Unsupervised Machine Learning Using Fp-Growth in Service and Maintenance of Asset Management

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ABSTRACT

Preventive maintenance is one of effort in manufacturer industry to maintain an infrastructure that has an important thing in the industry. One of module that was provided from this system, like service and maintenance or Work Order (WO). This module has behavior data like brain jobs in human beings. Where is the data that record in memory used to learn to get a solution in the next experienced because the data WO be saved like data in the market basket analysis. The transaction data may be repeated in the next problem. so this data is interesting to be processed to get the best solution by involved it as machine learning like the recommended solution in the brain of human beings. The total WO data involved in this research is more than 720, include problem, symptom and root cause from technician knowledge. This research will be focused on using fp-growth association rule as unsupervised machine learning to process data as a recommended solution for the technician. A different method like previous research using apriori algorithm. This research has a goal to prove the effect of minimum support with the result of decision support in fp-growth algorithm, this method will be passed process of condition pattern base, condition fp-tree and frequent pattern. The result of study shows the best condition of the result in this method is between 0.002 until 0.004 for minimum support, because the best precision, recall, and accuration value more than 50% in that range of minimum support.

1. INTRODUCTION

The world of the industrial system now, can not be separated with information technology as a part evolution of industrial 4.0. IT use in an industrial company not only to support accounting to make the report but now was help some activity in all areas like maintenance machines, buildings, computers, and others. [1-2] using IT as technology like Enterprise Resource Planning (ERP) in maintenance apply to reduce some failure and cost for repairing infrastructure. [3] ERP system often used in administration in the process of business in industry and maintenance data is only a bank of data, so need a study on how to make data in maintenance more useful. This is like a machine learning to learn about the pattern of data that can use a solution of the problem that records in system memory. Like brain job in human being, when people get some problem in this real world, the brain will work to think about the best solution to this problem. Based on data that record from the past problem with the solution already saves in memory. [4] Like concept in the service of maintenance in asset management consist of solution and problem. Back to the problem of service maintenance in industrial problems. The procedure, when technician working to maintain some of the problems, that has a complex life cycle when applying it in industry, because some activity in the different area related with another area to support them to finish the job. As an example when a user found a machine problem in the production area, the user must fill request form in work order (WO) was

applied in Enterprise Resource Planning (ERP) as an integrated system of all functional component in the industry, and one of them is a function of maintenance. After WO enters to queue, and it selected based on working priority by the technician. The technician will handle the job request from the user about a machine failure.

The attention is about technician need time to prepare and handle activity like this, and can not finish quickly but this different with an experienced technician that has knowledge about this problem, know a root cause and solution. It can finish quickly than technicians that don't have experienced before. Focusing of this research is to make technician effective to handle the job about machine failure in industry, especially for a beginner. This like the brain job in a human being, the experienced brain will work more quickly than the beginner's brain. The record of the problem in service maintenance saves in work order data (WO), that collected about bank data of experienced technicians to use as data training in this research. The work order is a request form, or it is data from the user. WO has a variable problem, symptom, and solution in this system. The concept of WO in this system consists of a problem description that was got from the user, then applied by a technician as a summary of the description problem some infrastructure and use it to check failure. Description of WO will add by a technician after the found symptom, root cause then prepare requirement to repair some failure in the area was broken. Our focus in this research about work order in Information Technology (IT), like hardware, network, and software. After finding a solution, the technician adds a description of WO about the solution to this problem. So in WO has 4 summary description from user and technician. That is the problem, symptom, root cause and solution of failure machine. The concept data of WO, some problems in one user may be ever happening in another user with the same solution and in the condition in the field, a problem can appear repeatedly every weekly, monthly or yearly. Based on this statement WO has a pattern about the problem, symptom, root cause, and solution and it can use to get best solution of decision making to help a job of a technician. Based on this statement, WO can use as data training, like a brain job in human beings to search solutions when they know about experienced cases in the past and quickly to get the solution. So, the pattern of work order that occurred repeatedly every time in another area by the same problem, symptom and root cause, in wo data can be used as data training to help the technician to get the best solution of decision making. This is the case that can help the beginner technician [5] when finding a problem and solve it quickly, effective, and efficient. And hope this process can implement in the software application in the Work Order module. To process data training to be as mechine learning, need some algorithm like data mining. [6-8] on they research was proved it if data mining can help people to get the best decision making in weather forecasting and document grouping, [9-10] also already found to apply data mining in industry and healthcare. So this is interesting research for the author to prove data mining can use to work order to get a solution in the industry area.

