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Distribution Route Optimization Using Nearest Neighbor Algorithm and Clarke and Wright Savings

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Abstract: in the process of this research Problems that occur is an irregular delivery of goods that takes a lot of time and delivery distance, so the distribution delivery process is not optimal. Therefore, researchers will conduct research on how to determine the best distribution route in optimizing delivery distance and time. The purpose of this study is to find distribution routes that are more optimal by using the nearest neighbor and Clarke and Wright savings to find the best route and do a comparison with the company's current route. The nearest method Neighbor is a simple method, because in the process only Add customers who have the least travel time to be included in vehicle routes without any iteration calculations. But the nearest neighbor method is generally unsatisfactory, because This method has not been able to provide optimal results even though the method The process is shorter. For the clarke and wright saving method, The calculation requires many iterations depending on how much the point to which the distribution route will be sought in generating the solution Optimal. However, for the Clarke and Wright Saving method, the calculation is Obtained optimally, but the way of processing is longer when compared with the nearest neighbor method. This.. The company's current mileage route is 319.9 km while using the nearest neighbor algorithm, the total distance traveled so far is obtained 240.9 and experienced mileage savings of 79 km or 25.22% and with the Clarke and Wright savings algorithm, the distance traveled is obtained 239.2 km and experienced mileage savings of 80.7 km or 25.22 %. Therefore, the Clarke and Wright Savings algorithm is more.

Keywords: VRP; Distribution; Nearest Neighbor; CWS; Distance

INTRODUCTION

Distribution is process of sending or distributing goods from depots to customers or consumers. Distribution is one of the important activities for the company, because the profit of a company depends on the distribution process. Determining the optimal delivery route is one way to reduce distribution costs and can optimize delivery times. Several main factors need to be considered in shipping goods, namely service costs, speed of service, and consistency (Melina Sari, Maini Heryanto, & Santoso, 2020). A vehicle Routing Problem (VRP) is a distribution system problem that aims to create an optimal transportation route for a group of vehicles with a known capacity to meet customer demand with a known location and the number of requests. Routing is one of the most important factors in distributing products to customers.

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PT. XY is a building material distributor company that distributes various products including ceramics, gypsum, toilets, glass blocks, cement, and others. The products are then sent to various building stores or projects located in Medan, Binjai, Aceh, and others. In determining the delivery route, the company does not consider the distance between stores and the distance traveled on the route. Companies usually divide routes by grouping customers who are in line or in the same direction. The distribution is in the form of a list of customers that will be visited by each vehicle. But for the rest, the driver determines which customers will be visited first (Darma, 2019). The Nearest Neighbor algorithm is one method to determine the path by finding the customer point closest to all other customer points visited. The Nearest Neighbor algorithm has the advantage of being simple and can also be implemented as the basis of other metaheuristic methods for determining routes and solving Vehicle Routing Problems (VRP) (Leymena, Suryo, Yuniaristanto, & Sutopo, 2019). The Clarke and Wright Saving algorithm is a heuristic method commonly used in route problems with a considerable number of saving matrix calculations and reducing delivery time by connecting dots and making them into routes based on the largest saving value. Previous research related to this study was research conducted by (Engraini, Meirizha, & Dermawan, 2020) route determination using the Clarke and Wright Saving Heuristic method resulting in 3 tours with a total distance of 187.28 km and a total completion time of 676.02 minutes. While determining the distribution route using the Nearest Neighbor method resulted in 3 tours with a total distance of 124.89 km and a total completion time of 582.43 minutes. In this study, the distribution route produced by the Nearest Neighbor method is more optimal because it has a smaller total distance traveled and total completion time than the route produced by the Clarke and Wright Saving Heuristic method. The Nearest Neighbor method produces more optimal distribution routes than the company's current distribution routes because it is able to produce smaller total mileage, turnaround time and distribution costs with savings of 19.9% for mileage, 9.6% for turnaround time and 24.4% for distribution costs.

Based on previous research by (Putra, Rakhmawati, & Cipta, 2021) on determining the transportation route of public transportation in Medan using the Nearest Neighbor Method and closed Insertion Method. The results of calculations and route determination obtained using the Nearest Neighbor Method and Closed Insertion Method resulted in different routes between KPUM 64, RMC 120 and U-MORINA 138 public transportation routes that have been operating so far. Public transportation routes with the Nearest Neighbor Method on the RMC 120 public transport route get a distance result of 21.05 km.

