



## Data pattern of computer maintenance management system with eclat algorithm

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### Abstract

Decision support system, basically used to help choosing some solution for stakeholder to take the best decision in manufacturer. In manufacturer company using Enterprise Resource System (ERP) that has Work Order (WO) modul as request maintenance from user. But many of data from WO still didn't use to help decision making and only as warehouse data about infrastructure maintenance from last time. Because that, author use that data to help technician to take decision making by using association rule as pattern processing. This is because WO has unique pattern that has problem (p), symptom (s), and root cause (r). Previous research was proved if association rule can use to help technician to take decision making, but it is just involved two variable, that is symptom (s), root cause (r) and using apriori algorithm as association rule. And focussing in this research is using that three variable and eclat algorithm as association rule method. Result of this research has purpose to take the best pattern when using eclat algorithm. The best condition to get the rule from this method in the range of minimum support 0.006 to 0.01.

## 1. Introduction

In this globalization era, the use of Enterprise Resource Planning (ERP) systems in each industry is familiar. Some ERPs such as SAP owned by Oracle, Microsoft Dynamic AX owned by Microsoft and even some IT industries in Indonesia have developed several ERPs although they have not been as good as the two companies. And in ERP itself has a part of Computer Maintenance Management System (CMMS), where this module used to maintenance process of an infrastructure in the company, such as IT infrastructure or machines. [1][2][3][4][5] Maintenance process of infrastructure is inseparable from the solution recommendation process and prediction. [6][7][8] shows that if the prediction process in all fields needs to be done is no exception in the industry, [6][7][8] has proven that the use of solution recommendations has developed in the weather prediction, then [9][10] the proven of prediction in manufacturing and healthcare field. And must to know that maintenance is carried out regardless of the problems that arise when the failure of a system. And process of work order itself which describes the user report in the form of a problem, and then continued to handle the problem, and after found the solutions, the technicians fill data in the work order module. Work orders are often used by computer and machine technicians to save or record the cases that occur within the company related with system failures. The system failure in this statement can be caused by errors from humans or machines. The work order consisting of several important points like as filling the description of the problem, description of symptoms, description of the root cause of the problem, and description of the solution and others. But in this study just focus on the relation of descriptions like problems, symptoms and root causes. And then looking for the results of the pattern was provided by the system as decision support of a technician for making decisions.

In previous studies [11][12] have proven the relationship between symptoms and root causes using apriori algorithm as association rule method. And conducted by [11][12], there was an influence between the symptoms and root cause to get the solution using the Association Rule and correlation process with Chi-Square or Fisher Exact Test. [13][14][15] Association rule is one of the best method to get correlation of cause-effect data like in work order and [16] already proved in problem solving data in manufacturing. [17][18][19] The association rule has support and confidence to measure the correlation bad or good. And this is strengthened in the study [20] about safety related in incident investigation and [12] which reinforces the use of correlation between symptoms and root cause using the Fisher Exact Test One Side P-Value method and then compares it with the Double One Side P-Value Fisher Exact Test.

[11][12] this studies only shows a correlation in utilizing work order data in the Computer Maintenance Management System just only involves two variable. Where are in that research, still limit the two descriptions of work

order, namely the symptoms and root problems without considering the description of the problem provided by the user. Besides that, must to know the Association Rule has several methods that can be used, and in the previous research researchers just used the apriori method. So that in this study the researcher intends to find a pattern involving three variables, namely the problems, symptoms, and root causes and using association rule method with eclat algorithm for determining the pattern of recommendation solutions. [12] has proven that the use of association rules gives significant results when used in the searching process between relationship of groups descriptions of work order, so that researchers maintain using association rule process by changing the type of algorithm used. [21] says that the eclat algorithms in association rules can save execution time and RAM when there are large transactions in a market basket analysis. And this is in accordance with the research that will be carried out because the data owned amounts to thousands. And research [11][12] show that the execution process is longer when the data used is getting bigger, so researchers intend to use other methods. And the focus of this research is not on execution time but more on the pattern generated in the eclat algorithm with data transactions contained in work orders within the CMMS. So that it is expected to be able to find a pattern of problems that often occur in the industry and can be a candidate solution for some of the solutions raised.

