

PENENTUAN RUTE DISTRIBUSI DENGAN ALGORITMA TABU SEARCH DUA FASE PADA HETEROGENOUS FLEET VEHICLE ROUTING PROBLEM WITH TIME WINDOW DI PT. XYZ UNTUK MEMINIMASI JARAK TEMPUH

DESIGNING ROUTE DISTRIBUTION USING TWO PHASE TABU SEARCH ON HETEROGENOUS FLEET VEHICLE ROUTING PROBLEM WITH TIME WINDOW IN PT. XYZ TO MINIMIZE TRAVEL DISTANCE

Citra Septi Brilliane¹, Ari Yanuar Ridwan², Rio Aurachman³

¹²³Prodi S1 Teknik Industri, Fakultas Rekayasa Industri, Universitas Telkom

¹brilliane96@gmail.com, ²ariyanuar@telkomuniversity.ac.id, ³rioaurachman@telkomuniversity.ac.id

Abstrak— PT. XYZ adalah perusahaan pengolahan susu pasteurisasi yang memproduksi minuman susu dari susu sapi murni. PT. XYZ tidak menjual produk mereka secara langsung kepada pengguna akhir, namun mereka mendistribusikan produk mereka ke banyak perusahaan yang menyajikan susu untuk karyawan atau operator mereka pada waktu makan siang. Jadi, pelanggan mereka kebanyakan adalah perusahaan manufaktur dari berbagai jenis industri. Mereka memiliki sekitar 40 pelanggan dan kebanyakan berada di luar Bandung. Namun, pengirimannya mungkin tidak dilakukan sesuai rencana. Rata-rata pengiriman tepat waktu sekitar 96%. itu dibawah target PT. XYZ yaitu 98%. Dampak penundaan itu sendiri bervariasi antar pelanggan. Karena ketika terjadi keterlambatan, setiap pelanggan memiliki peraturan sendiri yang telah diselesaikan dalam kontrak kesepakatan. Berdasarkan rekapitulasi di atas, ada beberapa faktor yang menyebabkan masalah ini. Keterlambatan deparatur adalah faktor yang paling berpengaruh. Itu karena PT. XYZ tidak memiliki jadwal pengiriman yang tetap dan mereka salah menghitung waktu deparatur karena penentuan rute yang tidak tepat yang juga menyebabkan waktu tempuh lebih lama. Dalam penelitian ini, kasus ini akan dilakukan dengan membuat penjadwalan dan masalah routing kendaraan dengan karakteristik yang terdapat Kendaraan Heterogenous Armada. Routing Problem dengan Time Window menggunakan Two Phase Tabu Search Algorithm untuk meminimalkan jarak tempuh. Pada akhirnya, jarak tempuh bisa diminimalisir 19.48%.

Kata kunci: Vehicle Routing Problem (VRP), Heterogenous Fleet VRP, VRP with Time Window (VRPTW), Heuristics, Two Phase Tabu Search Algorithm.

Abstract— PT. XYZ is a pasteurization milk processing company that produce milk drink from pure cow milk. PT. XYZ don't sell their product directly to end user, instead they distribute their product to many companies which serve milk for their employees or operators in lunch time. So, their customer is mostly a manufacture company from various kinds of industry. They have about 40 customers and most of them are outside Bandung. However, the delivery may not be done as planned. The average on time delivery is around 96%. it is below PT.

XYZ target which is 98%. The impact of the delay itself is vary between customers. Because when delay occur, each customer has their own regulation that has been settled in agreement contract. Based on the delay recapitulation above, there are several factors that caused this problem. Delay in departure is the most influential factors. It is because PT. XYZ don't have fixed schedule of delivery and they miscalculate the departure time because of improper route determination that also leads to longer travel time. This case is categorized as Vehicle Routing Problem with Heterogeneous Fleet and Time Window (VRPHFTW) that will be solved using one of metaheuristics algorithm which is Two Phase Tabu Search Algorithm to minimize travel distance. In the end, the travel distance can be minimized 19.48%.

Keywords: Vehicle Routing Problem with Heterogenous Fleet and Time Window (VRPHFTW), Meta-Heuristics, Two Phase Tabu Search Algorithm.

