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DETERMINING THE OPTIMAL ROUTE OF BULOG RICE DISTRIBUTION USING SEQUENTIAL INSERTION AND NEAREST NEIGHBOUR METHOD

Yayang Safitri[1], Fibri Rakhmawati[2], Rima Aprilia[3]

[1,2,3]Program Studi Matematika, Universitas Islam Negeri Sumatera Utara
[*]Email: [1]yayangsafitri12@gmail.com, [2]fibri_rakhmawati@uinsu.ac.id, [3]rima_aprilia@uinsu.ac.id

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Abstract

Rice consumption in Indonesia is the 4th highest in the world, with an annual average of 35.3 million tonnes. Apart from that, domestic rice production is relatively low, so finding an optimal distribution pattern to meet Indonesia's food consumption needs is necessary. This research aims to find the best route for rice distribution using sequential insertion and nearest-neighbor methods. The aim is to compare the two methods to determine which is suitable for distributing rice. Apart from that, comparisons are made to find the distribution route with the shortest distance and fastest time. The research results show that the optimal travel distance using the sequential insertion method is t = 1, namely 519 Km with a travel time of 779 minutes. Meanwhile, the optimal travel distance using the nearest neighbor method at r = 1 is 506 km with a travel time of 535 minutes. Thus, this problem's nearest neighbor method performs better than sequential insertion.

Keywords: *Distribution Route, Nearest Neighbour, Sequential insertion,*

**Corresponding Author: Yayang Safitri*

1. INTRODUCTION

Every company engaged in the service and good sector cannot avoid distribution activities. Distribution activities not only concern the interests of the company, but also cover the economic activities of a country. One of the distributions that is very important and must be optimized is the distribution of food, which includes all foodstuffs derived from natural resources and water, both in raw and processed form, which can be consumed by humans as food and drink. Perum Bulog is one of the State-Owned Enterprises (BUMN) that specializes in food distribution with its largest commodity being rice. [1], [2].

The distribution process of Perum Bulog North Sumatra Regional Office relies on a subsidiary partner named JPL as a transportation rental service. In addition, Perum Bulog North Sumatra does not have a fixed route arrangement, the distribution paths are still intuitionistic relying only on the driver's experience, and the existence of multiple trips is a term that refers to the condition of deliveries made with respect to a predetermined plan. Some of the issues that must be addressed during the distribution process include different demands from each customer, delivery time limits, vehicle capacity, average line speed, and specific times. Therefore, if there is no prior determination of distribution routes, the predetermined goals or targets will not be achieved optimally. Perum Bulog North Sumatra regional office needs to have an understanding of the best route and the optimal number of deliveries to deal with more efficient transportation costs based on the HPS (Own Calculation Price) that will be submitted to JPL to be more minimal. This becomes the basis of research on which route is the best that can be applied in distributing rice according to Bulog's policy to several Bulog branches and warehouses in North Sumatra. [3]

Vehicle routing problem (VRP) refers to a challenge in transportation or distribution that involves selecting vehicle routes, scheduling vehicles, and the type of vehicles used. Basically, VRP is done to find the optimal vehicle route in order to serve a group of customers efficiently. Each customer has a location point by knowing the customer's demand, there is a connection between the depot and the customer, and also between one customer and another through a predetermined route [4]

The advantage in this research is that in solving VRP and its variations, this research uses the heuristic method. Heuristic method is an approach used to solve search problems and find solutions that can be verified

or tested. Heuristic method emphasize simple computational performance or conceptual simplification. Heuristic method are problem-dependent, which means that they depend on the problem and can only be used in certain problems, such as sequential insertion and nearest neighbour method applied to CVRP. [5]

This research can contribute to the calculation and organization of the Bulog rice distribution process by minimizing the paths to be taken using the VRP (Vehicle Routing Problem) method. By performing data processing to design alternative routes, the distribution process can become more efficient.[6]

2. RESEARCH METHOD

VRP (Vehicle Ranking Problem) is a challenge that involves determining the path of transportation trips that transport products from factories to customers. The main objective of VRP is to reduce the overall distance that must be passed by the vehicle, so as to reduce transportation costs and the time required by the vehicle in making the trip.[7]

Capaciated Vehicle Rounting Problem (CVRP), is a model developed from the VRP model. CVRP is similar to VRP along with another element, which is that each vehicle has a unique capacity for one type of goods. [8]

the problem is modeled to reduce the overall vehicle miles traveled. So in this case the decision variable is defined as follows:

$$x_{ij}^{k} = \begin{cases} 1 \\ 0 \end{cases} \quad (1)$$

If vehicle k travels from point v_i to point v_j.
And vehicle k travels from point v_i to point v_j.

