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Data Mining Analysis of Commodity Distribution in Central Aceh Through an Integrated Auction Market System Using the Android-Based Association Rule Mining Method

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Abstract

Commodity distribution in Central Aceh faces inefficiencies due to lengthy distribution chains and limited price control, often leading to higher consumer costs and lower farmers' profits. To address these issues, this study develops an integrated auction market system based on Android, utilizing the Association Rule Mining (ARM) method to optimize the distribution and pricing of commodities. ARM is a data mining technique that uncovers high-frequency patterns in transaction data. By applying ARM with the apriori algorithm, the system identifies key associations among commodities, allowing for more efficient and targeted price recommendations. The system calculates the highest bid for each commodity and recommends optimal pricing strategies to sellers based on frequent pattern analysis, improving transparency and reducing distribution inefficiencies. Testing and implementing this system indicate that it successfully lowers distribution costs while increasing the effectiveness and speed of the auction process. Overall, the Android-based auction market system shows promise as a tool for enhancing distribution efficiency, optimizing bid values, and supporting local economies in Central Aceh through more equitable commodity pricing. The final result of this process resulted in four association rules based on predefined parameters, namely a minimum support of 20% and a minimum confidence of 50%. These rules indicate that 60% of the Integrated Auction Market system transactions, including Cassava, also include Carrots. In other words, a bidder who buys Cassava has a 60% probability of buying Carrots. This rule is significant as it shows that 20% of all transactions recorded in the system contain both items. This analysis provides important insights into the relationship patterns between items that can be used to provide item recommendations based on purchasing patterns.

Keywords: *Data Mining, Association Rule Mining, Commodity Distribution, Android Studio, Apriori Algorithm.*

1. Introduction

The length of the distribution chain for essential goods in Aceh Tengah still faces several challenges that can be addressed through a commodity auction market mechanism. By controlling distribution more efficiently, it is estimated that household expenditures on food can be better managed. Consequently, household expenses can be reduced, especially for low-income and extremely low-income families. One issue that drives up costs in the distribution chain is the mug (intermediaries) travelling from house to house to collect goods or the multi-level distribution process in the marketing chain. Additionally, frequent occurrences of overproduction often lead to very low selling prices at the farmer level. Therefore, an efficient system is needed to optimize the distribution of commodities in Aceh Tengah to enhance both the quality and quantity of distribution.

Data mining technology can be utilized to determine the priority types in commodity distribution. This study employs the Association Rule Mining (ARM) method, one of the data mining techniques used to identify associative rules between item combinations. One aspect of associative analysis that has gained significant attention from researchers is frequent pattern mining, which aims to develop efficient algorithms. In general, associative rules are written as LHS => RHS, where LHS and RHS represent sets of items. If all items in LHS appear in a transaction, then the items in RHS also appear. These associative rules are usually expressed in equations.

The application of data mining in the Integrated Auction Market System (*Sistem Pasar Lelang Terpadu* or SPLT) involves implementing the association rule mining method using the Apriori algorithm to determine the highest bid value within the SPLT. This aims to increase farmers' selling prices and optimize commodity distribution in Aceh Tengah [1].

2. Literature Review

2.1. Data Mining

Data Mining is the process of discovering useful information from large databases. It can also be defined as extracting information from vast data to support decision-making[2]. In the context of commodity distribution, data mining helps understand distribution patterns and market behaviour for commodities in Central Aceh. Data mining is defined as a set of processes helpful in exploring and searching for values in the form of information and complex relationships that have been stored within a database. By extracting information patterns from data, it becomes possible to manipulate data into new, more helpful information obtained by extracting and recognizing valuable or interesting patterns found within the database [3]. From various perspectives, data mining is a field of knowledge that can be divided into characteristics, discrimination, association, classification, clustering, trends, and outliers. Techniques in data mining include databases, machine learning, statistics, and visualization. The data types used include relational, transactional, multimedia, web, and text data [4].

