Time and Cost Optimization of Parallel Services on Line Balancing Problem using Integer Programming

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***Abstract*— Human resources are one of the most crucial assets of any enterprise. Optimal usage of manpower is a pivotal assignment to a manager of a dynamic control system. on this observe, we introduce a way of the concern constraints and the station limits for the parallel offerings on line Balancing problem. in lots of realistic settings, despite the fact that the real task time of a task is modeled as an growing characteristic of its starting time due to deterioration outcomes the produced man power develops constantly by means of repeated the equal or comparable activities. The technique aimed toward determining the effective size of manpower to be hired to make sure most earnings, contemplating, manufacturing or demand capacity and time of operation. This paper additionally discusses the edition of the Linear Integer Programming approach to make sure maximum earnings, deliberating, production or call for capacity and time of operation.**

Keywords—resource allocation; queue; line balancing; m/m/s; integer programming

I. INTRODUCTION

The workload to be borne in an organizational unit is closely associated with the efficiency and effectiveness of a company. that is due to the fact the workload is included inside the regulation of human resources that is an important resource within the enterprise. Many approaches that can be completed in phrases of performance of human resources, amongst others, is to further optimize the number of personnel to carry out activities appropriately [1]. Corporations sector need to strive to improve effective, efficient and flexible offerings which will innovate quick and appropriately due to the growing of the competition that results in the needs of patron desires both of best and quantity. A business process are formed from a variety of activities with various objectives . The business processes that occur in sales are related to many divisions. This can lead to waiting times, not only when the activity moves to other activities, but also additional waiting times are incurred because one worker is still doing the activity.

When a task is executed simultaneously, there is a waiting process to complete before moving on to another task. Then, when a task is executed synchronously, the next task can not be continued to another task before it finishes [3]. When the standard time of service on a business process can be optimized, then to clear up the trouble the researchers tried to implement the queue approach. Time spent on an activity to be in a queue, which are overlong, can causes the demand to be stacked up. The general purpose of this study is to determine whether the quantity of sources (server) of employee is maximized in serving queries in quality control (QC) process.

An activity in a business process calls for the assignment of resources [4]. The proper time and cost applied in order to minimize the waiting time of each activity need to be. The order in an activity becomes the main detail in the business procedure model. Moreover, the second one essential detail is the connection among those activities. There are two sorts of relationships inside the business process model, which can be parallel and sequential relationships. Sequential relationships are used to attach one activity and other activities, while parallel relations are used to attach one or extra different activities and sports. If the timestamp within the event log overlaps, then the technique version relationship is parallel [5]. Within the meantime, if the timestamp does not overlap, then the method version courting is sequential. Optimization in a business process is used to offer the highest quality, efficient and effective solution. It is able to additionally be used to clear up business process assignments [6]. this paper proposes Integer Programming for optimizing Parallel Services on Line Balancing Problem, which is a common problem in business process management. Business process optimization aims to lessen time and cost, enhance service quality, and improve client satisfaction and employees in order that the competitive benefit of an agency can be maintained.

II. LITERATURE REVIEW

A. Queue

In queuing theory, the queuing model is used to estimate the actual situation or queuing system so that queue behavior can be analyzed mathematically. The queuing model allows a number of useful steady state performance measures to be determined [7]. The achievement and queue model parameters are determined by the following notation.

λ = average arrival speed (number of arrival time unity)

$1/\lambda$ = average inter arrival time

μ = average service speed (number of units served by unity of time when server is busy)

$1/\mu$ = average time required by the server
ρ = factor of server usage (proportion of server's busy time)
Pn = the probability of n units arrivals in the system
Lq = average number of units in the queue (average queue length)
Ls = average number of units in the system
Wq = average waiting time in the queue
Ws = average waiting time in the system

Determination of the best methods to be adopted is needed to improve service delivery, reduce waiting times and optimize earnings. Arrival of goods on the business process QC company PT. XYZ occurs randomly and independently from other arrivals. Therefore, this obeys the Poisson probability distribution. The service time follows an exponential probability distribution, whilst the first come first served (FCFS) first serve queue area. The opportunity and size of model overall performance is decided analytically.

