Sales Display Re-layout Based on Analysis of Item Sets Pattern Using Combination of Complete Linkage Hierarchical Clustering Method and Association-Rule Method with Apriori Algorithm

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Abstract

PT XYZ Furniture Store is a household furniture retail industry with more than 200 types of items. The main problem at PT XYZ Furniture Stores is product placement done indiscriminately, resulting in decreased consumer satisfaction when shopping. This study aims to identify patterns of sales transactions using a combination of clustering methods and association rules. The method used in this research is a complete linkage and apriori algorithm to determine the optimal sales transaction pattern. Meanwhile, the preparation of the product layout uses an activity relationship chart to determine the qualitative relationship between products. The resulting shows six optimal rules that can be used for improving product layout at the firm. The change in the distance also indicates it after a repair that is shorter than before the repair.

Keywords
Complete Linkage, Association Rule, Apriori Algorithm, Sales Transaction Pattern, Product Layout

1. Introduction

In the current digital era, marketing is developing very rapidly, especially in the retail industry. The high level of public consumption of daily needs makes the retail industry one of the industries heavily invaded by the wider community. As a result of these conditions, the retail industry must compete with similar competitors by developing a higher-quality marketing strategy. Business owners must have the best solution to run a retail business during today's high competition. A good marketing strategy can be seen from various aspects, one of which is product layout.

PT XYZ furniture store is one of the industries engaged in the retail of household furniture. There are more than 200 types of products, and the more dominant are food packaging products, cooking utensils, and plantation tools. Every day there is an average of 375 items sold. In contrast, the current layout is arranged in an irregular manner (random) which causes reduced consumer convenience in buying products. Consumers will take longer if the product layout is not arranged based on current sales trends. Knowing new information related to consumer spending behavior patterns can help business people find out the types of products that sell quickly and make more optimal product layouts. This strategy will create easy access for consumers to find the products they want to buy.

Therefore, to overcome these problems, data mining is used to find patterns of sales transactions that follow sales data trends from November 2020 to January 2021. Data mining is considered as a structured extraction of a set of data that complements the manual method used. very prone to data processing errors in research (Kurniawati, 2014). In addition, using data mining will save more on data processing even though the data is significant. In this

study, data mining begins by grouping sales transaction data using the complete linkage hierarchical clustering method.

The hierarchical clustering method is one of the clustering methods arranged in a branched manner similar to a hierarchical tree with the farthest reference distance to form the same group. (Ramadhani, et al, 2018). The clustering method will help in trimming so that fewer data variations are obtained. By applying the complete linkage hierarchical clustering method, the best group will be sought, which results will later be input to the association rule process (determination of sales transaction patterns).

The association rule method is considered to determine the pattern of sales transactions (rule) based on the minimum confidence and minimum support values. (Mulya, 2019). One of the association rule algorithms used in this study is the Apriori Algorithm. The apriori algorithm is an algorithm that is easy to apply in determining high-frequency patterns between itemsets. In addition, the apriori algorithm is more widely applied to the retail industry, such as supermarkets and e-commerce. Based on the pattern of sales transactions generated, the next step will be to prepare the product layout by considering quantitative and qualitative proximity (Andari, et al, 2013). Quantitative closeness can be seen from the final result of the association rule process. In contrast, qualitative closeness can be analyzed with the help of activity relationship chart (ARC) tools. The activity relationship chart (ARC) is one of the tools used in compiling the layout of products and facilities based on the reasons for the relationship and the degree of proximity (Permatasari, et al, 2020). Considering these two aspects will provide optimal layout recommendations so that they can be more effectively applied at PT XYZ Furniture Stores.

This research arises because PT XYZ Furniture Store does not have an optimal layout arrangement system and seems irregular. So this causes consumers to take longer to find the desired paired product. Therefore, the combination of clustering and association rules is expected to produce a more accurate pattern of sales transactions with a minimum of data variation. The resulting transaction pattern will later be used as a recommendation for the preparation of product layouts at the PT XYZ Furniture Store.

1.1 Objectives

Based on the background discussed above, the research objectives include:

a. Determine the cluster in the sales transaction data of PT XYZ Furniture Store.

b. Determine the pattern of sales transactions between item sets at PT XYZ Furniture Store

c. Improving the layout of product placement based on the results of the formed transaction pattern.

2. Literature Review

2.1 Sales Theory

According to Gusrizaldi and Komalasari (2016), Sales are activities to move goods or services as a final provision to maintain company stability based on the profits obtained. Sales have become an essential part of the industrial world. It is because, through sales activities, profit will be obtained to maintain the sustainability of the company. The higher the frequency of sales, the higher the level of profit or profit will be.