$$u_{ij}^{k} = \begin{cases} 1 \\ 0 \end{cases} \quad (2)$$

If point v_i is not served by vehicle k. And point v_i is served by vehicle k.

the objective of this problem is to achieve the minimum total vehicle miles traveled. If z is the objective function,
minimizing z,

$$\sum_{k\in k}\sum_{i\in v}\sum_{j\in v} c_i x_{ij}^{k} \quad (3)$$

With constraint,

$$\sum_{k\in K}\sum_{j\in V, i\neq j} x_{ij}^{k} = 1, \forall i \in V \quad (4)$$

2.1 Sequential Insertion Method

The sequential insertion method is an approach that seeks to solve problems by inserting clients between established bus arcs to achieve optimal results. [9]

In this study, to describe the completion of the sequential insertion method can be seen from figure 1.

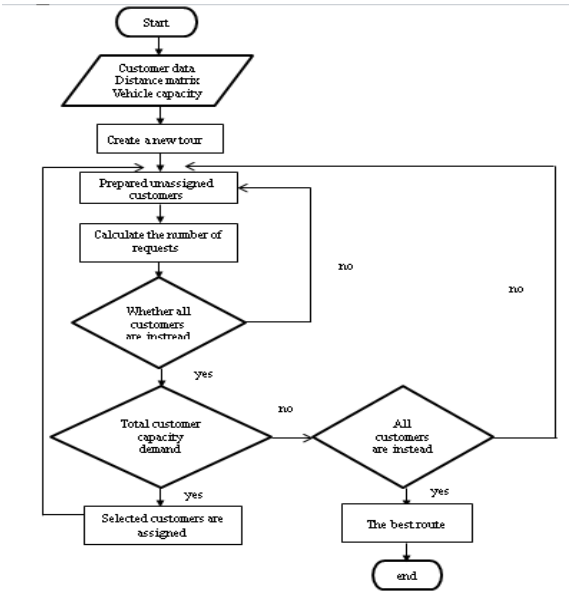

Figure 1. Flowchart Of Sequential Insertion Method

2.2 Nearest Neighbour Method

The nearest neighbour method is applied because delivery routes that can be adjusted to field conditions can be made with this method. In addition, this method is easier to use than other route determination method and can solve problems quickly.[4]

To describe the completion of the nearest neighbour method can be seen from figure 2.

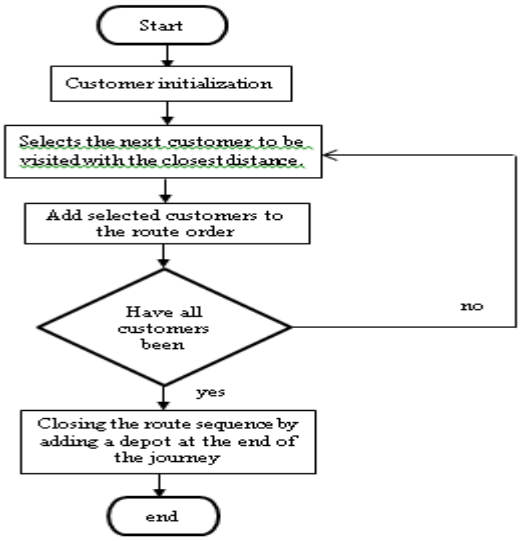

Figure 2. Flowchart Of Neirest Neighbour Method

3. RESULT AND DISCUSSION

3.1 Completion Using Sequential Insertion Method

The sequential insertion method can be used to find bulog rice carrier routes. The main principle of this technique is to insert customers between the insertion arcs that already exist on the previously formed route. The inserted customers are selected based on the closest distance from the depot (Z) and viewed through the distance matrix. [10] Input

customer data, customer location (with symbol), the number of requests from each customer, and the capacity of the vehicle used can be seen in table 1.

Table 1. Symbol of Outlet Customer

No	Symbol	Outlet/customer	Demand (Tons)
1	Z	Komp. GD PBD I (Depot)	0
2	A	Komp. GD Labuhan Deli	0,7
3	B	Komp. GD PBD II	0,8
4	C	Komp. GD Mabar	0,75
5	D	Komp. GD Paya Pasir	1,15
6	E	GBB. Kisaran Naga	0,85
7	F	GBB. Naga Pita	1,5
8	G	GSP. Huta Lombang	1,5
9	H	Komp. GD Sumber Mufakat	1,25
10	I	GBB. Lumban Pea	1,25
11	J	GBB. Bakaran Batu	1,2
12	K	GBB. Palopat	2,85
13	L	GBB. Sitataring	1,2
	Total customer demand		15 tons
	Truck capacity		10 tons

Figure 3 shows the distance matrix 1 with the provisions on the first trip (t=1), the route starts from the depot and goes to the first customer before returning to the depot. In selecting the first customer, the customer with the closest distance to the depot is selected.

