Strategy for Optimizing Cost and Time of After Sales using Integer Programming

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***Abstract*— After-sales service is a service that companies use to increase customer loyalty and trust in their products. in the handling, the company will implement two processes, namely replacement of goods or repairs. the decision to repair and replace certain items will cause problems. where the company will take optimal steps to choose to repair and replace. there are advantages and disadvantages in choosing one of these decisions. the repair process has the advantage that the cost of replacement of goods is minimal but has weaknesses in workmanship, while the replacement process has excess time but has a fairly expensive replacement cost. Continuous optimization is a way to produce results that will produce the best results that is appropriate. choices are based on variables used as decision supported. There are several methods that can be used to solve problems, one of which is Integer programming. Integer programming is a mathematical method used for optimization by maximizing or minimizing objective functions of constraints with decision variables in integers. Integer programming is chosen because it can produce replacement decisions or improvements with 0 or 1 notation. Integer programming supports decision making about replacement or repairment of returned products. The results show that the costs of the aftersales process is reduced by 12.14%, while the time is increased by 7.4%**

Keywords—optimizing; integer programming; replacement strategy;)

I. Introduction

Optimization in progress is a way to produce results that will produce the best results accordingly. Besides that, with the proper formulation, it can provide optimal decision [1, 2] There are several methods that can be used to solve the problem, one of these methods is linear programming [3]. Linear programming aims to determine and make good corrective decisions from several alternative options [4]. Linear programming can also be used in solving the problem of allocating limited resources [5]. The objective function consists of the ability to measure to minimize or maximize output while constraints are the boundaries in determining decisions. There are several types of linear programming, Integer programming is a mathematical model that allows the results of split linear programming in integer. In a previous study, Lawrie in [6] and Akkoyunlu in [7] present a linear programming model and integer programming for various types of problems and thus succeed in computing the optimal solution to the problem of the schedules of each school and university. The selection of optimum integer programming solutions is also used by P. Zwaneveld a, *, G. Verweij a, S. van Hoese in [8] to determine an optimal economic embankment investment strategy to protect against flooding. In [9] the in other cases integer programming is also used to optimize forecasts in banking cases.

In this case, the problem that must be optimized is how to minimize costs and time in the after-sales process of the company. in this study, the company used as the research subject was PT. XYZ. PT. PT. XYZ is a wireless device distributor company. The company does not have a control limit of the cost of handling the after-sales process. The aftersales process includes repair and replace. In determining repair and replace, often companies find it difficult. Repair process has advantages that are replacement cost only on broken spare parts, so the cost is cheaper. But has a long time to implement because it must use a try and check strategy. While the replace process has advantages that are a short time because it directly replaced the new item without any checks. but the cost incurred is greater than the repair process. This research will be proposed using integer programming to solve the optimization problem for choosing repair or replace. The optimization problem aims to determine which items will be replaced or repaired. Usually the result of the purpose function using integer programming is how much the maximum and minimum values. However, in this paper the mathematical method of integer programming will result in a value of 0 or 1. That is used as a decision on a good will be repaired or replaced

This paper is separated into several steps of workmanship. first is to set limit optimization using Return on Investment (ROI), second is to make optimization model and used model using integer programming method. at the end will explain the results of the research.

II. Research Methods

A. ROI (Return of investment)

Profitability in relation to investment, using two measures of Return on Investment (ROI) and Return on Asset (ROA). ROI can measure the effectiveness and show the company ability to generate profits from the assets used [10]. In this study, ROI is used as a limitation of existing resources. The resources in this study are costs. Thus, the total costs incurred for repairs or replacements in the aftersales process must not exceed ROI. If it exceeds ROI, the company does not benefit. The result of the calculation of ROI is usually a ratio, the ratio is used as a measure of the percentage efficiency of a company in utilizing their invested capital. Besides, with the ratio can also be labeled as the company's ability to generate payback [11]. The limits determination of this paper first determines the ROI of the company in the case study. ROI is a performance measure used to evaluate the efficiency of investment or to compare the efficiency of a number of different investments. To calculate ROI [12].