I. INTRODUCTION

One of the critical function in the supply chain is the distribution and transportation across various entities. Chopra and Meindl define transportation as movement of goods from one location to another to make its path from the beginning of a supply chain to end users [1]. Transportation is a value adding activity as mentioned by Simons D [2]. Effective transportation management required in both supply and distribution process in a company. Because it poses a significant role at all the three levels of supply chain which are strategic, tactical and operational planning.

Transportation reliability and punctuality have significant impact on customer satisfaction level and delays also required company to pay for penalty cost to their customers. For consumer goods supply chain, time windows are very common to use. Time windows for each customer may be vary. Early arrival may result in waiting time for truck and driver, while late arrival will result in penalty cost or undelivered order. Therefore, it is important to arrive on time within the given time window and to avoid late delivery, company has to make distribution planning while considering resources such as vehicle. Proper route selection will also affect distribution process and

transportation cost because least distance means less time and less cost. This problem is called Vehicle Routing Problem (VRP). This research presents a case study of vehicle routing problem in PT. XYZ which is a pasteurization milk processing company that produce milk drink from pure cow milk. PT. XYZ produce 16 variants of milk drink such as chocolate, strawberry, mocca, etc. PT. XYZ receive raw material every morning, which is fresh cow's milk, from local cattle breeder cooperatives that located near their factory. PT. XYZ production quantity is determined after customer's order is received so they use just-in-time philosophy which is to produce goods at the time required by customer, in the amount that meet the customer's need in the most economical or most efficient way through eliminating waste and continuous improvement [3].

To meet customer's demand, PT. XYZ have to ensure that their distribution process is going smoothly. Because it is one of the key process of their supply chain. Their truck is equipped by GPS, so that the location of the truck can be known and if there's route change, the company will also know. PT. XYZ have two type of refrigerator truck which explained in the Table I.1.

Table I.1 Fleet Type

Fleet Type	Numbers of fleet	Capacity
Colt Diesel Double (CDD)	5	18.000 cup of milk
Colt Diesel Engkel (CDE)	2	9.000 cup of milk

PT. XYZ determine the fleet used based on customer order, so in one day all of the fleet may be used or only just several fleet. The deparature delivery will also be adjusted. Usually there are two deparatures, in the morning and evening. However, if customer orders are high there can be three deparatures. PT. XYZ also devide the route into Cikampek-Cikarang route and Cikarang-Jakarta route to make the delivery easier, but which customer will be deliver first is determined by driver operator. PT. XYZ just inform the delivery order (DO) to driver operator that contain which customer will be delivered, what flavor is ordered by each customer, and the quantity of each customer's order. The driver operator also informed about each customer time window, so he can estimate the sequence of the delivery.

However, the delivery may not be done as planned. From the given time window by each customer, the delivery cannot make it on time. It can be seen in the data of delivery delay frequency at Table I.2.

Table I.2 Delivery Frequency

Month	Delivery Frequency	Delay Frequency	Percentage of On Time Delivery
Jan	57	5	91.2%
Feb	41	0	100.0%
Mar	48	3	93.8%
Apr	53	3	94.3%
Mei	40	0	100.0%
Jun	59	2	96.6%

PT. XYZ always monitor the delivery process to customer. By using GPS in their vehicles, they know whether the delivery is on time or not. PT. XYZ also can monitor the sequence of delivery to customer in each vehicle. Based on the recapitulation of each delay from PT.

XYZ, there are several factors that influenced than can be seen in Figure I.1.

