Time and Cost Optimization Using Dynamic Programming and FMS Scheduling

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***Abstract*—Quality of information system at a company in Surabaya which is engaged in buying and selling *wireless* devices greatly affect the business performance of the company. One of the processes that support the running of this company is the process of *Return Material Automatically (RMA)*. In this study, a RMA model business processes used by the authors for optimizing time and costs. To generate an alternative direction, the author uses an scheduling algorithm referred to Flexible Manufacturing System (FMS). After a time the optimal alternative route is obtained, it become *input* of programming objectives that will be calculated with Dynamic Programming, then the best route will be obtained using the optimal time and cost. The results of this study indicate that FMS Scheduling can be used to optimize time, and Dynamic Programming can be used to optimize the cost of this research. The results show that Trace 2 provides the optimal results compared to Trace 1.**

Keywords—Optimizing, FMS Scheduling, Dynamic Programming

I. INTRODUCTION

Along with the development of competition in the business world and the increasingly complex sales transactions as well as the broader range of sellers in the company, it has become a necessity for companies to compile, organize and discipline the jobs. The aim is to explain the details or fixed standards regarding repetitive work activities held in an organization to be able to make a better work flow..

The company that we use in this research is a company in Surabaya which is engaged in buying and selling *wireless* devices which is designated as a distributor of Ubiquiti and Mikrotik products in 2010 and a master reseller for Asia. The company itself has committed to providing quality / quality of professional products and services that ensure customer satisfaction.

Return Material Automatically (RMA) is a return transaction of damaged goods from the customer to the seller (supplier) within the warranty period / not to be repaired or replaced with other similar items / one product. RMA is a part of the process that affects the performance of companies engaged in buying and selling this wireless device. This company realizes that the time can be optimized with the right business processes in each department by accelerating the ongoing business processes and emphasizing the costs of optimizing a business process. The company's RMA has a target of achieving maximum service goods not more than 2 weeks with minimum cost.

Scheduling is needed with a view to get the high-quality time and most fee based at the referred to issues [1]. In this study, first, performed with scheduling optimization time in business processes using Flexible Manufacturing Systems (FMS). After reaching optimal time, the target to be carried out is determined [2].There are some methods used to solve the problems and give optimal result−optimization of non-linear approaches and linear optimization [3]. In the prior study, cost optimization is used using goal programming, in this study, the writer uses different method to optimize the cost, it is Dynamic Programming.

Dynamic Programming targets to optimize the cost primrily based on time, getting the quickest time, lowest cost and earnings. Goal is determined based totally on policies or SOP by the company and seeing event log / notes in that company. Dynamic Programming has been used before in a research about TSP with different constraint, and successfully used to find optimal solutions [4][5][6].

This paper is divided into several parts. Fist part explains this study problem. Second part explains about matters related to this research. The third part explains parameters and targets for FMS and Dynamic Programming methods. For the results analysis and discussion explained in fourth part. The conclusions will be explained in part five.

II. LITERATURE REVIEW

A. *Scheduling*

Doing a job effectively and efficiently in order to achieving the goals is what every company management desires. Scheduling is needed. Scheduling is method that aims to arrange or allocate existed resources or machine to carry out several tasks within a certain period of time [2]. Basically scheduling is a very important process to determine when an activity must begin and when the time is finished.

B. *Event Log*

Event log is note of all of the activity process, from the activity starts to complete. Event log basically consists of date, time, user, and source. Every activity from a business process has special characteristic, it depends on what the organization needs to record. With event log file automatically saved in database, it helps the company to keep and resolve some problems if there is a mistake. Event log is also used for optimizing process efficiency, in several cases which reduces cost and activity time [7]. Trace from each business process has activities and each activity has its own time and cost according to the noted event log. In this study we use 2 traces; trace 1 and trace 2. The different between 2 traces is the number of activity which is done; Trace 1 has 13 activities shown in Table 1 while Trace 2 has 12 activities shown in Table 2.

