Time and Cost Optimization using Goal Programming and Priority Scheduling

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Abstract— The success indicator of an institution and company is when the available resources have been used effectively and efficiently. The limited resources available can cause delays in ongoing business processes. The delay in a business process is always closely related to financing. The slower the business process runs, the more the expenses that must be incurred for labor and material costs. Therefore, it is necessary to optimize the cost and time for an organization. It can be minimized by using goal programming. In goal programming, weights are given to make sense of which activities to be watched. In this research using lingo software to calculate goal programming.

Keywords—Optimization; Schedulling; Goal Programming; Time; Cost

I. INTRODUCTION

In this era of increasingly tight business competition, companies are required to compete in winning market share so that the main objectives of the company can be achieved. One of the company's short-term goals is to make the most profit, while the long-term goal of a company is to maintain survival. The high competition is caused by higher quality and competitive prices of product and substitution products. This condition encourages the company to change the business operation pattern to remain exist. Cost effective in business process is an important issue in optimization problem [1].

This research was conducted at PT.XYZ. PT. XYZ is a company engaged in the field of wireless device sales distribution, where sales activity is the main activity of the company. The accumulation of activity on the sales business process leads to the occurrence of lost time on other business processes. This can impact the profits generated by the company, which can be known from the amount of increasingly bloated expenses incurred for labor and material. The swelling costs are due to improper use of labor. Time– cost enhancement might be characterized as a procedure to distinguish appropriate development exercises to get the base span of process and least extra cost which is required [2]. It can be minimized by using goal programming.

Goal Programming aims to minimize deviations from certain objectives by considering the priority hierarchy [3]. Goal programming can be solved by graphical methods and simplex methods. The simplex method in goal programming is slightly different from the simplex method in linear programming that is the calculation of objective function for each priority. In this research, the optimization of the time performed and the cost incurred in sales activity in PT. XYZ was carried out using goal programming. Goal programming can give an ideal arrangement in cost and time enhancement [4].

II. LITERATURE REVIEW

A. Scheduling

Scheduling is a technique that expects to arrange or apportion leaving assets or machine to play out some assignment inside a specific time span. Scheduling intends to sort out or allot leaving assets or machines to play out some undertaking inside a specific time span. Essentially this is a procedure which decide the action of when it has no begin and stop [5].

B. Priority Scheduling

Priority scheduling algorithm is a scheduling algorithm that prioritizes high priority processes. Each process has its own priorities that have dependencies when executed. In this algorithm, the process that has the highest priority will be run first. Priority scheduling basically has similarities with first come first serve (FCFS) algorithm, but the priority scheduling depends on the highest priority. FCFS is a scheduling algoritm where every ready process will be included in FIFO queue [6]. Here is the formula of the first come first serve algorithm:

$$RT = FT - AT \quad (1)$$

$$TA = \sum RT \quad (2)$$

$$AWT = \frac{TA}{\sum Proses} \quad (3)$$

Where,

RT = Respon Time
FT = Finish Time
AT = Arrival Time
TA = Turn Around
AWT = Average Waiting Time

C. *Goal Programming*

Goal programming is a development of linear programming. Introduced by Charnes and Cooper in the early 1960s [7]. Then, the technique was perfected by Ijiri in the mid 1960s. Thereafter, there was a complete explanation with several development applications by Ignizio and Lee in 1970.

The striking difference between linear programming and goal programming is the structure and the use of the objective function [8]. In linear programming, there is only one goal to be achieved, while there are more than one goal to be achieved in goal programming.

In linear programming, the objective can be either maximization or minimization. While in goal programming, the objective is to minimize deviations from certain goals [9] . This means goal programming is a matter of minimization. There are 3 types of objective function of linear goal programming. The objectives are described below:

1) The objective function in equation 4 is used if the deviation variable in a problem is not distinguished by priority

$$\text{Min } Z = \sum_{i=1}^{m} (d_1^- + d_2^+) \quad (4)$$

2) The objective function in equation 5 is used if the order of objective is required, but the deviation variables within each priority level have the same importance.

$$\text{Min } Z = \sum_{i=1}^{m} P_k(d_1^- + d_2^+);\ k=1,2,..,k \quad (5)$$

3) The objective function in equation 6 is used if the objectives are sorted and the deviation variables at each priority level are differentiated by using different weights.

$$\text{Min } Z = \sum_{i=1}^{m} W_{ki} P_k(d_1^- + d_2^+);\ k=1,2,..,k \quad (6)$$

Where,

m = Number of product or the amount of activity

d_i^- = Deviation variable (presence of destination deviation) below target

d_i^+ = Deviation variable (presence of destination deviation) above target

W_{ki} = The coefficient that represent the contribution to goal k on decision variable i