2.2 Data Mining

According to Wirdasari and Calam (2011), Data Mining or Knowledge Discovery in Database (KDD) is a structured technique with a computerized system to find important information in the database. So that exciting information is obtained that was not detected before. In everyday life, data mining is needed to solve the problem of collecting data with substantial sizes and dimensions and heterogeneous data automatically using electronic devices.

2.3 Clustering Analysis

Clustering in data mining solves a problem by grouping an item based on the similarity between item sets. According to Maysaroh (2015), The clustering method is a way of grouping data into several clusters, aiming to produce maximum dissimilarity between clusters with the minimum similarity between each object. The Clustering method is included in unsupervised learning. This is because clustering does not have a label for each class so that it is directly grouped based on the characteristics it has.

2.4 Complete Linkage Hierarchical Clustering

The complete linkage hierarchical clustering method is a technique for grouping multivariate statistics based on the furthest distance between several previously formed clusters. The search for the farthest distance involves clusters with a maximum similarity matrix between objects (Ningsih, et al, 2016). Grouping on complete linkage hierarchical clustering begins with determining the shortest distance in the data and then forms a new matrix

based on the furthest distance of each object. Objects that have the new farthest distance matrix will then be grouped in the same cluster. Several steps that can be taken to achieve Complete Linkage Hierarchical Clustering include the following processes (Laraswati, 2014):

a. Data Standardization
b. Determination of Similarity Size
c. Complete Linkage Hierarchical Clustering Analysis
d. Determination of the Number of Cluster Members

2.5 Association Rule

Association Rule is a method of Data Mining that is used to determine relationships/patterns that often occur between itemsets. The transaction data used must have at least two items in one transaction. This is because the association rule uses the if and then the pattern, meaning that when buying product X, it is also will buy product Y (Latifah, et al, 2018).

2.6 Apriori Algorithm

The Apriori algorithm is a technique that exists in the association rule to facilitate the process of searching for high-frequency patterns in the items studied. The Apriori algorithm is often applied to supermarkets, banks, hospitals, to e-commerce to offer information from patterns obtained following association rules (Nursikuwagus & Hartono, 2016). The use of a priori algorithm benefits the industrial world, such as making it easier to do product layout, arranging product promotions from the information obtained, and showing recommendations for combinations between itemsets to be used as references for reference sales strategies.

2.7 Layout

According to Arifianti (2016), determining the layout is related to the structured arrangement of materials, products, facilities, and tools for an efficient production process and flow. Dynamically designed layouts provide convenience for consumers when shopping for daily necessities and help businesses maintain their business.

2.8 Activity Relationship Chart

Activity Relationship Chart (ARC) is one of the methods used to determine company facilities' layout. According to Permatasari, et al (2020) ARC is a tool to arrange the layout of products/goods/facilities based on the close relationship. The reasons for quality can be in the form of environmental conditions, the condition of the goods, or the chemical properties of the object. This method is composed of 2 indicators, namely the degree of proximity and the symbol of proximity between objects.

3. Methods

The data in the study were collected quantitatively. Where used is sales history data for three months, from November 2020 to January 2021. The amount of data collected is 7,193 transactions. In addition, observations and interviews directly with employees and shop owners to obtain more detailed information on the buying and selling process at PT XYZ Furniture Stores.

Observations are carried out as direct observations of shop-buying transaction activities and see how employees arrange product layouts. Meanwhile, interviews were used to collect sales activity information by asking business owners and employees questions. The interview results are in the form of information related to products that consumers purchase, the current condition of the product layout, and the process of recording purchases. All information obtained from the interview process will be written down in writing.

The variables used in this study were 241 items sold at PT XYZ Furniture Stores. Furthermore, these 241 variables will be trimmed by selecting a clustering process, which produces more sales transaction patterns based on the optimal cluster.

The stages of data processing are carried out by two main methods, namely clustering and association rules. The first step is the clustering process with the complete linkage method (farthest distance) to group sales transactions into several clusters. The best class is selected based on the calculation of the silhouette average. The next best cluster will be the input for the association rule process, which is processed with the concept of an apriori algorithm that considers the minimum support and minimum confidence. Consumer shopping habits at PT XYZ Furniture Stores will obtain transaction patterns from the association rule process.

The last stage is the refinement of the results of the association rule. A qualitative closeness analysis is carried out using an activity relationship chart to determine the relationship between products based on similarity in type and

use. The results of the activity relationship chart will be linked with the results of the association rule so that the optimal layout proposal will be obtained to be applied at the PT XYZ Furniture Store.

