Optimizing Time and Cost using Goal Programming and FMS Scheduling

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Abstract—Recently port container terminals plan to minimize dwelling time. In this context we utilize process business model to optimize time and cost of the activities. First, Flexible Manufacturing System (FMS) scheduling algorithm is employed to generate alternative routes, which have ascending order of times. Then, the time and cost of the alternative routes became to input of Goal Programming, which obtain the best route with optimal time and cost.

The result of this research showed that scheduling can increase work time so that the execution time becomes more optimal, whereas Goal Programming lower the production costs in accordance with the desired target in the company.

Index Terms—Optimization, Scheduling, Goal Programming

I. Introduction

Logistics is the study of the process of storage, distribution, maintenance, and elimination of goods. In today's sophisticated world, logistics plays an important role in the development and development of world trade. In order for the trade to run smoothly and no fluctuations occur, goods ordered or purchased must arrive at the destination properly and efficiently. So, in general, the mission of logistics is how to get the right goods at the right time, the right amount, the right conditions, at an affordable cost but still increase the profit for the logistics company.

Port Container Terminal in Surabaya is one of the world-class standard terminals in Indonesia. Containers coming from various ports in Indonesia such as Bali, Mataram, Kupang, and Papua [1]. In addition to Domestic crossings, this terminal also provides the International crossing. On one trip, the container freight trains can carry 30 carriages or the equivalent of 60 TEUs (container units) [2]. Development requires for the current system that can manage logistics properly so that it can support the smooth production process. So that, a logistics company should have some targets to be made within a certain time so that the service will increase as well [3].

Container Terminals have several targets to be achieved in one hour such as, for International Crane route must transport 25 containers and for a Domestic route, Cranes must carry 18 containers [4]. In addition, the target to be achieved in a secured process to reduce the number of theft of goods or container or facilities owned by Port Container Terminal.

And the main target of a logistics company is to maximize work at the lowest possible cost.

It required a scheduling to get the best time and maximum profit [5]. So this research proposes an activity scheduling by using Flexible Manufacturing Systems (FMS) to optimize the processing time. Once reach the optimal time, then determine the target to be achieved.

Goal programming is used to optimize costs based on time, achieve the fast time, low cost, and also gain profit [6]. The target is determined based on the rules or SOPs by the company and view the event log/record over the last few months.

This paper is separated into following sections. Second section is the explanation of all implemented methods, the third section is defining parameters and target for the FMS and Goal programming methods. Discussion results will be explained in section four and the conclusion in the fifth section.

II. Literature Review

A. Scheduling

Scheduling is a method that aims to organize or allocate existing resources or machines to perform some tasks within a certain timeframe. Scheduling aims to organize or allocate existing resources or machines to perform some tasks within a certain timeframe. Basically this is a process which determine the activity of when it has to start and stop.

B. Optimization Cost and Time

Optimization is a normative approach to identify the best solution in making a decision of a problem. The problem solving in the optimization is aimed to obtain the maximum or minimum point of the optimized function [7]. This always applies to a company in determining the amount of production in order to get maximum profit and minimum cost.

In the optimization, a problem will be solved to obtain optimum results in accordance with the given constraints. If the problem is formulated appropriately, it can provide the optimum decision variable value. Once the optimum solution is obtained, the problem is often re-evaluated under different conditions to obtain a new solution.

Activity	Cost	Time
Document Entry via PDE	0	87
Vessel Berthing Process	64278.76	14999
Discharge Container	609.39	1668
Bring Container to Yard	68.27	148
Stack Container in Yard	24.04	44980
Verification Document Behandle	7.03	21736
Create document SPPB	2668.25	45
Create Job Order Document Delivery	22.47	147
Truck in	7.83	76
Dispatch WQ Delivery to CHE	0.64	165
Determine Container Type	1.48	137
Determining Refeer	18.97	90
Decide Task Before Lift Container	1.53	450
Unplug Refeer Cable	7.31	150
Lift on Container Truck	19.87	3119
Truck Go To Gate Out	1.44	90
Check Container before Truck out	1.49	88
Truck Out	7.45	1