[11-12] about in they research about applying data of work order in industry case about recommendation solution, show if any relation between variable problem, symptom and solution and get different solution when minumum support and minimum confidence was differences, but on they research only using apriori aglorithm as methode of association rule and this methode [13] already check about relationship in using contingency table for driven data. Based on that literature show about relation beetween variable but not test about precision and recall with the real data. So the research can be a reference about getting the best solution with association rule. So hope with this research can show about accuration of the decision support in the system based on minimum support and minimum confidence. [14] ask about association rule only can be processed if has a group of data in all transaction or market basket analysis that has requirement needed about minimum support and minimum confidence and with this threshold [15] can be found important hidden information in a big data. So in this research want a show about the relation of between variable WO with fp-growth algorithm and to know about accuration of this algorithm to get the solution. Because [16-17] show if this algorithm has execution time less than the apriori algorithm and using an efficient resource of memory. But our focus is showing a pattern of result in this algorithm and does not explain about execution time and resource of memory because it was proved by another research if this algorithm useful than another association rule algorithm for efficiency. So this research trying to explain about accuration rule of pattern that results by the fp-growth algorithm when using different minimum support.

2. RESEARCH METHOD

In this section, explained some data in service maintenance as asset management as data training. This data better known as Work Order (WO) in industrial field. Another section is explained about the FP-growth algorithm. How to use it and step to apply it in this study.

2.1. Work order or Service Maintenance Data

A data warehouse in this study uses work order as a part of ERP system module that has a collection of description data from the user as a problem and technician that contain the symptom, root cause, and solution have been handled. Description of WO from a technician not directly filled when the user reports a failure in an IT system in that time. But the technician will observe first the problem from the user and take action what technicians do, to handle the problem. [18] Because solving the problem in the industry must go through of six stages before taking action, that is definition, verification, observation, development, inspection, and execution.

WO as data warehouse has characteristic in this study so interesting to observe it. One of them has been found some pattern of WO that occurred in another time with the same problem, symptom, root cause in the database. In another time has the same problem and symptom but different root causes or has the same problem and root cause but different symptoms. This is unique as a pattern of data and can use decision making for a technician to solve the problem. Because some of the data was repeated occurred in another time, that proves the solution of the technician is failure or success. Failure of problem-solving from the technician may be occurred the wrong analyze about the symptom and root cause, or symptom analyzed correctly by them but the root cause is wrong. So the different symptoms or root cause in work order data cause different methods from other technicians to solve the problem or maybe less knowledge about a problem in the area. Because of that the wo data can use as a part of the decision making in the industry to help the technician to get the solution without searching solution in another source. Because in this data has some best solution from some collection of data with the same problem. Table 1 shows about work order was mention in that statement.

Refer to table 1 about sample of work order described above that has the same problem but in other viewpoint has a different symptom, root cause and solution is indicated in point 1 until 6. In this study just focuses on three variables in work order to establish the rule of decision making. That is a problem, symptom and root cause already available in WO data, and this study only needs to process that data as decision making for the technician. The data is obtained from corrective maintenance technicians related to the type of unplanned breakdown work. Data before being processed using the FP-Growth algorithm is preprocessed to eliminate missing values, data noise, and inconsistent data.