**2. Research Method**

Figure 1 show about the concept to build the rule of work order using eclat algorithm based on 3 variable, that is problem (p), symptom (s) and root cause (r). The result is generated 3-itemset that has support more than minimum support as a threshold in eclat algorithm.

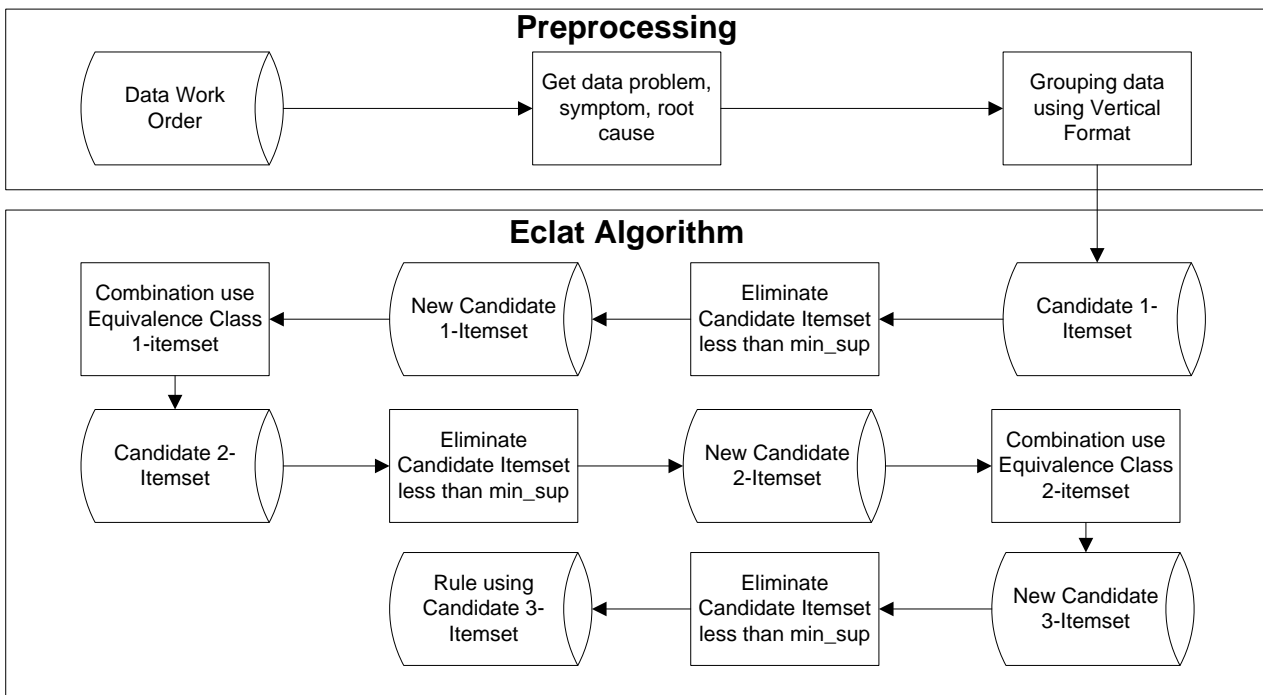


Figure 1. Concept of Eclat Algorithm in Work Order

**2.1 Work Order**

The work order is one of part of the CMMS. This part is one of the basic job of a technician in determining to maintenance of a system, that is both of machine and an organization. In this study more emphasis on work orders of maintenance system in IT infrastructure like as software, hardware, and networks. Must to know, work orders are the results of reports from users and technicians about the existence of a problem from a system can cause engine problems, engine damage or the need for development and improvement of a system. As earlier stated is the report from the user, then will be processed by a technician to check the system and when compilation has been found, the technician will be checked the description of the problem and the root cause of the problem by discussed with the user. The technician then will look for a solution from the root cause and if it is necessary to prepare the tools for new parts replacement. Work Orders that run within a system like a bank or a data warehouse that provides a collection of problems and solutions from time to time. Associated with collection of work orders problems, the one work order by requested with diiferent user may be has different problems, root causes and solutions. So need the different action. Table 1 shows sample samples of the work order.