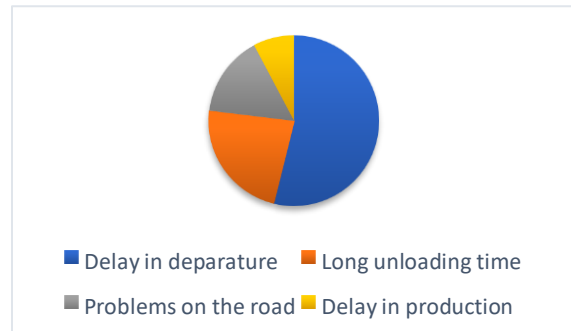


Figure I.1 Factors Causing Delay

Based on the Figure I.1 about factors causing delivery delay, the most influential factors is delay in deparature. It is because PT. XYZ don't have fixed schedule of delivery and they miscalculate the deparature time because of improper route determination that also leads to longer travel distance. Route determination is left entirely to driver operator therefore there's no proper calculation that can optimize the distrubution processes. They also spent a lot of time in goods unloading activity because operators have to move the milk from the vehicle into customer's refrigerator and put each cup one by one to stack the milk neatly inside the refrigerator.

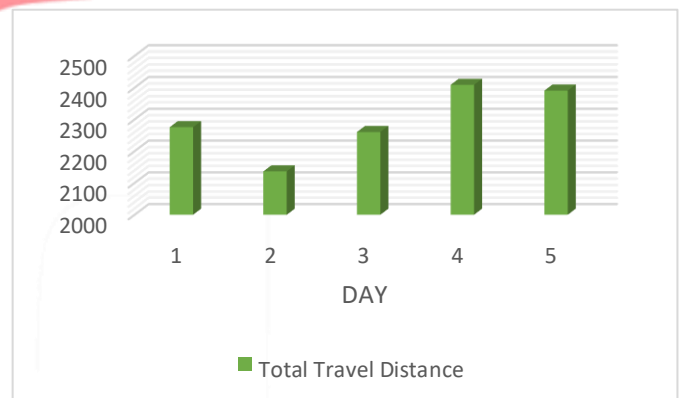


Figure I.2 One Week Travel Distance

Based on Figure I.2, the total travel distance is different each day. Even though the customer who must be visited is the same, but the driver operator chooses different route and sequence of delivery each day. From this data, we can conclude that route selection is influential factors in distribution. Improper distribution route can lead to late delivery and also longer distance means longer travel time. This problem occurs because PT. XYZ not precisely choosing the route and they miscalculate the deparature time because of improper route determination. Route determination is left entirely to driver operator therefore there's no proper calculation that can optimize the distrubution processes. They also spent a lot of time in goods unloading activity because operators have to move the milk from the vehicle into customer's refrigerator and put each cup one by one to stack the milk neatly inside the refrigerator.

Based on the issues that have been stated, the main problem that occur in PT. XYZ is a classical transportation problem which is Vehicle Routing Problem (VRP). In this research, capacitated VRP with heterogeneous fleet of vehicles considering time windows will be solved.

II. STUDY OF LITERATURE

A. Vehicle Routing Problem

The most widely used routing problem is Travelling Salesman Problem (TSP) with purpose to minimize the transportation distance of several nodes and return to the starting point. Ganesh and Narendran defined TSP as a determination of route from set of N nodes with the distance between every node where each node is just visited once and the total distance travelled is minimum [4]. Vehicle Routing Problem (VRP) is the same as TSP but the salesmen are replaced by vehicles. VRP also consider demand at each node and carrying capacity of each vehicles. VRP used in many filed such as industrial goods, public transport, courier services, waste collection, etc.

B. Vehicle Routing Problem with Time Window

VRP with Time Window (VRPTW) is applied by considering the time window owned by the customer. Products have to arrive within the given time window given by each customer. If customers have more than one tie window then it is called multiple time windows.

C. Vehicle Routing Problem with Heterogenous Fleet

VRP with Heterogenous Fleet means that companies may have several types of vehicle to use for distributing their product to customers.

D. Meta-Heuristics Algorithm

The most effective and promising problem-solving methods for VRP is meta-heuristics, which is a mechanism for solving hard optimisation problems because it performs deep exploration to obtain global optimum solution and can combine with neighbourhood search rules, memory structures and recombination of solutions. The solution usually has much higher quality than the result from classical heuristics, despite the increased computing time. [5]

E. Two-Phase Tabu Search Algorithm

A two-phase tabu-search algorithm is proposed by Jiang, et al., [6] to solve numerous problem variants including VRP with heterogeneous fleet and time window which less studied other than other type of VRP. This algorithm is extend into two phase which in the first phase contain sorting of vehicles using greedy capacity rule, sorting of customers using greatest distance rule, and after sorting is tabu moves to find neighborhood solution using several kinds of move. While in the second phase contain post-processing moves that split the usage of vehicle. The moves are to transfer between each route that can be some part of the route or even the whole route, but without changing the sequence order. However, in this research, the author will replace the sorting in the first phase by using one of heuristics method which is Nearest Neighbor to generate the initial solution. Nearest neighbor algorithm is defined as a simple and open technique for a variety of problems [7]. The detail of the algorithm can be seen in Fig 3.