Table 1. Sample of Work Order

No	Problem	Symptom	Root Cause	Solution
1	Monitor off but CPU is on	Blank screen condition	RAM didn't install correctly	Check memory unplug from slot then plug again to the slot or try to use another slot
2	Can't open Dynamic AX	Message 'Failed Establish Connection'	Password computer expired	After change password restart computer
3	Monitor off but CPU is on	Blank screen condition	RAM didn't install correctly	Check memory unplug from slot then plug again to the slot or try to use another slot
4	Can't open Dynamic AX	Message 'Failed Establish Connection'	Password computer expired	After change password restart computer
5	Can't open Dynamic AX	Message 'Failed Establish Connection'	Password computer expired	After change password restart computer
6	Can't open Dynamic AX	Message 'Failed Establish Connection'	Invalid IP address in AX-PROD server	Disable network then enable again
7	Can't open Dynamic AX	Message 'Failed Establish Connection'	Invalid IP address in AX-PROD server	Disable network then enable again
8	Can't print	Printer offline	Cable not connect with printer	Check condition cable from printer to computer
9	Can't print	Not connected with printer	No install printer driver	New printer device in computer

10	Can't open Dynamic AX	Wrong configuration for DNS server	DNS server go to another DNS not tpcindo	Go to properties network and choose TCP IP then go to advanced - DNS, and make sure DNS server for tpcindo in first order

2.2 FP-Growth Algorithm

This algorithm is one of the methods in association rule to get a relation between a variable that has a correlation to establish some rule to help people as decision making. And this algorithm is a part of data mining [19] because it involves data warehouse to process the data. [20] As a part of association rule this mehode can apply to get relationship entity of variable in the database. In the process of data mining contains three things of concept, they are data structure, efficiency using of RAM and checking repeated of data. Which one all of this concept already has in association rule methode and this data. This research use fp-grow algorithm as a part of association rule methode to get pattern of WO because proved in some study [16-17][19] that use this method more efficient than another algorithm that need of association rule. Where is this algoritm avoid of using a same repeated data and different with apriori algorithm that need greedy of execution time when it has threshold low minimum support.

FP-growth algorithm in the study of data mining better knows as FP-Tree because the data structure of this algorithm uses a tree in the process. This method also has efficient RAM utilization, it is just of this method that still needs the recursive technique as looping to process data. Based on this, the FP-Growth algorithm implemented in memory space by using an integer array. The process of this algorithm [21] first is arranged of items from high to low then eliminated item data that has a frequency less than a threshold of minimum frequency that has set by the user. Arrange of item from high to low proved [21] indication of execution time more quickly than arrange items with the opposite direction. The processing of this algorithm must through three steps such as conditional pattern-base, conditional FP-tree and establish the frequent pattern. In conditional pattern base generated from some transaction in the database then group them by the item that begins from low greedy frequency. And continue to result in conditional fp tree for eliminating some transaction that has frequency item less than a threshold of frequency. After that frequent pattern resulted by process of fp-tree, will combine with some item in the conditional pattern and basic item of the tree. And the result of the frequent pattern is used to compute support value this pattern, then use to eliminate pattern that has support less than minimum support was set before. Detail of explanation of this algorithm based on table 1 can be seen in chapter 2.2.1 until 2.2.4.

2.2.1. Transaction of Items

The first step on how to use this algorithm, in this case, is to sort transaction of item from high to low frequency. [21] FP-growth working efficient of execution when all items in the transaction already sorting first. Based on table 1, a show about the transaction in the work order then table 2 shows about the item with frequency for every item. And need to know if the variable that uses in table 2 are items from table 1 such as problem, symptom and root cause.

Table 2 shows about 14 items from table 1, and how much item frequency from that transaction. Table 2 indicates the high-frequency transaction of the item is "Can't open dynamic AX" with a total 6 frequency of item. Beside that any of the items that has low frequency with a total of 5 items. They are from item number 9 until 14. In this step has an elimination process of items with using a minimum frequency set by the user. This is used by the user to remove some items in the transaction that so not significant to use.