There are several essential things associated with data mining, including:

1. Data mining is an automated process that makes predictions based on available information.
2. The data to be analyzed is a group of complex data.
3. Data mining aims to identify relationships that can produce helpful results[5].

2.2. Data Mining Classifications

1. Describe patterns and trends in data to provide insights, such as the relationship between the level of professionalism and support in elections.
2. Estimation is similar to classification, but the target variable is numeric, which is predicted based on other variables.
3. Prediction: Predict future values using classification and estimation techniques.
4. Classification Grouping data into categories, such as high, middle and low income.
5. Clustering Grouping objects with similar characteristics without specific target variables.
6. Association Analyzing relationships between attributes often co-occur, such as in market basket analysis.[6]

2.3. Architecture of Data Mining

The central architecture of data mining, according to Fernando[7], consists of:

1. Data Storage In the form of a database, data warehouse, or other format as a source of information.
2. Data Search Retrieving relevant data according to user requests.
3. Knowledge Base: A knowledge base that helps search for specific patterns.
4. Mining Engine Function modules for characterization, classification, and clustering based on algorithms.
5. Pattern Evaluation Evaluates and finds relevant patterns in data mining.
6. GUI (User Interface) User interaction facility with the system to manage the data mining process.

2.3. Apriori Algorithm

The Apriori algorithm is a data mining algorithm that utilizes association rules by meeting the support and confidence thresholds. It formulates association rules using parameters to determine relationships between item combinations that meet the minimum criteria for support and confidence values[8]. The Apriori algorithm is a data mining method that explores data in a structured manner without needing to examine all candidate itemsets. In the next step, this algorithm extracts strong association rules. Frequent itemsets are groups of items that frequently appear together in transactional data. For example, items A and B are often purchased together in a retail store. After identifying frequent itemsets, the algorithm continues by further analyzing the knowledge derived from the previously found frequent itemsets to extract additional information. The Apriori algorithm applies an iterative approach with a level-wise search, where a k-itemset is used to find a (k+1)-itemset[9]. The a priori algorithm is divided into several steps known as narratives. The steps are as follows:

1. Formation of candidate itemsets. The k-itemset candidates are created from the (k-1) combination of itemsets generated from the previous iteration. The method in the apriori algorithm is to prune the k-itemset candidates where the subset has k-1 items that do not belong to a high-frequency pattern of length k-1.
2. Calculation of support for each candidate k-itemset. The support of each candidate k-itemset is obtained by scanning the database to count the number of transactions that contain all items in that candidate k-itemset. This characteristic of the a priori algorithm requires counting for the entire database for the longest k-itemset.
3. Determine high-frequency patterns. A high-frequency pattern that includes k items or k-itemsets is determined from the candidate k-itemsets with more significant support than the minimum support.
4. If a new high-frequency pattern is not found, all processing is terminated[10].

2.3. Association Rule Mining

Association Rule Mining is a data mining method that finds associative rules between items frequently appearing together in transactions. ARM is crucial for identifying item relationships, which helps generate pricing and bidding recommendations within the auction system[11]. Association analysis, or association rule mining, is a data mining technique aimed at discovering patterns of association rules between combinations of items. The primary step in association rules is identifying how often item combinations appear in the database, commonly referred to as frequent patterns. There are two references in association rules:

1. Support: the number of transactions containing a particular itemset or the frequency of occurrence of the itemset.

2. Confidence: the certainty value, which indicates the strength of the relationship between itemsets. Confidence can be determined once the frequent pattern of an itemset's occurrence is found[12].

Association Rule Mining (ARM) consists of frequently occurring items that generate strong association rules in a specific format. These rules also meet the minimum confidence threshold. Associations can be further analyzed to reveal statistical correlation rules between itemsets A and B. ARM is considered a data mining technique that does not rely on assumptions and can uncover meaningful hidden relationships within large datasets[13].

