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Time and cost optimization of business process RMA using PERT and goal programming

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Abstract

As a company engaged in the distribution of wireless devices, Return Material Authorization (RMA) is a mandatory service that must be owned by the company. RMA is a part of the process of returning a product to receive a refund, replacement, or repair during the product's warranty period. The business process of RMA used functionally design, which is not considered to be effective in terms of time and cost for the company of 2880 minutes for IDR 348242. In this research, Project Evaluation and Review Technique (PERT) was used to select the optimal traces; to optimize time and cost, the researcher used goal programming. This technique allows the creation of a controlled and orderly activity because the schedule and budget of a job are predetermined prior to the implementation. The optimization results show that the process time is reduced by 50% and the cost is reduced by almost 55% which show improvement on the performance of the business processes.

Keywords: *goal programming, optimization, PERT, RMA, time and cost*

1. Introduction

Return Material Automatically (RMA) is the process of returning a product to distributor for repairing or replacement [1]. Usually, RMA has inefficiencies in terms of time and cost [2, 3], and it usually takes lengthy period of time for a company to detect the problems [4, 5]. Without the RMA system, the customer will end up spending an unnecessary amount of time on returns. In this context, this paper proposed goal programming as the method for optimizing time and cost of RMA business process in real-time.

Many previous studies were undergone to establish the optimization of time and cost. Therefore, this research used goal programming method [6-12] based on research by Nan Zhang [11] where the efficiency cost of manufacturing product using the virtual age method, the research merely shows the formula without directed implementation of the real case. There is one commonly used method to optimize time and cost. Goal programming model is an extension of linear programming. The difference lies only in a pair of divisional variables that appear in the destination function and in the constraint functions [13]. Hence, the basic concept of linear programming underlies the discussion of this model [7]. Some research used Goal Programming to solve the problem, but none of which used Project Evaluation and Review Technique (PERT) to choose the selected traces of business process and optimalize time and cost of those traces with Goal Programming.

Yet Another Workflow Language (YAWL) is used to create the business model and simulate the cases to become references for the next step, YAWL can also explore the history of each activity that have been done [1, 2]. Time optimization is drawn and calculated using PERT of which privilege is an attempt to accelerate the duration of a project or trace [13, 14]. PERT helps in selecting the trace that has the best time period, where PERT is used to improve the efficiency of all sizes projects [15-17].

Event logs help create normal time by calculating the average of time in all activities in the RMA business process; however, pessimistic time and optimistic time are obtained based on the interviews and observations in the company. In this research, the optimization time was conducted using PERT [18-20] and cost optimization using goal programming [21, 22].

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2. Research Method

2.1. Drawing the Business Process using YAWL

Based on the interviews and observations, the business process of RMA was drawn by YAWL, Figure 1 is the main process of RMA of 8 traces. Time and cost are set in every activity. There are 22 activities which are written using alphabet to simplify the naming Activities are defined as distinct steps towards completion of the project that takes time [23]. There are 8 traces established from this business process.

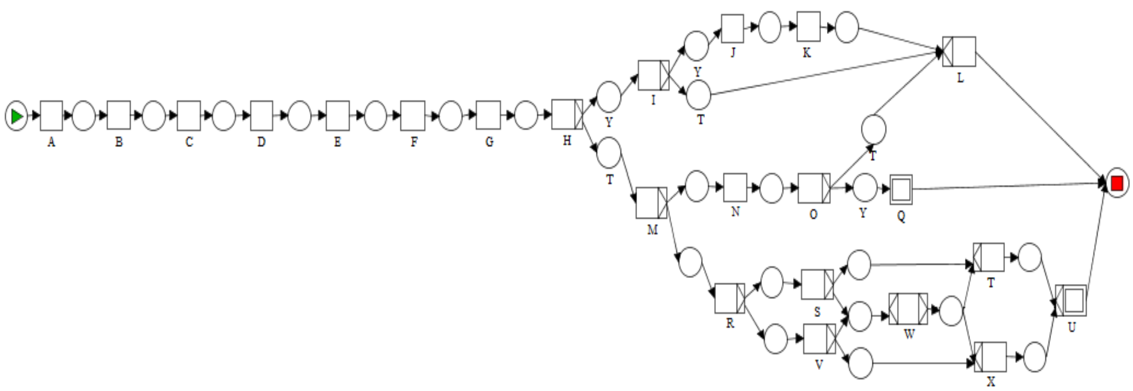

Figure 1. The business process of RMA

Trace 1
A → B → C → D → E→ F → G→ H→ I→ J → K→ L
Trace 2
A → B → C → D → E → F → G → H → I → L
Trace 3
A → B → C → D → E → F → G → H → M → N → O → L
Trace 4
A → B → C → D → E → F → G → H → M → N → O → Q
Trace 5
A → B → C → D → E → F → G → H → M → R → S → T → U
Trace 6
A → B → C → D → E → F → G → H → M → R → S → W → T → U
Trace 7
A → B → C → D → E → F → G → H → M → R → V → X → U
Trace 8
A → B → C → D → E → F → G → H → M → R → V → W → X → U

2.2. Data Log In Discovering Business Process

Table 1 is the sample of data log containing 3 columns: case, activities, start timestamp written of an event log. The information of event logs is obtained from observation and record history from each activity.