TABLE I. EVENT LOG RMA DATA TRACE 1

No	Activity	Time	Cost
1	Request RMA	4	21170
2	Check Device Status	2	3670
3	Status Info	4	3670
4	Create a Service Receipt	8	22170
5	Fill Form Registration RMA	10	21170
6	Submit The Goods To The Technician	10	17500
7	Service	120	82670
8	Check Service Results via Web RMA	10	3670
9	Check Warranty	10	3670
10	Replacement	40	26170
11	Check Stock RMA	15	3670
12	Fill in the Goods Request Form	10	4870
13	Make Job Costing	10	0

TABLE II. EVENT LOG RMA DATA TRACE 2

No	Activity	Time	Cost
1	Request RMA	4	21170
2	Check Device Status	2	3670
3	Status Info	4	3670
4	Create a Service Receipt	8	22170
5	Fill Form Registration RMA	10	21170
6	Submit The Goods To The Technician	10	17500
7	Service	120	82670
8	Check Service Results via Web RMA	10	3670
9	Check Warranty	10	3670
10	Create Notice Form Damaged Goods	15	4870
11	Customer Info	15	3670
12	Make a DO RMA	30	0

C. *Optimization*

Optimization is parts that cannot be estranged from design process engineering. The focus of optimization is finding optimal solutions in design problem through systematic consideration of the alternatives given to resource satisfaction and cost constraints. There are many open technical problems and complex. The entire purposes of optimization are minimizing the cost, maximizing the profit, streamlining production activities, improving process efficiency, and so on. In defining the optimal solution, careful consideration of several alternatives that are often compared to several criteria is needed [8].

III. RESEARCH METHODOLOGY

A. *Flexible Manufacturing Systems*

FMS is job shop made automatically. Job shop is a group of machine that performs certain job from each machine center to other machine. Job shop is not only using machine but also using activity from business process. FMS is used to automatically assign alternative job shop. Several regulations in FMS are First Come First Serve (FCFS), Last Come First Serve (LCFS) or precedence [9].

Flexible Manufacturing Systems is manufacturing method producing items which might be adapted to the product adjustments being made. This system is likewise applied to calculate several cases such as distribution, maintenance, and preservation, and removal of products inside the logistics process. The entire system handles various stages of manufacturing. Flexible Manufacturing Systems is best suited for a selection of mid-variety, mid-extent manufacturing.

B. *Dynamic Programming*

Dynamic Programming is design techniques which is similar with divide and conquer. Dynamic programming can be applied when sub problems are not independent. Dynamic Programming algorithm solves each sub problem only once and then saves the answer in a table, thus avoiding re-computing work to obtain the answer every time the sub-problem is found [10] [11].

Dynamic programming usually applied in optimization problem. In that case, there can be several probable solutions. Every solution has value and we want to find a solution with optimal value (minimum or maximum). That solution is often referred as optimal solutions, compared with optimal solutions, because there may be several solutions that achieve optimal values [9].

On solving problems with this method: 1) There are a limited number of possible choices. 2) Solutions at each stage are built from the results of the previous stage solutions, and 3) Using optimization requirements and constraints to limit a number of choices that must be considered at a stage [13].

The steps of solving problem of *dynamic programming* are:

1. Problems can be divided into several stages, in which each stage is taken only at one decision.
2. Each stage consists of a number of states related to that stage. Generally, the state is a possible input at that stage.
3. The result of the decisions taken at each stage is transformed from the relevant status to the next status at the next stage.
4. Cost in a stage increases regularly with increasing number of stages.

5. Weight at a stage depends on the weight of the steps that have been run and the weights at that stage.
6. The best decision at a stage is independent on the decisions made in the previous stage
7. The existence of a recursive relationship that identifies the best decision for each status at stage k gives the best decision for each status in stage $k + 1$.
8. The principle of optimality applies to the problem [13].