Table 1. Sample of Work Order

No	Problem	Symptom	Root Cause	Solution
1	Can't login computer	Password computer expired	Can't change password from computer user	Reset password in active directory. Open AX-AD - Active Directory - TPCINDO.com - Choose of group account - right click account - reset password then restart user computer
2	Can't login computer	Security login is fulfilled	Security menu for event viewer was fulfilled	Overwrited security login in event viewer
3	Can't login computer	Password computer expired	Can't change password from computer user	Reset password in active directory. Open AX-AD - Active Directory - TPCINDO.com - Choose of group account - right click account - reset password then restart user computer
4	Can't login computer	Account is locked out in active directory	Wrong type password more than 3 times	Check in AX-AD server, active directory then disable locked out in tab account
5	Can't login computer	User forgotten computer password, and can't change a new password	User error	Reset password in active directory. Open AX-AD - Active Directory - TPCINDO.com - Choose of group account - right click account - reset password then restart user computer. And then try to change password from user use CTRL+ALT+DEL then Change password

Table 1 shows the existence of problems, symptoms, root causes and the same solution in numbers 1 and 2. In that table are only samples and in the actual conditions there can be dozens of similarities in the work order data so that it can be said the experienced has the higher level accuracy of suggested solutions because has many experienced handle of work order. So that there needs to be a system that gives advice to a technician about the best solution so that the resolution of a problem is faster, more accurate and efficient. [2] say a good system is a system that is able to reduce a failure and improve the improvement of a system. Therefore this study intends to find the best associations of several variables from work orders. Especially the problem variables, symptoms, and root causes.

## 2.2 Naive Algorithm

This method is one of the data mining methods used to filter data patterns from transactions in market basket analysis. Where this method will provide a level of confidence value from a data that be supports to find data patterns that often occur in a transaction database. And it is emphasized by [22] who said that in the process of association rule, confidence and support values are used to assess a data that has a high correlation between each item. The are several method of association rules in market basket that can be applied such as the Apriori Algorithm, like as the Eclat Algorithm and the FP-Growth algorithm. The basically of the three methods have involved pruning. Pruning process itself is a process of eliminating data, items or itemset that does not support the association between each item. Previous association rules did not recognize the pruning process. And it is said [22] that the current method of association rule is now too old to be used because there is a better method for applying it using apriori algorithm where the pruning process, where this method uses minimum confidence and support to eliminate a transaction. Based on that statement, association rules can be done without passing pruning, but will require a lot of time when involving a large amount of data. Equation 1 and Equation 2 respectively shows how to get confidence and support values in the association rule.

$$\text{Support} = P(A \cap B) = \frac{\text{Jumlah transaksi yang mengandung } A}{\text{Total keseluruhan transaksi}} \quad (1)$$

$$\text{Confidence} = P(B|A) = \frac{\text{Jumlah transaksi yang mengandung } A \text{ dan } B}{\text{Jumlah transaksi yang mengandung } A} \quad (2)$$

Naive algorithm in association rule, [21] was formed from all possible itemset that involved in the process of association rule and this is making the cost of the algorithm increase. The naive algorithm is explained in Figure 2.

Based on Figure 1 shows the naive algorithm of association rule that has looping to result a new itemset, combination of items in that transaction use limitation until a number of m-itemset. And that illustration, the algorithm has no pruning both of using minimum support or confidence only but only using the new itemset frequency to check whether the new itemset are in market basket or transactions in the database. And if it is not found in the database, it will be eliminated as the new itemset. So that it can be said if the overall itemset of this algorithm, the possible transaction

will certainly be involved in each looping process when generate new itemset. And the cost that must be needed in this algorithm is  $O(n^2)$ . This refers to each itemet formation always requires two loops to get new itemset.