LITERATURE REVIEW

Distribution

According to (Mirza & Irawan, 2020) distribution is the activity of distributing items or goods to certain locations or units needed in a company. According to (Rohyana, 2021), distribution is an activity used to deliver products to consumers, however, consumers do not need to know how to transport purchased goods. However, distribution is an activity that is considered very important in the company. This distribution is used to distribute products to consumers. In transport on a route, each available road is a working network (links) and each location represents each *node*. *Link* can be lived in one direction (*directed*) or bidirectional (*undirected*). Each *link* relates to the length or time of the trip, the type of vehicle and the time period of travel made on *of that* link so that *link* can be said to relate to costs (Aida & Rahmanda, 2020).

Travelling Salesman Problem (TSP)

The Traveling Salesman Problem (TSP) was proposed in 1800 by Irish mathematician William Rowan Hamilton and English mathematician Thomas Penyngton. TSP is known as the classic optimization problem where there is no best solution other than testing all possible solutions. This issue concerns a seller who has to visit all the cities on the road once before returning to the starting point, so that his journey is considered complete.

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***Vehicle Routing Problem* (VRP)**

A Vehicle Routing Problem (VRP) is a delivery route problem that involves routing vehicles that converge at one depot to serve customers in different delivery areas, each with demand. VRP solutions are different transportation routes to meet customer needs, whereby vehicles leave the depot, then reach the customer and return to the depot.

Vehicle Routing Problem (VRP) is a problem that focuses on distributing goods from depots to customers. The provision of such goods includes services provided by the company during a certain time to several customers using certain vehicles where the warehouse can be located in one or more places. Vehicle Routing Problem (VRP) solution is a route that can be traveled by vehicles to meet all customer demands, where each path is traversed by one vehicle that begins and ends at the depot.

METHOD

Algorithm *Nearest Neighbor*

The Nearest Neighbor method was first introduced in 1983 and is a very simple method. Each iteration looks for the customer closest to the last customer to add to the end of the route. If a new customer cannot be accommodated due to capacity or timeframe constraints, a new route is started by the same method. Braysy and Gendreau (Firmansyah, 2022).

The steps of the nearest neighbor algorithm according to Gunawan (Prasetyo & Tamyiz, 2017) are as follows:

1. Step 0: Initialize
   a. Determine the starting point of the journey
   b. Specify C={1,2,3,4...,n} as the point to visit
   c. Determine the order of the current travel route or temporary route (R)
2. Step 1: Choose the point to visit next, if n_1 is the last point of route R, the next route will be found, n_2 which has the minimum distance to n_1, where n_2 is a member of C. If there are many optimal options, it means that there is more than one point that has the same distance from the last point in route R and that distance is the minimum distance, then choose randomly.
3. Step 2: Add the point selected in step 1 to the next route sequence. Add n_2 point to the end of the temporary route and exclude the selected one from the list of unvisited points.
4. Step 3: If all the points to visit have been included in the route or C=θ then there are no more points in C. Then close the route by adding an initialization point or starting point of the journey at the end of the route. In other words, the route is closed by returning again to the point of origin. Otherwise, re-perform step 1.

Algorithm *Clarke and Wright Savings*

The Clarke and Wright Savings algorithm is one algorithm that is often used to solve Vehicle Routing Problems (VRP). The purpose of this algorithm is to minimize the total vehicle distance and to reduce the number of vehicles required to serve customers.

The steps to solve using the Clarke and Wright Saving Algorithm according to Octora (Emelia Rahmadany, 2021) are:

1. Step 1: Create a distance matrix between depots to customers and between customers
2. Step 2: Calculate the saving value with the equation $S_{ij} = c_{i0} + c_{0j} - c_{ij}$ for each customer then create a saving matrix
3. Step 3 : Sort customer pairs by largest to smallest saving value
4. Step 4 : Establish the first route (t=1)
5. Step 5: Determine the first customer to enter the route by selecting the combination of customers who have the greatest saving value

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6. Step 6: Count the number of requests from selected customers. If it still meets the vehicle capacity, then proceed to step 7. However, if it has met capacity, then proceed to step 8
7. Step 7: Select the next customer based on the last customer selected with the next largest saving value, go back to step 9
8. Step 8: Remove the last customer who exceeded capacity, then go to step 9
9. Step 9: Enter the pre-selected customer to be assigned to the established route t. If there are still routes that have not been assigned, then establish a route continue to step 10. However, if all customers have entered the route, the process is complete
10. Step 10: Create a new route (t=t+1)

RESULTS

The data collected in this study was obtained from PT. XY in 2023. The data obtained are data on customer areas, demand and pick-up of goods for each customer, vehicle capacity and number of vehicles.