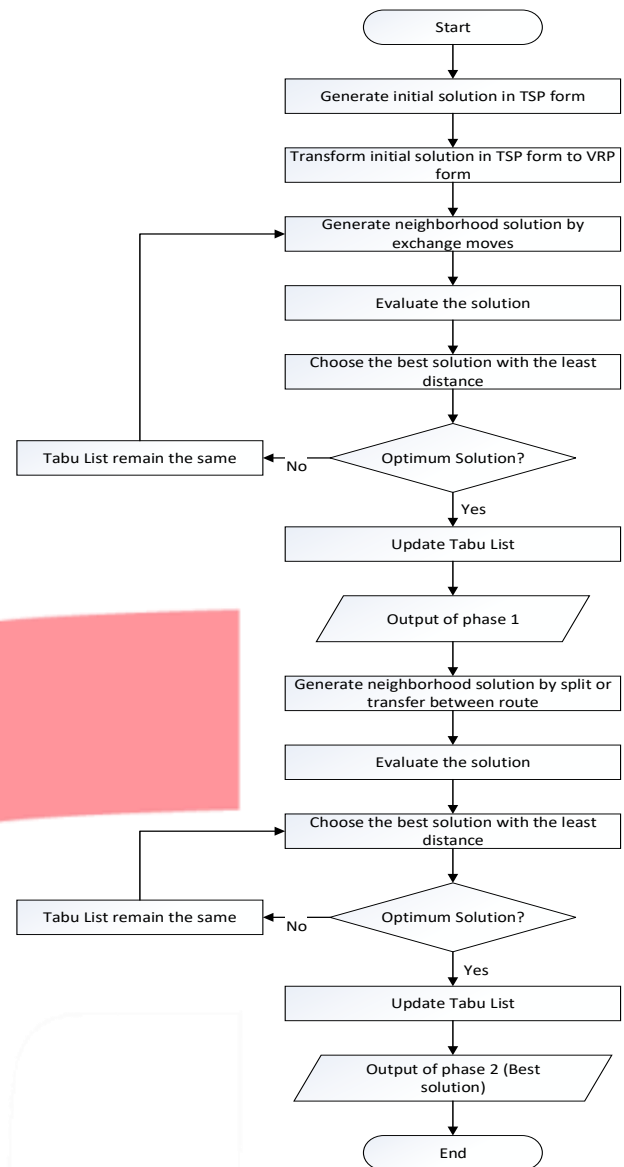


Fig. 3 Flowchart Algorithm

2.7 Mathematical Model

The objective function of this research is to minimize travel distance. Below, is a mathematical model that has been formulated from the problem on the existing condition :

The mathematical model can be defined on a graph $G(V, A)$ where

V = node set

$= \{0, 1, \dots, n\}$, node 0 represent DC while customer represent by

N = customer set

$= \{1, 2, \dots, n\}$

A = arc set or connections between nodes

$= \{(i, j) : 0 \leq i, j \leq n, i \neq j\}$

K = fleet of vehicle set

C = vehicle type set

Indexes:

i = notation index, $i = 1, 2, 3, \dots, N$ is customer that start distribution activity.

j = notation index, $i = 1, 2, 3, \dots, N$ is customer that start distribution activity.

k = notation index, $k = 1, 2, 3, \dots, K$ is fleet of vehicle that used for distribution activity.

c = notation index, $c = 1, 2, 3, \dots, C$ is vehicle type that used for distribution activity.

