Repair and Replacement Strategy for Optimizing Cost and Time of Warranty Process using Integer Programming

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Abstract
Warranty is an assurance issued by a company as the manufacturer to guarantee that its product is damage-free within a specified period. The warranty process is usually carried out when a complaint or damage regarding the product is received. The warranty process consists of two decisions that the company establishes to handle the process. The occurring problem is in the warranty process; there is not any standard established to determine the cost to incur for the warranty process. In this research, integer programming method was used to do optimization on repair and replacement strategy in warranty process. Before doing optimization, mathematical model must be created. Using that mathematical model, the results show that the costs of the warranty process decrease by 16.97%, while the time increases by 13.9%. So, with this method company will be increase the profit.

Keywords: optimization, repair, replacement strategy, integer programming

1. Introduction

Warranty is an assurance issued by a company as the manufacturer to guarantee that its product is damage-free within a specified period (warranty period) [1, 2]. Warranty is usually used as a contract between the manufacturer and the customer [3] to gain customer's trust, so that it can be used as a means to attract customers [4]. In this research, the problem used is the warranty process on the distributor of wireless devices, since distributor is considered to be the connector between producer and customer. As a matter of fact, the distributor cannot suppress the cost of goods in the warranty process because it is predetermined by the manufacturer. In the warranty process, there are two choices: repair and replace. In the process of selecting whether to repair or to replace, there are advantages and disadvantages to each choice. The replacement versus repair is a classic problem that has long occurred [5]. The problem is based on two criteria: cost and time. To obtain the maximum decision result, it requires optimization between costs and time. Optimization is the activity conducted to produce the best result in accordance with the requirement. In the optimization process, the formulation is considered to be essential because with precise formulation produces an efficient and optimal decision [6]. One of the methods which can be used for optimization to solve the problem is linear programming method [7, 8]. With various alternatives available, the method can determine the optimal decision [9] by minimizing or maximizing objective functions with the existing constraint variables. Thus, it can solve problems using the available/limited resources [10]. Linear programming has several types, one of which is integer programming. Integer programming is an optimization method that provides limits of the results of decision variables are integers [11, 12, 13].

In previous research, many researchers use problems in the warranty. In [4], goal programming method is employed for warranty optimization in manufacturing companies with multi-objective optimization. In other previous research [14], repair and replacement strategy decision is under Markov Deterioration; in [15], AHP is used to decide priority improving parts in automotive industry to decrease warranty. All of that previous research, the problem they examined is manufacturing side. In this paper, the problem on warranty process is distributor

side. In distributor side, they cannot change the goods of cost. But, the manufacturing can change the goods of cost to minimize production. Integer programming method is opted to optimize costs and time because it is in accordance with the problems formulated. The result of this research is the choice of the decision to repair or replace which is in contrast to previous studies [4, 6] indicating reduced costs.

In this research, optimization is conducted to optimize process warranty. In previous research [16], optimization problem aims to determine which items are replaced or repaired by generating the value of 0 or 1. It means that if the result of repair or replace is 0, the process is not choosed, but if the decision result is 1, the process is choosed. The decision is based on two options whether to replace or to repair meaning that the decision is obliged to opt one of the modeled decisions. The previous method [16] uses the operational cost variable from repair and replaces process. In this paper, the researcher added the customer satisfaction variable. In reality, customer satisfaction is in terms of grading; however, the researcher converted customer satisfaction into cost. Customer satisfaction is assessed in terms of the time spent for the warranty process. By conversing to cost, the longer the warranty process is the company is more likely to lose the assumed costs, vice versa; when the warranty process is finished quickly, the company is more likely to reduce the cost incurred. It means that time is the influential factor in the warranty process. In other words, time affects customer satisfaction. In this research, the process taken is divided into three procedures. The first one is setting limit resource for optimization; the second is making a model optimization with integer programming method. The final procedure is result and analysis.