4. Data Collection

The data selection is carried out according to the amount of data in the history of retail sales transactions. The data in this study is sales transaction data from November 2020 to January 2021, with 7,193 transactions. In addition to sales transaction data, item placement is also collected to be compared with the proposed layout based on the formed pattern. The selected data will be cleaned of noise and duplication by eliminating transactions containing only one sales item. The cleaning phase resulted in clean data of 5,508 transactions.
Furthermore, the distance calculation is carried out following the complete linkage hierarchical clustering formula. At this stage, the most optimal cluster group will be selected. The optimal cluster will be the input for the association rule process. At the association rule stage, a priori data pruning algorithm is needed to get product pairs that meet the minimum support and minimum confidence rules. The results of the association rule are then compiled in a proposed layout using an activity relationship chart (ARC).

5. Results and Discussion

5.1 Numerical Results

The estimation of the optimal number of clusters is seen from the value of the largest ratio of distance measure (Widaningsih & Suheri, 2018). Based on Table 1, the most significant ratio of distance measure is in the 2-cluster with a value of 1.259. That is the most optimal number of clusters in the two groups. However, before using the 2-cluster results as input for the association rule process, an experiment must be conducted to find out the members of each group. If further analyzed in 2 groups, cluster 1 has 45 members, while cluster 2 has 47 members. Meanwhile, the 2-cluster involve all variables, namely 241 products sold at PT XYZ Furniture Stores. Therefore, 2-cluster cannot be used as input for the association process because it is not by the purpose of clustering in this study to minimize data variation. Thus, a re-experiment was carried out on the estimated number of clusters with the following most significant ratio of distance measure value.

Table 1. Estimated Number of Clusters

Number of Clusters	*Schwarz's Bayesian Criterion (BIC)*	*BIC Change*[a]	*Ratio of BIC Changes*[b]	*Ratio of Distance Measures*[c]
1	18670,625			
2	20355,389	1684,765	1,000	**1,259**
3	22226,341	1870,952	1,111	1,207
4	24220,713	1994,373	1,184	**1,213**
5	26319,939	2099,226	1,246	1,123
6	28473,029	2153,090	1,278	1,113
7	30670,606	2197,576	1,304	1,100
8	32903,978	2233,372	1,326	1,037
9	35150,078	2246,100	1,333	1,021
10	37403,359	2253,282	1,337	1,054
11	39673,829	2270,469	1,348	1,003
12	41945,164	2271,336	1,348	1,178
13	44264,756	2319,592	1,377	1,010
14	46587,118	2322,362	1,378	1,017
15	48914,056	2326,937	1,381	1,047

It shows in Table 1, the estimated number of the following possible cluster is 4-cluster with a value of 1,213. Furthermore, the number of these clusters will be re-analyzed to determine suitability for clustering in the study. In the division of these four groups, cluster 1 consists of 37 members, and cluster 2 has 39 members. In

contrast, cluster 3 and cluster 4 have eight members. The division of these groups will be identified to find out what items are involved. Clusters 1 and 2 have 241 variables (products).

Meanwhile, clusters 3 and 4 have 208 and 192 variables (products), respectively. Thus the 4-cluster is considered to have fulfilled the purpose of using the clustering method. It is because there is a decrease in the number of variables. Furthermore, each group will be interpreted based on the average number of cluster analyses. Based on previous research by Tenriawaru (2018), The characteristics of each cluster are formed from the variables involved and the average value of the variables. The average cluster analysis in the four groups is shown in Table 2.

Table 2. Average Cluster Analysis

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Average value	329,486	373,308	402,125	492,286

It can be seen in Table 2 that the characteristics of each cluster are formed the average number from the lowest to the highest. Cluster 1 is in the low purchase category with an average of 329,486 and the product that is primarily purchased in pots. Cluster 2 is in the medium purchase category with an average number of 373.308. The product that is often sought after by consumers is peacock mica. Cluster 3 belongs to the reasonably high purchase category with an average cluster value of 402.125, and mica 2C is one of the products that consumers often buy. Cluster 4 is included in the very high purchase category based on an average value of 492.286, and mica peacock is the most purchased product. The four groups were then analyzed using silhouette statistics to determine the most optimal cluster, shown in Table 3.

Table 3. Silhouette Statistics

Silhouette Statistics				
Cluster	**Statistics**			
	Case Count	**Mean**	**Minimum**	**Maximum**
1	37,000	0,162	-0,081	0,288
2	39,000	0,096	-0,058	0,217
3	8,000	0,183	0,038	0,268
4	8,000	0,162	0,033	0,275
Total	92,000	0,136	-0,081	0,288

The average silhouette test is carried out to determine the most optimal and feasible cluster to input in the following process. The highest mean value indicates that the cluster is the best group. Based on Table 3, the most significant average value (mean) is owned by cluster 3. Thus, cluster 3 becomes the most optimal group for the association rule input process in determining the pattern of sales transactions at PT XYZ Furniture Stores.