Naive Algorithm	
1.	<b>Input :</b> D is all transcation of items in database L is all items in database
2.	<b>Output :</b> I is itemset that formed from some combination items
3.	<b>Method :</b>
4.	F ← combination form itemset that saved in array
5.	for j ← 1 to Sizeof (I) do
6.	for k ← 1 to Sizeof (L) do
7.	begin
8.	lj ← Combination lj and L
9.	Calculate frequency of new lj in D, is more than 0?
10.	end
11.	<b>return</b> lj as new itemset Looping until m-temset

Figure 2. Naive Algorithm

Table 2. Sample Transaction of Work Order Based on 3 Variable

No	Problem	Symptom	Root Cause
1	Always blue screen when open windows	Windows update detected by symantec and make windows crash	Rtvscan activated and need kill process before to login windows again
2	Button new in General Ledger not active	No have permission access some menu in AX-PROD-LIVE, limited grant for user	No register as AP01
3	Always blue screen when open windows	Windows update detected by symantec and make windows crash	Rtvscan activated and need kill process before to login windows again
4	Always blue screen when open windows	Windows update detected by symantec and make windows crash	Rtvscan activated and need kill process before to login windows again
5	Button new in General Ledger not active	No have permission access some menu in AX-PROD-LIVE, limited grant for user	No register as AP01
6	Button new in General Ledger not active	No have permission access some menu in AX-PROD-LIVE, limited grant for user	No register as AP01
7	Can't acces folder sharing	No have permission to access this file	No account by his or her name in the folder share

Table 2 is a sample of work order transactions consisting of variables p, s and r. And it seems that in Table 2 consists of 9 items that involved in the transaction as presented in Table 3.

Table 3. Item from Table 1

No	Item
1	Always blue screen when open windows
2	Windows update detected by symantec and make windows crash
3	Rtvscan activated and need kill process before to login windows again
4	Button new in General Ledger not active
5	No have permission access some menu in AX-PROD-LIVE, limited grant for user
6	No register as AP01
7	Can't acces folder sharing
8	No have permission to access this file
9	No account by his or her name in the folder share

From Table 3 when process the naive algorithm is used, bad possibility of a total recurrence that appears is 81 looping for each item formation so that if the formation is at least 3-itemset then the looping might occur is  $81 \times 2 = 162$  loop. The illustration in Figure 3 illustrates the process of using the naive algorithm.

The red color in Figure 2 shows if the itemset has a frequency of 0 in the transaction. For example, in the formation of 2-itemset, associations between items 1 and 4, which respectively in Table 3 are "Always blue screen when open windows" and "New button in General Ledger not active". When examined in Table 2 based on a collection of transactions from work orders, the pattern of itemset is not found, so that for the next iteration, that itemset it is not necessary to revive to new formation of the 3-itemset. Based on Figure 3 it can be said that this algorithm is not optimal if it involves hundreds of items because it will take a large amount of time for each looping of each itemet.