Table 2. Frekuensi Item

No	Item	Frequeny
1	Can't open Dynamic AX	6
2	Message 'Failed Establish Connection'	5
3	Password computer expired	3
4	Monitor off but CPU is on	2
5	Blank screen condition	2
6	RAM didn't install correctly	2
7	Invalid IP address in AX-PROD server	2
8	Can't print	2
9	Printer offline	1
10	Cable not connect with printer	1
11	Not connected with printer	1
12	No install printer driver	1
13	Wrong configuration for DNS server	1
14	DNS server go to another DNS not tpcindo	1

Because did not appear in the work order very often. Based on table 2 if the threshold of minimum frequency is 1, then only 8 items suitable with the requirement of the threshold to process in the next step. Table 3 shows the frequency of items after eliminating them by using minimum frequency.

Table 3. Items after eliminate using minimum frequency

No	Item	Frequency
1	Can't open Dynamic AX	6
2	Message 'Failed Establish Connection'	5
3	Password computer expired	3
4	Monitor off but CPU is on	2
5	Blank screen condition	2
6	RAM didn't install correctly	2
7	Invalid IP address in AX-PROD server	2
8	Can't print	2

Table 3 shows the elimination of items that has a frequency item of less than 2 to establish the rule of the FP-growth algorithm. Based on table 3, the transaction in table 1 that has items that were eliminated in table 3 must modification with a new transaction without some item was lost from table 3. The transformation of modification data from table 3 is shown in table 4 after eliminating some items that did not meet the requirement of minimum frequency.

Look at the transaction in a row such as 8 9 10, 8 11 12, 1 13 14 which contains an elimination item of 9 10 11 12 13 14 shown in table 3. Where is all item in that transaction has been deleted from a transaction. So that transaction now has been changed like 8 9 10 to be 8 because this transaction has items 9 and 10 must elimination. And look transaction 8 11 12 already has item 11 12 was eliminated again, so the transaction change to 8. Likewise, transaction 1 13 14 that has items 13 and 14 eliminated from a list this transaction and only has 1 as an item in this transaction. While the transaction has a minimum frequency more than 1 no have modification when looking in table 4.

Tabel 4. Transformation of transaction of WO data after elminated item

After Elimination	Before Elemination
4 5 6	4 5 6
1 2 3	1 2 3
4 5 6	4 5 6
1 2 3	1 2 3
1 2 3	1 2 3
1 2 7	1 2 7
1 2 7	1 2 7
8 9 10	8
8 11 12	8
1 13 14	1

2.2.2. Conditional Pattern Base

The conditional pattern base is one of a part in the process of the fp-growth algorithm to establish a pattern from some items that result from the previous step. The pattern of the rule will generate from the low frequency of the item. Before making a conditional pattern base, the first step is to generate a tree to get a data structure from table 4. Because tree on this algorithm based on table 4, the deepest node is an item that has low frequency and the high frequency will place in the top of the tree as a parent. The purpose of using the tree in this algorithm is to describe clearly data structure when to establish a conditional pattern base. Figure 1 shows the tree from the transaction in table 4.