B. *Determining Probability And Performance Measures In Multi-Channel Models*

There are servers on this technique. each those servers run in parallel. They take as shown in a single channel method. control desires to do queuing studies to assist decide the satisfactory approach to lessen ready times and enhance service [2]. The look at performed in the case study at the quality control (quality controls) process confirmed that the average arrival price became 367 units consistent with hour. The probability of x arrival requests for one minute may be calculated the usage of the Poisson probability function.

$$P(x) = \frac{(\lambda^x e^{(-\lambda)})}{x!n} \quad (1)$$

Where,
x = quantity of arrivals in a given period
λ = average range of arrivals in a given duration
through the use of the exponential opportunity distribution, the chance that the service time may be less than or equal to the duration of time t can be calculated the use of the subsequent equation.

$$P(services\ time) \leq t = 1 - e^{(-\lambda)} \quad (2)$$

Where μ is the average of the units that can be served for a certain period

C. *Line Balancing*

Line balancing is the process of grouping work tasks in a production line into several resources by observing the balance of time and load between each work station in order to create a smooth and smooth activity process [8].

1) *Determining cycle time*
One-cycle cycle times of QC process obtained by utilizing working hours and QC requests.
2) *Determine the minimum number of Resources and Path Efficiency*
3) *Determining mathematical model of Integer Programming for Line Balancing.*

The primary task in line balancing is to remove or lessen WIP (work in process) at bottleneck operations, maintains inventory charges low [9]. That means making better production planning by generating higher net income and allows operators to work all day to make more money and increase efficiency keep fixed prices that turn into repeat sales.

D. *Integer Programming*

Integer programming is the development of a linear program where some or all variables have integer (integer) and discrete values. Integer programming is said to be mixed or pure depending on whether some or all of these variables are limited to integer values [10]. This method is the development of linear programming method so that in the process almost have the same way. Basically, linear programming has the following count function.

1) *Linear's Function*

For the purpose of writing mathematical purposes, can be seen at the Equation (1) (2) as follows.

$$maximize = nX1 + nX2 + \cdots + nXn \quad (4)$$
$$minimize = nX1 + nX2 + \cdots + nXn \quad (5)$$

The formulation of maximize is used for purposes whose functionality improves goals and minimizes to minimize goals.
Where,
n = the positive value of the variable
$X1, X2, ..., Xn$ = the variable used to achieve the purpose function

2) *Constraints*

Constraints are the variables that limit a model in achieving its objectives. Writing restrictions can be seen at the Equation (6) (4) as follows.

$$Constrain\ 1 = nX1 + nX2 + \cdots + nXn \geq p \quad (6)$$
$$Constrain\ 2 = nX1 + nX2 + \cdots + nXn \geq q \quad (7)$$

Where, constraints 1 and 2 are the variables that become the boundary in achieving the objective function. While p and q are constraint values that become limiting on each boundary.

This usually applies to a corporation in figuring out the quantity of production so that you can get most profit and minimum cost [11].

The simple assembly line balancing problem is applicable for directly single product assembly traces where only precedence constraints among duties are to be taken into consideration. The simple assembly line balancing problem can be presented as the following integer programming problem.

$$\text{Min } \sum_{k=1}^{K} A_k \quad (8)$$

Subject to,

$$\sum_{k=1}^{K} t.X_{ik} \leq C, \forall k = 1,2,\ldots,K \quad (9)$$

$$\sum_{k=1}^{K} t.X_{ik} \leq C, \forall k = 1,2,\ldots,K \quad (10)$$

$$\sum_{k=1}^{K} (kx_{jk} - kx_{ik}) \geq 0, \forall i,j = 1,2,\ldots,N \text{ and } i \in P_i \quad (11)$$

$$\sum_{k=1}^{K} X_{ik} \leq nA_k, \forall k = 1,2,\ldots,K. \quad (12)$$

The objective function (8) minimizes the range of workstations. Condition (9) guarantees that every task is assigned to precisely one work station. The cycle time constraints (10) assure that the cycle time isn't always exceeded by using station time of any station. situation (11) represents the precedence constraints making sure that no task is assigned to an in advance station than a predecessor.