All transactions in cluster 3 will then be processed by the association rule method using an apriori algorithm to look for paired product patterns that may be formed. The association rule process must pay attention to the minimum support and minimum confidence values used. In this study, the researcher determined the minimum support value of 0.6% and the minimum confidence of 50%. This value arises from experiments conducted in the support value range of 0.6%-1% and confidence between 50% to 80%. Experiments with these values show that the 0.6% support limit and 50% confidence limit have more rules than others. A rule can only be formed following the association rules if it meets the limits (support and confidence) given. Meanwhile, the rule can be said to be optimal and can be applied to PT XYZ Furniture Stores if it has a lift ratio value > 1 (Takdirillah, 2020). The pattern of sales transactions with the apriori algorithm that can be formed is shown in Table 4.

Based on the processing, 19 rules can be generated in cluster 3 sales transaction data with minimum support of 0.6% and minimum confidence of 50%. In Table 4, it can be seen that the smallest support value is 0.006 owned by rules 4, 8, 9, 10, 11, 12, and 19, while the largest is 0.1 in rule 5. This shows that rule 5 appears in PT XYZ Furniture Store sales transactions, and rules 4, 8, 9, 10, 11, 12,19 do not show up much. Moreover, the confidence value, which is considered as the level of confidence that describes how significant the relationship between items, is (Kurniawati, 2014), shows the lowest value of 0.5 (50%) in rules 1, 2, 3, and 4. This value is right at the minimum limit. The confidence indicates that the confidence level in the paired product of rules 1 to 4 is not so strong.

Furthermore, the highest confidence value is 1,000 (100%) owned by rules 18 and 19. This shows a robust level of confidence compared to other rules. Consumers always buy products simultaneously according to rules 18 and 19.

Table 4. Results of Sales Transaction Patterns with Apriori Algorithm

No	*Premises*	*Conclusion*	*Support*	*Confidence*	*Lift Ratio*
1	M146	M107	0,016	0,5	9,423
2	M34	M177	0,008	0,5	17,5
3	M67	M177	0,008	0,5	17,5
4	M82	M138	0,006	0,5	35
5	M9	M110	0,1	0,555	24,747
6	M189	M178	0,008	0,571	23,333
7	M149	M152	0,008	0,571	28
8	M217	M48	0,006	0,6	24,5
9	M156	M18	0,006	0,6	29,4
10	M200	M30	0,006	0,6	32,667
11	M91, M110	M9	0,006	0,6	32,667
12	M110, M9	M91	0,006	0,6	18,375
13	M94	M39	0,01	0,625	13,92
14	M186	M151	0,008	0,8	5,764
15	M151, M4	M173	0,008	0,8	35,636
16	M173	M151	0,018	0,818	5,896
17	M209	M151	0,02	0,909	6,551
18	M4, M173	M151	0,008	1.000	7,206
19	M91, M9	M110	0,006	1.000	4,4545

Based on Table 4, all lift ratio values have a value > 1, which means that the resulting rule is optimal and can be applied at PT XYZ Furniture Stores. This follows the principle of the association rule that the transaction pattern (rule) that provides benefits and can be applied is the one with a value above 1 (Kharosim, 2019). Table 4 shows the smallest and largest lift ratio values, respectively, 4.454 and 35,636. The greater the lift ratio value, the stronger the resulting relationship, so it is appropriate to be applied as a layout improvement recommendation. When compared with other studies by Prahartiwi and Dari (2019) where the lift ratio value only ranges from 2.41 to 2.47, as well as research by Hartomo, et al (2020) With a lift ratio between 0.784 to 6.131, the transaction pattern generated in this study is considered to have relatively high associative power.