2.4. Marketing Strategy

Digital technology has changed how people interact, act, and make decisions. Marketing activities are also inseparable from the impact of digital technology. Digital marketing has evolved from the original activity of selling goods and services through digital channels to a more comprehensive definition, which is attracting consumers, building consumer favourability, marketing brands, retaining consumers, and increasing sales[14]. Marketing strategy plays a crucial role because no matter how good the segmentation, target market, and market positioning are, they will be useless without a suitable strategy. Instead, marketing strategy is the key to attracting as many consumers as possible. In addition, the purpose of the marketing strategy also serves to counter attacks from existing and future competitors. The implementation of a marketing strategy, also known as a marketing mix strategy, consists of four elements, namely:

1. product strategy
2. price strategy
3. location or distribution strategy and
4. promotion strategy[15].

In general, there are three types of targets in market selection, namely mass marketing (undifferentiated marketing), which is usually applied in situations where customers have similar characteristics, and targeted marketing (differentiated marketing), which divides the market into groups of customers with slightly different wants and needs. Niche marketing (concentrated segmentation marketing) emphasizes a relatively small number of customers in the market or consumers with specific characteristics [16]

2.5. Commodity Distribution

The logistics service business is one of the business fields that is now experiencing rapid growth, along with the increasing needs of society and the advancement of increasingly sophisticated technology. The role of logistics companies in Indonesia will also continue to grow due to improvements in economic growth. This development must be supported by efforts to achieve an effective and efficient logistics system. The success is influenced by the condition of Indonesia, which has 17,504 islands, 225 million people, and abundant natural resources such as oil, gas, coal, and palm oil. The diversity of Indonesia's commodity potential also provides opportunities for the logistics industry. This situation shows Indonesia is a promising market thanks to its rich resources.[17]. The marketing system of food products is closely related to the way prices are set at the farm level as well as at the consumer level. A price-taker attitude is generally taken for producers and consumers, while the existing market price is determined by a number of intermediary traders who play with the price. Problems that make the marketing system of agricultural products inefficient include weak market infrastructure and information, small farm size, lack of understanding of grading and handling by marketing actors, high transaction costs, and lack of effective marketing policies. A marketing system is considered efficient if all marketing activities that include commodity collection at the farm level, commodity packaging, transport, processing, and distribution (wholesaling and retailing) are done at minimal cost[18]

2.6. Auction

An auction is a system for buying and selling goods or services by bidding for bids, which allows people to bid and sell to the highest bidder. Bidders compete against each other, with each subsequent bid higher than the previous one. Once the item is offered for sale, the auctioneer will start at a reasonably low price to attract bidders. The price increases each time someone makes a new, higher bid until no other bidder is willing to bid higher than the last bid, and the highest bidder gets the item. The auction is complete when the seller accepts the highest bid awarded, and the buyer pays for the goods or services and picks them up[19].

2.7. Android Studio

Android is an operating system for mobile phones based on Linux. Android offers an open platform for developers to create applications for various mobile devices. Initially, Google Inc. bought Android Inc., a start-up company that developed software for mobile phones. Android Studio is an IDE for developing Android-based applications using Java and XML. Android Studio is the official integrated development environment (IDE) for creating Android applications, and it is based on IntelliJ IDEA. In addition to being a code editor and IntelliJ's developer features, Android Studio provides various tools that increase efficiency when developing Android apps[20]. To develop apps in Android Studio, we need to be proficient in the Java/Kotlin programming language and understand object-oriented programming (OOP) and Gradle. The skills required to do well in Android app creation and development include UI/UX design, rigour, marketing skills, problem-solving, analysis, cybersecurity, and creativity. The sector offers ample job opportunities, so delving into this field is promising. Features in Android Studio include how to create a new project, various types of minimum SDKs and their functions, the structure of Android Studio projects, such as manifest files that contain application information, activities as the main component that manages user interaction with the application, layouts which are codes for creating application interfaces using XML, drawables that store assets for applications, and values that store colours, strings, and even themes for applications. In addition, there is also an Android Virtual Device that functions as an Android device emulator to test applications created without the need to use a physical device [21].

