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; Scheduling; 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 perform 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 algorithm where every ready process will be included in FIFO queue [6]. Here is the formula of the first come first serve algorithm:

\[ RT = FT - AT \] (1)
\[ TA = \sum RT \] (2)
\[ AWT = \frac{TA}{\sum \text{Proses}} \] (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
\[
\text{Min } Z = \sum_{i=1}^{m} (d_i^-+d_i^+) \quad (4)
\]

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.
\[
\text{Min } Z = \sum_{i=1}^{m} \sum_{k=1}^{k} P_k (d_i^-+d_i^+) \quad (5)
\]

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.
\[
\text{Min } Z = \sum_{i=1}^{m} W_{ki} P_k (d_i^-+d_i^+) \quad (6)
\]

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

<table>
<thead>
<tr>
<th>Minimize</th>
<th>Goal</th>
<th>If Goal is Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>( d_i^- )</td>
<td>Minimize the underachievement</td>
<td>( d_i^- = 0, d_i^+ = 0 )</td>
</tr>
<tr>
<td>( d_i^+ )</td>
<td>Minimize the overachievement</td>
<td>( d_i^- = 0, d_i^+ = 0 )</td>
</tr>
<tr>
<td>( d_i^- + d_i^+ )</td>
<td>Minimize the both under- and over achievement</td>
<td>( d_i^- = 0, d_i^+ = 0 )</td>
</tr>
</tbody>
</table>

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](image)

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:
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 SCHEDULING

<table>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Arrival</th>
<th>Burst</th>
<th>Start</th>
<th>Finish</th>
<th>Resp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stuff Come</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Unloading Stuff</td>
<td>1</td>
<td>300</td>
<td>10</td>
<td>310</td>
<td>309</td>
</tr>
<tr>
<td>3</td>
<td>Seal of stuff</td>
<td>2</td>
<td>480</td>
<td>310</td>
<td>790</td>
<td>788</td>
</tr>
<tr>
<td>4</td>
<td>Entry Stuff Database</td>
<td>3</td>
<td>60</td>
<td>790</td>
<td>850</td>
<td>847</td>
</tr>
<tr>
<td>5</td>
<td>Receive Order</td>
<td>4</td>
<td>10</td>
<td>850</td>
<td>860</td>
<td>856</td>
</tr>
<tr>
<td>6</td>
<td>Check Availability of Stuff</td>
<td>5</td>
<td>5</td>
<td>860</td>
<td>865</td>
<td>860</td>
</tr>
<tr>
<td>7</td>
<td>Create Sales Order</td>
<td>6</td>
<td>15</td>
<td>865</td>
<td>880</td>
<td>874</td>
</tr>
<tr>
<td>8</td>
<td>Customer Info</td>
<td>7</td>
<td>5</td>
<td>880</td>
<td>885</td>
<td>878</td>
</tr>
<tr>
<td>9</td>
<td>Receive Sales Order</td>
<td>8</td>
<td>5</td>
<td>885</td>
<td>890</td>
<td>882</td>
</tr>
<tr>
<td>10</td>
<td>Checking Input Balance From Bank</td>
<td>9</td>
<td>15</td>
<td>890</td>
<td>905</td>
<td>896</td>
</tr>
<tr>
<td>11</td>
<td>Entry Cash In</td>
<td>10</td>
<td>25</td>
<td>905</td>
<td>930</td>
<td>920</td>
</tr>
<tr>
<td>12</td>
<td>Check Customer Limit</td>
<td>11</td>
<td>6</td>
<td>930</td>
<td>936</td>
<td>925</td>
</tr>
<tr>
<td>13</td>
<td>Info Warehouse For Stuff Out</td>
<td>12</td>
<td>2</td>
<td>936</td>
<td>938</td>
<td>926</td>
</tr>
<tr>
<td>14</td>
<td>Stuff Issued</td>
<td>13</td>
<td>25</td>
<td>938</td>
<td>963</td>
<td>950</td>
</tr>
<tr>
<td>15</td>
<td>Create Delivery Order</td>
<td>14</td>
<td>15</td>
<td>963</td>
<td>978</td>
<td>964</td>
</tr>
<tr>
<td>16</td>
<td>Make Billing</td>
<td>15</td>
<td>20</td>
<td>978</td>
<td>998</td>
<td>983</td>
</tr>
<tr>
<td>17</td>
<td>Create Invoice</td>
<td>16</td>
<td>15</td>
<td>998</td>
<td>1013</td>
<td>997</td>
</tr>
<tr>
<td>18</td>
<td>Entry Database Dept</td>
<td>17</td>
<td>20</td>
<td>1013</td>
<td>1033</td>
<td>1016</td>
</tr>
<tr>
<td>19</td>
<td>Create invoices from tax department</td>
<td>18</td>
<td>10</td>
<td>1033</td>
<td>1043</td>
<td>1025</td>
</tr>
<tr>
<td>20</td>
<td>Entry Tax Previous Day</td>
<td>19</td>
<td>180</td>
<td>1043</td>
<td>1223</td>
<td>1204</td>
</tr>
</tbody>
</table>