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

B. Integer programming

Integer programming is one type of linear programming method used to obtain optimal results. In addition to integer programming many methods are used for optimization. as in the case of [13] which aims to optimize the time and cost of the container port using goal programming method, goal programming can also be combined with fuzzy to optimize time and cost [14]. In this case integer programming is the most appropriate method because the optimal result is a repair or replace decision. The form of integer programming arises, because of the fact on the optimization result not all the decision variables are worth the fractional numbers as performed by linear programming. In [15], integer programming forces optimization results in the form of integers because optimization problem using 0 – 1 variable.

In integer programming, optimizing a problem will require a mathematical model. the mathematical model that will be used must represent the existing problem into a variable. In making the model on integer programming, there are three parts. There is the decision variable, constraint function and objective function

The decision variable is the variables which decide output and represent solution. For this research, the decision variable denoted by RP_n and RR_n (n = 1,2,3 ……*n*) where *RP* is replaced and *RR* is repaired

The constraint function is restriction or limitations on the decision, in this case the limit used ROI. The model constraint is:

$$(X_nBRP + X_nOP + X_nBRPO)x\ X_nRP + (X_nBRR + X_nOP + X_nBRRO)x\ X_nRR \leq ROI \quad (2)$$

Where:

$X_n BRP$ = cost of replace in number of item *n*
$X_n OP$ = cost of operational in number of item *n*
$X_n BRPO$ = cost of operational replace in number of item *n*
$X_n BRR$ = cost of repair in number of item *n*
$X_n BRRO$ = cost of operational repair in number of item *n*

In the model it is explained that all costs incurred in the repair or replace process are entered in one type of total cost per item, the cost is in amount with each other cost. At the end of the model it is known that the resulting model of the optimization to be generated must not exceed the set limits. The objective function is defined as the objective of making decision. The model objective function is:

$$MinZ = \sum_{n=1}^{X} RP + \sum_{n=1}^{X} RR \quad (3)$$

Where:

X : number of items.
RP : item replaces
RR : item repair

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

III. Result and Analysis

A. Set limit optimization using ROI

In integer programming limits for capacity to be optimized is important. In this case then it is known sales at the company is IDR 17,631,936.39 and the company investment is IDR 13,521,360.89 then use the following formula:

$$ROI = \frac{(17,631,936.39 - 13,521,360.89)}{13,521,360.89} = 30,40\% \quad (4)$$

So, the company's ROI is 30.40% from the sales that is IDR. 17,631,936.39. So, the result is IDR 5,360,215.32.

B. Optimize using Integer Programming

Before doing optimization, the first step is to determine the data that will be used in the function constraint model that has been created (Formula 2). The data used are operational cost, replacement cost and repair cost. The data are detailed in detail in order to produce a balanced and accurate results. In this research, the data used is existing data in September 2017 of PT. XYZ.

The process of data collection is done by performing data request directly to company management. Data to be taken is data related to after sales process. Such as operational cost data, data history service monitoring, data replacement cost each item, data repair each item and data sales

First, operational cost contains the cost of the operational activities on the administration process when the goods come for the service. In the operational process there are several activities as follows:

TABLE I. OPERATIONAL ACTIVITIES

No.	ID Task	Task name	Description
1	T1	Request RMA	Make a document of application service of goods from the customer
2	T2	Check status	Check the warranty status of the goods
3	T3	Info status	notify the warranty status of the goods
4	T4	Create document receipt service	Making documents for receipt of goods from customers
5	T5	Fill out the registration form	Making documents for receipt of goods from customers
6	T6	Submit the goods to the technician	Sending the goods to be service to technician

From some of the above activities, the following will explain the cost of the company for some of these activities. That cost includes computer costs, employee salaries, paper, pencils and printing costs contained in the operational process.

TABLE II. OPERATIONAL COST

ID. Task	Resources	Description	Cost
T1	Receptionist	- Computer (per/hour) - Salary (per/hour)	- IDR 3.460 - IDR 16.500
T2	Admin RMA	- Computer (per/hour) - Salary (per/hour)	- IDR 3.460 - IDR 17.500
T3	Admin RMA	- Computer (per/hour) - Computer (per/hour)	- IDR 3.460 - IDR 7.500
T4	Admin RMA	- Paper - Print - Pen	- IDR 100 - IDR 1000 - IDR 2200
T5	Admin RMA	- Computer (per/hour)	- IDR 3460
T6	Admin RMA	- Paper - Print	- IDR 200 - IDR 1000

Second, data history service monitoring is a data history about the goods from the customer entered in aftersales process. Table III is data history service monitoring and shows there are a total of 14 items that are serviced with 5 replace and 9 repair statuses.