Table 1. Data Log of RMA

Case	Activities	Start Timestamp	Case	Activities	Start Timestamp
1	A	1/31/18 8:00 AM	1	H	1/31/18 10:30 AM
1	B	1/31/18 8:04 AM	1	M	1/31/18 10:40 AM
1	C	1/31/18 8:06 AM	1	R	1/31/18 11:00 AM
1	D	1/31/18 8:10 AM	1	S	1/31/18 11:13 AM
1	E	1/31/18 8:18 AM	1	T	1/31/18 11:13 AM
1	F	1/31/18 8:23 AM	1	U	2/1/18 9:00 AM
1	G	1/31/18 8:30 AM			

2.3. Planning and controlling the time using PERT

PERT is directed to get the best time (in a more accurate way). PERT uses the probability element [14]. Through beta distribution, it uses time estimates to determine the timing of completion of an activity to be more realistic. The approximation of the average duration is called expected return (Te) is calculated using (1).

$$Te = \frac{a+4m+b}{6} \tag{1}$$

in which:
Te = Expected duration
a = Optimistic time
m = Most likely time
b = Pessimistic time

The amount of uncertainty depends on the value of and is formulated by (2).

$$\mathrm{S} = \frac{1}{6}\,(\mathrm{b} - \mathrm{a}) \tag{2}$$

in which:
S = Standard deviation of activity
a = Optimistic time
b = Pessimistic time

Explains that conducting critical path analysis undergoes two two-pass processes, consisting of forward pass and backward pass [14-17]. ES and EF are determined during forward pass while LS and LS are determined during the backward pass. ES (earliest start) is the time before an activity can begin, assuming all the predecessors are done. EF (earliest finish) is the time before an activity can be completed. LS (latest start) is the maximum time an activity can start, in order not to delay the completion time of the whole project. LF (latest finish) is the maximum time an can be completed in order not to delay the completion time of the whole project: (3)-(7).

$$ES = \text{Max } EF \tag{3}$$

$$EF = ES + Activities\ Time \tag{4}$$

$$LF = \text{Min } LS \text{ of all activities that immediately follow} \tag{5}$$

$$LS = LF - Activities\ Time \tag{6}$$

$$\text{Slack} = LF - ES \text{ or } LF - EF \tag{7}$$

Table 2 shows the main activities of RMA business process. The most likely time is the normal time from event log by calculating the average time in all activities in the RMA business process; meanwhile pessimistic time and optimistic time are obtained based on the interviews and observations with the company.

2.4. Optimizing cost using Goal Programming

Goal programming is a method that is used to minimize and maximize a problem with the restrictions that have been specified, with the deviation of variables [24]. Goal programming has advantages that can result in decision boundary where with the restrictions [25] the decision can be taken in a way to minimize it using (8), (9).

$$Min = \sum_{i=0}^{k}(d_i^+ + d_i^-) \tag{8}$$

$$\begin{aligned} f(x) + d_i^- - d_i^+ = b_i \qquad & i = 1, \dots, k, \\ x \in X, \qquad & i = 1, \dots, k, \end{aligned} \tag{9}$$

$$d_i^- d_i^+ = 0 \qquad i = 1, \dots, k,$$
$$d_i^-, d_i^+ \geq 0 \qquad i = 1, \dots, k,$$

in which:
x = Number of units of Product of i to produce per day
b_i= Level demand for the product i
d_i^- = Amount under goal b_i
d_i^+ = Amount above goal b_i

The main porpose of goal programming is to minimize the deviation amount between goals from (8), (9), $f(x)$ and these acceptable aspiration levels, b_i $(i = 1, \dots, k)$ for d_i^-, d_i^+ are each, under goal- and above goal- of the i goal.

Table 2. The Main Activities Consisting of Optimistic Time, Most Likely Time, Pessimistic Time

Activity Number	Activity name	Immediate Predecessor (list number/name, separated by ',')	Optimistic time (a)	Most likely time (m)	Pessimistic time (b)
1	A		4	5	7
2	B	A	3	3	5
3	C	B	13	16	18
4	D	C	5	8	10
5	E	D	5	7	9
6	F	E	18	21	23
7	G	F	200	226	250
8	H	G	30	37	40
9	I	H	17	19	23
10	J	I	8	10	12
11	K	J	27	30	32
12	L	I, K, O	9	11	15
13	M	H	17	19	23
14	N	M	14	15	16
15	O	N	3	4	6
16	P	O	10	13	16
17	Q	M	14	15	16
18	R	Q	15	17	18
19	S	Q	15	17	18
20	T	R,S	16	21	24
21	U	R,T	5	9	12
22	V	S,T	15	19	22
23	W	U,V	10	14	16

3. Results and Analysis

3.1. Analyzing the Event Log

To obtain the event log of RMA, YAWL simulates the business process with data log in Table 1 and the result is exported to .csv format. Table 3 is the result of the simulation of RMA business process by YAWL and the attributes of event log consist of Case, Activities, and Complete Timestamp.