3. Research Method

3.1. Place and Research Period

In this study, the authors took data from the Central Aceh Cooperative and UMKM Office and the Central Aceh Agriculture Office in February 2024. This research location makes it very easy for researchers to collect data and references for the system to be built so that this research can run well.

3.2. Research Steps

1. Data collection
   In collecting data for this study, the authors sought data directly from the Central Aceh Cooperative and UMKM Office and the Central Aceh Agriculture Office; the authors took data in February 2024.
2. Literature Study
   A literature review must be done before starting any research. The literature review for this research was carried out by reading articles, journals, and online journals, as well as references from student final assignments related to the Association Rule mining approach.
3. Performing Data Analysis
   After the data has been collected, it will be managed using the Association Rule Mining method.
4. Database Design
   Designing a database on Commodity Distribution data using MySQL database.
5. Interface Design
   Designing a system or application that uses Java and Android programming.
6. System Implementation
   The design results using the Association Rule Mining Method are implemented to get the maximum or highest bid value in the SPLT application.
7. System Testing Stages
   At this point, testing the system created is very helpful in determining whether it is functioning as it should.

2. Result and Discussion

Implementing an auction application using the Association Rule Mining (ARM) method aims to maximize bidding and selling strategies in an auction by utilizing patterns of purchasing and bidding on items. Association Rule Mining, a subset of data mining, works by identifying patterns and relationships between items in a transaction, which in the context of an auction can be products that are often bid on together or prices that are usually the point of a particular bid. In auction applications, ARM can be used to understand and predict bidders' behaviour, provide insight into optimal items, and increase bidding value.

4.1. System Implementation

4.1.1. Seller Page Form

Fig 1. Seller Page Form (Indonesia)

The main page for sellers in the Central Aceh Integrated Auction Market Application provides quick access to core features, namely Item Auction to manage auction items, Item Data to view or update item information, About to find out brief information about the application, and Logout to exit the account. A simple and consistent interface design with informative icons makes it easy for sellers to navigate, ensuring quick access to essential functions in a visually appealing and auction-themed setting.

4.1.2. Buyer's Main Page

Fig 2. Buyer's Main Page (Indonesia)

The main page for buyers in the Central Aceh Integrated Auction Market Application displays several main menus that facilitate navigation, namely the List of Goods to view items available in the auction, List of Bids to monitor bids that have been submitted, About for information about the application, and Logout to log out of the account. The simple design and clear icons make it easy for buyers to find the desired features, with a consistent and brightly coloured display for visual comfort.

4.1.3. Product List Page

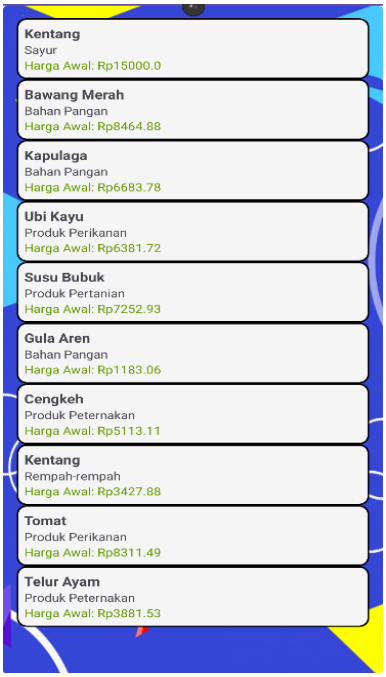

Fig 3. Product List Page (Indonesia)

On this page, users can view the various items available for auction, complete with item category information and starting price. Each item is listed, displaying the item name, product type (such as vegetables, food, agricultural products, etc.), and starting price in an easy-

to-read format. This makes it easy for users, especially buyers, to evaluate items that interest them before bidding. Its neat and consistent design with bright background colours helps users comfortably browse through the list of auction items.

