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Product and Store Recommendation System Using K-Means Clustering and Hybrid Filtering on Marketplace *(Case Study of CV. Talongka Jaya)*

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Abstract

The development of information and communication technology has driven significant changes in the digital business landscape, particularly in the e-commerce sector. Marketplaces have become crucial platforms for connecting consumers with product providers, including supporting the growth of Micro, Small, and Medium Enterprises (MSMEs). As transaction volumes and product diversity continue to increase, new challenges have emerged in providing consumers with relevant product recommendations. This study aims to develop a product and store recommendation system by combining K-Means Clustering for customer segmentation and Hybrid Filtering to enhance recommendation accuracy. The system was developed using an experimental approach based on software engineering, with historical transaction data from the CV. Talongka Jaya marketplace as the primary data source. Customer segmentation resulted in five clusters based on purchasing behavior patterns, such as transaction frequency and product category preferences. These clustering results were then used to tailor product and store recommendations to the characteristics of each segment. The recommendation system was built by integrating Collaborative Filtering and Content-Based Filtering with optimal weights of 0.7 and 0.3, respectively. Evaluation using 5-fold cross-validation demonstrated that Hybrid Filtering achieved a Precision of 0.78 and an F1-Score of 0.74, outperforming single-method approaches. These findings confirm that the integration of clustering and hybrid filtering is effective in enhancing service personalization and improving users' shopping experience. This research makes a significant contribution to the development of data mining-based recommendation systems for MSME marketplaces, although there remains room for further improvement through the integration of real-time data and deep learning-based sequential recommendation methods.

Introduction

The development of information and communication technology has driven fundamental changes in the business landscape, particularly in digital commerce or e-commerce. Marketplaces have become the primary platforms facilitating interactions between consumers and product providers on a large scale, including supporting the growth of Micro, Small, and Medium Enterprises (MSMEs). As transaction volumes and product diversity on marketplace platforms continue to increase, new challenges have emerged, particularly in helping consumers find products that align with their preferences amidst the abundance of available options (Bisht & Varma, 2024; George & Baskar, 2024; Chowdhury & Nath, 2024; Kimmel, 2010). This is where the role of recommendation systems becomes increasingly critical,

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serving as an information filtering tool that enhances the shopping experience and fosters customer loyalty (Yoonet al., 2013; Tongxiao et al., 2011; Silvester & Kurian, 2023; Tarnowska et al., 2020).

Recommendation systems based on Collaborative Filtering (CF) and Content-Based Filtering (CBF) have been widely used to deliver relevant product recommendations to users (Siti Aminah, 2024; Thorat et al., 2015; Widayanti et al., 2023). However, each method has its limitations; CF is susceptible to cold start and sparsity issues, while CBF struggles to enrich recommendations with users' historical interaction data. Consequently, the Hybrid Filtering approach, which combines CF and CBF, presents a potential solution to overcome these shortcomings. Hybrid systems can improve recommendation accuracy by leveraging the strengths of both methods (Afoudi, et al. 2021; Geluvaraj et al., 2024; Burke, 2007; Chaudhari et al., 2024).

In addition to recommendation systems, a deeper understanding of consumer behavior through customer segmentation analysis is also crucial to enhance recommendation effectiveness (Sundareswaran et al., 2022; Liu et al., 2019; Khodabandehlou et al., 2021). One widely used segmentation method is K-Means Clustering, which can group customers based on purchasing behavior patterns. The resulting segmentation can then be used to tailor product and store recommendations to the specific needs of each customer group. A study by Pily and Rio (2025) indicated that applying K-Means Clustering in e-commerce-based recommendation systems improves the relevance of recommendations compared to approaches that do not utilize segmentation.

Further research by Gao et al. (2021) developed a hybrid model for product recommendations in e-commerce, demonstrating that combining clustering methods with hybrid filtering significantly increases user engagement. Study by Romero, et al. (2023) on local MSME marketplaces showed that hybrid recommendation systems could improve conversion rates compared to traditional methods. Additionally, research by Warianta et al. (2024) proved that consumer behavior segmentation based on clustering can more effectively support e-commerce platform personalization, promoting greater customer loyalty and higher transaction values.