**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 activities.

<table>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Time</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stuff Come</td>
<td>10</td>
<td>20960</td>
</tr>
<tr>
<td>2</td>
<td>Unloading Stuff</td>
<td>300</td>
<td>462500</td>
</tr>
<tr>
<td>3</td>
<td>Seal of stuff</td>
<td>480</td>
<td>495280</td>
</tr>
<tr>
<td>4</td>
<td>Entry Database Barang</td>
<td>60</td>
<td>20960</td>
</tr>
<tr>
<td>5</td>
<td>Receive Order</td>
<td>10</td>
<td>20960</td>
</tr>
<tr>
<td>6</td>
<td>Check Availability of Stuff</td>
<td>5</td>
<td>3460</td>
</tr>
<tr>
<td>7</td>
<td>Create Sales Order</td>
<td>15</td>
<td>4960</td>
</tr>
<tr>
<td>8</td>
<td>Customer Info</td>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>9</td>
<td>Receive Sales Order</td>
<td>5</td>
<td>3460</td>
</tr>
<tr>
<td>10</td>
<td>Checking Input Balance From Bank</td>
<td>15</td>
<td>21960</td>
</tr>
<tr>
<td>11</td>
<td>Entry Cash In</td>
<td>25</td>
<td>3460</td>
</tr>
<tr>
<td>12</td>
<td>Check Customer Limit</td>
<td>6</td>
<td>3460</td>
</tr>
<tr>
<td>13</td>
<td>Info Warehouse For Stuff Out</td>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>14</td>
<td>Stuff Issued</td>
<td>25</td>
<td>17500</td>
</tr>
<tr>
<td>15</td>
<td>Create Delivery Order</td>
<td>15</td>
<td>4960</td>
</tr>
<tr>
<td>16</td>
<td>Make Billing</td>
<td>20</td>
<td>4460</td>
</tr>
<tr>
<td>17</td>
<td>Create Invoice</td>
<td>15</td>
<td>22460</td>
</tr>
<tr>
<td>18</td>
<td>Entry Database Dept</td>
<td>20</td>
<td>3460</td>
</tr>
<tr>
<td>19</td>
<td>Create invoices from tax department</td>
<td>10</td>
<td>4460</td>
</tr>
<tr>
<td>20</td>
<td>Entry Tax Previous Day</td>
<td>180</td>
<td>83460</td>
</tr>
<tr>
<td>21</td>
<td>Membuat Laporan Pajak Masukan</td>
<td>60</td>
<td>24960</td>
</tr>
<tr>
<td>22</td>
<td>Entry output tax previous day</td>
<td>21</td>
<td>180</td>
</tr>
<tr>
<td>23</td>
<td>Create an expense tax report</td>
<td>22</td>
<td>60</td>
</tr>
<tr>
<td>24</td>
<td>Create tax invoice</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td>25</td>
<td>Submit tax invoice to Acc</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>26</td>
<td>Submit invoices and tax invoices to sales</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>27</td>
<td>Receive all documents and stuff</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>28</td>
<td>Handover of documents and stuff to the customer</td>
<td>27</td>
<td>5</td>
</tr>
<tr>
<td>29</td>
<td>Sending tax invoice online to KPP</td>
<td>28</td>
<td>30</td>
</tr>
</tbody>
</table>

**GOAL:**

|                  | 1608 | 1418480 |

**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.
Here are the variables used in goal programming calculation:

- X₁ = Stuff Come
- X₂ = Unloading Stuff
- X₃ = Seal of stuff
- X₄ = Entry database barang
- X₅ = Receive Order
- X₆ = Check Availability of Stuff
- X₇ = Customer Info
- X₈ = Receive Sales Order
- X₉ = Checking Input Balance From Bank
- X₁₀ = Entry Cash In
- X₁₁ = Check Customer Limit
- X₁₂ = Info Warehouse For Stuff Out
- X₁₃ = Stuff Issued
- X₁₄ = Create Invoice
- X₁₅ = Create delivery order
- X₁₆ = Make Billing
- X₁₇ = Create Invoice
- X₁₈ = Entry Database Dept
- X₁₉ = Create invoices from tax department
- X₂₀ = Entry Tax Previous Day
- X₂₁ = Make tax report
- X₂₂ = Entry output tax previous day
- X₂₃ = Create an expense tax report
- X₂₄ = Create tax invoice
- X₂₅ = Submit tax invoice to Acc
- X₂₆ = Submit invoices and tax invoices to sales
- X₂₇ = Receive all documents and stuff
- X₂₈ = Handover of documents and stuff to the customer
- X₂₉ = 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:

\[
\text{Min } Z(x) = 10X_1 + 300X_2 + 480X_3 + \ldots + 30X_{29}
\]  
(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:

\[
\text{Min } H(x) = \begin{align*} 
20960X_1 + 462500X_2 + 495280X_3 + 20960X_4 + \ldots \\
+ 23460X_{29} 
\end{align*}
\]  
(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:

\[
\text{Min } H(x) = \begin{align*} 
20960X_1 + 462500X_2 + 495280X_3 + 20960X_4 + \ldots \\
+ 23460X_{29} \leq 1608
\end{align*}
\]  
(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:

```
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

<table>
<thead>
<tr>
<th>Objective Value</th>
<th>Constraint</th>
<th>Variable</th>
<th>d₁²</th>
<th>d₁</th>
<th>d₁</th>
<th>Reduced Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>29007</td>
<td>36</td>
<td>33</td>
<td>29004</td>
<td>0</td>
<td>0</td>
<td>29004</td>
</tr>
</tbody>
</table>
```

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.
Based on this sales business process, it can be known that the profit generated is 29007 with constraint of $X_1$ to $X_{29} \geq 1$. The Slack or Surplus section in the Solution Report demonstrates how tight the constraint is \cite{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 column 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>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Constraint Time</th>
<th>Burst Time</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stuff Come</td>
<td>10</td>
<td>10</td>
<td>Passed</td>
</tr>
<tr>
<td>2</td>
<td>Unloading Stuff</td>
<td>300</td>
<td>300</td>
<td>Passed</td>
</tr>
<tr>
<td>3</td>
<td>Seal of stuff</td>
<td>480</td>
<td>480</td>
<td>Passed</td>
</tr>
<tr>
<td>4</td>
<td>Entry Database Barang</td>
<td>60</td>
<td>60</td>
<td>Passed</td>
</tr>
<tr>
<td>5</td>
<td>Receive Order</td>
<td>10</td>
<td>10</td>
<td>Passed</td>
</tr>
<tr>
<td>6</td>
<td>Check Availability of Stuff</td>
<td>5</td>
<td>5</td>
<td>Passed</td>
</tr>
<tr>
<td>7</td>
<td>Create Sales Order</td>
<td>15</td>
<td>15</td>
<td>Passed</td>
</tr>
<tr>
<td>8</td>
<td>Customer Info</td>
<td>5</td>
<td>5</td>
<td>Passed</td>
</tr>
<tr>
<td>9</td>
<td>Receive Sales Order</td>
<td>5</td>
<td>5</td>
<td>Passed</td>
</tr>
<tr>
<td>10</td>
<td>Checking Input Balance From Bank</td>
<td>15</td>
<td>15</td>
<td>Passed</td>
</tr>
<tr>
<td>11</td>
<td>Entry Cash In</td>
<td>25</td>
<td>25</td>
<td>Passed</td>
</tr>
<tr>
<td>12</td>
<td>Check Customer Limit</td>
<td>6</td>
<td>6</td>
<td>Passed</td>
</tr>
<tr>
<td>13</td>
<td>Info Warehouse For Stuff Out</td>
<td>2</td>
<td>2</td>
<td>Passed</td>
</tr>
<tr>
<td>14</td>
<td>Stuff Issued</td>
<td>25</td>
<td>25</td>
<td>Passed</td>
</tr>
<tr>
<td>15</td>
<td>Create Delivery Order</td>
<td>15</td>
<td>15</td>
<td>Passed</td>
</tr>
<tr>
<td>16</td>
<td>Make Billing</td>
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<td>Entry Database Dept</td>
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<td>19</td>
<td>Create invoices from tax department</td>
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<td>Entry Tax Previous Day</td>
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<td>Submit tax invoice to Acc</td>
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<td>26</td>
<td>Submit invoices and tax invoices</td>
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<td>27</td>
<td>to sales</td>
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</tr>
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<td>28</td>
<td>Handover of documents and stuff</td>
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<td>Send tax invoice online to KPP</td>
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REFERENCES