TABLE III. ITEM ON SERVICE

No	Item name	Mac. Address	Status
1	RB 1100 AHx2 ROUTERBOARD	00:0C:02:77:12:23	Repair
2	RB 450 ROUTERBOARD	00:0C:02:88:22:22	Replace
3	RB 750 r2 (EU) hEX lite ROUTERBOARD	00:0C:02:65:66:71	Replace
4	RB 951Ui-2HnD ROUTERBOARD	00:0C:02:66:59:2D	Replace
5	RB433AH ROUTERBOARD	00:0C:02:88:4D:2A	Repair
6	RB450G ROUTERBOARD	00:0C:02:88:22:22	Repair
7	RB450G ROUTERBOARD	00:0C:02:88:22:35	Repair
8	RB450G ROUTERBOARD	00:0C:02:88:12:67	Repair
9	RB750Gr3 ROUTERBOARD	00:0C:02:65:86:1A	Replace
10	RB941-2nD-TC ROUTERBOARD	00:0C:02:55:3D:55	Repair
11	RBDynaDishG-5HacD ROUTERBOARD	00:0C:02:75:64:91	Repair
12	RBGroove-52HPn MIKROTIK	00:0C:02:55:6A:21	Repair
13	RBGrooveA-52HPn MIKROTIK	00:0C:02:55:8E:43	Repair
14	RBLHG-5nD ROUTERBOARD	00:0C:02:55:AA:7F	Repair

Third, after it is known what items will be processed in service. After it is known what items will be processed in the aftersales, next how much it costs if the item is replaced. Cost replace item as follows:

TABLE IV. REPLACEMENT COST

No	Name item	Cost
1	RB 1100 AHx2 ROUTERBOARD	IDR 3,153,692.78
2	RB 450 ROUTERBOARD	IDR 480,148.25
3	RB 750 r2 (EU) hEX lite ROUTERBOARD	IDR 400,750.32
4	RB 951Ui-2HnD ROUTERBOARD	IDR 559,953.65
5	RB433AH ROUTERBOARD	IDR 1,380,047.81
6	RB450G ROUTERBOARD	IDR 935,504.26
7	RB450G ROUTERBOARD	IDR 935,504.26
9	RB450G ROUTERBOARD	IDR 373,874.87
10	RB750Gr3 ROUTERBOARD	IDR 211,238.14
11	RB941-2nD-TC ROUTERBOARD	IDR 2,340,000,00
12	RBDynaDishG-5HacD ROUTERBOARD	IDR 549,810.00
13	RBGroove-52HPn MIKROTIK	IDR 730,560.12
14	RBGrooveA-52HPn MIKROTIK	IDR 534,772.17

Four, the cost repair used average cost of the component to be repaired. because in the process of repair costs incurred is the cost of replacing components. to calculate average cost of the component is as follows:

$$Cost\ average = \frac{Total\ of\ component\ price}{Total\ of\ item\ quantity} \quad (5)$$

$$Cost\ average = \frac{750.000}{7} = 107.142 \quad (6)$$

So, cost of each components is IDR 107.142

Cost technical replace is the cost in the load on the replace process is done. That cost includes the cost of computers and salaries of employees who handle the replace process

TABLE V. COST TECHNICAL REPLACE

No	Resources	Description of Cost	Cost
1	Admin RMA	-Computer (per/hour) - Salary (per/hour)	IDR. 3.460 IDR. 35.000

Cost technical repair is the cost in the load on the repair process. The cost is the cost to the repair technician. That cost includes the cost of computers, equipment and salaries of employees who handle the replace process. In the repair process, it takes 5 hours for the process. The process includes analysis to select the defective component, component replacement and final device testing to determine the resistance of devices that have been repaired

TABLE VI. COST TECHNICAL REPAIR

No	Resources	Description Cost	Total
1	Technical support	- Computer (per/hour) - (Salary (per/hour) * 2 technician) * 5 hours - Tools	IDR. 17.300 IDR. 175.000 IDR. 29.100

After determining data and set limit resource with ROI to be used. Next is to collect various data that had been in prepared to know result of optimal decision to replace and repair. The data that has been prepared is entered into the optimum model integer programming that has been made before (Formula 2).