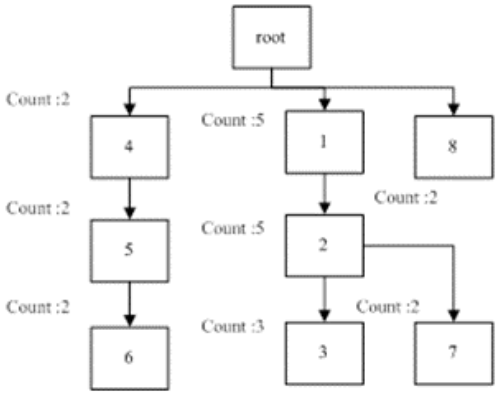

Figure 1: Tree of transaction in table 4

Need attention from figure 1 about the tree from the data work order in table 1. This concept explained [21] that fp-tree must have 4 items in the tree such as 1) signed of the item, 2) counter of the item, 3) pointer as a node of the parent, and 4) successor of a node. Based on that points of statement, figure 1 already has a requirement as fp-tree. About point 1 of requirement in this tree, in figure 1 show numbering in every node. Then every numbering of the node has counter value as a frequency of item. Look at table 3 in the frequency column and figure 1 in counter value, they have the same value. In other side counter value in the fp-tree indicate total transaction of data that uses the item. Look at item (6) in figure 1, the form of conditional pattern base is (4:2, 5:2, 6:2). That means, the item (6) in the database has a pattern (4 5 6) with the total transaction is 2. The result of the conditional pattern every item in figure 1 can be found in table 5.

Table 5. Conditional Pattern Base

Item No	Conditional Pattern Base
8	∅
7	{(1:2,2:2)}
6	{(4:2,5:2)}
5	{(4:2)}
4	∅
3	{(1:3,2:3)}
2	{(1:5)}
1	∅

2.2.3. Conditional FP-Tree

The next step after using the conditional pattern base in the fp-growth algorithm is conditional fp-tree. This step only uses a set of the item as a pattern of transaction in conditional pattern base that total of group item more than 1 for every item. The purpose of conditional fp-tree when finding a group of item in conditional pattern base more than 1 then using the intersection to get members of a group item that has the same item in some group. Example when item number 7 has conditional pattern base with groups of members like {(1:2, 2:2, 3:2), (1:2, 2:2)} then use the intersection to get members that have by two of the group. The result of a group item for conditional fp-tree to be {(1:2, 2:2)}|7. This is also applied when then item has 3 conditional pattern base, for example, item number 7 has groups of it like {(1:2), (1:2, 2:2, 3:2), (1:2, 2:2)} then the result of conditional fp-tee is {(1:2)}|7. When the condition of conditional pattern base in item has a null {∅}

item then conditional fp-tree also set a null (∅). The goal of this step [21] is to establish a frequent pattern to get a combination rule on every item. Based on table 5 and table 6, when trying to check no have different results after this process. Because the group of the member in table 5 only has 1 group in every item so the result of conditional fp-tree has the same member.

Table 6. Conditional FP-Tree

Item No	Conditional Pattern Base	Conditional FP-Tree
8	∅	∅
7	{(1:2,2:2)}	{(1:2,2:2)}|7
6	{(4:2,5:2)}	{(4:2,5:2)}|6
5	{(4:2)}	{(4:2)}|5
4	∅	∅
3	{(1:3,2:3)}	{(1:3,2:3)}|3
2	{(1:5)}	{(1:5)}|2
1	∅	∅

2.2.4. Frequent Pattern

A frequent pattern is a result combination of every item in conditional fp-tree. Every item that has conditional fp-tree then process to establish some candidate of rule by combining member of item. Already explain in part 2.23 about the item in number 7 has conditional fp-tree is {(1:2,2:2)}|7 then can generate to candidate rule. That is {(17:2),(27:2), (127):2} with frequency for every rule is 2. The frequent pattern that result in this candidate rule will apply to get the value of support for every candidate. Then the value of support used to eliminate a rule that has support less than minimum support as a threshold from the user. The result of candidate rule when using conditional fp-tree in table 6 can be seen in table 7.

Table 7. Frequent Pattern

Item No	Conditional Pattern Base	Conditional FP-Tree	Frequent Pattern
8	∅	∅	∅
7	{(1:2,2:2)}	{(1:2,2:2)}|7	{(17:2),(27:2),(127:2)}
6	{(4:2,5:2)}	{(4:2,5:2)}|6	{(46:2),(56:2),(456:2)}
5	{(4:2)}	{(4:2)}|5	{(45:2)}
4	∅	∅	∅
3	{(1:3,2:3)}	{(1:3,2:3)}|3	{(12:3),(23:3),(123:3)}
2	{(1:5)}	{(1:5)}|2	{(12:5})
1	∅	∅	∅

The frequent pattern already establishes in the previous step will use to compute support for every pattern and to determine the pattern has been met requirement of minimum support or not. If the pattern did not meet this requirement then eliminate it from candidate rule. Table 8 shows support for every pattern from table 7.