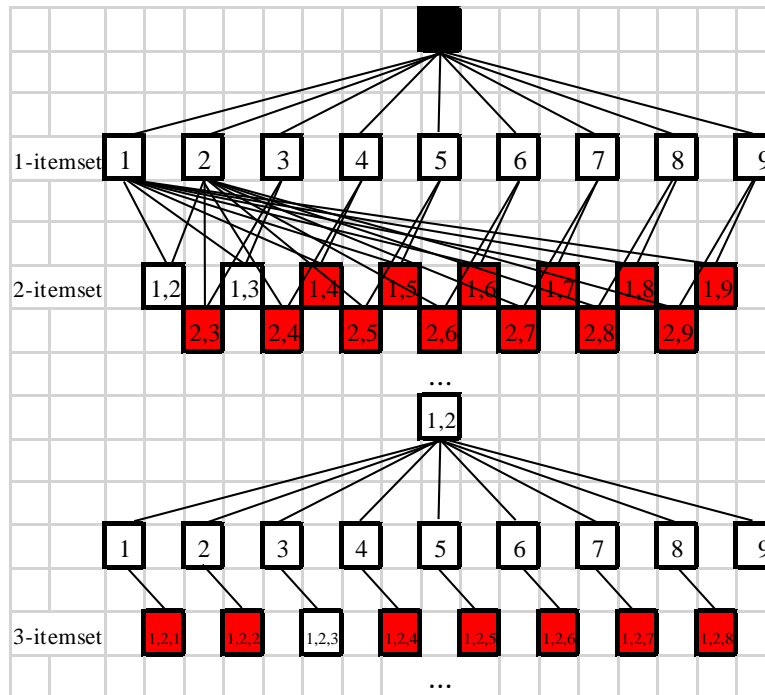


Figure 3. Illustration Itemset from Naive Algorithm

### 2.3 Eclat Algorithm

The implementation this algorithm in association rules is more efficient than using apriori algorithm. This algorithm involves recursive techniques so that it saves more RAM and this is confirmed, [23] that the recursive technique in this method is useful for reducing complexity and in the process begins from the frequent 2-itemset. [24] the principal of this method is different from apriori algorithm, if the apriori method uses a horizontal format then the eclat method uses a vertical format. The horizontal format is described as TID-Item, while the vertical format is described as Item-TIDset. Where TID itself is a marker as a transaction contained in the database. And the example of using horizontal format is in Table 4 based on Table 2 and Table 3. In Table 4 the symbol (P) is a problem or problem, (S) is a symptom or symptom and (R) is the root cause. While the use of vertical data format in the eclat algorithm illustrated in Table 5 is based on Table 2 as TID set and Table 3 as items.

Table 4. Horizontal Format

TID	Itemset	Description of Itemset
1	I1, I2, I3	Always blue screen when open windows (P), Windows update detected by symantec and make windows crash (S), Rtvscan actived and need kill process before to login windows again (R)
2	I4, I5, I6	Button new in General Ledger not active (P), No have permission access some menu in AX-PROD-LIVE, limited grant for user (S), No register as AP01 (R)
3	I1, I2, I3	Always blue screen when open windows (P), Windows update detected by symantec and make windows crash (S), Rtvscan actived and need kill process before to login windows again (R)

4	I1, I2, I3	Always blue screen when open windows (P), Windows update detected by symantec and make windows crash (S), Rtvscan actived and need kill process before to login windows again (R)
5	I4, I5, I6	Button new in General Ledger not active (P), No have permission access some menu in AX-PROD-LIVE, limited grant for user (S), No register as AP01 (R)
6	I4, I5, I6	Button new in General Ledger not active (P), No have permission access some menu in AX-PROD-LIVE, limited grant for user (S), No register as AP01 (R)
7	I7, I8, I9	Can't acces folder sharing (P), No have permission to access this file (S), No account by his or her name in the folder share (R)

Table 5. Vertical Format

Item	Description of Item	TIDset
I1	Always blue screen when open windows	1, 3, 4
I2	Windows update detected by symantec and make windows crash	1, 3, 4
I3	Rtvscan actived and need kill process before to login windows again	1, 3, 4
I4	Button new in General Ledger not active	2, 5, 6
I5	No have permission access some menu in AX-PROD-LIVE, limited grant for user	2, 5, 6
I6	No register as AP01	2, 5, 6
I7	Can't acces folder sharing	7
I8	No have permission to access this file	7
I9	No account by his or her name in the folder share	7

Basically the eclat algorithm uses bread first search technique recursively, same with the apriori technique but only in this algorithm has equivalence class process. If described by tree, the process of using the ECLAT algorithm is depicted in Figure 3. Where in Figure 3 the minimum support is 0.3 for generating the new itemset.

In Figure 4 shows the process of slices between each TID and then combines each item in the 2-itemset process. For example, in the 2-itemset obtained itemset (I1, I2) with the result tid which is 1,3,4 which means itemset I1, I2 is found in transactions 1, 3 and 4. And shown again in the formation of 3-itemset namely I1, I2, I3 from the combination of items I1, I2 and I2, I3 obtained the itemset. Where the itemset are found in tid 1, 3 and 4. This process is called equivalence-class which is only found in the eclat algorithm. Figure 5 shows the use of the eclat algorithm based on the explanation in Figure 5.