Table 1. Customer region data

Number	Store Name	Store Code	Number of requests (dus)
1	Tb. Wira Sejati	T1	36
2	UD Mitra Sejati	T2	30
3	Bangun Jaya Keramik	T3	35
4	UD Mulia Jaya	T4	45
5	Asean Keramik	T5	20
6	CV. Mulia Makmur Abadi Jaya	T6	25
7	Ucok Keramik	T7	20
8	Toko Maju Jaya	T8	37
9	Langgeng Jaya	T9	20
10	Usaha Baru	T10	15
11	Saut Arta Jaya	T11	20
12	Tk Keramik Karya Maju	T12	37
13	Toko Lina Jaya	T13	25
14	Sanjaya Keramik	T14	20
15	Sumber Rezeki Keramik	T15	25
16	M andiri Keramik	T16	50
17	Medan Keramik	T17	35
18	Permata Indah Keramik	T18	20
19	UD. Mitra Jaya	T19	15
20	Wikka Ceramic	T20	15

Solving Using Nearest Neighbor Algorithm

The delivery system of goods is carried out by land travel, so the calculation of distance must take into account the presence or absence of roads that can be passed by four-wheeled vehicles. So, the calculation of the distance from the depot to the customer and between customers will be obtained with the help of Google Maps in units of kilometers.

The steps contained in solving the nearest neighbor algorithm are as follows:

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Clustering Stage

The steps contained in the clustering stage are:

a. Determine the coordinate point of each store and set the warehouse location as the coordinate center (0,0)
b. Determine all polar coordinates of each customer with the warehouse. The steps to convert cartesian coordinates (x,y) to polar coordinates (r,θ) are

$$r = \sqrt{x^2 + y^2}$$
$$\theta = arc\tan\frac{y}{x}$$

c. Clustering starts based on the smallest to largest polar angle values by taking into account the vehicle capacity
d. Make sure all customers have entered the cluster
e. The clustering stage stops if one cluster has exceeded the maximum vehicle capacity
f. If there are still customers who have not entered the cluster, repeat the previous step until complete

The first step in clustering is to describe each customer and warehouse in a cartesian diagram based on imaginary lines of the earth, and draw a cartesian diagram and establish the location of the warehouse as the coordinate center (0,0) in the 2D plane. Cartesian diagram drawing and determination of coordinate points will be done with the help of Auto Cad software.