Activity	Cost	Time
Document Entry via PDE	0	87
Vessel Berthing Process	86387.53	117954
Discharge Container	752.05	2396
Bring Container to Yard	219.36	147
Stack Container in Yard	0	27421
Verification Document Behandle	6.33	13251
Create document SPPB	2616.47	28
Create Job Order Document Delivery	37.53	153
Truck in	13.76	83
Dispatch WQ Delivery to CHE	1.17	159
Determine Container Type	2.53	139
Determining Uncontainer	14.79	90
Decide Task Before Lift Container	2.57	53
Prepare Tools	77.83	150
Lift on Container Truck	47.94	3841
Truck Go To Gate Out	2.71	90
Check Container before Truck out	3.05	91
Truck Out	13.56	1

C. Event Log

Event log is a record of the process from all activity, from start to finish. The record is basically consist of date, time, user, event ID, type, and source. Each activity has different attribute, depends on what the company need to record. The file is automatically stored in a databases, it helps the company to maintain and do some troubleshooting if there is an error. It also used for optimizing the efficiency of a process, in some cases it reduce the cost and time of an activity [8].

Each trace has several activities and each activity has its own time and cost according to the recorded event log. There are two traces that can be seen in Table I and II.

III. THE PROPOSED METHOD

A. Flexible Manufacturing System

FMS is a job shop that is created automatically. Job shop is a group of machine that do some particular jobs from any machine center to another machine. Each job has a special groove between machine centers. FMS is used to specify job shop job alternatives automatically. Some rules in FMS are First Come First Serve (FCFS), Last Come First Serve (LCFS) or Priority [9].

Flexible Manufacturing System is manufacturing method for producing goods that is adjusted to the changes of product that is being manufactured. This system is also implemented to calculate some cases for example the distribution, maintenance, and elimination of goods in the logistics process. The whole system handle varying levels of productions. The Flexible Manufacturing System is most suited for the midvariety, mid-volume production range.

B. Goal Programming

Goal Programming is a method used to minimize errors or deviations in doing a goal by considering the priority of the objective [10]. Goal Programming method can be applied in production planning, because Goal Programming has the potential to resolve aspects that conflict with elements in product planning, i.e. consumers, products, and manufacturing processes [11].

The basic approach of goal programming is to set a goal that is stated with a given value for each goal, to formulate a function of purpose for each goal, and then provide the solution that minimizes the number of deviations on the objective function [12]. Goal Programming model has three main elements, that are the decision variable, objective function, and constraint function.

Decision variable is a set of unknown variables that are under the control of decision maker, which affects the solution of the problem and the decision to be taken. Usually denoted by Xj (j = 1, 2,3, ..., n)

Objective function, is the mathematical function of decision variables that has the relationship with the value of the right side and minimize deviational variable in the Goal Programming.

Deviational variable (deviation), is a variable that indicates the possibility of negative and positive deviation from right side value of objective function. Negative deviation variables will accommodate deviations that are below the desired target, whereas the positive deviation variable will accommodate deviations that are above the target. In Goal Programming, it is denoted by d_i^- and d_i^+ for positive deviation from right side value of the goal that can be seen in Table III. Then the source code is used to calculate the Goal Programming for Case 1 that shown in the Table IV.

Goal Programming Method Formula

$$ConstraintFunction = X_i + d_i^- - d_i^+ = P_i \quad (1)$$

Where :
X_i = Number of product i in production
P_i = Level of demand for the product i
d_i^- = Deviation value below P_i
d_i^+ = Deviation value above P_i

Minimize	Goal	If Goal is Achieved
d_i^-	Minimize the underarchievement	$d_i^- = 0, d_i^+ = 0$
d_i^+	Minimize the overachievement	$d_i^+ = 0, d_i^- = 0$
$d_i^+ + d_i^+$	Minimize the both under-and over-achievement	$d_i^- = 0, d_i^+ - = 0$