Minimize:

$$MinZ = RP1 + RP2 + RP3 + +RP4 + RP5 + RP6 + RP7 + RR1 + RR2 + RR3 + RR4 + RR5 + RR6 + RR7 + RR8 + RR9 + RR10 + RR11 + RR12 + RR13 + RR14 \quad (7)$$

Subject to:

*(3153692.78 + 38,460 + 56,100) * RP1+ (480148.25+ 38,460 + 56,100) * RP2 + (559,953.65 + 38,460 + 56,100) * RP3 + (400750.32+ 38,460 + 56,100) * RP4 + (559953.65+ 38,460 + 56,100) * RP5 + (1380047.81+ 38,460 + 56,100) * RP6 + (935504.26+ 38,460 + 56,100) * RP7 + (935504.26+ 221400+ 56,100) * RP8 + (935504.26+ 221400+ 56,100) * RP9 + (373874.87+ 221400+ 56,100) * RP10 + (211238.14+ 221400+ 56,100) * RP11 + (2340000+ 221400+ 56,100) * RP12 + (549810+ 221400+ 56,100) * RP13 + (730560,12+ 221400+ 56,100) * RP14 + (534772.17+ 221400+ 56,100) * RR1 + (107.142 + 221400 + 56,100) * RR2 + (107.142 + 221400 + 56,100) * RR3 + (107.142 + 221400 + 56,100) * RR4 + (107.142 + 221400+ 56,100) * RR5+ (107.142 + 221400+ 56,100) * RR6 + (107.142 + 221400 + 56,100) * RR7 + (107.142 + 221400 + 56,100) * RR8 + (107.142 + 221400 + 56,100) * RR9 + (107.142 + 221400 + 56,100) * RR10 + (107.142 + 221400 + 56,100) * RR11 + (107.142 + 221400 + 56,100) * RR12 + (107.142 + 221400 + 56,100) * RR13 + (107.142 + 221400 + 56,100) * RR14 = 2,722,287.30 ....Constraint 1*

$RP_n + RR_n = 1$ .... *Constraint 2* (8)

From the model can be applied directly to the software solver that will be used

Source code of integer programming

```
MODEL:
! integer programming
        optimizing cost and time;
SETS:
  PROD / X1, X2, X3, X4, X5, X6, X7/   : REPAIR, REPLACE, BRP, BRR,
BRRO, BRPO, OP;

  TUNGGAL /TUNG/ : BREPLACE, BREPAIR;
ENDSETS


 [OBJ1] MIN = @SUM( TUNGGAL : BREPLACE + BREPAIR);

 @SUM (TUNGGAL(I) : BREPLACE(I) + BREPAIR(I)) <= 2722287.30;

@FOR(PROD (PRD):
        REPAIR (PRD)+ REPLACE  (PRD) = 1);

@FOR(TUNGGAL(I) :

@SUM (PROD  (PR) :
                (BRR  (PR)+BRRO(PR)+OP(PR)  )*  REPAIR(PR))=
BREPAIR (I);

@SUM (PROD  (PR) :
                (BRP  (PR)+BRPO(PR)+OP(PR)  )* REPLACE(PR))=
BREPLACE(I););


DATA:
  BRP     =
```

```
        221238.14,400750.32,559953.65,3153692.78,730560.12,534772.
17,373874.87;

BRR    =         107142, 107142, 107142, 107142, 107142, 107142,
107142;

BRRO   =
        221400,221400,221400,221400,221400,221400,221400;

BRPO   =         38460,38460,38460,38460,38460,38460,38460;

OP                =
        56100,56100,56100,56100,56100,56100,56100;
ENDDATA
END
```

Fig. 1. Source code to optimizing with integer programming

Fig.1 is the source code to optimize the aftersales process by using the integer programming method based on the previously created model