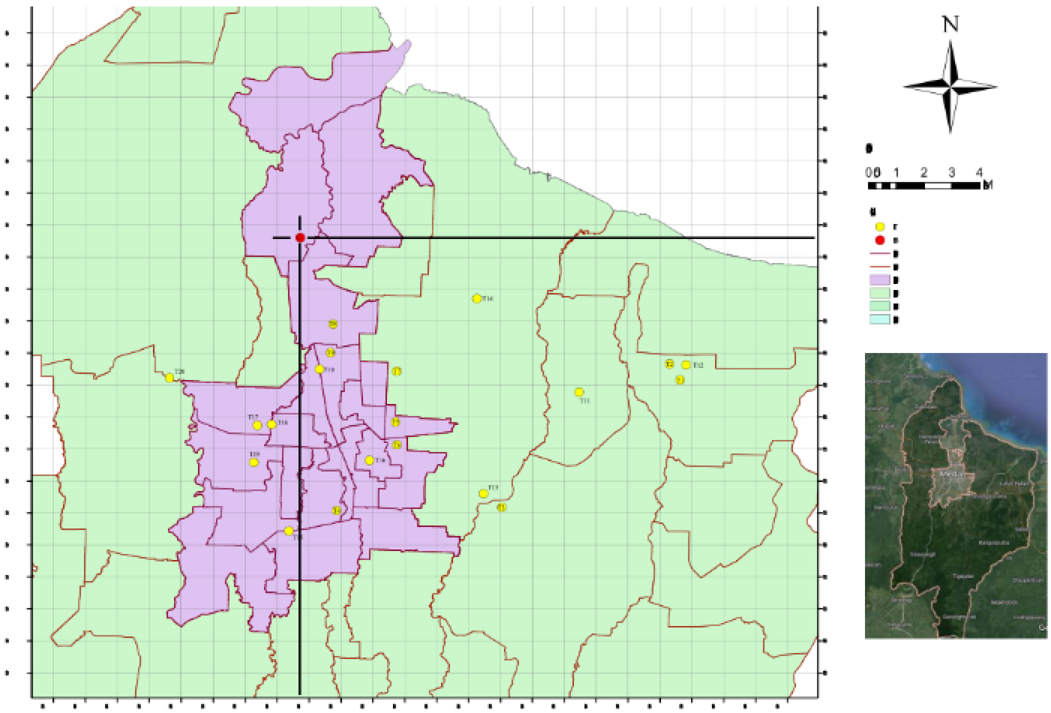

Figure 1. Cartesian diagram

The next step in the clustering stage is to determine the polar angle based on the coordinate points of each store and warehouse. Each customer has their polar angle calculated against the store that has a coordinate point (0.0). The step in converting cartesian coordinates (x,y) into polar coordinates (r,θ) is

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Table 2. Polar angle

Point	*Lattitude* (°LS)	*Longitude* (°BT)	Polar angle(°)
G	3.6789122321797523	98.65812624428933	0
T1	3.5590302104543030	98.87461655197352	329,71
T2	3.5610867940990754	98.86687874793076	329,75
T3	3.5175289207222042	98.79161342128532	310,16
T4	3.5527100443655050	98.70594955197350	297,16
T5	3.5979043963599358	98.71020032498986	306,02
T6	3.5883844148834885	98.70581639430159	303,90
T7	3.6159316132626420	98.70180803662961	312,01
T8	3.631204249608767	98.68090749430170	300,83
T9	3.620863559612394	98.68042272128548	298,76
T10	3.621912859338313	98.68102386546560	298,94
T11	3.549232594656553	98.81789652128542	320,58
T12	3.562071742398296	98.87682945197362	330,31
T13	3.521850393695658	98.78638550964558	310,35
T14	3.662213648752037	98.74105868080981	341,06
T15	3.539353105786172	98.68494085382570	288,36
T16	3.584976384626742	98.69153499244948	297,25
T17	3.5916612881508585	98.64797246442954	189,02
T18	3.5907714829761734	98.64959482122235	189,52
T19	3.5774267188834536	98.64321417275286	191,63
T20	3.5981094962820057	98.60990342307375	209,85

Then, it sorts the largest to smallest polar angles and groups delivery routes by vehicle capacity

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Table 3. Delivery Route Group

Vehicle routes	Store	Request (dus)	Number of requests (dus)
1	T17	35	160
	T18	20	
	T19	15	
	T20	15	
	T15	50	
	T16	25	
2	T4	45	197
	T9	20	
	T10	15	
	T8	37	
	T6	25	
	T5	20	
	T3	35	
3	T13	25	183
	T7	20	
	T11	20	
	T1	36	
	T2	30	
	T12	37	
	T14	20	

Route formation stages

Route 1

The first route starts from the warehouse to the store and back again to the warehouse

C= T17, T18, T19, T20, T15, T16

Table 4. Route distance matrix group 1

	0	**T17**	**T18**	**T19**	**T20**	**T15**	**T16**
0	0						
T17	17,8	0					
T18	13,0	0,2	0				
T19	14,2	2,2	2,4	0			
T20	17,9	4,7	4,8	6,0	0		
T15	24,9	11	10	9,4	15	0	
T16	12,8	7	6,3	6,7	11	6,5	0

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The routes formed using the Nearest Neighbor algorithm are:

a. The route starts from point 0 (warehouse). The closest point to point 0 is T16. So that the temporary route formed is 0-T16 with a distance of 12.8 km
b. The closest point to T16 is T18, so the temporarily formed route is 0-T16-T18 with a distance of 19.1km
c. The closest point to T18 is T19, so the temporarily formed route is 0-T16-T18-T19 with a distance of 21.5 km
d. The closest point to T19 is T17, so the temporarily formed route is 0-T16-T18-T19-T20 with a distance of 27.5 km
e. The closest point to T17 is T20, so the temporarily formed route is 0-T16-T18-T19-T17-T20 with a distance of 32.2 km
f. The closest point to T20 is T15, so the temporarily formed route is 0-T16-T18-T19-T17-T20-T15 with a distance of 47.2 km

Each route starts from the warehouse and ends at the warehouse, so that route I is obtained is 0-T16-T18-T19-T17-T20-T15-0 with a distance of 72.1 km
And so on, until the delivery route of group 3.
So the route of results obtained using the Nearest Neighbor algorithm can be seen in table.