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Source Code of Goal Programming
min Z = D1plus + D1minus +D2plus + D2minus ;
0*x1+64278.76*x2+609.39*x3+.........+ 1.49*x17+7.45*x18-
D1plus+D1minus=67746.24;
87*x1+14999*x2+1668*x3+.....+88*x17+1*x18-
D2plus+D2minus=88177;
X1 >= 1;
X2 >= 1;
X3 >= 1;
X4 >= 1;
X5 >= 1;
X6 >= 1;
X7 >= 1;
X8 >= 1;
X9 >= 1;
X10 >= 1;
X11 >= 1;
X12 >= 1;
X13 >= 1;
X14 >= 1;
X15 >= 1;
X16 >= 1;
X17 >= 1;
X18 >= 1;
```
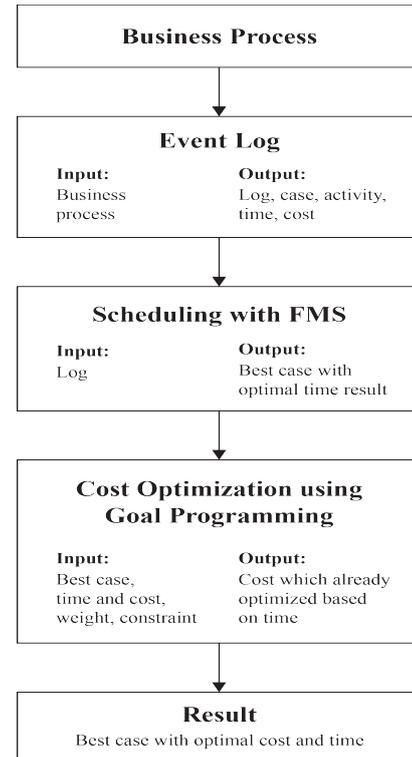
In order for d_i^- and d_i^+ minimum then the goal function equation Z becomes

$$MinZ = \sum (d_i^- d_i^+) \qquad (2)$$

The target constraints to maximize sales revenue

$$MinZ = \sum_{i=1}^{m} H_i X_i \qquad (3)$$

Where H_i = Selling price per unit of product i
X_i = Number of products i produced
m = Number of product types
Constraints to minimize production costs

$$MinZ = \sum_{i=1}^{m} B_i X_i \qquad (4)$$

Where B_i = Production cost per product unit i

In general, the process begins by entering the data information from the event log with the output of logs, cases, time, and cost. Then FMS calculates the scheduling data according to the data from the event log. The results of the FMS calculation is the optimal time that continue to optimizing the cost and time production by using Goal Programming method. The result will be the best case with optimal time and cost. The business process can be seen in the Figure 1.

IV. RESULT AND DISCUSSION

A. Collecting Data

Event Log is a record of a set of activities that take place in an organization or company. Event Log is a big data in which have important information that can be extracted and analyzed. The process of analyzing event logs is called mining process. Mining process is a method that can find and create a business process workflow. This method can detect the activities that performed concurrently at the time [13]. Generated event log then will be compared with the mining process at the company.

In this research, event log that has been obtained for one month in January 2016 [4] as many as 80622 Log with 2500 cases and 7 kind of traces.

The target is generated from the average calculation of each activity throughout the resulting log. In the Figure 2 shows that trace 1 has a value that still does not meet the desired target, as well as trace 2 that can be seen in Figure 3.

Fig. 1. Schemes of this research

B. Scheduling

From the event log that has been provided, to get the workflow of optimal business process needs to do the scheduling process. Scheduling is very important in a company. Proper scheduling will produce a short time with large production, which can reduce excessive production costs.