P_k = Decision variable to k

TABLE I. PROCEDURE FOR ACHIEVING GOAL PROGRAMMING

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

III. METHODOLOGY

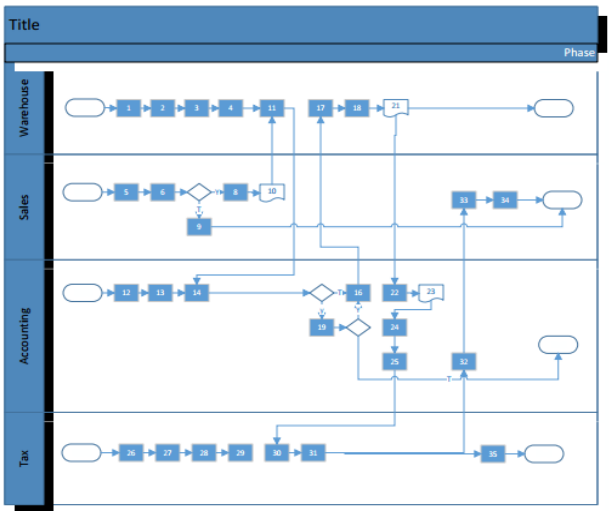
The methodology of this research was arranged systematically as a research framework. Steps of research that will be done, showing in Fig.1.

Fig. 1. The proposed method

IV. IMPLEMENTATION

A. *Priority Scheduling*

Based on the priority scheduling algorithm, the first step that must be performed is to determine the priority on the activity [10]. After the activity priority has been determined, then the next step is to calculate the response time, turn around and average waiting time. Here are the priorities on the sales business process:



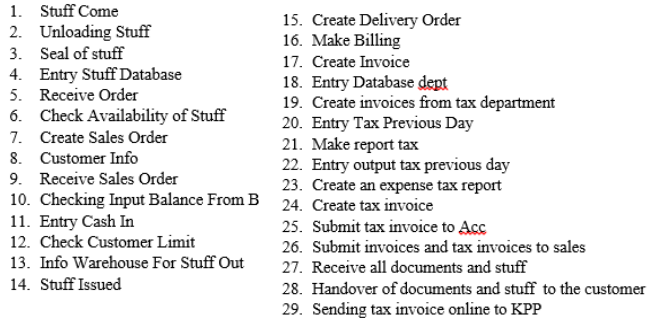


Fig. 2. Sales Business Process

Priority scheduling algorithms can be preemptive or non preemptive [11]. If there is a P1 process that arrives when the P0 process is running it will be seen as priority P1, if priority P1> P0 then:

- In Non Preemptive, the algorithm will still complete P0 until its burst time is finished and put P1 in the head queue position.
- In Preemptive, P0 will be stopped first and the process is allocated to P1

Based on the activity in figure 2, it can be known that the arrival time, finish time, response time and average waiting time can be calculated by using priority scheduling algorithm as in table II.

TABLE II. CALCULATION USING PRIORITY SCHEDULLING

No	Activity	Arrival Time	Burst Time	Start Time	Finish Time	Respon Time
1	Stuff Come	0	10	0	10	10
2	Unloading Stuff	1	300	10	310	309
3	Seal of stuff	2	480	310	790	788
4	Entry Stuff Database	3	60	790	850	847
5	Receive Order	4	10	850	860	856
6	Check Availability of Stuff	5	5	860	865	860
7	Create Sales Order	6	15	865	880	874
8	Customer Info	7	5	880	885	878
9	Receive Sales Order	8	5	885	890	882
10	Checking Input Balance From Bank	9	15	890	905	896
11	Entry Cash In	10	25	905	930	920
12	Check Customer Limit	11	6	930	936	925
13	Info Warehouse For Stuff Out	12	2	936	938	926
14	Stuff Issued	13	25	938	963	950
15	Create Delivery Order	14	15	963	978	964
16	Make Billing	15	20	978	998	983
17	Create Invoice	16	15	998	1013	997
18	Entry Database Dept	17	20	1013	1033	1016
19	Create invoices from tax department	18	10	1033	1043	1025
20	Entry Tax Previous Day	19	180	1043	1223	1204
21	Membuat Laporan Pajak Masukan	20	60	1223	1283	1263
22	Entry output tax previous day	21	180	1283	1463	1442
23	Create an expense tax report	22	60	1463	1523	1501
24	Create tax invoice	23	35	1523	1558	1535
25	Submit tax invoice to Acc	24	5	1558	1563	1539
26	Submit invoices and tax invoices to sales	25	5	1563	1568	1543
27	Receive all documents and stuff	26	5	1568	1573	1547
28	Handover of documents and stuff to the customer	27	5	1573	1578	1551
29	Sending tax invoice online to KPP	28	30	1578	1608	1580
					∑Respon Time	**30611**
					Average Waiting Time	**1055.55**

B. *Goal Programming*

The time and cost incurred for the sale activity in this case is taken through the event log, where the unit of time is in minutes and unit of cost is in IDR. The following table is a breakdown of time and expenses incurred on sales activites.