Based on the gaps identified in previous literature, this study aims to develop a product and store recommendation system by combining K-Means Clustering and Hybrid Filtering on the CV. Talongka Jaya marketplace. This research seeks to address cold start and data sparsity challenges, enhance recommendation accuracy and relevance, and support a more personalized user experience. The expected benefits of this study include contributing to the development of data mining-based recommendation systems in the context of MSME marketplaces in Indonesia, enhancing the competitiveness of MSMEs in the digital era, and providing academic insights that can serve as a reference for further studies in the field of recommendation systems and e-commerce personalization.

Methods

This study employs a quantitative approach based on software engineering using an experimental method. This approach was chosen to develop and test a recommendation system based on K-Means Clustering and Hybrid Filtering to enhance the accuracy and relevance of product and store recommendations on the CV. Talongka Jaya marketplace. Additionally, the study adopts the principles of Research and Development (R&D) in system development, involving iterative stages from system design, implementation, to evaluation of the resulting recommendation system.

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Types and Sources of Data

The data used in this study are secondary data obtained from the internal database of CV. Talongka Jaya. The data include customer transaction histories, product descriptions, and store information available on the marketplace. Specifically, the transaction data cover attributes such as customer ID, product ID, purchase quantity, transaction date, and product price. Moreover, product profile data include product categories, brief descriptions, prices, and popularity based on the number of purchases. These datasets are collected to construct the user-item interaction matrix and the product feature base required for the recommendation process.

Research Procedure

This study consists of the following stages:

Data Collection and Preprocessing

The initial stage involves collecting historical transaction data and product attributes from the marketplace database. Preprocessing is conducted to ensure data quality, including data cleaning (removing duplicates, handling missing values), data transformation (normalizing prices and preference scales), and feature selection to retain relevant attributes. For clustering analysis preparation, transaction data are processed into features such as purchase frequency, total spending, and product category preferences.

Customer Segmentation Using K-Means Clustering

To understand customer behavior patterns, segmentation is performed using the K-Means Clustering algorithm. The optimal number of clusters is determined using the Elbow Method by observing the inflection point in the Within-Cluster-Sum-of-Squares (WCSS) graph. Once the clusters are formed, each cluster is analyzed to identify the demographic characteristics and purchasing behavior of the customers within them.

Development of the Recommendation System with Hybrid Filtering

The recommendation system is developed using a Hybrid Filtering approach that combines Collaborative Filtering (CF) and Content-Based Filtering (CBF).

Collaborative Filtering is built using the user-item interaction matrix to predict products that users might like based on the interaction patterns of similar users (user-based collaborative filtering).

Content-Based Filtering uses product attributes such as category and description to calculate product similarity employing the cosine similarity method.

The hybrid model combines the CF and CBF scores with a weighting factor α, determined empirically through preliminary experiments (Salam, et al. 2024). The final recommendation score is calculated as follows:

$$\boldsymbol{Score_{Hybrid} = \alpha \times Score_{CF} + (1 - \alpha) \times Score_{CBF}}$$

System Evaluation

The performance of the recommendation system is evaluated using the k-fold cross-validation method with 5 folds to avoid evaluation bias (Febrianti, et al. 2023). Evaluation metrics include Precision, Recall, and F1-Score, which are widely used in recommendation system testing to measure the relevance and accuracy of the recommendations produced.

Precision measures the proportion of recommended products that are truly relevant.

Recall measures the proportion of relevant products successfully recommended from all available relevant products.

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F1-Score is the harmonic mean of Precision and Recall, providing a comprehensive measure of the model's performance.

System Implementation

The system is developed using the Python programming language, with MySQL for data storage. CodeIgniter and Tailwind CSS are used to build the web-based user interface for the recommendation system.

Results and Discussion

Customer Clustering Results

The initial stage in developing the recommendation system involved segmenting customers to better understand the diverse shopping patterns within the CV. Talongka Jaya marketplace. Segmentation was performed using the K-Means Clustering algorithm based on customers' historical transaction data, which included variables such as purchase frequency, total transaction amount, average purchase value, and favorite product category. The data set used in this study consists of 500 active customers with a transaction history over the last six months. The optimal number of clusters was determined using the Elbow Method by analyzing changes in the Within-Cluster-Sum-of-Squares (WCSS) across different values of k.