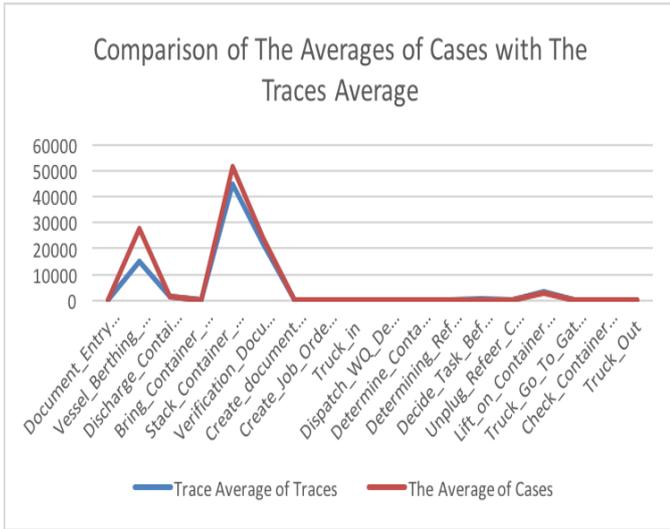
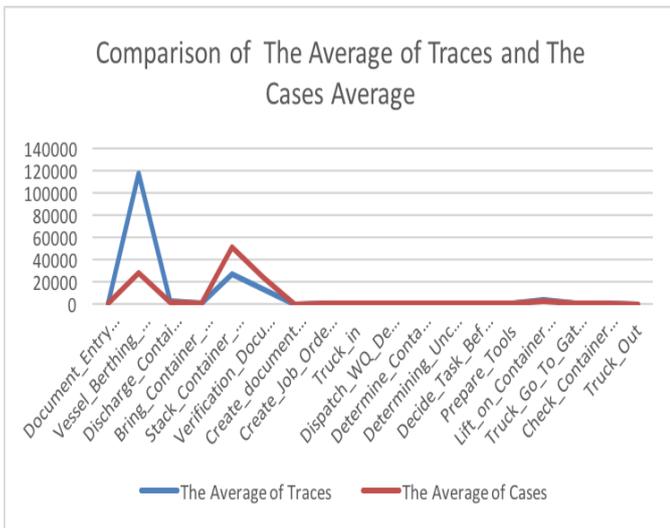Fig. 2. Comparison of the Averages of Cases with the Average of Traces 1

Fig. 3. Comparison of the Averages of Cases with the Average of Traces 2

Fig. 4. Step-by-step of Goal Programming

TABLE V
PARAMETERS RESULT OF GOAL PROGRAMMING

Parameters	Trace 1	*Trace 2*
Objective Value	1369	1.00006
Constraint	21	21
Variable	22	22
d_2^+	1369	1.00006
d_1^+	0	0
d_1^-	0	0
d_2^-	0	0
Reduced Cost	1369	1.00006

To do the scheduling of workflow process can not be executed directly, it must follow the existing rules and possibly executable to enter the scheduling process.

C. Optimasi Cost

After obtaining the combination with optimal time, next is optimizing the production cost based on the optimal time. Optimization cost in this study is using Goal Programming where each activity will be calculated its optimal cost.

In Goal Programming, weight is given to determine which activities should be more attention. The weight can be either 0 or 1 where 0 is the lower bound or still equal of the mean, while 1 is the upper bound of the activity that must be in the optimization because the value is greater than the expected target [14].
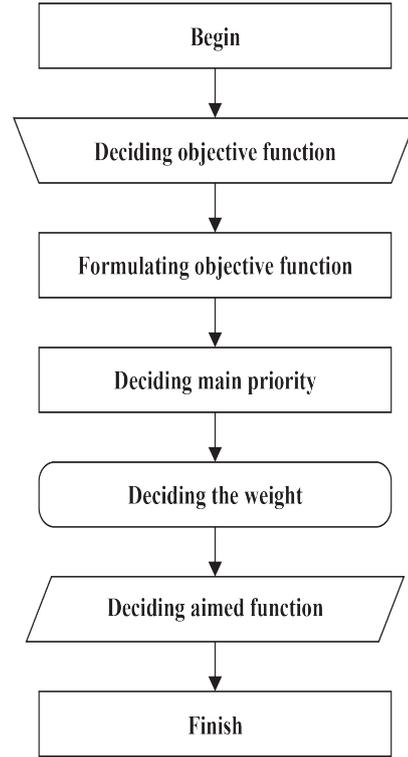
The target value is given to each activity so that it can be analyzed whether the activity is in matched with the target or not and how much the objective produced. Objective is the deviation value between the original value and the given target value. The smaller the objective value generated then the activity has almost fulfilled the given target and vice versa. The Goal Programming process can be seen in Figure 4 and the parameters result is in the Table V.

Object Value is the maximum profit that can be generated, in this case is 1369. Variable-value reduce cost shows which activity that has a role in producing more profit. Variable is the activity, Value is a constraint that must be executed to gain profit, and the company will lose or the profit will be reduced if reduce cost variable is removed.

From the result of case 1 profit generated as much as 1369 with the constraint x1 as 1, to x18 as 1.

Slack is a problem of forming objective function that still

TABLE VI
RESULT OF SLACK OR SURPLUS IN TRACE 1

Row 1	Slack or Surplus	*Dual Price*
1	1369	-1.000
2	0	0
3	0	1.000
4	0	-87
5	0	-14999
6	0	-1668
7	0	-148
8	0	-44980
9	0	-21736
10	0	-45
11	0	-147
12	0	-76
13	0	-165
14	0.365	0
15	0	-90
16	0	-450
17	0	-150
18	0	-3119
19	0	-90
20	0	-88
21	0	-1

TABLE VII
RESULT OF SLACK OR SURPLUS IN TRACE 2