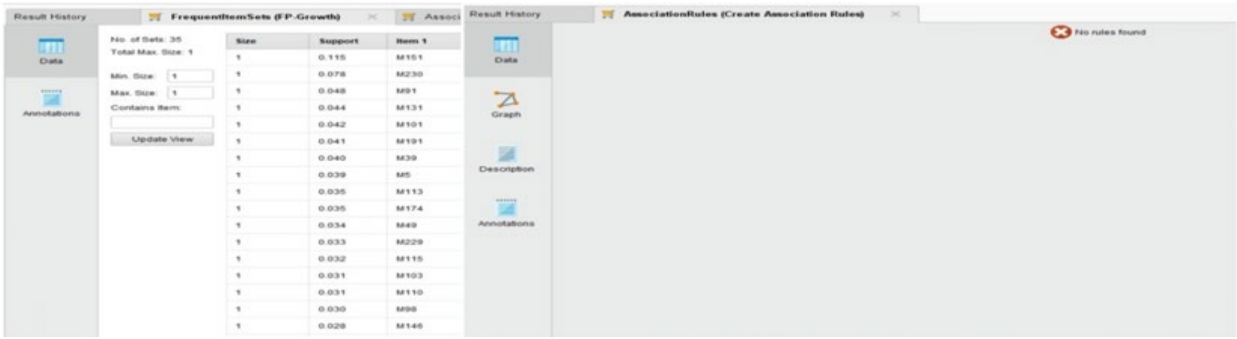

Figure 1. Association Rule Results Without Clustering Combination

The results of the pattern of sales transactions using a combination of clustering and association rules in Table 4 are very different if only done with the association rule process. Figure 1 below shows the association rule process without involving the clustering method. It can be seen that no rule can be formed when using the data in this study. As a result, the clustering combination is appropriate for determining the pattern of sales transactions on transaction data at the PT XYZ Furniture Store.

5.2 Graphical Results

After obtaining the results of the association rule process, the next step is to arrange the product layout. In compiling the product layout, two aspects must be considered, namely quantitative proximity and qualitative proximity (Agestyana, 2016). Quantitative closeness is seen based on the results of the association rule process. In contrast, qualitative closeness is analyzed with the help of the Activity Relationship Chart (ARC) tool. When analyzing the activity relationship chart (ARC), what must be considered is the origin of the close relationship and the degree of proximity (Putri, 2014). The close relationship is related to what is an indicator that the product can be brought closer. In this study, researchers only used several reasons, such as the similarity of types and diversity (similarity of use). Meanwhile, the degree of proximity will contain symbols that indicate how important the product should be (Pradana & Nurcahyo, 2014). The degree of closeness symbol is written with A, E, I, O, U, and X. The paired product of the symbol A must be brought closer because it is bound to each other. The symbol E is an essential close because it has similarities based on several aspects. The I symbol is essential to bring closer. The O symbol represents products that are usually brought closer to view based on their placement habits. The U symbol is a product group that is not important to bring together because it is unrelated to each other. The symbol X consists of product pairs that should not be brought near because it is affected by the nature of the carry.

In this research, product groups that can be compiled using activity relationship charts have a confidence value of 50%. This is done to obtain more accurate and optimal results of transaction patterns so that they can be applied at PT XYZ Furniture Stores. Three stages must be carried out when compiling a product layout based on quantitative and qualitative proximity considerations. Firstly, product identification of the association rule to use what products can be involved. The identification stage shows that there are 27 products from the analysis of association rules. Second, quantitative proximity analysis with activity relationship chart. This stage is compiling an activity relationship chart of 27 previously identified products. The results of the activity relationship chart are shown in Figure 2.