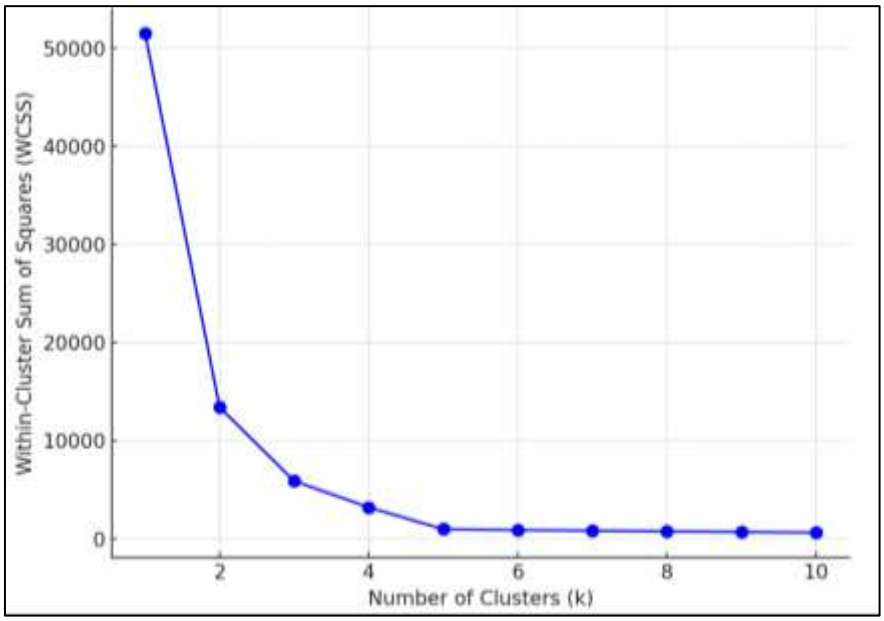

Figure 1. Elbow graph

The elbow graph indicated that k = 5 was the optimal point, as the decrease in WCSS became relatively small after k = 5, suggesting that five clusters provided an effective segmentation of the customers.

The clustering process produced five customer segments with distinct characteristics, summarized in the following table:

Table 1. Customer Clustering Results

Cluster	Number of Members	Purchase Frequency (Average)	Total Purchase Value (Average)	Favorite Product Category
1	125 customers	14 times	IDR 5,200,000	Household Furniture
2	100 customers	8 times	IDR 2,700,000	Kitchen Appliances
3	90 customers	4 times	IDR 1,200,000	Home Decorations

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4	95 customers	11 times	IDR 3,600,000	Office Furniture
5	90 customers	5 times	IDR 1,800,000	Stationery & Accessories

Cluster 1 consists of active customers with high purchase frequency and transaction value, particularly in household furniture products. They are the primary target for premium promotions and volume-based loyalty programs. Cluster 2 comprises regular customers who tend to prefer kitchen appliances. This segment is well-suited for targeted campaigns involving household product bundling. Cluster 3 represents seasonal customers who primarily shop for home decorations, usually aligned with specific moments such as religious holidays or year-end events. Cluster 4 includes customers from small businesses or office sectors who make routine purchases for office furniture. These customers can be targeted with business subscription programs or specialized after-sales services. Cluster 5 consists of customers with moderate purchase frequency focused on stationery and accessories, making them ideal candidates for quantity-based discounts or weekly promotions.

Clustering Visualization

The distribution of customers within the feature space was visualized using Principal Component Analysis (PCA) to reduce the data dimensions to two principal components.

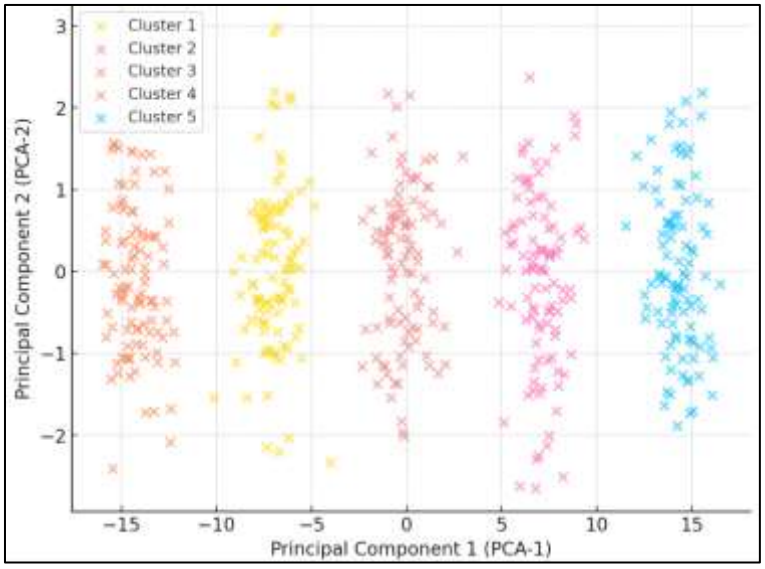

Figure 2. Scatter Plot of Customer Clustering Results

The scatter plot of the clustering results illustrates the distribution of the five customer clusters, with each color representing a different cluster. It can be observed that customers within the same cluster tend to exhibit similar purchasing behavior characteristics. This indicates that customer segmentation has successfully separated groups with homogeneous preferences.