Parameters:

m_{ij}	= travel distance between arc (i, j)
t_{ij}	= travel time between arc (i, j)
d_i	= demand of customer i ($i \in N$)
$[e_i, l_i]$	= time window of customer i (earliest arrival and latest arrival)
s_i	= service time of customer i ($i \in N$)
$[e_0, l_0]$	= time window of DC (earliest departure, latest return)
q_c	= capacity of vehicle type c ($c \in C$)
n_c	= number of available vehicle for vehicle type c ($c \in C$)

Decision Variables:

$x_{ij}^k = 1$, if arc (i, j) is passed by vehicle k

$= 0$, if arc (i, j) is not passed by vehicle k

a_{ik} = arrival time of vehicle k at customer i

Objective Function:

$$\text{Min} \sum_{k \in K} \sum_{(i,j) \in A} m_{ij} x_{ij}^k$$

Objective function above is based on this research objective which is to minimize total travel distance in distribution activity from depot to customers in order to prevent late delivery or passed the range of customer time window. m_{ij} is distance between arc (i, j) , while x_{ij}^k is distribution route between arc (i, j) using fleet of vehicle k .

Constraint:

$$\sum_{k \in K} \sum_{j \in V} x_{ij}^k \leq 1 \quad \forall i \in N \quad (1)$$

Constraint (1) means that route from customer i to customer j can only be visited once by vehicle k or in the other words, any customer can only be visited by one vehicle.

$$\sum_{j \in N} x_{0j}^k \leq 1 \quad \forall k \in K \quad (2)$$

Constraint (2) ensure that vehicle k only can depart once from DC to customer. So, one vehicle cannot be assigned twice.

$$\sum_{i \in N} x_{i0}^k \leq 1 \quad \forall k \in K \quad (3)$$

Constraint (3) ensure that vehicle k only can arrive once at DC from customer. So, one vehicle cannot be assigned twice.

$$\sum_{i \in V} x_{ij}^k = \sum_{i \in V} x_{ji}^k \quad \forall j \in V, k \in K \quad (4)$$

Constraint (4) means that route from arc (i, j) is the same as route from arc (j, i) . So, it ensure that after vehicle leave the customer, it will not return afterwards.

$$\sum_{i \in N} d_i \sum_{j \in \Delta_i^+} x_{ij}^k \leq q_c \quad \forall k \in K, c \in C \quad (5)$$

Constraint (5) ensure that for each route, the accumulated demand of any customer must not exceed vehicle's capacity.

$$x_{ij}^k (a_{ik} + s_i + t_{ij} - a_{jk}) = 0 \quad \forall k \in K, (i, j) \in A \quad (6)$$

Constraint (6) means precedence relationship among arrival time of vehicle at customers in the route which is a sum of arrival time, waiting time, service time of customer i , and travel time between arc (i, j) minus arrival time in customer j equal to zero.

$$e_i \sum_{j \in \Delta_i^+} x_{ij}^k \leq a_{ik} \leq l_i \sum_{j \in \Delta_i^+} x_{ij}^k \quad \forall k \in K, i \in N \quad (7)$$

Constraint (7) is time window constraint where sum of arrival time and waiting time is within customer's time window or earliest and latest arrival.

$$e_0 \leq a_{0k} \leq l_0 \quad \forall k \in K \quad (8)$$

Constraint (8) is DC time window constraint where arrival of vehicle at DC is within DC time window or earliest departure and latest return.

$$\sum_{k \in S_c} \sum_{j \in N} x_{0j}^k \leq n_c \quad \forall c \in C \quad (9)$$

Constraint (9) limits the available number of vehicle for each type.

$$a_{ik} \geq 0 \quad \forall k \in K, i \in N \quad (10)$$

Constraint (10) restrict the values of variable which is arrival time must equal to or greater than zero.

$$x_{ij}^k \in \{0,1\} \quad \forall k \in K, (i,j) \in A \quad (11)$$

Constraint (11) restrict the values of variable which is route from arc (i, j) using vehicle k must equal to 0 or 1. 0 if arc (i, j) is not passed by vehicle k and 1 if passed by vehicle k .