Table 3. Event Log Simulated by YAWL

Case	Activities	Complete Timestamp	Case	Activities	Complete Timestamp
1	A	05:00.1	1	H	37:49.8
1	B	03:11.2	1	M	19:47.6
1	C	16:20.9	1	R	17:30.3
1	D	10:43.4	1	S	17:31.5
1	E	07:19.2	1	T	21:57.5
1	F	21:24.4	1	U	09:14.1
1	G	1:26:10.4			

3.2. Analyzing Time using PERT

By analyzing time using PERT, the result indicates that there are 3 critical paths of 3 different completion time on 3 traces. The critical path founded of this business process by PERT is described on Figure 2 and the critical path consists of 14 activities.

06-18-2018	Critical Path 1	Critical Path 2	Critical Path 3
1	A	A	A
2	B	B	B
3	C	C	C
4	D	D	D
5	E	E	E
6	F	F	F
7	G	G	G
8	H	H	H
9	M	M	M
10	Q	Q	Q
11	R	S	S
12	T	T	V
13	V	V	W
14	W	W	
Completion Time	426.33	426.33	426.33
Std. Dev.	8.98	8.98	8.88

Figure 2. Critical path by PERT

The Expected return of the activities is

$$Te(A) = \frac{a + 4m + b}{6}$$

$$Te\ (A) = \frac{4+4(5)+7}{6} = 26.3$$

and for the standar deviation is

$$S\ (A) = \frac{1}{6}\ (b - a)$$

$$S(A) = \frac{1}{6}\ (7 - 4) = 0.5$$

3.3. Analyzing cost using Goal Programming

From the result of the critical path using PERT, the optimilized time is on trace 6, trace 7 and trace 8, this research focuses on the case of the traces. The result of simulation shown in Table 4 throughput time and cost.

Table 4. Throughput Time and Cost

Log Trace	Throughput time (minutes)	Cost	Log Trace	Throughput time (minutes)	Cost
1	362.75	IDR 267,640	13	158.75	IDR 428,660
2	188.75	IDR 373,240	14	158.75	IDR 518,660
3	158.75	IDR 465,660	15	398.75	IDR 301,660
4	158.75	IDR 428,660	16	151.99	IDR 333,140
5	158.75	IDR 518,660	17	1140.89	IDR 107,320
6	398.75	IDR 301,660	18	1140.89	IDR 78,580
7	151.99	IDR 333,140	19	362.75	IDR 267,640
8	1140.89	IDR 107,320	20	188.75	IDR 373,240
9	1140.89	IDR 78,580	21	158.75	IDR 465,660
10	1143.93	IDR 103,580	22	362.75	IDR 267,640
11	1140.93	IDR 72,320	23	398.75	IDR 301,660
12	1143.93	IDR 68,580			

The critical path occurs on trace 6, trace 7 and trace 8. The traces aimed to optimize cost are on case 8, case 9, case 10, case 11, case 12, case 17, and case 18. Lingo is used as a tool to write the source code of the goal programming as shown in Figure 3 which is the source code of goal programming and Table 5 shows the result.

```
The Goal programming source code

Min = d1minus+C8+C9+C10+C11+C12+C17+C18+d2plus;
-
d1minus+107320*C8+78580*C9+103580*C10+72320*C11+68580*C12+107320*C17+78580*C1
8+d2plus=1000000;
C8>=0;
C9>=0;
C10>=0;
C11>=0;
C12>=0;
C17>=0;
C18>=0;
```

Figure 3. The goal programming source code

Table 5. The Goal Programming Result

Variable	Value	Reduced Cost
D1minus	0.00	1.00
C8	0.00	0.00
C9	0.00	0.26
C10	0.00	0.34
C11	0.00	0.32
C12	0.00	0.36
C17	9.31	0.00
C18	0.00	0.26
D2Plus	0.00	0.99

Table 4 is the solution report of goal programming; the optimal time and case is on case 17 of 1140 minute and IDR.107,320 and compared to the result using PERT based on critical path, the optimal time on trace 6, trace 7 and trace 8 is 426.33 minutes.

4. Conclusion

In this research, PERT is used to select the most critical traces of business process with the most effective time; on the other hand, goal programming helps obtain the optimal time and cost of the business process. From this research, the optimization results show that the process time is reduced by 50% and the cost is reduced by almost 55%, which indicates improvement in the business process performance.

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