2.   Research Method
2.1. Return on Investment (ROI)

Profit has to do with investment. To determine the advantages there are two methods of measurement. By measuring Return on Investment (ROI) and Return on Asset (ROA). The result of ROI is that it can produce an evolutionary measure that shows how large a company is able to generate profits from used assets [17]. Results generated from the size of the ROI is the size of the ratio. The ratio can also be used as a benchmark how big a company in generating payback [18]. Besides, the ROI size can also be used to compare the efficiency of a number of different investments in the company. The formula ROI [19] as (1).

$$ROI = \frac{(total\ sales - investment)}{investment} \tag{1}$$

2.2. Integer Programming

Integer programming is one type of optimization method used to solve problems to generate optimal decisions. Integer programming is part of a linear type programming. Many types of optimization methods of linear part programming are used for optimization with various problems. For example, one of the types of methods is Goal programming, goal programming can be used to optimize the time and cost on the container port [20]. Besides that, goal programming can also be combined with fuzzy method which can also be used to optimize time and cost so as to maximize total production, production cost and maximize sales [21]. In the case to be examined in this paper. Integer programming is chosen because the decision result of the method is integer value. Because the problem is to choose between repair or replacing with notation 0 and 1 as a result of a decision. The decision will be forced to produce integer numbers [22].

To optimize a problem, an optimization model is needed. Optimization models must match the problems that occur. the model contains variables that will be used for optimization. To create mathematical model using integer programming method in need of three main parts. That is decision variable, constraint function and objective function.

Decision variables are variables that are the results generated by the integer programming method and will be the optimal solution. For this paper the decision variable denoted by R_i and P_i (i = 1,2,3 ......i) where R is repair and P is replaced.

The constraint function is a function used to limit the decision result to be used. In this study the limit used is 65% of ROI. The decision is obtained from the company's needs to be studied. The model constraint as (2).

$$(\sum_{i=1}^{n} BP_i + \sum_{i=1}^{n} BPO_i + \sum_{i=1}^{n} O_i + \sum_{i=1}^{n} BCP_i)\, P_i +$$
$$(\sum_{i=1}^{n} BR_i + \sum_{i=1}^{n} BRO_i + \sum_{i=1}^{n} O_i + \sum_{i=1}^{n} BCR_i)\, R_i \leq \text{ROI} \qquad (2)$$

Where:
BP = cost of replace items as many as i *(i … n)*
O = cost of operational items as many as i *(i … n)*
BPO = cost operational of replace items as many as i *(i … n)*
BR = cost of repair items as many as i *(i … n)*
BRO = cost operational of repair items as many as i *(i … n)*
BCR = cost of customers satisfaction repair items as many as i *(i … n)*
BCP = cost of customers satisfaction replacement items as many as i *(i … n)*

In the model described above there are several variables used such as operational costs for administration warranty process, replacement costs, repair costs, operational costs for the repair process, operational costs for the process of replacing and the cost of customer satisfaction conversion. After the constraint model is created, the next are to make the function objective. Objective function serves to obtain optimal results in decision making. Objective function model is described as (3)

$$MinZ = \sum_{i=1}^{X} P + \sum_{i=1}^{X} R \qquad (3)$$

Where:
X : number of items to be in service.
R : the amount of optimization results of items in the repair
P : the amount of optimization results of items in the replacement

In the objective function model explained that the result of the objective function is the total of the resulting decision result

3. Results and Analysis
3.1. Set Limit Resource of Optimization
Limitation is very important to limit the resources that will be used for mathematical models in optimizing problems. The limitations that will be used are the results of the company's ROI used in this study. In this case it is known that the profit from the sale in the company is 22.637.671,90 IDR and the value of the company's investment in the goods sold is 15.458.183,65 IDR. The result of ROI as (4).

$$ROI = \frac{(22637671.9 - 15458183.65)}{15458183.65} = 46\ \% \qquad (4)$$

From the above calculation, it is known ROI of the company is 46% from the provit of sales. The result of limit resource is 9.782.469,19 IDR.

3.2. Optimize using Integer Programming Method
Before doing the optimization process. The first thing is to collect data that will be used for the optimization process. The data is based on the results of the mathematical model that was made previously from (2).