Table 8. Result of support for Frequent Pattern

Variable 1	Variable 2	Variable 3	Support
Can't open Dynamic AX	Invalid IP address in AX-PROD server	-	0.182
Message 'Failed Establish Connection'	Invalid IP address in AX-PROD server	-	0.182
Can't open Dynamic AX	Message 'Failed Establish Connection'	Invalid IP address in AX-PROD server	0.182
Monitor off but CPU is on	RAM didn't install correctly	-	0.182
Blank screen condition	RAM didn't install correctly	-	0.182
Monitor off but CPU is on	Blank screen condition	RAM didn't install correctly	0.182
Can't open Dynamic AX	Message 'Failed Establish Connection'	-	0.364
Message 'Failed Establish Connection'	Password computer expired	-	0.182

Can't open Dynamic AX	Message 'Failed Establish Connection'	Password computer expired	0.182

In table 8 when using minimum support is 0.1 then no pattern in this table eliminate as candidate rule. But when using minimum support is 0.2 then only 1 pattern meets the requirement of minimum support and can be as candidate rule from fp-growth algorithm.

3. RESULTS AND DISCUSSION

This study uses some tools to help develop the source code of the program and to analyze data, such as XAMPP as an application and database server, Notepad++ as code editor to execution fp-growth algorithm in the application then excel use to help for analyzing data.

This study involves work order data as one module in ERP system for industry and there is three variable that is used in this research like a problem (p), symptom (s) and root cause (r). The total data of WO in this research is 712 to process in this algorithm. Observation for the candidate of rule after processing with fp-growth algorithm as explained before must be appropriate with the criteria of the work order. That is the rule of a result this algorithm must have 1 variable of problem, 1 variable of symptom and 1 variable for a root cause. Table 9 is an example result of rule for the problem "Can't login computer" with minimum support 0.02.

Table 9. Example Result of Rule “Can’t login computer” with minimum support 0.02

1	Can't login computer (p)	-	-	**0.1531**
2	Can't login computer (p)	No have access to login this computer (s)	Name computer in active directory not register in his or her account (r)	**0.0267**
3	Can't login computer (p)	Name computer in active directory not register in his or her account (r)	No have access to login this computer (s)	**0.0267**
4	Can't login computer (p)	Password computer expired (r)	Can't change password from computer user (s)	**0.0435**
5	Can't login computer (p)	Wrong type password more than 3 times (r)	Account is locked out in active directory (s)	**0.0562**
6	Can't login computer (p)	Wrong type password more than 3 times (r)	-	**0.0576**

Table 9 is the result of the rule from fp-growth algorithm. When looking in that table, the result support each rule is more than minimum support 0.002. Looked in no 1 that rule does not has symptom and root cause but has support 0.15 and no 6 does not has symptom has 0.056 for the support. But that rule not meet requirement for prcessing data. From 6 rule in those tables, only 4 rule has a meet requirement of the rule that already set in this study and explained above. The rules are number 4 until 5 that has problems, symptoms and root cause. While rule number 1 eliminates as the candidate of the rule because it just consists of 1 variable as a work order, that is problem. And for rule number 6 eliminate from the candidate of the rule because only has 2 variables from 3 variables as a requirement to establish a new rule. Moreover, another criterion of the rule in this study is relevant between problem, symptom and root cause. Based on that table, this study has a basic variable for implement work order in association rule, that must have at least 3 variable to get a rule in association rule. Our study in about work order must contain variables like problem, symptom and root cause. And if they do not include in the transaction of data, that be eliminated as a candidate of the rule.