Table 5. Nearest Neighbor Algorithm Results Route

No	Route	Region	Weight (dus)	Mileage (km)
1	0-T16-T18-T19-T17-T20-T15-0	6	160	72,1
2	0-T8-T10-T9-T5-T6-T4-T3-0	7	197	59,9
3	0-T2-T7-T14-T13-T11-T1-T12-0	7	183	108,9
Sum				240,9

Solving Using Clarke and Wright Saving Algorithm

This algorithm is one heuristic approach that can be used as a solution to the problem of vehicle routes where the route at each step is swapped to get the best route. The Clarke and Wright Savings algorithm is a combination of two customers based on the largest saving value. The search for the saving value of each customer is searched with the equation $S_{ij} = c_{i0} + c_{0j} - c_{ij}$ for each customer then create a saving matrix.

Table 6. saving matrix

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20
T1	0																			
T2	15,7	0																		
T3	54,1	18,3	0																	
T4	30,2	21	33,9	0																
T5	22,8	21,4	25,6	26,3	0															

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T6	22,8	22,6	25,5	30,5	28,7	0														
T7	13,8	19	16,6	22	22,9	24,4	0													
T8	6,7	14,2	9,4	5	15	16,4	15,2	0												
T9	6,5	16,4	14,1	17,2	17,2	18,7	17,4	14	0											
T10	6,4	15,4	9,2	16,4	16,1	17,7	16,4	13,9	16,5	0										
T11	61,6	18,2	52,5	32,4	25	26,4	19,7	9	8,9	7,9	0									
T12	81,7	18,3	55,9	32,5	25,1	26,1	19,8	9	9	8,6	65,4	0								
T13	53,7	18,2	52	32,5	25	25,6	19,7	15,6	10,1	8,1	50,9	55,7	0							
T14	29	12,4	14	9,6	17,4	18,8	16,5	9	11,6	11,3	13,2	12,9	13,4	0						
T15	35,7	26,3	39,1	38	30,4	33,9	25,6	9,7	21,1	21,8	37,8	37,5	39	16,2	0					
T16	17,9	20,6	20,7	25,7	23,1	27,2	19,3	13,8	16,5	15,8	19,7	19,4	19,9	13,1	31,2	0				
T17	18,4	21,8	9	25,3	24,2	25,7	20	16,7	18,6	18,2	7,7	8,4	8,9	14,1	31,7	23,6	0			
T18	14,1	17,4	16,8	20,9	19,8	21,3	14,9	11,7	13,6	13,2	2,8	3,5	3,1	8,3	27,9	19,5	30,3	0		
T19	17,2	16,5	20,6	23,1	18,9	21,1	15	11,7	13,7	13,2	19,1	18,8	20,3	3,5	29,7	20,3	29,8	24,8	0	
T20	14,6	17,8	9,1	21,3	8,9	21,4	14,1	10,6	13,9	12,9	7,6	8,3	8,9	8,2	27,8	19,7	31	26,1	26,1	0

Then after getting the saving value (saving) then the next step is to form the first route and determine the first customer who enters the route by choosing the combination of customers who have the greatest saving value. Do the same until all customers are assigned. Route search is complete when all customers have been assigned.