There are two kinds of *dynamic programming*; *Forward Dynamic Programming* (calculation from front to back) and *Backward Dynamic Programming* (calculation from back to front). This study uses *Forward Dynamic Programming* method, because it begins with only 1 activity from the start. This program seeks solutions from stage 1, 2, 3, … , n. the sequence of the decision change is $x_1, x_2, x_3, \dots, x_n$. The formula of *Forward Dynamic Programming* written below [13]:

$$f_k\ (s)\ =\ c_{sxk} \quad (1)$$

$$f_k(s) = min_{x_k}\{\ c_{sxk} + f_{k+1}(x_k)\}, k = 1,2,\dots,n$$

(2)

Explanation:
x_k = Decision changer in stage k
c_{sxk} = Cost from s to x_k
$f_k(s, x_k)$ = Cost track total from s ke x_k
$f_k\ (s)$ = Minimum value $f_k(s, x_k)$

IV. EXPERIMENT & DISCUSSION

A. Data Collection

Data used in this study is Event log. Data collection technique in this study is event log data given directly by the company. Event Log is a process record of all activities, from start to finish taken from this company. Before being processed, this event log will be extracted and analyzed first. In this study, the log event used is 8 traces, 1 trace has 2 cases.

B. Research Flow Chart

Below is the flow chart of this study shown in Fig. 1:

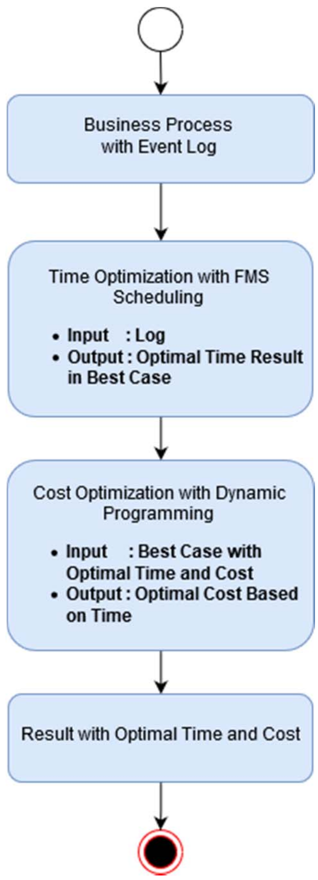

Fig. 1. Flowchart of Proposed Method

C. Time Optimization

From the given event log data, scheduling process is needed to obtain workflow of an optimal business process. Scheduling is an important process for a company. A good scheduling is one that can provide minimum time with large production in order to reduce excessive production costs. The following is a graphic showing the average time comparison of Cases and Trace 1 shown in Fig. 2 and Trace 2 shows the average time comparison of Cases and Trace 2 shown in Fig. 3 below that has been processed using *FMS Scheduling*.

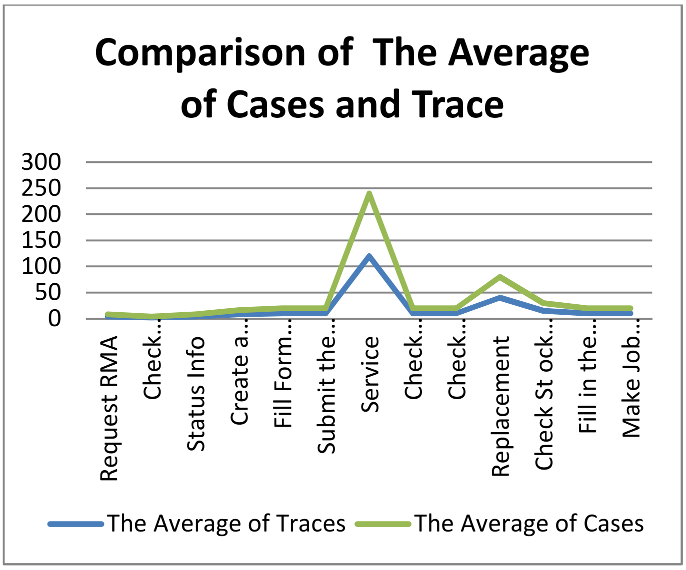

Fig. 2. Comparison of The Average of Cases and Trace 1

On Fig. above shows that Trace 1 still has not attained the desired target because there are some activities that the trace average that has not reached the average case, just as Trace 2 is shown in Fig. 3 below 2.