TABLE III. DETAIL OF TIME AND COST USED

	Activity	Time	Cost
1	Stuff Come	10	20960
2	Unloading Stuff	300	462500
3	Seal of stuff	480	495280
4	Entry Database Barang	60	20960
5	Receive Order	10	20960
6	Check Availability of Stuff	5	3460
7	Create Sales Order	15	4960
8	Customer Info	5	1000
9	Receive Sales Order	5	3460
10	Checking Input Balance From Bank	15	21960
11	Entry Cash In	25	3460
12	Check Customer Limit	6	3460
13	Info Warehouse For Stuff Out	2	1000
14	Stuff Issued	25	17500
15	Create Delivery Order	15	4960
16	Make Billing	20	4460
17	Create Invoice	15	22460
18	Entry Database Dept	20	3460
19	Create invoices from tax department	10	4460
20	Entry Tax Previous Day	180	83460
21	Membuat Laporan Pajak Masukan	60	24960
22	Entry output tax previous day	180	83460
23	Create an expense tax report	60	24960
24	Create tax invoice	35	24960
25	Submit tax invoice to Acc	5	5000
26	Submit invoices and tax invoices to sales	5	5000
27	Receive all documents and stuff	5	5000
28	Handover of documents and stuff to the customer	5	17500
29	Sending tax invoice online to KPP	30	23460
	GOAL	**1608**	**1418480**

Here are the variables used in goal programming calculation
X_1 = Stuff Come
X_2 = Unloading Stuff
X_3 = Seal of stuff
X_4 = Entry database barang
X_5= Receive Order
X_6 = Check Availability of Stuff
X_7 = Create Sales Order
X_8 = Customer Info
X_9 = Receive Sales Order
X_{10} = Checking Input Balance From Bank
X_{11} = Entry Cash In
X_{12} = Check Customer Limit
X_{13} =Info Warehouse For Stuff Out
X_{14} = Stuff Issued
X_{15} = Create delivery order
X_{16} = Make Billing
X_{17} = Create Invoice
X_{18} = Entry Database Dept
X_{19} = Create invoices from tax department
X_{20} = Entry Tax Previous Day
X_{21} = Make tax report
X_{22} = Entry output tax previous day
X_{23} = Create an expense tax report
X_{24} = Create tax invoice
X_{25} = Submit tax invoice to Acc
X_{26} = Submit invoices and tax invoices to sales
X_{27} = Receive all documents and stuff
X_{28} = Handover of documents and stuff to the customer
X_{29} = Sending tax invoice online to KPP

The steps for optimization using goal programming are described as follow:

1) Determination of the objective function to be achieved by the company is to minimize the time $Z_{(x)}$. Here is the time minimization equation:
   $\text{Min } Z_{(x)} = 10X_1+300X_2+480X_3+...+30X_{29}$ (7)
2) Determination of the objective function. The objective function to be achieved by the company is to minimize costs. Here is the cost minimization equation:
   $\text{Min } H_{(x)}= 20960X_1+462500X_2+495280X_3+20960X_4\ldots + 23460X_{29}$ (8)
3) Formulation of time limit, Time limits are used according to this following equation:
   $\text{Min } Z_{(x)}=10X_1+300X_2+480X_3+\ldots+30X_{29}\leq 30611$ (9)
4) Formulation of cost limit. Cost limits are used in accordance with this following equation:
   $\text{Min } H_{(x)} = 20960X_1+462500X_2+495280X_3+20960X_4\ldots +23460X_{29} \leq 1608$ (10)

C. *The Result of Goal Programming*

After obtaining goal programming equation based on time and cost, it can be implemented by using lingo software to get optimal time and cost. Here is an input formula on lingo software:

TABLE IV. FORMULA INPUT IN LINGO

Source Code of Goal Programming

```
min Z = D11 + D12 + D21 +D22 ;
20960*x1+462500*x2+495280*x3+...23460*x29-
D11+D12=1418480;
10*x1+300*x2+480*x3+...30*x29-D21+D22=1608;
D11 >=1;
D12 >=1;
D21 >=1;
D22 >=1;
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;
X19 >= 1;
X20 >= 1;
X21 >= 1;
X22 >= 1;
X23 >= 1;
X24 >= 1;
X25 >= 1;
X26 >= 1;
X27 >= 1;
X28 >= 1;
X29 >= 1;
end
```

In goal programming, weights are given to make sense of which activities to be watched. Weight can be feeble 0 or 1 where 0 is as far as possible or still equivalent to mean, while 1 is the farthest point of movement that must exist in the streamlining in light of the fact that the esteem is more noteworthy than anticipated. The outcome parameters of the goal programing are described in table V.