TABLE VII. RESULT OF OPTIMIZATION

No	Item Name	Mac. Address	Repair	Replace
1	RB 1100 AHx2 ROUTERBOARD	00:0C:02:77: 12:23	1	0
2	RB 450 ROUTERBOARD	00:0C:02:88: 22:22	1	0
3	RB 750 r2 (EU) hEX lite ROUTERBOARD	00:0C:02:65: 66:71	1	0
4	RB 951Ui-2HnD ROUTERBOARD	00:0C:02:66: 59:2D	1	0
5	RB433AH ROUTERBOARD	00:0C:02:88: 4D:2A	1	0
6	RB450G ROUTERBOARD	00:0C:02:88: 22:22	1	0
7	RB450G ROUTERBOARD	00:0C:02:88: 22:35	1	0
8	RB450G ROUTERBOARD	00:0C:02:88: 12:67	1	0
9	RB750Gr3 ROUTERBOARD	00:0C:02:65: 86:1A	1	0
10	RB941-2nD-TC ROUTERBOARD	00:0C:02:55: 3D:55	0	1
11	RBDynaDishG-5HacD ROUTERBOARD	00:0C:02:75: 64:91	1	0
12	RBGroove-52HPn MIKROTIK	00:0C:02:55: 6A:21	1	0
13	RBGrooveA-52HPn MIKROTIK	00:0C:02:55: 8E:43	1	0
14	RBLHG-5nD ROUTERBOARD	00:0C:02:55: AA:7F	1	0

Table VII is the result of optimization on fig. 1. As for attribute information in this table is item name, mac.address and results

TABLE VIII. RESULT COMPARATION

No.	Item Name	Macc. Address	Before	After
1	RB 1100 AHx2 ROUTERBOARD	00:0C:02:77:12:23	Repair	Repair
2	RB 450 ROUTERBOARD	00:0C:02:88:22:22	Replace	Repair
3	RB 750 r2 (EU) hEX lite ROUTERBOARD	00:0C:02:65:66:71	Replace	Repair
4	RB 951Ui-2HnD ROUTERBOARD	00:0C:02:66:59:2D	Replace	Repair
5	RB433AH ROUTERBOARD	00:0C:02:88:4D:2A	Repair	Repair
6	RB450G ROUTERBOARD	00:0C:02:88:22:22	Repair	Repair
7	RB450G ROUTERBOARD	00:0C:02:88:22:35	Repair	Repair
8	RB450G ROUTERBOARD	00:0C:02:88:12:67	Repair	Repair
9	RB750Gr3 ROUTERBOARD	00:0C:02:65:86:1A	Replace	Repair
10	RB941-2nD-TC ROUTERBOARD	00:0C:02:55:3D:55	Repair	Replace
11	RBDynaDishG-5HacD ROUTERBOARD	00:0C:02:75:64:91	Repair	Repair
12	RBGroove-52HPn MIKROTIK	00:0C:02:55:6A:21	Repair	Repair
13	RBGrooveA-52HPn MIKROTIK	00:0C:02:55:8E:43	Repair	Repair
14	RBLHG-5nD ROUTERBOARD	00:0C:02:55:AA:7F	Repair	Repair

Table VIII shows the results of the comparison of existing data in table III with the data after optimization in table VII. can be seen in the item RB 450 ROUTERBOARD with mac address 00: 0C: 02: 88: 22: 22, RB 750 r2 (EU) hEX lite ROUTERBOARD with mac address 00: 0C: 02: 65: 66: 71, RB 951Ui-2HnD ROUTERBOARD with mac address 00: 0C: 02: 66: 59: 2D, RB750Gr3 ROUTERBOARD with mac address 00: 0C: 02: 65: 86: 1A the results obtained after the optimization process are from replace to repair. but in item RB941-2nD-TC ROUTERBOARD with mac address 00: 0C: 02: 55: 3D: 55 the results obtained are the opposite, that is, from repair to replace.

The results can be concluded that integer programming can produce optimization in after sales process. out of a total of 14 items in service there are total of 5 items that have changed from replace to repair or repair to replace. from the results of this study improved that the reduction in costs in the aftersales process is 12.14%. With costs before the optimization process is IDR 6,039,387.09 become IDR 5,306,144.14

IV CONCLUSION

This study shows the results of optimizing cost and time of after sales using integer programming. Four items change process from replacement to repairment, and one item changes from repairment to replacement. The change could reduce the previous cost of IDR 6,039,387.09 to IDR 5,306,144.14. Therefore, the optimization can reduce cost by 12.14%, while the time increases by 7.4%.

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