	Z	A	B	C	D	E	F	G	H	I	J	K	L
Z	0	12,2	0,8	4,2	66,6	127,7	83,3	250,9	58,8	85,5	213,2	256,4	255,3
A		0	11,4	8	77,7	135,4	94,4	262	71	96,6	222	270	266,4
B			0	3,5	66,6	128,8	84,4	250,9	59,9	86,6	213,1	257,5	255,3
C				0	68	129,9	86,6	255,3	63,3	88,8	216,5	266,4	255,3
D					0	62,2	42,2	210,9	82,1	43,3	155,4	222	215,3
E						0	62	174,3	126,5	60	100	191	177,6
F							0	172,1	65,5	2,22	129,9	182	177,6
G								0	204,2	169,8	96	23,3	51
H									0	67,8	187,6	266,4	208,9
I										0	127,7	181	175,9
J											0	117,7	100
K												0	20
L													0

Figure 3. The distance matrix from sequential insertion

The closest travel distance from Z is (Z-K) then (Z-K) is inserted into the graph t = t + 1. And can be seen from Figure 4.

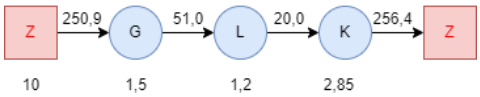

Figure 4. t = t + 1 (Z – G – L – K- Z)

For t = t + 1 (Z – G – L – K – Z)

Vehivle capacity (Q) > demand $d_{G,L,K}$

$10\ tons \quad > 1{,}5 + 21{,}2 + 2{,}85$

$10\ tons \quad > 5{,}55\ tons\ (compliant)$

Distance traveled $c_{ij} = 250{,}9 + 51{,}0 + 200 + 256{,}4 = 578{,}3\ km$

travel time (WT][) = $\frac{578{,}3}{40} \times 60 = 836\ minutes$

The sequential insertion method produces two routes. The first route, resulting in a distance of 519, 12 km with a travel time of 779 minutes. While the second route, produces a distance of 578,3 km with a travel time of 836 minutes.

3.2 Completion Using the Nearest Neighbour Method

The basic principle of this method is that transport vehicles serve the customer closest to the last location visited when they create a travel route. It initially finds the closest customer point to the depot (Z), then that customer becomes the starting point for finding the next closest customer from that location.[11], [12].

Figure 5 shows the initial initialization, routes (r = 1), and tours (t = 1). Establishing the first route on the first tour, the truck starts from Z and ends at Z.

	Z	A	B	C	D	E	F	G	H	I	J	K	L
Z	0	12,2	0,8	4,2	66,6	127,7	83,3	250,9	58,8	85,5	213,2	256,4	255,3
A	12,2	0	11,4	8	77,7	135,4	94,4	262	71	96,6	222	270	266,4
B	0,8	11,4	0	3,5	66,6	128,8	84,4	250,9	59,9	86,6	213,1	257,5	255,3
C	4,2	8	3,5	0	68	129,9	86,6	255,3	63,3	88,8	216,5	266,4	255,3
D	66,6	77,7	66,6	68	0	62,2	42,2	210,9	82,1	43,3	155,4	222	215,3
E	127,7	135,4	128,8	129,9	62,2	0	62	174,3	126,5	60	100	191	177,6
F	83,3	94,4	84,4	86,6	42,2	62	0	172,1	65,5	2,22	129,9	182	177,6
G	250,9	262	250,9	255,3	210,9	174,3	172,1	0	204,2	169,8	96	23,3	51
H	58,8	71	59,9	63,3	82,1	126,5	65,5	204,2	0	67,8	187,6	266,4	208,9
I	85,5	96,6	86,6	88,8	43,3	60	2,22	169,8	67,8	0	127,7	181	175,9
J	213,2	222	213,1	216,5	155,4	100	129,9	96	187,6	127,7	0	117,7	100
K	256,4	270	257,5	266,4	222	191	182	23,3	266,4	181	117,7	0	20
L	255,3	266,4	255,3	255,3	215,3	177,6	177,6	51	208,9	175,9	100	20	0

Figure 5. The distance matrix from Nearest neighbour

Then figure 6 define the closest point to K is the replacement L which has a distance of 20 km.