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Table 7. Iteration 1 Clarke and Wright Saving

	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**	**T13**	**T14**	**T15**	**T16**	**T17**	**T18**	**T19**	**T20**
T1	0																			
T2	15,7	0																		
T3	54,1	18,3	0																	
T4	30,2	21	33,9	0																
T5	22,8	21,4	25,6	26,3	0															
T6	22,8	22,6	25,5	30,5	28,7	0														
T7	13,8	19	16,6	22	22,9	24,4	0													
T8	6,7	14,2	9,4	5	15	16,4	15,2	0												
T9	6,5	16,4	14,1	17,2	17,2	18,7	17,4	14	0											
T10	6,4	15,4	9,2	16,4	16,1	17,7	16,4	13,9	16,5	0										
T11	61,6	18,2	52,5	32,4	25	26,4	19,7	9	8,9	7,9	0									
T12	**81,7**	18,3	55,9	32,5	25,1	26,1	19,8	9	9	8,6	65,4	0								
T13	53,7	18,2	52	32,5	25	25,6	19,7	15,6	10,1	8,1	50,9	55,7	0							
T14	29	12,4	14	9,6	17,4	18,8	16,5	9	11,6	11,3	13,2	12,9	13,4	0						
T15	35,7	26,3	39,1	38	30,4	33,9	25,6	9,7	21,1	21,8	37,8	37,5	39	16,2	0					
T16	17,9	20,6	20,7	25,7	23,1	27,2	19,3	13,8	16,5	15,8	19,7	19,4	19,9	13,1	31,2	0				

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T17	18,4	21,8	9	25,3	24,2	25,7	20	16,7	18,6	18,2	7,7	8,4	8,9	14,1	31,7	23,6	0			
T18	14,1	17,4	16,8	20,9	19,8	21,3	14,9	11,7	13,6	13,2	2,8	3,5	3,1	8,3	27,9	19,5	30,3	0		
T19	17,2	16,5	20,6	23,1	18,9	21,1	15	11,7	13,7	13,2	19,1	18,8	20,3	3,5	29,7	20,3	29,8	24,8	0	
T20	14,6	17,8	9,1	21,3	8,9	21,4	14,1	10,6	13,9	12,9	7,6	8,3	8,9	8,2	27,8	19,7	31	26,1	26,1	0

Choose the largest saving value in the saving matrix, in the column above the largest saving value is 81.7 located in column T1 and row T12. T1 and T12 stores are merged into 1 route. Then calculated the number of requests is 36+37=73 and still does not exceed the vehicle capacity of 200 boxes. So the route formed temporarily is 0-T1-T12

And on until all routes have been assigned

So the route of results obtained using the Clarke and wright savings algorithm can be seen in the table

Table 8 Clarke and Wright Savings Yield Route

No	Route	Region	Weight (dus)	Mileage (km)
1	0-T1-T12-T11-T3-T13-T15-0	6	178	92,4
2	0-T4-T17-T19-T5-T6-T20-T7-0	7	175	83,4
3	0- T16- T2-T18-T14-T8-T9-T10-0	7	197	63,4
Sum				239,2

Route Comparison Using Nearest Neighbor and Clarke and Wright Savings Algorithms with Corporate Routes

The route obtained by PT. XY currently has 4 shipping routes that can be seen in the table

Table 9. Corporate Routes

No	Route	Region	weight	Mileage (km)
1	0-T18-T17-T20-T16-T19-0	5	185	50,1
2	0-T13-T14-T15-T11-0	4	90	125
3	0-T7-T9-T8-T10-T5-T6-0	6	137	42,9
4	0-T4-T2-T3-T1-T12-0	5	183	101,9
Sum				319,9

Based on the table above, a comparison of the company's route mileage with the route using the nearest neighbor algorithm and Clarke and wright savings is obtained as follows:

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Table 10. Comparison route

No	Nearest Neighbor Route	*Clarke and Wright Savings* Route
1	0-T16-T18-T19-T17-T20-T15-0	0-T1-T12-T11-T3-T13-T15-0
2	0-T8-T10-T9-T5-T6-T4-T3-0	0-T4-T17-T19-T5-T6-T20-T7-0
3	0-T2-T7-T14-T13-T11-T1-T12-0	0- T16- T2-T18-T14-T8-T9-T10-0
Total	240,9	239,2

Table 11. mileage comparison

Route	Corporate Routes	*Nearest Neighbor*	*Clarke and Wright Savings*
1	50,1	72,1	92,4
2	125	59,9	83,4
3	42,9	108,9	63,4
4	101,9	-	-
Total	319,9	240,9	239,2

Based on the results of the route using the nearest neighbor algorithm with the company's route, the percentage of total mileage savings is obtained as follows.