In this paper the data used is the overall data process warranty in December 2017. The data collected is data from the monitoring service that is in the warranty process. The data explains what data goes into the warranty process of the customer.

In Table 1, there are five columns, namely type, mac address, description, solution and process. For example, in the first data type RB SXT-5nDr2 ROUTERBOARD with mac address 6C:3B: 6B:9D:0E:56 has been damaged in phy ic, then the solution for replacing AR9344-BC2A Network Processor components and process status is repair.

First, determine collect data operating Costs Company. The cost includes the costs incurred by the company for the administration process in the process of warranty process. In the process of administration of the warranty process there are several activities as follows. Table 2 describes the types of tasks in the operational warranty process. In each task there are resources, descriptions, time and total costs incurred.

Table 1. Sample Data of Process Warranty in December 2017

Type	Macc. Address	Description	Solution	Process
RB SXT-5nDr2 ROUTERBOARD	6C:3B: 6B:9D:0E:56	replaced phy ic	AR9344-BC2A Network Processor	Repair
DISC Lite 5 MIKROTIK	64: D1:54:22:6E:40	unit can't acces, mainboard problem	unrepairable	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B4:61	casing has been damaged	unrepairable	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B4:41	casing has been damaged	unrepairable	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B:CF:24: FB	casing has been damaged	unrepairable	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B2: FB	casing has been damaged	unrepairable	Replace
RB941-2nD-TC ROUTERBOARD	E4:8D: 8C:E7: D7:65	unit can't acces, mainboard problem	unrepairable	Replace
RBGroove-52HPn MIKROTIK	6C:3B: 6B:3E: 1B:0E	replaced phy ic	AR8032-BL1A Phy IC single port low cost	Repair
RB 951Ui-2HnD ROUTERBOARD	6C:3B: 6B:F2: 29:94	unit has been dead, mainboard problem	unrepairable	Repair
RB 951Ui-2HnD ROUTERBOARD	6C:3B: 6B:F2: 6A:E6	unit can not be accessed	reinstall OS	Repair
RB 750 r2 (EU) hEX lite ROUTERBOARD	64: D1:54:1A: 5F:3B	unit can not be accessed	reinstall OS	Repair
RB750Gr2 ROUTERBOARD	E4:8D: 8C:D7: EB: ED	unrepairable		Replace

Table 2. Operational Cost of Warranty Process

Task	Resources	Description	Cost	Time	Total cost
Create document warranty	Receptionist	Computer (per/ minutes)	57,00 IDR	3 minutes	171,00 IDR
		Salary (per/minutes)	275,00 IDR		825,00 IDR
Check warranty status	Admin warranty	Computer (per/minutes)	57,00 IDR	3 minutes	171,00 IDR
		Salary (per/minutes)	291,00 IDR		873,00 IDR
Info warranty status	Admin waranty	Computer (per/minutes)	57,00 IDR	4 minutes	228,00 IDR
		Salary (per/minutes)	291,00 IDR		441,00 IDR
Create RMA document for service	Admin waranty	Paper	100,00 IDR		100,00 IDR
		Print	1.000,00 IDR		1.000,00 IDR
		Pen	2.200,00 IDR		2.200,00 IDR
Registration warranty document for receipt item from customer	Admin warranty	Computer (per/minutes)	57,00 IDR	7 minutes	399,00 IDR
Send item warranty to technician process	Admin waranty	Paper	200,00 IDR		200,00 IDR
		Print	1.000,00 IDR		1.000,00 IDR

Second, the next is to collect how much the company will cost to replace the goods received from customers for the warranty process. The replace cost used is equal to the price of the item. In Table 3, there are some replacement costs for each item. For example, in the first data, the price of the DISC Lite 5 MIKROTIK cost of replace is 558.900,00 IDR. Third, determine the costs incurred for the repair process. in this paper the repair process is divided into three parts according to the level of difficulty in process repair.

Table 4 explain the more difficult the repair process, the more expensive costs will be. whereas, the easier the repair process is, the costs will be cheap. In this contex, salary is the salary of the technician and the component is the cost of replacing the damaged part.