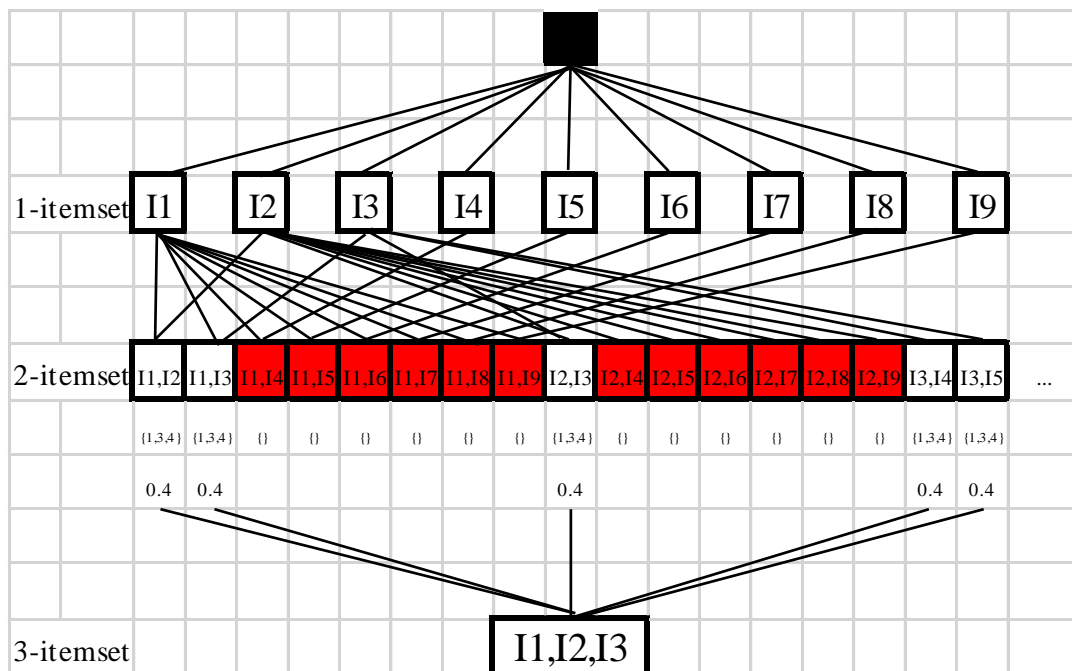


Figure 4. Illustration of Eclat Algorithm

The explanation of Figure 4, there is a recursion in line 29 for generating of new itemset. And the pruning of this algorithm occurs in line 7 for the formation of 1-itemset and line 21 for the formation of k-itemset. Equivalence classes in the algorithm occur at line 23 and 24 which function to generate of new itemset based on slices of the TID for each new itemset formed.

Eclat Algorithm	
1.	Input : I all items in database T all transactions in the database
2.	Output : IT vertical format (item - Tidset)
3.	Method :
4.	For $i \leftarrow 1$ to Sizeof(I)
5.	begin
6.	support $\leftarrow$ Sizeof(IT[i]) / Sizeof(I)
7.	if (support $\gt$ Min_sup)
8.	begin
9.	I_new $\leftarrow$ I
10.	end
11.	end
12.	Candidate_itemset (IT, I, Min_Sup, I_baru)
13.	
14.	Function Candidate_itemset (IT, I, Min_Sup, itemset_new)
15.	begin
16.	For $i \leftarrow 1$ to Sizeof (IT)
	begin
17.	$j \leftarrow i+1$
18.	For $j \leftarrow 1$ to Sizeof (IT)
19.	begin
20.	support $\leftarrow$ Sizeof(IT[i] $\cap$ IT[j]) / Sizeof(I)
21.	if (support $\gt$ Min_sup)
22.	begin
23.	I_new $\leftarrow$ Combine (I[i] dan I[j])
24.	IT_new $\leftarrow$ (IT[i] $\cap$ IT[j])
25.	end
26.	end
27.	if (looping has not been fulfilled)
28.	begin
29.	Candidate_itemset (IT_baru, I, Min_Sup, I_new)
30.	end
31.	end
32.	end

Figure 5. Eclat Algorithm

### 3. Result and Discussion

This research uses tools and programming that support data processing. Where the tools that are excel, notepad ++, apache and MySQL and programming use PHP technology.

#### 3.1 Dataset

This research using work order transactions in database of the Computer Maintenance Management System (CMMS) that consisting of problems (p), symptoms (s), and root causes (r). These three variables are used to find the rule pattern of WO data transactions to determine the most common rules and have a high level of support. And the number of transactions used is 712 data.

#### 3.2 Testing

In this section, the candidate rule obtained from the eclat algorithm must meet the requirements of the three variables mentioned earlier. Where rules are formed at least have one problem (p), symptoms (s), and root causes (r). Table 6 is sample of rule obtained from an eclat algorithm where the color of the red block indicates that the candidate rule does not meet these requirements and eliminated as a candidate rule.