Integration of Clustering into the Recommendation System

The segmentation results serve as the foundation for the recommendation system to tailor product and store suggestions to individual customers. For example, customers in Cluster 1 are predominantly recommended premium furniture products, while Cluster 3 is more focused on seasonal or event-related home decoration items.

The marketplace interface clearly demonstrates the results of this personalization. On the user dashboard upon login, the system displays:

List of Recommended Stores tailored to customer segment preferences, as shown on the "Store Recommendations" page.

ISSN: 2716-3865 (Print), 2721-1290 (Online)

Selected Products Based on Preferences derived from cluster analysis, as featured on the "Product Recommendations" page.

This approach not only enhances the relevance of recommendations but also has the potential to increase conversion rates and user loyalty. This is supported by research from Ratnawati, et al. (2024), which states that integrating customer segmentation into recommendation systems can significantly improve user engagement and purchase intention.

Hybrid Filtering Recommendation System Results

After segmenting customers using the K-Means Clustering method, the next step was to build a recommendation system capable of delivering personalized product and store suggestions to each customer on the CV. Talongka Jaya marketplace platform. To optimize the relevance of recommendations, a Hybrid Filtering approach was implemented, combining Collaborative Filtering (CF) and Content-Based Filtering (CBF). This approach was chosen to overcome the shortcomings of traditional methods, such as the cold start problem in CF and the limited generalization capability in CBF.

Recommendation System Implementation

The recommendation system was designed to serve two types of users: **guests** (non-logged-in users) and **logged-in users**. The recommendation flow is differentiated based on the user type, as illustrated in the diagram below:

For Guests: Guest users do not have transaction histories; therefore, the system utilizes Content-Based Filtering based on store features, such as main product categories, store location, and product popularity, to recommend the best stores. If available, the system also considers popular products based on the highest number of viewers (top viewers).

For Logged-In Users: For users who are logged in, the system can provide more personalized recommendations by utilizing their transaction histories. First, users are grouped based on their shopping behavior clustering results. Then, user preferences are combined with the results of Association Rule Mining (ARM) to identify relevant purchasing patterns. These results are integrated with Collaborative Filtering based on the user-item interaction matrix and Content-Based Filtering based on product and store features, resulting in a hybrid model with the following weighting scheme:

$$\boldsymbol{Hybrid\ Score} = \mathbf{0.7} \times \boldsymbol{Score_{CF}} + \mathbf{0.3} \times \boldsymbol{Score_{CBF}}$$

Users are then presented with a customized list of recommended products and stores tailored to their individual profiles and preferences.

System Interface Display

The implementation results of the recommendation system can be observed through two main interface displays on the Talongka Jaya marketplace:

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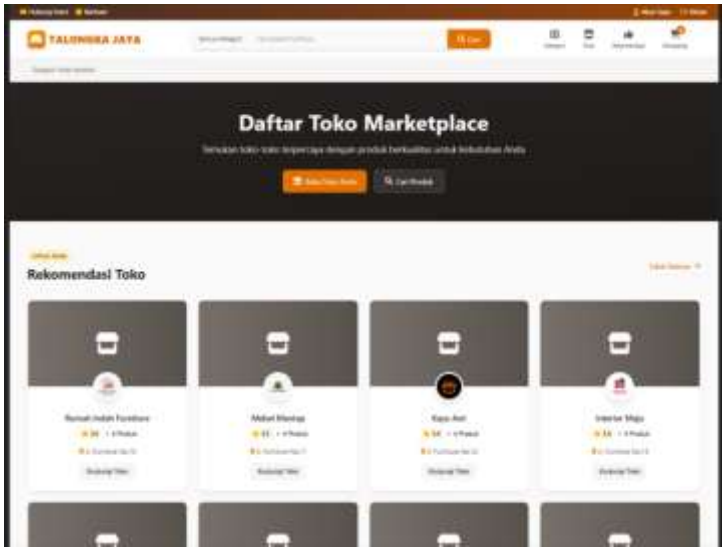

Figure 3. Store Recommendations for Guests and Logged-In Users

The system presents a list of recommended trusted stores to users based on feature analysis and transaction patterns. The interface displays information such as the store name, number of products, and average rating. This feature aims to facilitate users in finding stores that are relevant to their needs.

