select the User Page 2. Click the "Add" Button 3. Enter Account Details 4. Click the Save Button	The owner successfully registers a new account into the database.	Success
Account Deletion	1. Select the User Page 2. Click the "Delete" Button 3. Confirm Account Deletion	The owner successfully deletes an account from the database.	Success
View Daily Report	1. Select the Daily Report Page 2. Select a Date	The owner can view a summary of sales information for the selected day.	Success
View Sales Dashboard	1. Select the Dashboard Page	The owner can view a summary of the cafe's overall sales information.	Success
Logout	1. Click the Log Out Button	The user successfully logs out of the account and returns to the landing page.	Success

Fig. 30. Black Box Testing Result

IV. CONCLUSION

Based on the results of this research, the implementation of Association Rules using the FP-Growth algorithm was successfully applied to the transaction data of Two Much Coffee & Roastery, generating 30 association rules with a minimum support of 0.01 and a lift value of 1.0. These rules identified combinations of menu items that frequently appear together in historical transactions, indicating recurring purchasing patterns within the dataset.

The generated association rules were then integrated into a web-based cafe information system and implemented on the Ordering Page, where recommendations are automatically displayed when the cashier selects menu items during a transaction. This mechanism enables the system to utilize historical purchasing patterns to provide real-time cross-selling recommendations.

System testing using black box testing confirmed that all functional features, including transaction processing and recommendation display, operate correctly according to the system requirements. However, this evaluation was limited to functional validation and did not measure the effectiveness or accuracy of the generated recommendations in influencing customer purchasing behavior.

Future research may include additional evaluation methods to measure the effectiveness of the recommendation feature, such as user acceptance testing or experimental studies to assess the impact of cross-selling recommendations on sales performance. Further studies could also evaluate recommendation accuracy using quantitative metrics or compare FP-Growth with alternative recommendation approaches, such as collaborative filtering or hybrid recommendation models, to determine the most effective method for supporting sales strategies in cafe environments.

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