Tabel 6. Elimination Rule not Meet Requirements

Monitor off but CPU is on (p)	Blank screen condition (s)	RAM didn't install correctly	
Monitor off but CPU is on (p)	Blank screen condition (s)	-	
Monitor off but CPU is on (p)	Blank screen condition (s)	Screen can't start when plug to VGA card (s)	
Monitor off but CPU is on (p)	RAM didn't install correctly (r)	-	
Monitor off but CPU is on (p)	RAM didn't install correctly (r)	-	Blank screen condition (s)
Monitor off but CPU is on (p)	RAM didn't install correctly (r)	Blank screen condition (s)	
Monitor off but CPU is on (p)	-	Cable VGA not plug in correctly (r)	
Monitor off but CPU is on (p)	-	Cable VGA is loose (r)	
Monitor off but CPU is on (p)	-	Blank screen condition (s)	
Monitor off but CPU is on (p)	-	RAM didn't install correctly (r)	Blank screen condition (s)
Monitor off but CPU is on (p)	Cable VGA not plug in correctly (s)	Cable VGA is loose (r)	
Monitor off but CPU is on (p)	Cable VGA not plug in correctly (s)	-	
Monitor off but CPU is on (p)	Cable VGA is loose (r)	-	
Monitor off but CPU is on (p)	Cable VGA is loose (r)	Cable VGA not plug in correctly (s)	-

The use of relevant candidates is to reduce the number of rules in the process of eclat algorithms that have no connection in the transaction database. It can be seen in red blocked data that only has 2 variables from the 3 required variables.

Tabel 7. Percentage Relevant Rule

Min_Sup	Total of Candidate (Eclat)	Total Relevant Candidate (Eclat)	Percentage Candidate Eclat Algorithm	Percentage Candidate Apriori Algorithm
0.002	387	199	51.42%	100%
0.003	387	199	51.42%	100%
0.004	186	99	53.23%	100%
0.005	186	99	53.23%	100%
0.006	103	48	46.60%	100%
0.007	103	48	46.60%	100%
0.008	69	27	39.13%	100%
0.009	58	25	43.10%	100%
0.01	58	25	43.10%	100%
0.02	25	9	36.00%	100%
0.03	11	4	36.36%	-
0.04	8	3	37.50%	-
0.05	8	3	37.50%	-

Based on Table 7 when using apriori algorithm, the best condition to generate rule until minimum support 0.002 – 0.02 but when using eclat algorithm the minimum support can used between 0.002 – 0.05. For the result candidate rule is the best when using apriori algorithm. But this study not to see in another side of factor like execution time and



duplicate rule. The focusing how the best minimum support that can be used of eclat algorithm in the case of work order in computer maintenance management system.

Table 7 shows the percentage of rules generated from the eclat algorithm using 712 data of work orders where the rule results obtained the ranged from 37% - 52% using this the requirements, and this study using a minimum support between 0.002 - 0.5. This study use minimum support is not less than 0.002 because there are many rules that are not relevant and must be eliminated as a candidate rule. Similarly, when using the minimum support more than 0.5 where the candidate rule is not obtained. For the pattern of the rule generated from the eclat algorithm, it can be seen that Figure 6 and Figure 7 that take 4 samples from the symptom rule pattern (s) and root problem (r) which have the same problem variable (p).