In this research using minimum support between 0.002 until 0.02. Because when using this minimum support, the result of the rule will generate until a thousand of the rule. When minimum support getting smaller than 0.002 then a total of unrelevant rules generated, so this condition not effective to get new rules. While the condition of the maximum of minimum support is 0.02 because many of important rule lost when using this minimum support getting higher, so not useful to increase the value higher than 0.02 and if enforce this process, many of the information in a database not be found. Limitation for minimum support in this research not only to eliminate some rule that is not important but to use for getting the best transaction in data of work order and the impact is to decrease execution time when generating rule of a work order.

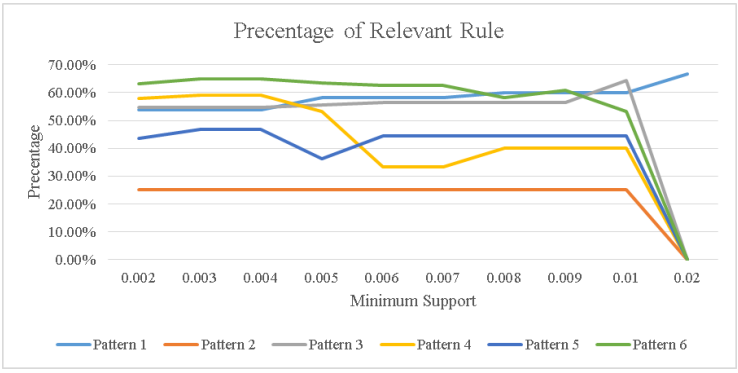

Figure 2. Graph precent of relevant rule in variable of problem (p)

The result of the percent of rules in this study is comparing the total of relevant rule and total of the rule that result from the problem (p). For pattern 1 when observing more detail about the frequency of relevant rule that was occurred decreasing significantly from minimum support 0.002 to next minimum support and this is a maximum threshold of minimum support in this study. But when looking at the percent of the relevant rule, pattern 1 is relatively stable when using different minimum support. A big difference is in pattern number 4 don't have a stable pattern when using different minimum support for frequency or percent relevant rule. And for other results of a rule in other pattern is stable when using different support. And for proof, this result is stable when using different minimum support. Look at figure 3 and figure 4 about the result of precision and recall every pattern in each minimum support.

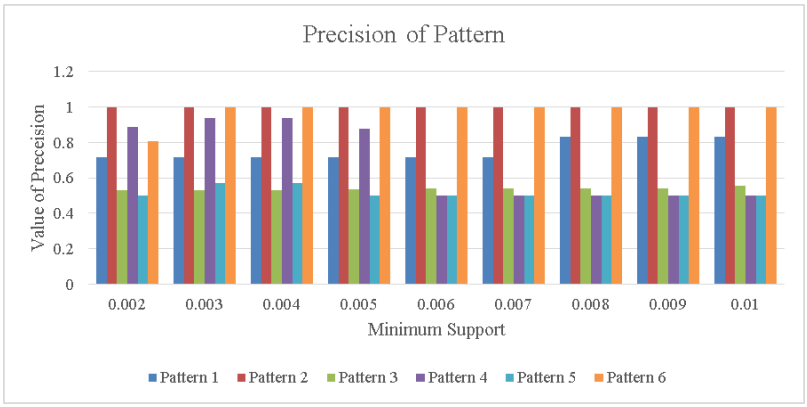

Figure 3. Precision of Pattern

Figure 3 shows precision the result of the rule based on the system. And when we look at this graph, the precision of the pattern is stable in each minimum support. When minimum support is increasing and decrease the precision of the rule is not significantly changed. And based on that graph, the best result of a solution that can be found by the system is higher than 50% with different minimum support.