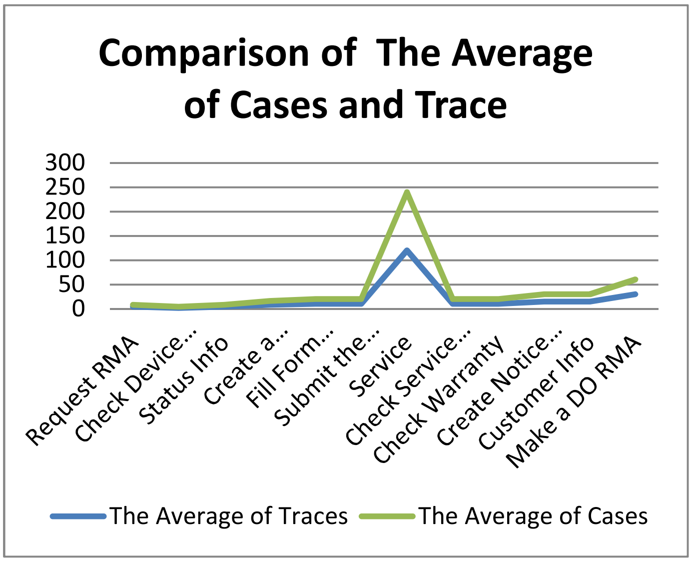

Fig. 3. Comparison of The Average of Cases and Trace 2

D. Cost Optimization

The subsequent is to optimize the cost based on optimal time done by FMS. In this stage, cost optimization is done using *Forward Dynamic Programming*. The following will show business process *Return Material Automatically (RMA)* mapped into the graphs of Trace 1 and Trace 2 that were previously processed with FMS Scheduling are shown in Fig. 4 below.

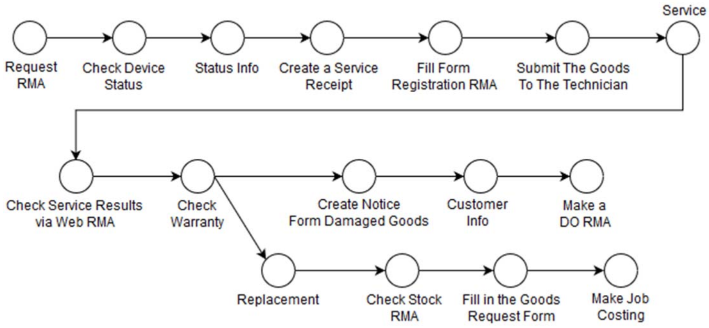

Fig. 4. Graph of Business Process Trace 1 and Trace 2

The next is making data list to calculate cost optimization by determining the value of each activity from the business process above which will be shown in Table III below.

TABLE III. LIST DATA FOR COST OPTIMIZATION

s	Activity	Cost
1	Request RMA	21170
2	Check Device Status	3670
3	Status Info	3670
4	Create a Service Receipt	22170
5	Fill Form Registration RMA	21170
6	Submit The Goods To The Technician	17500
7	Service	82670
8	Check Service Results via Web RMA	3670
9	Check Warranty	3670
10	Replacement	26170
11	Create Notice Form Damaged Goods	4870
12	Check Stock RMA	3670
13	Customer Info	3670
14	Fill in the Goods Request Form	4870
15	Make a DO RMA	0
16	Make Job Costing	0

Next is analogizing the cost of each activity from Table III above as the cost in the graph, then a more complete graph is obtained like Fig. 5 below.