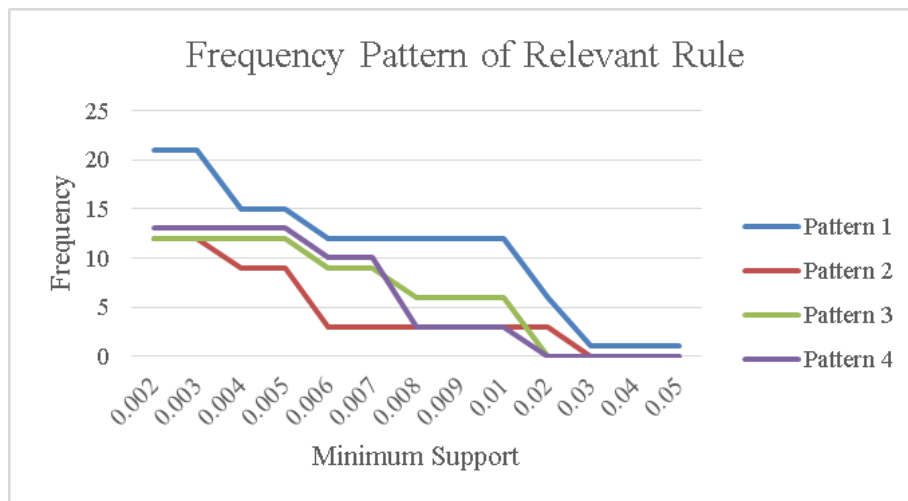


Figure 6. Graph Frequency Relevant of Rule Based on Problem

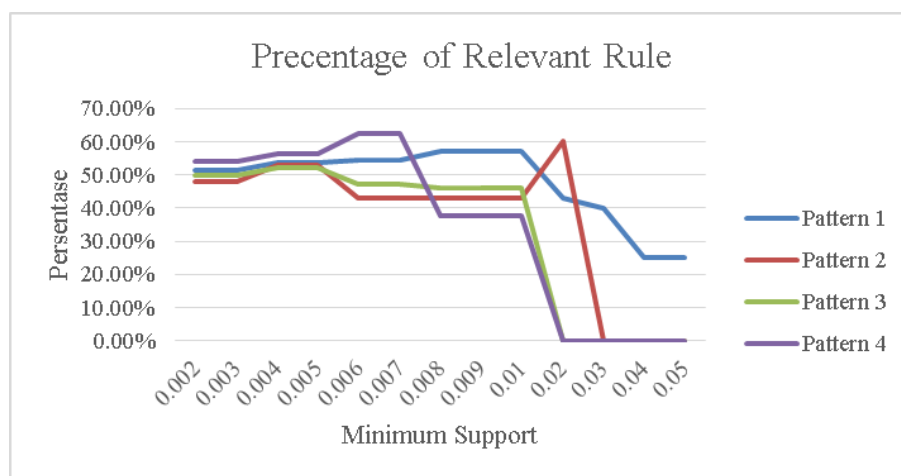


Figure 7. Graph Percentage Relevant of Rule Based on Problem

Figure 6 and Figure 7 has a relation, where graph 5 is an illustration of the relevant frequency rule based on the problem variable. While Figure 6 is the percentage of the relevant rules obtained from the eclat algorithm based on the calculation between frequency rules that are relevant to the total rule generated from the eclat algorithm based on the problem variable (p). Based on Figure 5 and Figure 6 can be seen patterns 1, 2, 3 4 have stability based on frequency and percentage at minimum support between 0.006 until 0.01. In pattern 3 in Figure 5 there is a decrease in frequency from 0.007 to 0.008 but when compared to Figure 6 shows an insignificant decrease and almost looks the same. It's just that in pattern 4 there is a significant decrease when use of the minimum support. However 3 from 4 patterns that are produced, can be seen if the best or stable rule for recommending solutions using the eclat algorithm, which use in minimum support 0.006 - 0.01. It is said as stable because the relevant rule for the pattern is generated at the minimum support, there is no significant change when there is an increase and decrease in minimum support in that range. So that it can be said that the smaller of minimum support from 0.006 the rule is not relevant will appear. While the greater the minimum support value of 0.01, the more rules are eliminated as candidate rules.

#### 4. Conclusion

Work order as warehouse data of decision making in this studyn has the pattern like problem, symptom, root cause and problem. Where is this study want show about the effect of using minimum support with the candidate rule that be result by eclat algorithm as one of association rule method. Based on the research, conducted on the results of the trials in the discussion above, it shows that the best use of eclat algorithms in the case of work order data on the CMMS system is at a minimum value of support between 0.006 to 0.01. It is best said because it produces more relevant rules with more stable than using minimum support outside the range. And the minimum support less than 0.006, the more irrelevant rules show and higher the minimum support more than 0.01, more relevant rules are eliminated as candidate rules. And this is range minimum support relevant with another method like apriori, where is the candidate rule found in the maximum of minimum support of 0.01. The both of method when look of the candidate rule that was generated, apriori algorithm better than eclat algorithm. But this is need to prove again about execution time and duplicate rule the both of that algorithm.

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