4.1.4. Bid List Page

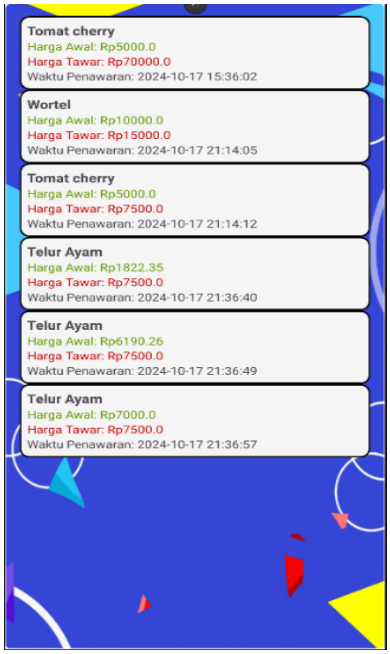

Fig 4. Bid list Page (Indonesia)

This image displays the Bid List page in the Central Aceh Integrated Auction Market Application, which details the various bids buyers submit for each auction item. Each item shows the Item Name, Starting Price, Bid Price, and Bid Time. This information helps users, both buyers and sellers, to monitor the progress of bids received for each item in real time, including the amount and time of each bid. This structured and informative design makes it easy for users to quickly evaluate the bidding status, ensuring transparency in the auction process.

4.1.5. Transaction Data Page

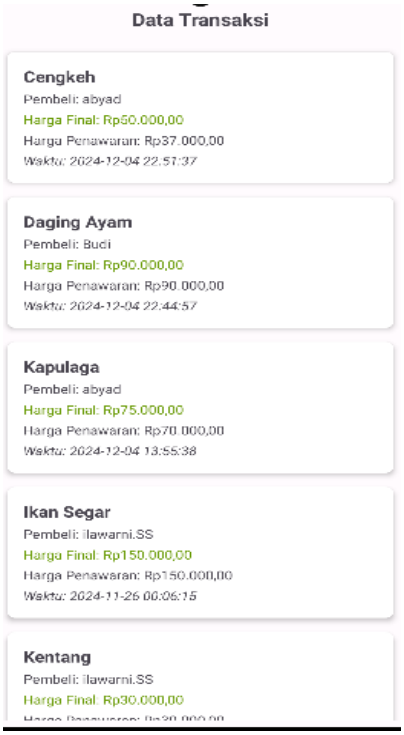

Fig 5. Transaction Data Page (Indonesia)

This image shows the Transaction Data page in the Central Aceh Integrated Auction Market Application; this page records the details of each transaction in the system, with information columns such as Item Name, Buyer Name, Bid Price, Final Price, and Transaction Time. This transaction data helps users, both buyers and sellers, track the purchase history and final price of items that have been successfully

auctioned. The systematic and structured display makes it easy for users to view transaction details thoroughly, supporting transparency and auditability in the Auction system.

4.1.6. Analysis Result Page

Fig 6. Analysis Result Page (Indonesia)

This figure shows the Support and Confidence page on the Central Aceh Integrated Auction Market Application. This page displays analysis related to auctioned items, with information including Item Name, Price, Support, and Confidence. The Support column shows the percentage of times the item appears in auction transactions. In contrast, Confidence shows the level of Confidence that the item will sell or sell based on existing transaction data. This structured view makes monitoring market trends in the Auction system easy.

4.2. Implementation of Association Rule Mining (ARM)

In the implementation of the association rule mining method in this research. The author uses 102 transaction data on the auction market entered into the database.

1. The first step is to compile a list of transactions based on the items bid by each bidder. The following is the data used in this study.

Table 1. Implementation Of Association Rule Mining

No	Name of Item	Bidder Name	Price
1	Cassava	Nuraini	50000
2	Shallot	Arjuna	30000
3	Cherry Tomato	Win G Hana	25000
4	Carrot	Darman	35000
5	Cardamom	Harun	45000
6	Carrot	Nasrul	20000
7	Potato	Fauzi	15000
8	Shallot	Darman	30000
9	Carrot	M Yamin	20000
10	Cherry Tomato	Lasinan	25000
….	…….	……..	……..
95	Ground Coffee	Ilawarni SS	35000
96	Potato	PM	25000
97	Cherry Tomato	Saptiah	25000
98	Red Chili	Arman	55000
99	Palm Sugar	Hidayat	60000
100	Chicken Egg	Lek Eong	40000
101	Shallot	Wagino	30000
102	Potato	Baharuddin	25000

2. Next, the data will be grouped based on the bidder's name by listing the items bid by each bidder. This grouping is done to facilitate the data analysis and processing process.