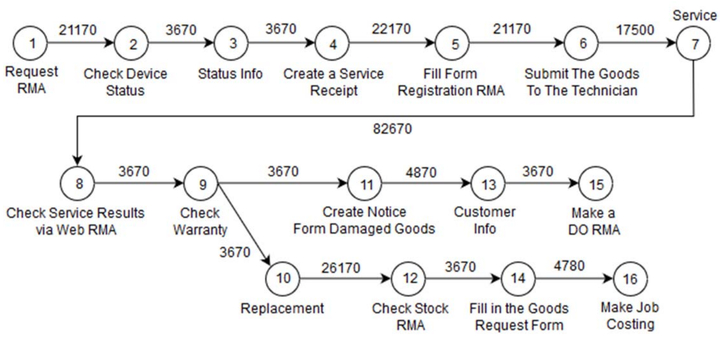

Fig. 5. Cost of Business Process Trace 1 and Trace 2

After determining the weight from each activity, calculation using *Forward Dynamic Programming* will be done with the following steps:

1) *Stage 1*

$$f_1(s) = c_{sx1}$$

s	$f_1(s) = c_{sx1}$	Optimum Solution	
	2	$f_1(s)$	x_1^*
1	21170	21170	2

2) *Stage 2*

$$f_2(s) = min_{x_2}\{ c_{sx2} + f_1(x_2)\}$$

s	$f_2(s) = c_{sx2}$	Optimum Solution	
	3	$f_2(s)$	x_2^*
2	24840	24840	3

3) *Satge 3*

$$f_3(s) = min_{x_3}\{ c_{sx3} + f_2(x_3)\}$$

s	$f_3(s) = c_{sx3}$	Optimum Solution	
	4	$f_3(s)$	x_3^*
3	28510	28510	4

4) *Stage 4*

$$f_4(s) = min_{x_4}\{ c_{sx4} + f_3(x_4)\}$$

s	$f_4(s) = c_{sx4}$	Optimum Solution	
	5	$f_4(s)$	x_4^*
4	50680	50680	5

5) *Stage 5*

$$f_5(s) = min_{x_5}\{ c_{sx5} + f_4(x_5)\}$$

s	$f_5(s) = c_{sx5}$	Optimum Solution	
	6	$f_5(s)$	x_5^*
5	71850	71850	6

6) *Tahap6*

$$f_6(s) = min_{x_6}\{ c_{sx6} + f_5(x_6)\}$$

s	$f_6(s) = c_{sx6}$	Optimum Solution	
	7	$f_6(s)$	x_6^*
6	89530	89530	7

7) *Stage 7*

$$f_7(s) = min_{x_7}\{ c_{sx7} + f_6(x_7)\}$$

s	$f_7(s) = c_{sx7}$	Optimum Solution	
	8	$f_7(s)$	x_7^*
7	172020	172020	8

8) *Stage 8*

$$f_8(s) = min_{x_8}\{ c_{sx8} + f_7(x_8)\}$$

s	$f_8(s) = c_{sx8}$	Optimum Solution	
	9	$f_8(s)$	x_8^*
8	175690	175690	9

9) *Stage 9*

$$f_9(s) = min_{x_9}\{ c_{sx9} + f_8(x_9)\}$$

s	$f_9(s) = c_{sx9}$		Optimum Solution	
	10	11	$f_8(s)$	x_8^*
9	179360	179360	179360	10 or 11

10) *Stage 10*

$$f_{10}(s) = min_{x_{10}}\{ c_{sx10} + f_9(x_{10})\}$$

s	$f_{10}(s) = c_{sx10}$		Optimum Solution	
	12	13	$f_{10}(s)$	x_{10}^*
10	205530	-	205530	13
11	-	184230	184230	

11) *Stage 11*

$$f_{11}(s) = min_{x_{11}}\{ c_{sx11} + f_{10}(x_{11})\}$$

s	$f_{11}(s) = c_{sx11}$	Optimum Solution	
	15	$f_{11}(s)$	x_8^*
13	187900	187900	15

Cost optimization is done to find out the most optimal cost of both traces to save costs. The testing was conducted twice using similar data; the unit cost limitation was rupiah. This evaluation aims to determine the average cost, and optimal cost with the Dynamic Programming algorithm implemented.