After the cost of the repair process in three parts according to the level of difficulty. The rules will be entered according to the level of difficulty repair to the goods that enter the warranty process. The results of the repair costs are shown in Table 5.

In Table 5, can be seen more in detail the cost of the warranty process. By adding colom criteria for difficulties. The total cost is obtained from calculations based on Table 4. Fourth, convert customer satisfaction into a value. Customer satisfaction is also a consideration

in the selection between repair and replace. The conversion is done so that the calculation in the mathematical model in the integer programming into one unit with variables used before. unit in the method to be used is to generate cost, then customer satisfaction is changed in unit cost.

Table 3. Replacement Cost per Item Type

Type	Cost of Replace
DISC Lite 5 MIKROTIK	558.900,00 IDR
RB 1100 AHx2 ROUTERBOARD	3.153.693,00 IDR
RB 750 r2 (EU) hEX lite ROUTERBOARD	400.750,30 IDR
RB 951Ui-2HnD ROUTERBOARD	559.953,70 IDR
RB SXT-5nDr2 ROUTERBOARD	547.413,10 IDR
RB750Gr2 ROUTERBOARD	402.012,40 IDR
RB941-2nD-TC ROUTERBOARD	558.900,00 IDR
RBGroove-52HPn MIKROTIK	549.810,00 IDR
RBGrooveA-52HPn MIKROTIK	730.560,10 IDR
RBMetal5SHPn ROUTERBOARD	933.453,40 IDR

Table 4. Level of Difficulty Repair Process

Easy	Medium	Hard
(Salary + component) x 115%	(Salary + component) x 135%	(Salary + component) x 150%

Table 5. Cost of Repair Item

Type	Macc. Address	Description	Component	Criteria	Cost
RB SXT-5nDr2 ROUTERBOARD	6C:3B: 6B:9D:0E:56 64:	replaced phy ic	AR9344-BC2A Network Processor	Medium	139.604,25 IDR
DISC Lite 5 MIKROTIK	D1:54:22:6E:4 0	unit can't acces, mainboard problem	unrepairable	Hard	844.927,50 IDR
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B4:61	the casing angle is cracked	unrepairable	Easy	115.000,00 IDR
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B4:41	the casing angle is cracked	unrepairable	Easy	115.000,00 IDR
DISC Lite 5 MIKROTIK	6C:3B:6B:CF:2 4: FB	the casing angle is cracked	unrepairable	Easy	130.000,00 IDR
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B2: FB	the casing angle is cracked	unrepairable	Easy	198.835,00 IDR
RB941-2nD-TC ROUTERBOARD	E4:8D: 8C:E7: D7:65	unit can't acces, mainboard problem	unrepairable	Hard	933.500,00 IDR
RBGroove-52HPn MIKROTIK	6C:3B: 6B:3E: 1B:0E	replaced phy ic	AR8032-BL1A Phy IC single port low cost	Medium	47.893,00 IDR
RB 951Ui-2HnD ROUTERBOARD	6C:3B: 6B:F2: 29:94	unit can't access, mainboard problem	indication of damage due to lightning, unrepairable	Hard	617.264,52 IDR
RB 951Ui-2HnD ROUTERBOARD	6C:3B: 6B:F2: 6A:E6	unit can't access	reinstall OS	Easy	133.946,50 IDR
RB 750 r2 (EU) hEX lite ROUTERBOARD	64: D1:54:1A: 5F:3B	unit can't access	reinstall OS	Easy	133.946,50 IDR
RB750Gr2 ROUTERBOARD	E4:8D: 8C:D7: EB: ED	unrepairable		Hard	443.529,16 IDR
RBMetal5SHPn ROUTERBOARD	E4:8D: 8C:F4: 60:92	replaced regulator ic controler, replaced phy ic	LSP5503 IC Regulator Controller, AR7241-AH1A Phy IC	Medium	120.946,50 IDR
RBMetal5SHPn ROUTERBOARD	6C:3B:6B:94:7 4:03	replaced regulator ic controler, replaced phy ic	LSP5503 IC Regulator Controller, AR7241-AH1A Phy IC	Medium	120.946,50 IDR