E. Event Log

Event logs are the procedure notes of all activities, from start to finish. Statistics or logs consist basically of date, time, user, event identification, type, and source [2]. Each activity has extraordinary attributes, relying on what the organization wishes to word. Documents are saved automatically inside the database, this enables the agency to keep and troubleshoot if there is an errors. It's also used to optimize manner performance, in a few cases lowering the fee and time of an interest [3].

III. Proposed Method

The proposed method introduced some definitions to cope with the algorithm presented in this paper. The algorithm employs this definitions together with the definitions mentioned in Literature Review. In pursuing the goal of the study, the data have been collected, classified, analyzed and the integer programming model become formulated based at the records analyzed. This QC log event will be analyzed and first using Excel Solver to see the results [12]. Because of technological and organizational conditions precedence constraints among the duties need to be located. So, the integer programming model we will put into LINGO to be optimized.

IV. Result Illustration and Analysis

As a manner to observe the conduct and to extract numerous decision parameters. The inputs are considered from the observations of a close-by offerings industry engaged in the distribution of wireless devices, as the study case. Statistics at the time consumption, mission time, precedence relationship between tasks, and the cost systems of company are acquired from the secondary data sources.

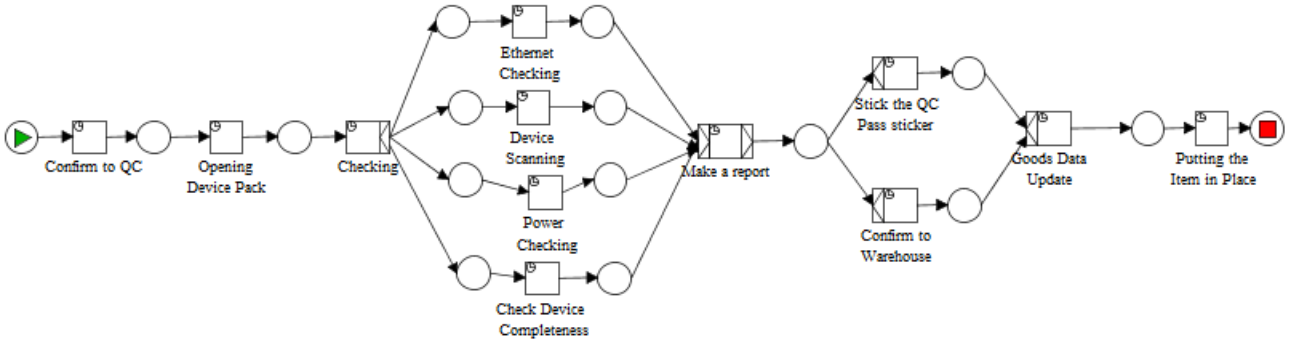

Fig 1. QC SOP in the process model by using YAWL

TABLE I. Activity Details

No	Aktivities	Cost	Duration Time	Start Time
1	Confirm to QC	143460	17.1	9:34
2	Opening Packing	3050	41.3	9:57
3	Checking	140000	41.2	10:03
4	Check Ethernet	9160	18.7	10:03
5	Scan Tool	3460	9	11:01
6	Check Power	1280	20.7	11:02
7	Check Device completeness	1700	15.2	11:01
8	Create Report	3460	70.3	12:00
9	Paste the AC Pass sticker	1720	4.5	13:15
10	Confirm to Warehouse	3460	8.3	13:15
11	Update Data Item	3460	23.9	13:40
12	Placing the Goods to the original place	3700	18.5	14:00

From the results of interviews and observations, The first step is to describe the SOP in the process model by using YAWL. It is also use for simulations, for SOP of the QC process as for Business process depiction at YAWL and setting time and cost are as follow at Figure 1.