III. RESEARCH METHODOLOGY

A. Preliminary Stage

Systematics stages of this research is depicted in figure above. In the preliminary stage, initial study of the research object regarding the problems is done. Initiation process of the existing conditions of research object is done with direct observation in the location itself (field study). After that, conditions that occurred in the field is linked with literature study that can be sourced from books, papers, or other references so that the problem can be formulated. Problem formulation then develop into objectives that this research will be achieved.

B. Data Collecting and Processing Stage

In this stage, data required for this research is collected which will be processed next.

1. Data Collecting

- Travelling distance

It is required to determine the initial route of the distribution as an input data.

- Average speed

It is needed to estimate the travel time of vehicle from the departure until arrival to customer.

- Customer locations

It is needed as an input to determine the initial route of the distribution.

- Vehicle capacity

It is required as an input for data processing to know the capacity of each vehicle type and other characteristics.

- Service time

It is needed to calculate how long the vehicle will be on customer's locations for analyzing the time required and optimal delivery schedule.

- Time Window

Is required for analyzing the optimal delivery schedule and the distribution routes.

- Data demand

This data is the same as customer order for PT. XYZ. It is needed for data processing in determining the optimum ways of using the available vehicles and distribution route.

2. Formulating mathematical model

In this stage, the modelling of goods distribution problem will be done mathematically from the existing condition. The result of the mathematical model is objective function from optimization performed along with the limiting functions. Later this model will be used as a reference in calculating distribution route with Two-Phase Tabu Search Algorithm. The objective function of the mathematical model itself is to minimize the total travel distance by optimizing route so that departure schedule will be obtain to prevent late delivery.

3. Calculating initial solution in phase 1 of Two-Phase Tabu Search Algorithm

After mathematical model has been formulated and all of the required datas are achieved, data processing to calculate the intial solution will be done. In this process, the service sequence of customer is determined by using the Greatest Distance Rule, while the service sequence of vehicles is determined by Greedy Insertion Rule. Then, tabu search procedured will be done which have five moves for the neighborhood of a solution.

4. Improving initial solution from phase 1 in phase 2 of Two-Phase Tabu Search Algorithm

After having found the initial solution in phase 1, then the determination of optimal route will be done in phase 2 by postprocessing procedure for the neighborhood of the solution which contain of two moves. This moves are defined to split the usage of larger vehicles to smaller vehicles.

5. Develop deparature schedule

From the calculated route distribution then the travel distance will also be known. After that, the deparature schedule can be obtain so that late delivey can be prevented.

C. Analysis Stage

In this stage, there two analysis that will be done as follow

1. Analysis of the route distribution result

Distribution routes and scheduling that has been formed in data processing will be analyzed for their effectiveness and efficiency whether it is necessary for further processing or not so that the result will be optimal. In this analysis, the distribution route will be observed and also calculate the distance and transportation costs.

2. Analysis of comparison between solution route and existing condition

The comparison will be done by comparing the travel distance and transportation costs between the existing condition and result of data processing that has been done using GAP Analysis. Primary output that expected to come out is the suggestion route can minimize the travel distance then also have less transportation costs compare to the existing condition.

D. Conclusion and Suggestion Stage

In this stage consists of overall conclusion of the research. Conclusion and Suggestions adjusted to problem formulations and research objectives that have been determined before. In additions, the shortcomings of the existing research will be made as suggestions and recommendations for similar studies next.

IV. RESULT AND ANALYSIS

A. Proposed Distribution Route

Based on the problem that occur in PT. XYZ, which is delay in delivery, there are two problem formulation that will be solved and one of it is optimal distribution route considering travel distance. In this research, designing distribution route for PT. XYZ is done with Two Phase Tabu Search Algorithm. It is done for one day delivery horizon. The result of calculation in this research with Two Phase Tabu Search Algorithm can be seen Table IV.1.