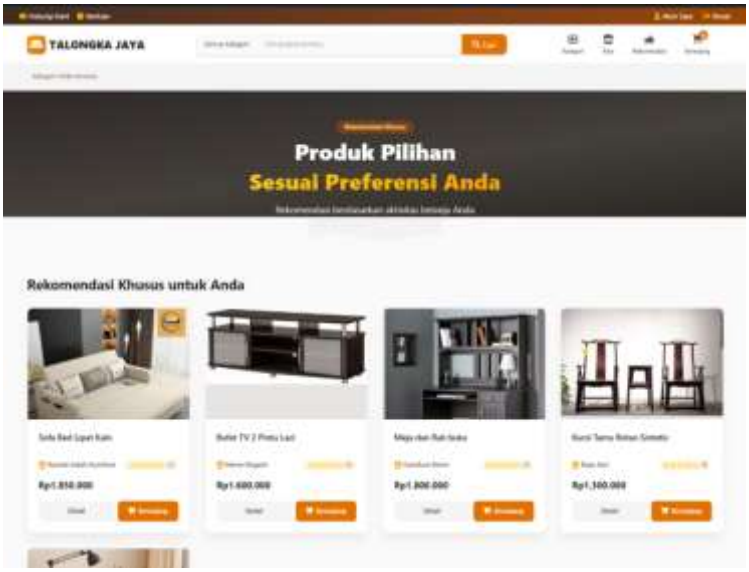

Figure 4. Product Recommendations for Logged-In Users

For users who are logged in, the system recommends selected products aligned with their shopping preferences. Product information includes the product name, price, store name, and quick actions such as 'Details' and 'Add to Cart.' This supports a more personalized and efficient shopping experience.

System Evaluation

The performance of the recommendation system was evaluated using Precision, Recall, and F1-Score metrics. The evaluation was conducted using 5-fold cross-validation on a dummy dataset of 500 customers. The system's performance was compared across Collaborative Filtering (CF), Content-Based Filtering (CBF), and Hybrid Filtering methods, as shown in the table below:

ISSN: 2716-3865 (Print), 2721-1290 (Online)

Table 2. Evaluation Results (Precision, Recall, F1-Score)

Metric	Collaborative Filtering	Content-Based Filtering	Hybrid Filtering
Precision	0.70	0.68	0.78
Recall	0.66	0.64	0.71
F1-Score	0.68	0.66	0.74

The results indicate that Hybrid Filtering achieves higher Precision, Recall, and F1-Score compared to single-method approaches, demonstrating that the combination of CF and CBF improves the accuracy and relevance of recommendations.

The application of Hybrid Filtering proved effective in enhancing recommendation relevance by combining the strengths of Collaborative Filtering in understanding user interaction patterns and Content-Based Filtering in capturing product and store attributes. Furthermore, integrating customer segmentation through clustering enables the system to deliver more targeted recommendations aligned with the shopping behavior of each customer segment. This finding is consistent with the study by Maristha, et al. (2021), which demonstrated that hybrid-based recommendation systems can enhance user retention and drive transaction growth in marketplaces.

This approach provides a competitive advantage for CV. Talongka Jaya by strengthening service personalization and increasing customer satisfaction on their managed marketplace platform.

Discussion

The results of this study indicate that the combination of K-Means Clustering and Hybrid Filtering approaches successfully enhanced the effectiveness of the product and store recommendation system on the CV. Talongka Jaya marketplace. Customer segmentation using K-Means Clustering effectively grouped customers into five clusters based on their shopping behaviors, such as transaction frequency, purchase value, and dominant product categories. This segmentation not only provided deeper insights into customer preferences but also served as the foundation for the personalization of product and store recommendations.