Modeling Queue fundamentals provides the most commonplace distributions in queuing fashions, the Poisson arrival distribution and exponential service distribution. It then covers Kendall's notation, the same old technique of describing a queue model, and covers some of the fundamental queuing version assumptions. A foundation set, the equations which allow the evaluation of queue overall performance and operating characteristics are offered and associated lower back to the choice makers price minimization decision.

Table I is a breakdown of the activity, cost and duration of each activity undertaken in the QC process. Company's target of one day completion products must be finished minimal 250 stuff. Human Resources for QC team there are two people. Its time has been set on YAWL (ideal time), where everyone finished 100 pieces every day. Through computational experiments, the performance of the proposed algorithm is

examined. The experimental results validate the effectiveness and efficiency of the proposed algorithms.

TABLE II. QUEUE QUEUE TEMPLATE M/M/S

Input Data Name	Input Data	
Arrival rate	46	hour
Service rate	26	hour
Number of servers	2	for queue
Cost of Service	317910	hour
Cost of Waiting	195410	hour

Table II shows the results of initial data processing of raw data obtained. Arrival rate, service rate, number of servers provided, cost of service, cost of waiting are the variables required to perform further calculations.

After analyze optimal of, the next step is optimizing the cost based on the optimal time. As described above, the optimization of cost will use integer programming method aimed toward determining the effective size of man power to be hired to make sure most earnings.

TABLE III. TOTAL COST BASED ON QUEUE

Resource	Service Cost	Wait Cost	Total Cost
2	635820.00	1244141.01	1879961
3	953730.00	95984.87	1049715
4	1271640.00	18942.12	1290582
5	1589550.00	4062.36	1593612
6	1907460.00	840.91	1908301
7	2225370.00	162.31	2225532
8	2543280.00	28.91	2543309

The technique aimed toward determining the effective size of man power to be hired to make sure most earnings. From the calculations that have been done, the results come out with three man-power saves more cost and time savings. It saves Rp. 830.246,00 per hour of total activities. The performance characteristic of the probability (% of time) system is empty also decrease. It can be shown at the Table IV below.

TABLE IV. QUEUE PERFORMANCE CHARACTERISTICS

Queue Performance Characteristics	2 Resource	3 Resource
Average server utilization (r)	61.5% busy time	59.0% busy time
Average number of customers in the queue (L_q)	0.750 in queue	0.491 in queue
Average number of customers in the system (L)	1.981 in system	2.260 in system
Average waiting time in the queue (W_q)	0.047 hour	0.011 hour
Average time in the system (W)	0.124 hour	0.049 hour
Probability (% of time) system is empty (P_0)	0.238 empty	0.152 empty

Table IV describes the queue of performance with various assessment criteria by comparing the number of resources, namely 2 Resources and 3 Resources. From the data above, it indicates the contrast of the consequences received using line balancing queue method of solution with the present models of staff wanted. It is able to be visible in table III that using existing fashions will queue performance characteristics.

The results of this study can be used as an alternative decision recommendation to maximize the appropriate human resources, taking into account the costs and duration of work on a business process.

CONCLUSION

Based on the experimental results, the entire model that has been built can solve the problem of determining many man power with computation time is quite short. The queuing model combined with Linear Integer Programming can produce optimal results, whereby the calculations can maximize the number of employees who implement them. The completeness of the process can deliver considerable results, meeting the demands of existing working hours, and minimizing targets and limitations of the company.

ACKNOWLEDGMENT

This studies is supported by Department of Management Technology, Institut Teknologi Sepuluh Nopember. The authors are thankful to the reviewers, who have given the useful feedback and recommendations in order that our research presentation may be improved.

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