Table IV.1 Suggestion Distribution Route

Fleet	Suggestion Distribution Route
CDE 1	DC – C08 – C27 – C28 – C01 – C19 – C36 – C32 – DC

CDE 2	DC – C35 – C40 – C39 – C37 – C38 – C06 – C16 – C17 – C22 – C05 – C30 – C21 – C29 – C23 – C18 – C11 – C15 – C13 – DC
CDD 1	DC – C20 – C24 – C12 – C14 – C34 – C26 – C25 – C03 – C10 – C04 – C09 – DC
CDD 2	DC – C07 – C31 – C33 – C02 – DC

Based on the calculation result that has been optimized using the algorithm, there are differences in number of route, total number of customer in each route, and total vehicle that used compared to the existing condition. From the result, it can be seen that the first route use vehicle CDE 1 to visit 7 customers, the second route use vehicle CDE 2 to visit 18 customers, the third route use vehicle CDD 1 to visit 11 customers, and the fourth route use vehicle CDD 2 to visit 4 customers. Therefore, it shows that for delivery to 40 customer, PT. XYZ needs four routes with different number of customer in each route which means it is less than the existing condition that need six routes to serve 40 customers.

It is because in order to obtain the optimal route, there are several things that has to be considered which are the sequence order of the customer, that based on travel distance between customer and the accumulated demand that must be less than vehicle capacity, and time window given by each customer. Having less route means that PT. XYZ can fully optimized the delivery system of PT. XYZ, because the combination of customers and its sequence order in each route is made to be as effective and efficient as possible, therefore use less resources but still deliver the product in the given time span without any delays.

B. Fleet Usage

From the calculation result, it can be seen in Table IV.2 about vehicle utilization, the use of vehicle in suggestion route is less than the available vehicle. The existing condition also not use all of the available vehicle as form total seven vehicle, the existing route use six vehicle with composition five CDD and one CDE, meanwhile for suggestion route only need four vehicle. The suggestion route only need two CDE and two CDD because in the Two Phase Tabu Search Algorithm prefer smaller vehicles to be used in the solution. The suggestion route also use less vehicle than existing route with reducing total two vehicles.

Table IV.2 Fleet Utilization

Fleet	Amount of Used Vehicle	
	Existing	Suggestion
CDD	5	2
CDE	1	2
Total	6	4

By using less vehicles, it will give advantages to PT. XYZ because it will reduce transportation cost such as fuel cost, TOLL cost, and driver operator cost. PT. XYZ also can take turn in using the vehicle so that they can maintain the vehicle condition to always be in a good condition. From the result, it is also can be concluded that by optimizing the distribution route, the utilization of the vehicle will also be optimized because in this case, the amount of the route is the same as the number of vehicle used. Therefore, it is important for a company to determine proper distribution route as it is not only for make the delivery on time but also to utilize the used of the vehicle that own by the company.

C. Analysis of Travel Distance

The research objective of this result is to minimize travel distance, therefore the determination of the route will be based on the least travel distance that can be obtained while considering the constraints. Based on comparing the result of existing route and suggestion route, there is a difference between total travel distance of vehicle from both route. It can be seen on Table IV.3 that there is a decrease in travel distance from 2136.49 Km to 1720.24 Km which means there's difference about 416.25 Km from existing route or decrease by 19.48 % from existing condition.

Table IV.3 Comparison of Travel Distance

Fleet	Travel Distance (Km)	
	Existing	Suggestion
CDD 1	241.208	469.19
CDD 2	357.111	540.58
CDD 3	609.436	-
CDD 4	299.959	-
CDD 5	298.604	-
CDE 1	330.171	278.29
CDE 2	-	432.18
Total Travel Distance	2136.49	1720.24

D. Analysis of Travel Time

Based on the result of calculation, travel time is influenced by amount of travel distance of each vehicle because both of them is correlated to each other. From existing travel time, there is a decrease in suggestion travel time because the distance itself is also decrease. Table IV.4 shows travel time needed of each vehicle and the total travel time compare with the existing one.

Table IV.4 Comparison of Travel Time

Fleet	Travel Time (Hour)	
	Existing	Suggestion
CDD 1	12.59	19.66
CDD 2	15.59	20.14
CDD 3	18.02	-
CDD 4	13.19	-
CDD 5	10.36	-
CDE 1	10.25	15.28
CDE 2	-	20.96
Total Travel Time	80.00	76.03

As we can see on the Table IV.4, total travel time is decrease from existing time which is 80.00 hour to suggestion time 76.03 hour. It

means there is decrease by 4.96% from existing condition or reduced around 3.97 hour. The travel time is also decrease because the duration of delivery for one route is not only determined by how much time is spent in each customer for unloading the goods, but also by the amount of distance. Therefore, even though the objective is not to minimize travel time, there still will be an impact on travel time. Less travel time will also give benefit to PT. XYZ as it means that the transportation cost is also reduced because the amount of fuel and also maintenance cost is determined by how long the vehicle is used.