The success of clustering was demonstrated by the well-separated distribution of customers based on Principal Component Analysis (PCA). Each formed cluster exhibited distinct characteristics, enabling the system to deliver more targeted recommendations. For instance, customers with a preference for household products received store and product recommendations related to furniture, aligned with their purchasing patterns. This validates that clustering-based segmentation is effective in supporting the development of a more personalized recommendation system. In developing the recommendation system, the implementation of Hybrid Filtering yielded better results compared to standalone Collaborative Filtering or Content-Based Filtering approaches. Hybrid Filtering combines the strengths of CF, which utilizes user interaction history, with CBF, which leverages product attributes, effectively addressing cold start issues for new users and new products. With an optimal weight combination (0.7 for CF and 0.3 for CBF), the system achieved a Precision of 0.78 and an F1-Score of 0.74, outperforming the individual methods. These results are consistent with findings from Sibuea et al. (2024), who stated that hybrid models generate more relevant recommendations and improve user engagement.

The implementation of the system in the marketplace interface visibly demonstrates the benefits of this approach. For guest users, the system displays a list of recommended stores based on the most popular store features and product categories. For logged-in users, the system presents personalized product recommendations based on their transaction history. These recommendation displays are designed to facilitate users in finding suitable products

ISSN: 2716-3865 (Print), 2721-1290 (Online)

and stores, enhancing shopping efficiency and user experience (Zimmermann et al., 2023; Aparicio et al., 2022; Özmen et al., 2022; Kushendriawan et al., 2021).

Additionally, the integration of Association Rule Mining (ARM) into the recommendation system for logged-in users adds value by identifying frequently co-purchased product patterns, enriching the recommendations generated by the hybrid model. This contributes to higher transaction conversion rates, as the suggested products are relevant both individually and associatively to the user's purchasing preferences. Overall, the implementation of a recommendation system based on clustering and hybrid filtering at CV. Talongka Jaya's marketplace demonstrates that data mining and machine learning-based approaches can serve as effective solutions for enhancing service personalization. These findings also contribute academically by reinforcing previous studies that emphasize the importance of personalization in boosting customer loyalty and transaction volumes on e-commerce platforms.

However, this study also has several limitations. First, the data used are historical and do not incorporate real-time updates, limiting the system’s responsiveness to changes in user behavior. Second, the model does not yet integrate external variables such as seasonal trends, promotional events, or emerging product trends, which could further enrich the quality of recommendations. Therefore, future research could develop models using deep learning-based sequential recommendation approaches to more adaptively and dynamically capture user behavior patterns in real time.

Conclusion

This study manages to come up with a product and store suggestion system using a hybridization of both the K-Means Clustering and the Hybrid Filtering on the CV. The Talongka Jaya market place is located within the Bandung city. It is about 20 meters away. K-Means Clustering algorithm can successfully be used to cluster customers into five segments, which reflect their shopping behaviors in terms of variables of frequency of purchase, amount of money being spent, and other products categories they buy. Such optimization has been demonstrated to have the capacity to make the recommendation system more personalized in that each cluster receives recommendations on products and store within their respective needs.

The evaluation gives better results with the use of Hybrid Filtering that combines both Collaborative Filtering (CF) and Content-Based Filtering (CBF) than using either of the one separately. A combined weight of 0.7 to CF, and 0.3 to CBF can result in the precision of 0.78 and F1-Score of 0.74 which means that the propositions of the model are more accurate, and relevant. The use of Association Rule Mining (ARM) incorporated into the recommendation system of logged-in users also enhances the product that is suggested in more complicated association patterns having more developed and efficient shopping experience. The system is also made to have two different approaches to the guests and logged-in guests. Not logged-in visitors receive recommendations based on the study of the properties of stores and popular products, and logged-in users get personalized recommendations by their transaction history and preferences. This not only enhances the effectiveness of search of the relevant goods, but also helps in the rise of transaction conversion rates and level of loyalty.

Despite the obtained results indicating an improvement in the work of the recommendation system, this work has some limitations. The historical information on which the data is still based is still not updated to the real-time data, external factors (seasons or product trends) have not been taken into account. Therefore, further research is recommended to integrate a deep learning approach based on sequential recommendations to improve the system's ability to capture user behavior dynamics adaptively and in real-time. Overall, this study provides a real contribution to the development of a data mining and machine learning-based

ISSN: 2716-3865 (Print), 2721-1290 (Online)

recommendation system in the Indonesian MSME marketplace environment, as well as strengthening academic literature related to effective and adaptive personalized recommendation systems.

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