$$= \frac{\text{total company route distance} - \text{total NN route distance}}{\text{total enterprise route distance}} \times 100\%$$

$$= \frac{319{,}9 - 240{,}9}{319{,}9} \times 100\%$$

$$= 24{,}69\ \%$$

While the comparison of the company's route mileage with the Clarke and Wright Savings algorithm is

$$= \frac{\text{total company route distance} - \text{total CWS route distance}}{\text{total enterprise route distance}} \times 100\%$$

$$= \frac{319{,}9 - 239{,}2}{319{,}9} \times 100\%$$

$$= 25{,}22\ \%$$

Thus, the difference in mileage using the Nearest Neighbor algorithm was obtained at 79 km and the presentation of the total savings in route mileage was 24.69%. Meanwhile, using the Clarke and Wright Savings algorithm, a mileage difference of 80.7 km was obtained and a total mileage savings presentation of 25.22%. So the results using the Clarke and Wright Savings algorithm are more optimal than the Nearest Neighbor algorithm

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DISCUSSION

The Vehicle Routing Problem (VRP) model is used to formulate the purpose function and constraint function in the distribution of ceramics. Before formulating the function of goals and constraints, it will first explain the index, variables and parameters to be used. The indices used are:
i: index for early consumers, i = 1.2,...,N
j : index for consumer purposes, j = 1.2,...,N
k : index for vehicles, k = 1.2,...,N
The variables and parameters used in the VRP Model are:
N : number of consumers
K : number of vehicles
Cij : Distance between consumers
Qij : Total Demand for K Vehicles to Consumer i
VK : Maximum Vehicle Capacity K

11. Polar angle search

Polar angle for shop (T1)

$$x = 7{,}10$$

$$y = -4{,}15$$

So, $\theta = \arctan\frac{-4{,}15}{7{,}10}$

$$= tan^{-1} - 0{,}584$$

$$= -30{,}28$$

Since the x value is positive and y is negative, then

the angle is: θ=360°-30,28 = 329,71°

Polar angle for shop (T2)

$$x = 7{,}03$$

$$y = -4{,}10$$

Maka, $\theta = \arctan\frac{-4{,}10}{7{,}03}$

$$= tan^{-1} - 0{,}583$$

$$= -30{,}24$$

Since the x value is positive and y is negative, then

the

$\theta = 360° - 30{,}24 = 329{,}75°$

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And so on until the point of store (T20). The search for polar angles can also be done with the help of AutoCAD software. The angle calculation is done by making a straight line based on the center point up to the customer's coordinate point and a straight line against the x-axi

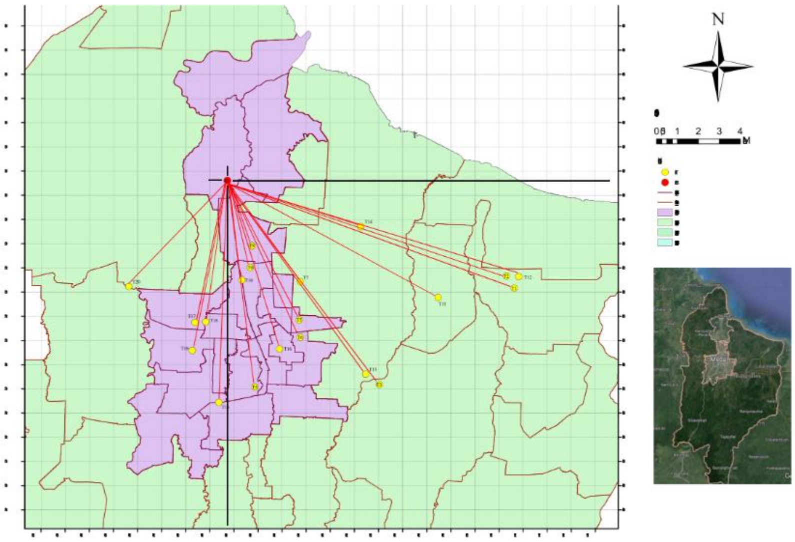

Figure 2. Line from Depot to Every Customer

CONCLUSION

From the results and discussion above, it can be concluded that the company's route with a total mileage of 319.9 km has decreased using two algorithms that have been tested, namely the Nearest Neighbor algorithm obtained distance savings of 79 km or 24.69% and Clarke and Wright Savings algorithms obtained mileage savings of 80.7 km or 25.22%. So that the Clarke and Wright savings algorithm is proven to reduce mileage and get optimal results.

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