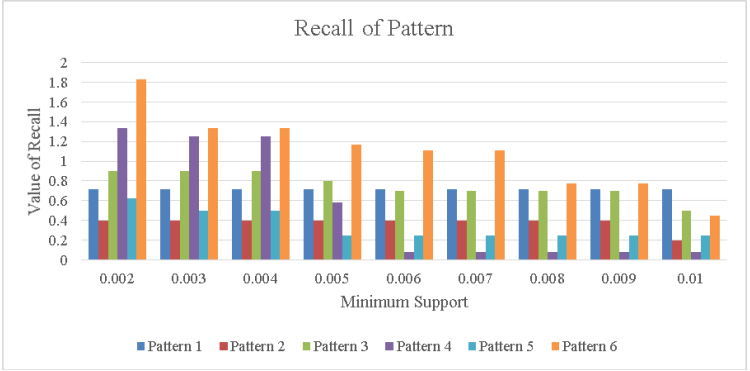

Figure 4. Recall of Pattern

Figure 4 shows about recall the result of rule based on the actual data if compared with manual grouping to get a rule in the WO data. Based on this graph, know it if the recall value will be decreased when increasing minimum support. This occurs because the frequency of the rule will be decreased. The recall has a good condition in the range of minimum support is 0.002 until 0.004. When a look at in figure 3 about precision, this is a range standard to get the same value with precision. Look at patterns 1 until 6 in figures 3 and 4, the precision and recall have the almost same value in that minimum support. Based on this study, know about the effective recommendation when using fp-growth algorithm in the range minimum support 0.002 until 0.004. Based on figure 3 and 4, we know about the effect of minimum support to the result of rule for decision support, by looking at precision and recall. And to confirm the best result in the range of minimum support is 0.002 until 0.004. Look at figure 5 about accuracy of rule by generating with fp-growth algorithm and the rule data from the actual data.

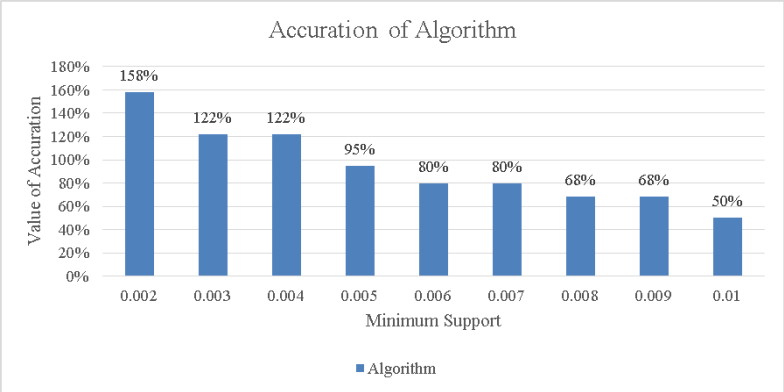

Figure 5. Accuration rule with FP-Growth

In figure 5, know how the effect minimum support to generate rule with the best result. The accuration is more than 100%, because the good rule that generate with association rule more than actual rule when grouping manual. This occured when the rule in actual rule is 1, then with this algorithm can be 2. In the actual rule consists of 1 problem, 2 symptom, 1 root cause, and 1 solution. With this algorithm the rule can be 3 pattern such as (1 problem, 2 symptom, 1 root cause, 1 solution), (1 problem, 1 symptom, 1 root cause, 1 solution) and etc. Figure 5, show the accuration more than 100% in minimum support 0.002 until 0.004. And the statement in above was confirmed in this accuration.

4. CONCLUSION

This study has indicated the best result for the recomendation solution for service maintenance in work order data by using fp-growth algorithm based on the standard of precision and recall. The same condition of that standard is found in minimum support between 0.002 until 0.04. And confirmed with accuration of algorithm more than 100% was found in that minimum support. This minimum support is to used to get the good precision and accuration of rule like problem, symptom and root cause that has relation by other, and the higher recommendation based on the system is used to help the technician in the process maintenance of asset management like the thinking of brain job when looking for solution about problem from the past experience. The next study is needed to compare some algorithm in the association rule with this case to know about the best algorithm.

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