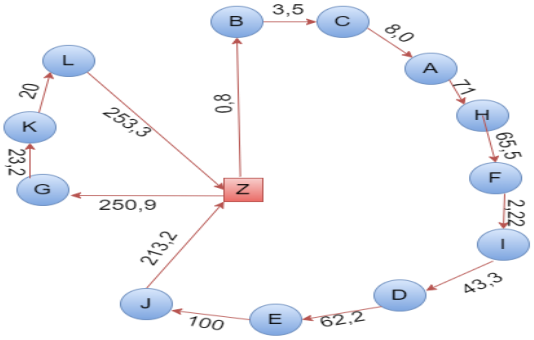

Figure 6. r = r + 1 (Z-G-K-L-Z)

- Calculate the travel time of delivery trips between locations (WT) $WT = \frac{20}{40} \times 60 = 30\ minutes$.
- Calculate the unloading time (UT), or unloading time $UTl = 1{,}2\ tons \times 3\ minutes = 3{,}6\ minutes$.
- Calculating the total completion time (CT), CT $= WT + UT + LT = 30 + 3{,}6 + 0$ $33{,}6\ minutes \leq T\ max$.
- Calculate vehicle capacity or load $(Q) = Q + d_I = 4{,}35 + 1{,}2 = 5{,}55\ tons \leq Q\ max$.
- All customers have been served, the distribution is complete.

The Nearest Neighbour method produces two routes. The first route, resulting in a total mileage of 505.82 km with a total travel time of 534.83 minutes. While the second route, produces a total mileage of 547.5 Km with a total travel time of 441.4 minutes.

3.3 Comparison of Routes Using Sequential Insertion and Nearest Neighbour Method

Comparison of routes using sequential insertion and nearest neighbour method under multiple trips conditions with a planning horizon. Thus, the distribution carried out pays attention to the maximum load limit of the transport vehicle. If the planning horizon has expired, but there are still customers who have not been served, the driver can return to the depot and continue by doing the next tour according to the location of the customer who has not been served. [13]- [15]

Based on the calculation of sequential insertion and nearest neighbour method, a route for transporting Bulog Regional Office of North Sumatra rice is obtained. Table 2 shows The routes are compared based on distance and travel time.

Table 2. Comparison of Sequential Insertion and Nearest Neighbour Method

Method	Route	Capacity	Travel distance	Travel time
Sequential Insertion	Z-B-C-A-H-D-F-I-E-J-Z	9,4 tons	510,12 km	779 minutes
	Z-G-L-K-Z	5,55 tons	578,3 km	868 minutes
Total		15 tons	1.097,42 km	1647 minutes
Nearest Neighbour	Z-B-C-A-H-F-I-D-E-J-Z	9,45 tons	508,82 km	534,83 minutes
	Z-G-K-L-Z	5,55 tons	547,5 km	441,1 minutes
Total		15 tons	10.532,32 km	976.23 minutes

4. CONCLUSION

In the sequential insertion solution, the first route GD. PBD I - GD. PBD II - GD. MABAR - GD. LABUHAN DELI - GD. SUMBER MUFAKAT - GD. PASIR - GBB. NAGA PITA - GBB. LUMBAN PEA - GBB. KISARAN NAGA - GBB. BAKARAN BATU - GD. PBD I and the second route GD. PBD I - GSP. HUTA LOMBANG - GBB. SITATARING - GBB. PALOPAT - GD. PBD I with a total distance of 1,097.42 km and a total travel time of 1647 minutes. While the nearest neighbour solution obtained the first route GD. PBD I - GD. PBD II - GD. MABAR - GD. LABUHAN DELI - GD. SUMBER MUFAKAT- GBB. NAGA PITA - GBB. LUMBAN PEA - GD. PAYA PASIR - GBB. KISARAN NAGA - GBB. BAKARAN BATU - GD PBD I and the second route GD. PBD I - GSP. HUTA LOMBANG - GBB. PALOPAT - GBB. SITATARING - GD. PBD I with a total distance of 1,053.32 km and a total travel time of 976.23 minutes. So it can be concluded that the route formed using nearest neighbour in this study is more optimal with a distance difference of 44.1 km shorter and a time difference of 670.77 minutes shorter than the route formed on sequential insertion.

Analysis of the nearest neighbour method as the optimal method for determining the route for this problem, the nearest neighbour method as a method for solving problems by considering the shortest distance so as to produce a fairly decent quality in determining the resulting distance, which can minimize the distance traveled and the travel time of the vehicle.

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