Table 5. Cost of Repair Item

Type	Macc. Address	Description	Component	Criteria	Cost
RBGrooveA-52HPn MIKROTIK	6C:3B:6B:54:99:34	replaced phy ic	AR8032-BL1A Phy IC single port low cost	Easy	47.893,00 IDR
RBGroove-52HPn MIKROTIK	E4:8D:8C:FD:8A:43	unit broken, mainboard problem	unrepairable	Hard	276.315,50 IDR
RBGrooveA-52HPn MIKROTIK	6C:3B:6B:56:20:54	unit cant not boot, mainboard problem	unrepairable	Hard	804.931,63 IDR
RB SXT 5HacD2n ROUTERBOARD	6C:3B:6B:D9:27:E3	replaced regulator ic controler	LSP5503 IC Regulator Controller	Easy	247.893,00 IDR
RB922UAGS-5HPacD-NM ROUTERBOARD	64:D1:54:0B:B4:C0	unit broken, indication of damage due to lightning induction	unrepairable	Hard	167.893,00 IDR
RB 1100 AHx2 ROUTERBOARD	64:D1:54:55:A5:9E	unit can't boot, RAM slot break	replace RAM slot	Medium	139.604,25 IDR
RB 951Ui-2HnD ROUTERBOARD	64: D1:54:CC:DC:60	replaced phy ic	AR9344-BC2A Network Processor	Medium	139.604,25 IDR
RB 951Ui-2HnD ROUTERBOARD	64: D1:54:CD:47:D0	replaced phy ic	AR9344-BC2A Network Processor	Medium	139.604,25 IDR

How to convert customer satisfaction into cost is by referring to company regulation. in the company rules mentioned that the replacement deadline is 12 days. 12 days will be converted to time units to be balanced with units multiplied by the cost used to calculate the cost of the replace and repair process in (5).

$$CC = \left(\frac{cost\ of\ items\ sold}{288\ (hour\ in\ 12\ days)}\right) \tag{5}$$

Where *CC* is cost customer satisfaction per item. Then the cost is multiplied by how long the process from customer until the warranty process is complete, the calculation is described as (6).

$$Cost_{total} = ((CC\ x\ 48\ (hours\ in\ 2\ days)\ + (\ CC\ x\ T\ )) \tag{6}$$

Where *T* is time of work on repair or replacement process. In the process the repair process takes 2 days, while the replace process requires a faster time that is only one day. From the formula above obtained the following results.

In Table 6, there are conversion results for customer satisfaction in each type of item. the results of the calculation are based on (5) and formula (6).

Table 6. Customer Satisfaction in Cost Replace and Repair Process

Type	Cost replace (@ one days)	Cost repair (@ two days)
DISC Lite 5 MIKROTIK	46.575,00 IDR	93.150,00 IDR
RB 1100 AHx2 ROUTERBOARD	262.807,70 IDR	525.615,50 IDR
RB 750 r2 (EU) hEX lite ROUTERBOARD	33.395,86 IDR	66.791,72 IDR
RB 951Ui-2HnD ROUTERBOARD	46.662,80 IDR	93.325,61 IDR
RB SXT-5nDr2 ROUTERBOARD	45.617,76 IDR	91.235,51 IDR
RB750Gr2 ROUTERBOARD	33.501,04 IDR	67.002,07 IDR
RB941-2nD-TC ROUTERBOARD	46.575,00 IDR	93.150,00 IDR
RBGroove-52HPn MIKROTIK	45.817,50 IDR	91.635,00 IDR
RBMetal5SHPn ROUTERBOARD	77.787,78 IDR	155.575,60 IDR
RBGrooveA-52HPn MIKROTIK	60.880,01 IDR	121.760,00 IDR

Fifth, determine operational costs in the replace process. In replace pores there is a computer usage fee and admin staff fee. The explanation in Table 7, is the resource that

handles the replace process. there is an RMA admin as a resource with a description of costs including salary and computer as the device used. and the time needed for the replace process. The total costs for technical replace is 9.600,00 IDR.