TABLE V. PARAMETERS RESULT OF GOAL PROGRAMMING

Objective Value	Constraint	Variable	d_2^+	d_1^+	d_1^-	d_2^-	Reduced Cost
29007	36	33	29004	0	0	0	29004

Objective value is the most extreme benefit that can be produced. In this case, the object value is 29007. Reduced cost indicates which exercises have a part in producing more benefits. Constraint are restricts on factor esteems. Factors are exercises that keep running on business forms. Here is the result of slack or surplus .

TABLE VI. RESULT OF SLACK OR SURPLUS

Row	Slack Or Surplus	Dual Price
1	29007	-1.000000
2	0.000000	1.000000
3	0.000000	-1.000000
4	0.000000	0.000000
5	0.000000	-2.000000
6	0.000000	-2.000000
7	29003.00	0.000000
8	0.000000	-20950.00
9	0.000000	-462200.0
10	0.000000	-494800.0
11	0.000000	-20900.00
12	0.000000	-20950.00
13	0.000000	-3455.000
14	0.000000	-4945.000
15	0.000000	-995.0000
16	0.000000	-3455.000
17	0.000000	-21945.00
18	0.000000	-3435.000
19	0.000000	-3454.000
20	0.000000	-998.000
21	0.000000	-17475.00
22	0.000000	-4945.000
23	0.000000	-4440.000
24	0.000000	-22445.00
25	0.000000	-3440.000
26	0.000000	-4450.000
27	0.000000	-83280.00
28	0.000000	-24900.00
29	0.000000	-83280.00
30	0.000000	-24900.00
31	0.000000	-24925.00
32	0.000000	-4995.000
33	0.000000	-4995.000
34	0.000000	-4995.000
35	0.000000	-17495.00
36	0.000000	-23430.00

Based on this sales business process, it can be known that the profit generated is 29007 with constraint of X1 to X29 ≥ 1. The Slack or Surplus section in the Solution Report demonstrates how tight the constraint is [12]. On the off chance that a constraint is totally fulfilled as a balance, at that point slack/surplus is zero. In the event that slack/surplus is positive, at that point this tells what number of more units of the variable could be added to the ideal arrangement before the constraint turns into an equity. In the event that slack/surplus is negative, at that point the limitation has been abused. The Dual Price coloumn portrays the sum to which the estimation of the target capacity would enhance if the compelling worth is expanded by one unit.

V. CONCLUSION

The sales case in PT. XYZ has an objective value of 29007 which means it has a very large deviation from the target. It is because the reduced cost for any variable included in the optimal solution value is always zero. The diminished cost for factors barred in the ideal arrangement shows how much the estimation of the target capacity will decline or increment on the off chance that one of the variable units is incorporated into the arrangement. Here is the final result of scheduling result and cost optimization - time that meet the target:

TABLE VII. FINAL RESULT OF SALE ACTIVITY

No	**Activity**	**Constraint Time**	**Burst Time**	**Result**
1	Stuff Come	10	10	Passed
2	Unloading Stuff	300	300	Passed
3	Seal of stuff	480	480	Passed
4	Entry Database Barang	60	60	Passed
5	Receive Order	10	10	Passed
6	Check Availability of Stuff	5	5	Passed
7	Create Sales Order	15	15	Passed
8	Customer Info	5	5	Passed
9	Receive Sales Order	5	5	Passed
10	Checking Input Balance From Bank	15	15	Passed
11	Entry Cash In	25	25	Passed
12	Check Customer Limit	6	6	Passed
13	Info Warehouse For Stuff Out	2	2	Passed
14	Stuff Issued	25	25	Passed
15	Create Delivery Order	15	15	Passed
16	Make Billing	20	20	Passed
17	Create Invoice	15	15	Passed
18	Entry Database Dept	20	20	Passed
19	Create invoices from tax department	10	10	Passed
20	Entry Tax Previous Day	180	180	Passed
21	Membuat Laporan Pajak Masukan	60	60	Passed
22	Entry output tax previous day	180	180	Passed
23	Create an expense tax report	60	60	Passed
24	Create tax invoice	35	35	Passed
25	Submit tax invoice to Acc	5	5	Passed
26	Submit invoices and tax invoices to sales	5	5	Passed
27	Receive all documents and stuff	5	5	Passed
28	Handover of documents and stuff to the customer	5	5	Passed
29	Sending tax invoice online to KPP	30	30	Passed

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