E. Analysis of Delivery Delay

The main problem that occur in PT. XYZ is the delays in delivery, thus it is important to obtain optimal route which not only has less distance but also can serve all of the customer in the range of time window. From the calculation, the arrival time in the customer for each route is obtained which already consider the amount of unloading time and administration time in each customer. From the result, it can be seen that with reducing total travel distance, there is an improvement in delivery delay that occur in PT. XYZ. This can be proved by looking at arrival time of vehicle in customer whether it is within time window or not. The following is the data of vehicle arrival time in each customer compare with time window.

Table IV.5 shows the arrival time of each customer in route 1 that in the range of time window. Then, the delivery is successful and there is no delay occur.

Table IV.5 Customer Arrival Time in Route 1

Route	Time Window		Arrival Time
	Earliest	Latest	
D	3:00:00	0:00:00	-
C08	6:00:00	9:00:00	5:10:49
C27	10:00:00	16:00:00	12:02:26
C28	12:00:00	16:00:00	12:30:35
C01	11:00:00	19:00:00	12:34:49
C19	10:00:00	15:00:00	12:49:47
C36	8:00:00	18:00:00	13:39:25
C32	8:00:00	16:00:00	14:03:35
D	3:00:00	0:00:00	18:16:32

As can be seen on the result of arrival time in each customer, all vehicle arrive within customer time window which means there is no delays occur in the suggestion route. Therefore, it indicates that when distribution route is properly calculated, then optimal route that effective and efficiency will be obtained because the resource owned by the company will be optimally utilized and all of the constraints especially time window will be considered. If the company just rely on intuition or estimation, which is currently happening in PT. XYZ, then there is a possibility that it is not the optimal route because there are many route that can be generated from 40 customers and delays can not be avoid. By improving the delivery performance, PT. XYZ will get many benefits such as first, able to avoid penalty cost as each customer has their own regulation of lateness, but it all can be avoid and will not affect the invoice, second is there will be no undeliver

product because the product will be successfully handed to the customer in the given time window, and lastly is improve customer satisfaction level as great performance in delivery will make customer trust the company and probably order more product.

To sum up, even though the research objective of this research is to minimize travel distance but it will also affect other variable because after obtaining optimal distribution route, the delivery system will also improved and delays can be prevented as long as there are no unexpected circumstances occur such as traffic congestion, disaster, and accidents.

V. CONCLUSION

After the result of this research of distribution route planning is obtained using

Two Phase Tabu Search algorithm, it can be concluded as follows

1. The optimal suggestion route that obtained in this research only have four routes using total four vehicles which are two CDE and two CDD which shows in Table VI.1 below. There is no delay occur in suggestion route, because the arrival time is between each customer time window. Table IV.3 Research Result

Fleet	Suggestion Distribution Route	Distance (Km)	Travel Time (Hour)
CDE 1	DC – C08 – C27 – C28 – C01 – C19 – C36 – C32 – DC	278.29	15.28
CDE 2	DC – C35 – C40 – C39 – C37 – C38 – C06 – C16 – C17 – C22 – C05 – C30 – C21 – C29 – C23 – C18 – C11 – C15 – C13 – DC	432.18	20.96
CDD 1	DC – C20 – C24 – C12 – C14 – C34 – C26 – C25 – C03 – C10 – C04 – C09 – DC	469.19	19.66
CDD 2	DC – C07 – C31 – C33 – C02 – DC	540.58	20.14
Total		1720.24	76.03

2. The total travel distance of suggestion route is reduce from the existing condition. The travel distance was initially 2340.95 Km, after optimization it decrease into 1720.24 Km. Therefore the reduction is about 19.48%.

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