Table 7. Cost of Technical Replace

Resources	Description Cost	Cost	Time	Total cost
Admin RMA	Computer (per/minutes)	57,00 IDR	15 minutes	855,00 IDR
	Salary (per/minutes)	583,00 IDR		8.745,00 IDR

Sixth, the cost for the repair process, the cost of the repair process is the cost incurred by the company in the process of repairing the goods. These costs include technician equipment and computer technicians. Table 8 explain that the technician takes 226 minutes to process. In this case it is from the total component checking activity, analyzing what is going on, replacing and installing the components and in the final stages of testing the repaired items. So the technician can repair the repair process completely completed or there are still obstacles in the repair process. So the costs incurred for technical repair amounted to 18.620,00 IDR

Table 8. Cost of Technical Repair

Resources	Description Cost	Cost	Time	Total cost
Technician	Computer (per/minutes)	57,00 IDR	226 minutes	12.800,00 IDR
	Tools	5.820,00 IDR		5.820,00 IDR

After determining the data. Then, apply the entire data that has been described above into the model that has been made before. Here are the results of mathematical models that have been applied with the data already described as (7) for objective function, (8) and (9) for constraint function.

Minimize:

$$\text{Min} Z = \sum_{i=1}^{21} P + \sum_{i=1}^{21} R \tag{7}$$

Subject to:

(3547413.06 + 9600 + 8808 + 45617.75) x P1 + (558900 + 9600 + 8808 + 46575) x P2 + (558900,9600 + 8808 + 46575) x P3 + ……. + (558900,9600 + 8808 + 46575) x P7 + (549810,9600 + 8808 + 45817.5) x P8 + (559953.65,9600 + 8808 + 46662.80) x P9 + (559953.65,9600 + 8808 + 46662.80) x P10 + (400750.32,9600 + 8808 + 33395.86) x P11 + (402012.42,9600 + 8808 + 33501.03) x P12 + (933453.41,9600 + 8808 + 77787.78) x P13 + (933453.41,9600 + 8808 + 77787.78) x P14 + (730560.12,9600 + 8808 + 60880.01) x P15 + (549810 + 9600 + 8808 + 45817.5) x P16 + (730560.12 + 9600 + 8808 + 60880.01) x P17 + (3153692.78 + 9600 + 8808 + 262807.73) x P18 + (559953.65 + 9600 + 8808 + 46662.80) x P19 + (559953.65 + 9600 + 8808 + 46662.80) x P20 + (933453.41 + 9600 + 8808 + 77787.78) x P21 + (139604.25 + 7100 + 8808 + 91235.51) x R1 + (844927.5 + 7100 + 8808 + 93150) x R2 + …. + (679323.25 + 7100 + 8808 + 93150) x R7 + (38354.25 + 7100 + 8808 + 91635) x R8 + (846507.975 + 7100 + 8808 + 93325.60) x R9 + (116973.25+7100+8808+93325.60) x R10 + (116973.25 + 7100 + 8808+66791.72) x R11 + (609596.13 + 7100 + 8808 + 67002.07) x R12 + (126104.25 + 7100 + 8808 + 155575.56) x R13 + (126104.25 + 7100 + 8808 + 155575.56) x R14 + (38354.25 + 7100 + 8808 + 121760.02) x R15 + (381577.5 + 7100 + 8808 + 91635) x R16 + (1102417.68+7100+8808+121760.02) x R17 + (207104.25 + 7100 + 8808 + 525615.46) x R18 + (139604.25 + 7100 + 8808 + 93325.60) x R19 +

$(139604.25 + 7100 + 8808 + 93325.60)$ x R20 + $(1406757.61 + 7100+8808 +$
$155575.56)$ x R21 …………………………………………….Constraint 1   (8)
RPn + RRn = 1 …………………………………………….Constraint 2   (9)

After entering the data into the mathematical model, the data will be in if using one application solver that is LINGO. By using LINGO, the researchers will find it easier to calculate the optimization results used in the case. As for the result as in Table 9.