Table 2. Bidder Transaction History

No	Name of Bidder	Bargained Items	Total Price
1.	Abyad	Shallots, Carrots, Cassava, Potatoes	130000
2.	Alfian	Ground Coffee, Carrot, Cardamom	85000
3.	Anwar	Potatoes, shallots, chicken eggs, red chilli peppers	140000
4.	Ardodi	Shallots, Carrots, Ground Coffee	85000
5.	Arjuna	Red Onion, Red Chili, Cherry Tomato	110000
…..	……	…….	…….
28.	Saptiah	Carrot, Gula Aren, Cherry Tomato	105000
29.	Wagino	Cherry Tomato, Potato, Chicken Egg, Red Onion	80000
30.	Win G Hana	Cherry tomato, palm sugar, chicken egg	160000

3. Next, a tabular table will be created to calculate the number of transactions. This can make it easier to calculate the support value for each item. This transaction data tabular can be seen in the following table:

Table 3. Transaction Tabular

Potato	Carrot	Cherry Tomato	Shallot	Chicken Egg	Cardamom	Cassava	Red Chili	Palm Sugar	Ground Coffee
1	1	0	1	0	0	1	0	0	0
0	1	0	0	0	1	0	0	0	1
1	0	0	1	1	0	0	1	0	0
0	1	0	1	0	0	0	0	0	1
0	0	1	1	0	0	0	1	0	0
…..	…..	…..	……..	…….	…	…..	…..	……	……
1	0	1	1	1	0	0	0	0	0
0	0	1	0	1	0	0	0	1	0
10	**15**	**14**	**10**	**12**	**8**	**10**	**11**	**7**	**5**

Table 4. Data Support

Itemset Name	Support Antecedent %	Support Item %	Confidence %
{Potato} → {Red Onion}	33,333334	20	60
{Shallot} → {Potato}	33,333334	20	60
{Carrot} → {Cherry Tomato}	50	20	40
{Cherry Tomato} → {Potato}	46,666667	20	42. 857143
{Cassava} → {Carrot}	33,333334	20	60
{Carrot} → {Cassava}	50	20	40
{Cherry Tomato} → {Chicken Egg}	46,666667	20	42. 857143
{Chicken Egg} → {Cherry Tomato}	40	20	50

Because the minimum confidence value applied is 50%, items whose confidence value is less than 50% will be eliminated. The final results of the final calculation can be seen in the table below.

Table 5. Combination Of 2 Itemset

Itemset Name	Support Antecedent %	Support Item %	Confidence %
{Potato} → {Shallot}	33,333334	20	60
{Shallot} → {Potato}	33,333334	20	60
{Cassava} → {Carrot}	33,333334	20	60
{Chicken Egg} → {Cherry Tomato}	40	20	50

The final result of this process produces four association rules based on predefined parameters, namely a minimum support of 20% and a minimum confidence of 50%.

4. Conclusion

The Android-based Integrated Auction Market System (ISMS) was successfully developed as a digital platform that facilitates commodity distribution through auction mechanisms, enabling more efficient, transparent, and structured transactions by connecting sellers, buyers, and quality assurance in one system. The Association Rule Mining (ARM) method is applied to analyze bidding data, determine the highest bid, and recommend products with high demand based on itemset relationship patterns so that the auction process can run faster and increase competitiveness. The test results show that 60% of the transactions that list Cassava also list Carrots, indicating a strong link between the two products. This rule provides insight for the system in determining price and product recommendations based on purchasing patterns so that the auction can run more optimally.

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