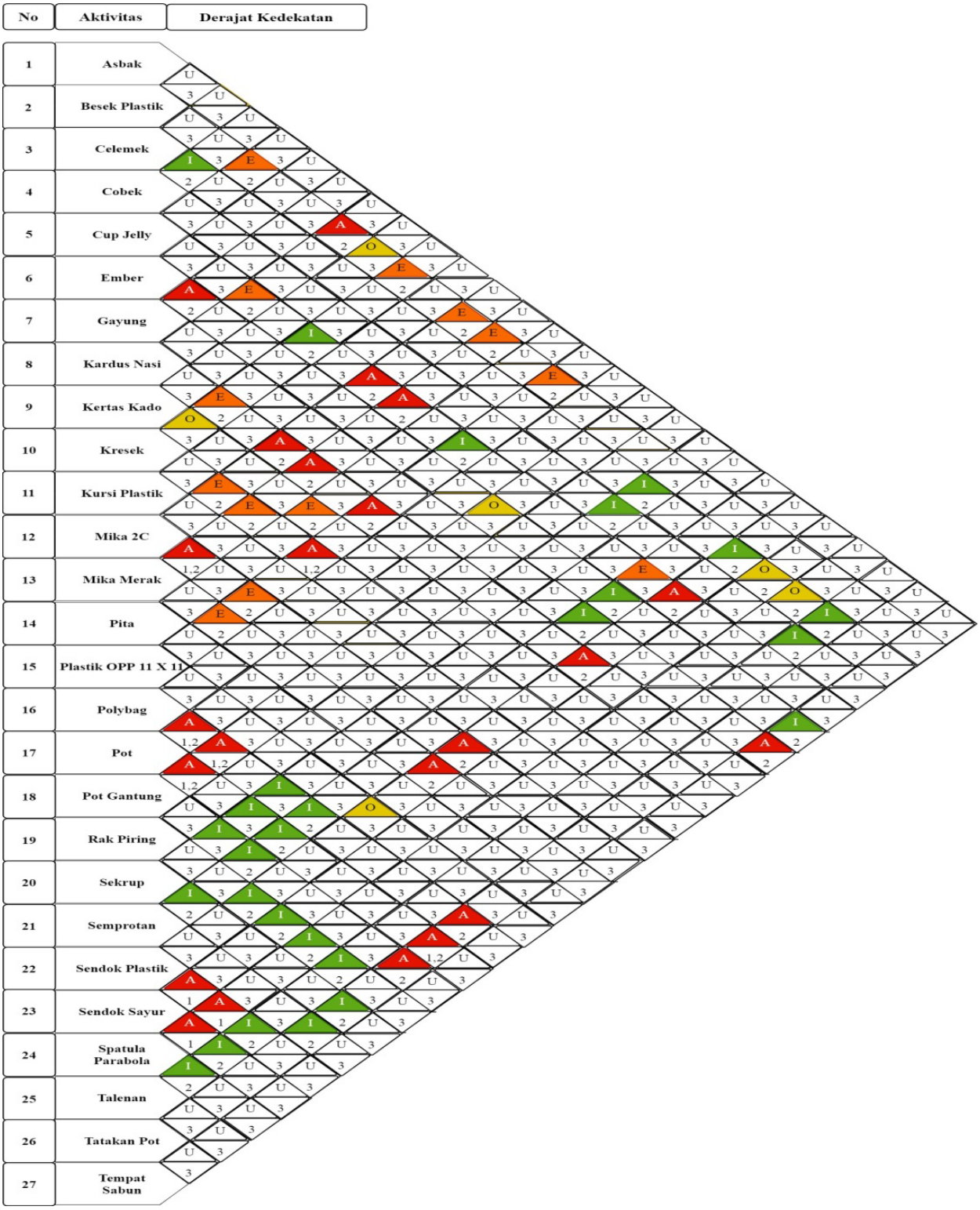

Figure 2. Activity Relationship Chart

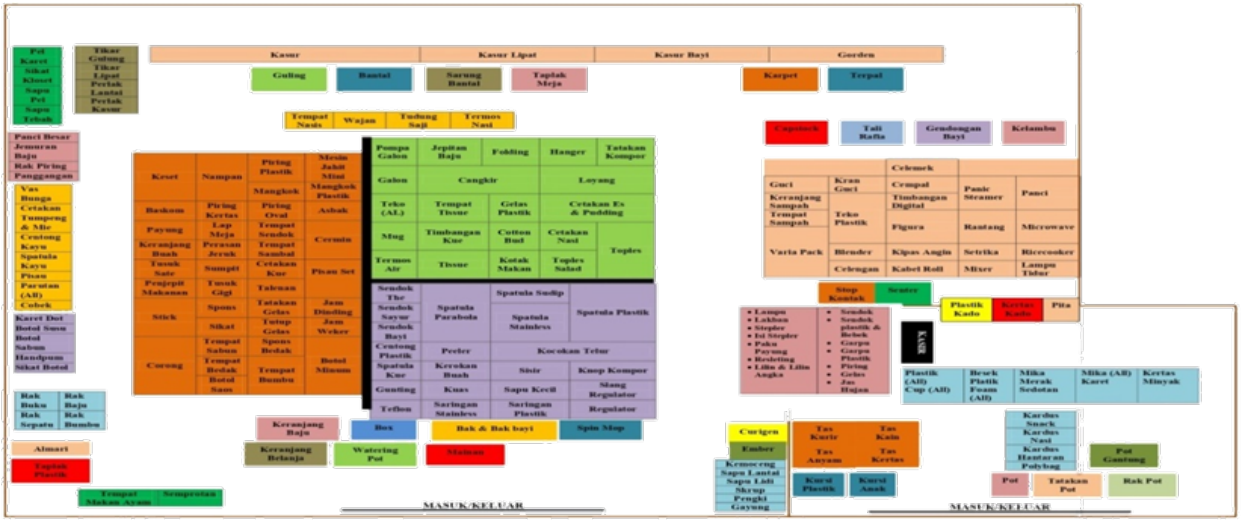

Figure 3. Current Product Layout

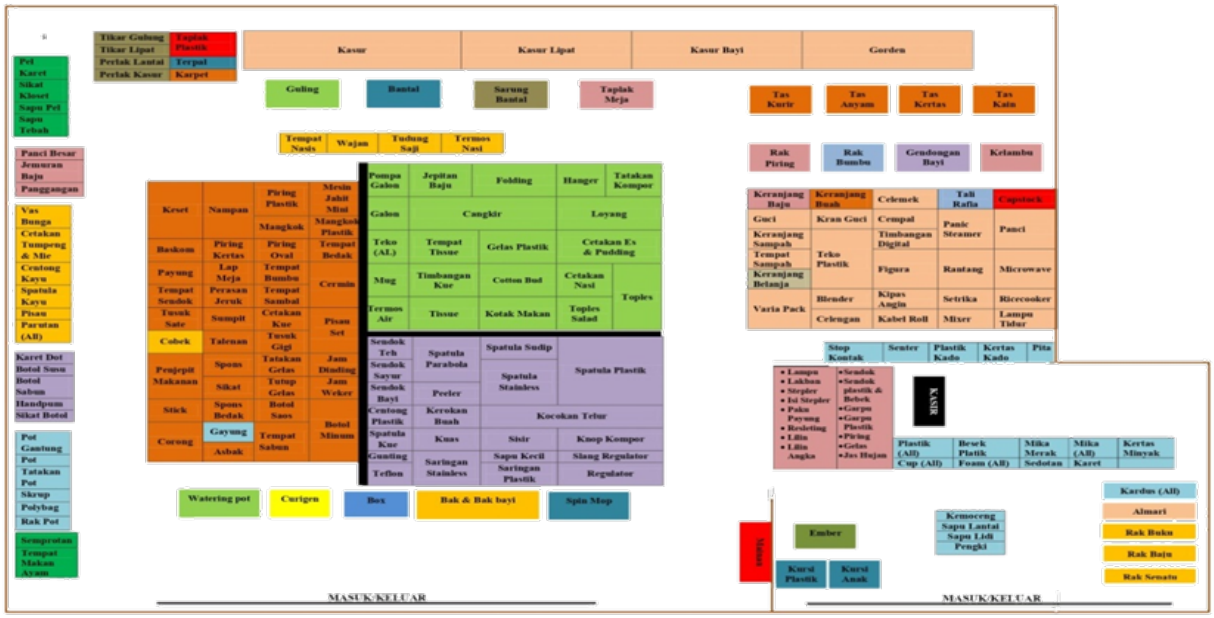

Figure 4. Proposed Layout

Figure 4 shows several changes that can be seen when compared to the current layout in Figure 3. First, the spray products, pots, and ashtrays were in different areas, according to Figure 3. However, because the confidence value in the pattern was 100% and ARC shows a close relationship I (2), namely the reason for the similarity of uses, this pair of products must be placed in the same area according to Figure 4. This also applies to the pair of products with a mortar à cutting board, dish rack à apron, soap holder à dipper, plastic chair à bucket, and spade à pot.

Second, crackles, plastic baskets, and merak mica products have a 100% confidence value. The reason for E's proximity (2) is based on similarity in use. However, this product pair did not experience a change in placement because the current condition was following the sales transaction pattern from the association rule results. This case also applies to pairs of 11 x 11 opp plastic à Merak mica, jelly cup à plastic spoon, rice box à plastic spoon, wrapping paper à ribbon, and parabolic spatula à vegetable spoon. In Figure 4, several products have changed places but have no reason for quantitative or qualitative closeness. These changes were made to fill the space and prevent

product buildup in one area that would interfere with consumer shopping access. In addition, products that consumers purchase can be considered to be placed in more strategic and accessible areas such as the entrance or close to the cashier (Pradana, 2016).

5.3 Proposed Improvements

Improvements in product layout at PT XYZ Furniture show that the distance between paired products is shorter than the previous position. After optimizing the association rule process, which produces 19 rules, then continues with the activity relationship chart, only six rules can be generated. This rule becomes the optimal pattern of sales transactions because it has met its quantitative and qualitative closeness. The change in the distance between the six rules shows that consumers' shopping access is easier and faster in finding the desired paired product. Changes in distance from the results of quantitative and qualitative proximity analysis are shown in Table 5.