Table 9. Result of Optimization

Tipe	Macc. Address	After	Before
RB SXT-5nDr2 ROUTERBOARD	6C:3B: 6B:9D:0E:56	Repair	Repair
DISC Lite 5 MIKROTIK	64: D1:54:22:6E:40	Replace	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B4:61	Repair	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B4:41	Repair	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B:CF:24: FB	Repair	Replace
DISC Lite 5 MIKROTIK	6C:3B:6B: CE: B2: FB	Repair	Replace
RB941-2nD-TC ROUTERBOARD	E4:8D: 8C:E7: D7:65	Replace	Replace
RBGroove-52HPn MIKROTIK	6C:3B: 6B:3E: 1B:0E	Repair	Repair
RB 951Ui-2HnD ROUTERBOARD	6C:3B: 6B:F2: 29:94	Replace	Replace
RB 951Ui-2HnD ROUTERBOARD	6C:3B: 6B:F2: 6A:E6	Repair	Repair
RB 750 r2 (EU) hEX lite ROUTERBOARD	64: D1:54:1A: 5F:3B	Repair	Repair
RB750Gr2 ROUTERBOARD	E4:8D: 8C:D7: EB: ED	Replace	Replace
RBMetal5SHPn ROUTERBOARD	E4:8D: 8C:F4: 60:92	Repair	Repair
RBMetal5SHPn ROUTERBOARD	6C:3B:6B: 94:74:03	Repair	Repair
RBGrooveA-52HPn MIKROTIK	6C:3B:6B: 54:99:34	Repair	Repair
RBGroove-52HPn MIKROTIK	E4:8D:8C: FD:8A:43	Repair	Replace
RBGrooveA-52HPn MIKROTIK	6C:3B:6B: 56:20:54	Replace	Replace
RB 1100 AHx2 ROUTERBOARD	64: D1:54:55: A5:9E	Repair	Repair
RB 951Ui-2HnD ROUTERBOARD	64: D1:54:CC: DC:60	Repair	Repair
RB 951Ui-2HnD ROUTERBOARD	64: D1:54:CD:47: D0	Repair	Repair
RBMetal5SHPn ROUTERBOARD	64: D1:54:0B:FC:7A	Replace	Replace

In Table 9, there are result from before and after optimization. From these results, it can be seen that there are several items that should be optimized. the item is the DISC Lite 5 Mikrotik with mac address 6C: 3B: 6B: CE: B4: 61, 6C: 3B: 6B: CE: B4: 41, 6C: 3B: 6B: CF: 24: FB and 6C: 3B: 6B: CE: B2: FB which before optimization chooses the replace process after being optimized into a repair process. Likewise, in the RBGroove-52HPn MIKROTIK type with mac address E4: 8D: 8C: FD: 8A: 43 before the optimization selects the replace process, after being preempted into a repair process. Optimization problem aims to determine which items are replaced or repaired by generating the value of 0 or 1. It means that if the result of repair or replace is 0, the process is not choosed, but if the decision result is 1, the process is choosed. With this optimization model the costs incurred for the warranty process are more efficient than before optimization. Integer programming method is more suitable for this problem, because the company on this paper is a distributor company. Thus, the result of optimization is the choice of repair and replace. With determine which items are replaced or repaired by generating the value of 0 or 1. It means that if the result of repair or replace is 0, the process is not choosed. But, if the decision result is 1, the process is choosed. Whereas in other methods, the results obtained do not results 0 or 1. But, the results are maximum and minimum costs. At the distributor company, the cost suppression does not apply.

The integer programming methio is able to produce more optimal cost results of 16.97%. The cost before optimization of 10.111.802,91 IDR and after being optimized it becomes 8.395.480,90 IDR, and for the time increases by 13.88%.

4. Conclusion

Integer programming has been proposed for optimizing cost and time in warranty process. This research show integer programming method is able to produce more optimal cost and time in warranty process by determining which items are replaced or repaired. The impact of this research is increasing company profits for services in the warranty process.

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