Row 1	Slack or Surplus	*Dual Price*
1	1.0006	-1.000
2	0	-0.10
3	0	1.000
4	0	-87
5	0	-117029
6	0	-2387
7	0	-144
8	0	-2741
9	0	-13250
10	0.21	0
11	0	-152
12	0	-82
13	0	-158
14	0	-138
15	0	-89
16	0	-752
17	0	-149
18	0	-3840
19	0	-89
20	0	-90
21	0	-0.854

TABLE VIII
FINAL RESULT OF TRACE 1

Activity	Constraint Time	Target Time	*Result*
Document Entry via PDE	87	87	Passed
Vessel Berthing Process	14999	14999	Passed
Discharge Container	1668	1668	Passed
Bring Container to Yard	148	148	Passed
Stack Container in Yard	24.04	24.04	Passed
Verification Document Behandle	7.03	7.03	Passed
Create document SPPB	2668.25	2668.25	Passed
Create Job Order Document Delivery	22.47	22.47	Passed
Truck in	7.83	7.83	Passed
Dispatch WQ Delivery to CHE	0.64	0.64	Passed
Determine Container Type	1.48	1.48	Passed
Determining Refeer	18.97	18.97	Passed
Decide Task Before Lift Container	1.53	1.53	Passed
Unplug Refeer Cable	7.31	7.31	Passed
Lift on Container Truck	19.87	19.87	Passed
Truck Go To Gate Out	1.44	1.44	Passed
Check Container before Truck out	1.49	1.49	Passed
Truck Out	7.45	7.45	Passed

TABLE IX
FINAL RESULT OF TRACE 2

Activity	Constraint Time	Target Time	*Result*
Document Entry via PDE	87	87	Passed
Vessel Berthing Process	117954	117954	Passed
Discharge Container	2396	2396	Passed
Bring Container to Yard	147	147	Passed
Stack Container in Yard	27421	27421	Passed
Verification Document Behandle	13251	13251	Passed
Create document SPPB	28	28	Passed
Create Job Order Document Delivery	153	153	Passed
Truck in	83	83	Passed
Dispatch WQ Delivery to CHE	159	159	Passed
Determine Container Type	139	139	Passed
Determining Uncontainer	90	90	Passed
Decide Task Before Lift Container	53	53	Passed
Prepare Tools	150	150	Passed
Lift on Container Truck	3841	3841	Passed
Truck Go To Gate Out	90	90	Passed
Check Container before Truck out	91	91	Passed
Truck Out	1	1	Passed

have not fulfill the target, while surplus is the objective function that already meet the desired target. Dual Prices is the generated value to increase the profit or is called max Z, while to reducing the cost is called min Z. Both results of trace 1 and trace 2 can be seen in Table VI and Table VII.

V. CONCLUSION

In 2 traces that have been analyzed shows that both can not be compared because it has a different activity, each has the objective value of trace 1 is 1369 and trace 2 is 1,0006. Trace 1 has a very big deviation from the target and trace 2 has much less deviation from the target. The results of scheduling and cost-time optimization meet the desired target and it can be seen in the Figure VIII.

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