From the process of finding the optimal cost value with Forward Dynamic Programming described above, it can be seen that the most optimum cost results from the above Business Process are Rp. 187,900 in Trace 2.

Based on the optimization time described in Fig. 2 and Fig. 3, the following results will be shown the calculation of the optimum time and the optimum cost of Trace 1 and Trace 2 shown in Table IV below.

TABLE IV. OPTIMAL TIME AND COST

Trace	Optimal Cost	Optimal Time
Trace 1	213980	60
Trace 2	187900	60

From Table IV above it is shown that it will return with a graph. For the average time result with FMS Scheduling calculation from each Trace is shown in Fig. 6 below, whereas for optimal cost result with Dynamic Programming calculation is shown in Fig. 7 below.

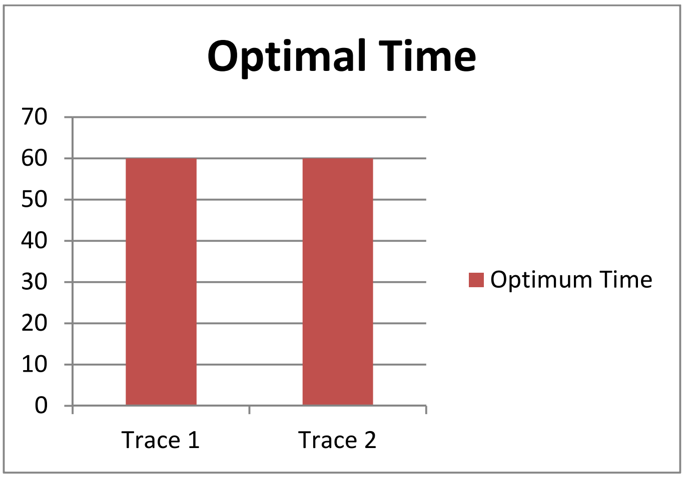

Fig. 6. Optimum Time in Each of Trace

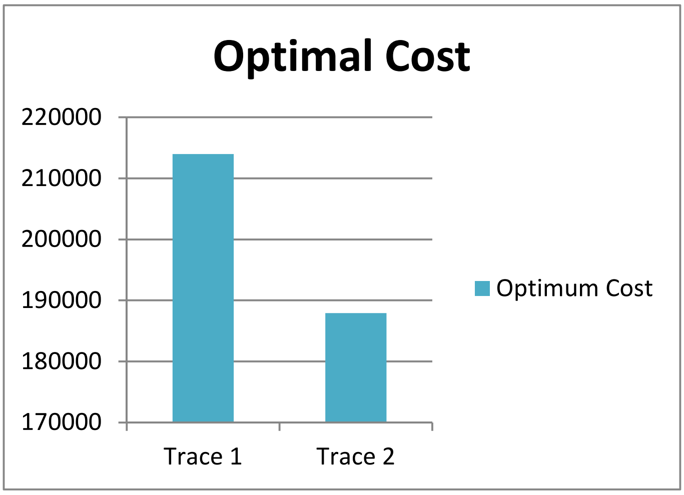

Fig. 7. Optimum Cost in Each of Trace

V. CONCLUSION

Based on the result of the calculation of time optimization with FMS Scheduling and cost optimization with Dynamic Programming on chapter IV, it can be concluded that from this study:

1. The result of time optimization on Trace 1 is 60 minutes, and the cost optimization is Rp 213,980
2. The result of time optimization on Trace 2 is 60 minutes, and the cost optimization is Rp 187,900

The results of this study can be concluded that the most optimal results is Trace 2 compared to Trace 1. Therefore, this research obtained better improvement in time optimization using FMS Scheduling and cost optimization using Dynamic Programming.

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