Table 5. Changes in distance from quantitative and qualitative proximity analysis

No	Rule	Pre-desaign	Re-design
1	Dish rack → Apron	3.8 meter	0.5 meter
2	Soap holder → Dipper	3.1 meter	0 meter
3	Spade → Pot	1.55 meter	0 meter
4	Spay, Ashtray → Pot	5.5 meter	0 meter
5	Bucket → Plastic chair	1.5 meter	0 meter
6	Mortar → Cutting board	1.1 meter	0 meter

Table 5 shows that rule 1 (dish rack à apron) changes the distance from 3.8 meters to 0.5 meters. Meanwhile, rules 2 to 6 have changed the distance to 0 meters, meaning they are in the same area.
Based on the overall analysis, determining the pattern of sales transactions with a combination of clustering methods and association rules provides more effective results than only association rules. Suppose the researcher only uses the association rule. In that case, there will be no transaction pattern that can be formed as a proposed layout improvement. The activity relationship chart technique is used to compliment when making product layouts that are more optimal and can be applied at PT XYZ Furniture Stores.

5.4 Validation

Based on the overall analysis, the combination of association rule and clustering methods shows better results than using only association rules. If only using the association rule method, no pattern of sales transactions can be generated according to the explanation in Figure 4.7. This study's combination of association rules and clustering resulted in 19 rules with more than 50% confidence. It lifted ratio > 1 as shown in figure 5. Figure 5 indicates that the paired products have a high association relationship and deserve to be recommended for layout improvement. The combination of association rules and clustering results are then trimmed using an activity relationship chart. After that, the remaining six optimal rules become recommendations for layout improvements at the PT XYZ Furniture Store.

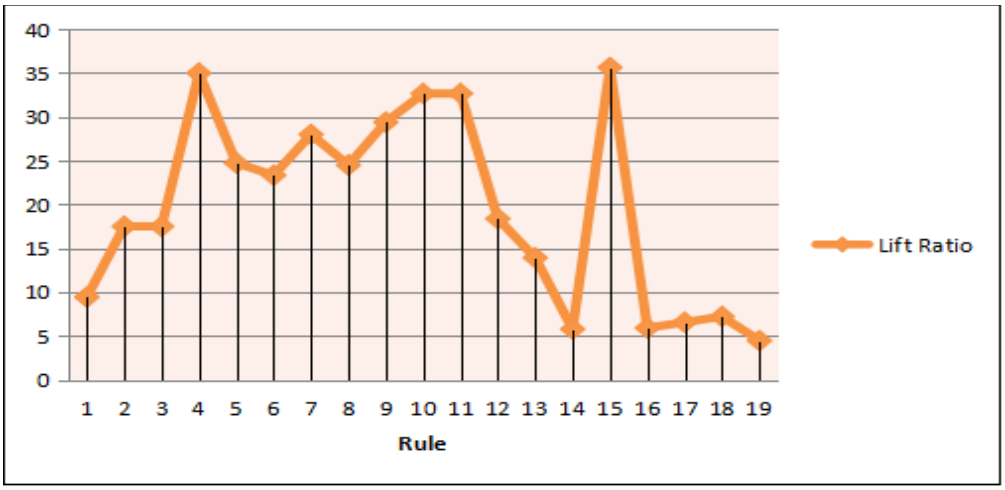

Figure 5 Graph of Lift Ratio Value

6. Conclusion

Based on observations, the clustering method with complete linkage divides sales transaction data into 4-clusters where each group has characteristics based on the information brought by members. Cluster 1, included in the category of low purchase frequency. Cluster 2, category of medium purchase frequency. Cluster 3 is a group with a reasonably high purchase category. Cluster 4 is a group with a very high purchasing frequency category. From the results of clustering processing, cluster 3 becomes the most optimal group so that it is used to input the association rule process. The results of the association rule process with the apriori algorithm show that 19 rules meet the minimum support of 0.6% and the minimum confidence of 50%. The highest support value is in rule 5, and the lowest is in rules 4, 8, 9, 10, 11, 12, and 19. Meanwhile, the most significant confidence value is represented by rules 18 and 19 with a value of 100%, and the smallest is in rules 1 to 4. The indicator of the feasibility of the sales transaction pattern seen based on the lift ratio value shows the highest value on rule 15 and the lowest value on rule 19, which indicates the strength of the associative rule. On the other hand, the preparation of the product layout considers two essential aspects, namely quantitative proximity (association rule) and qualitative proximity (activity relationship chart). From the research results, six rules become optimal sales transaction patterns applied at PT XYZ Furniture Stores. The six rules show a significant change in distance from before the layout change to after the repair. Previously, paired products in rules 2 to 6 had a distance of > 0 meters, indicating that they were not in the same area. However, after improvement, the distance between paired products became 0 meters. The change in the distance in the resulting rule will facilitate access to consumer shopping and make it easier for consumers when buying the desired pair of products because they are already in the same area.

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