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The Effectiveness of Clarke Wright and Sequential Insertion Algorithm in Distribution Routing Aqua

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ABSTRACT

With the Multiple Trips condition, the results obtained for the optimal distance route that starts and stops at PT. Tirta Investama Medan with Clarke Wright Algorithm at t = 1 is 22 km and at t = t + 1 is 15.2 km. While the optimal travel distance route with the Sequential Insertion Algorithm at t = 1 is 15.05 km, and at t = t + 1 is 22.9 km. Clarke Wright Algorithm looks for an optimal solution to get the best route, while Sequential Insertion Algorithm has an excess in the election of a customer by considering customer position with available insertion track location until all customer have been assigned. The Clarke Wright Algorithm obtained a total distance of 37.2 km. In comparison, the Sequential Insertion Algorithm solution obtained a total distance of 37.95 km. It can be concluded that the route formed using the Clarke Wright Algorithm in this case is more effective than using the Sequential Insertion Algorithm.

Keywords: Clarke Wright Algorithm, Distribution Routes, Multiple Trips, Sequential Insertion.

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INTRODUCTION

Every company can compete if customer demand needs are in the right amount and time. This is related to determining the distribution system to each customer, from a goods depot sent to customers which have ordered [1]. For the medium of transportation of these goods, many vehicles have been provided, where each vehicle has specific capacities as according to transported goods. The same vehicle used to solve this problem has to go through a route which has been determined, starting and terminating in a depot, where goods are sent to one or more customers [2]. For this reason, an effective algorithm needed to produce a route with minimum traveled distance in finishing the transportation process.

The Clarke Wright algorithm is suitable for solving a fairly significant problem in a large number of routes. The Clarke Wright algorithm is a calculation that makes savings measured from how much can be done to reduce the distance traveled and the time used by existing points and making a route based on the most significant saving value the distance between the origin and destination point [3], [4]. While Sequential Insertion Algorithm has excellence in chosen customer by paying attention, customer position at available insertion obtains the best results. This algorithm represents used to finish the problem by inserting customers between customers, which have been formed to be maximal [5].

PT. Tirta Investama Medan has a random route arrangement. For example, the first route can be chosen Depot - Jl. Diponegoro - Jl. Suka Mulia - Jl.Imam Bonjol - Jl. Pemuda - Jl. Pulau Pinang - Jl. Kapten Mulia - Depot) and the second route (Depot - Jl.Pimpinan - Jl. Pulau Pinang - Jl. Imam Bonjol - Jl. Pemuda - Depot) but has an allocation of delivery areas for each transport vehicle so that it can change at any time which has an impact on timeliness in product distribution. The solution used to the Clarke Wright and Sequential Insertion Algorithm to minimize the distance traveled in the distribution.

METHOD

This research was held in PT. Tirta Investama Medan which is located in Kapten Sumarsono street no. 74, district of Medan Helvetia. Qualitative research is used in this research. Data needed to solve the problem by conducting direct interviews with the authorities in the delivery area and collecting secondary data from documents of the company.

After the data is collected, the data is processed using the Clarke Wright and Sequential Insertion Algorithm.

The Clarke Wright Algorithm steps: [6], [7]

Step 1: Determining customer data, amount of vehicle capacities and request as required input

Step 2: Making matrix apart between depot to consumer and between consumer to consumer

Step 3: Counting the value of saving using $S_{ip} = h_{ij} + h_{op} - h_{ip}$ in each customer to know value saving

Step 4: Sorting customer to value of saving thrift matrix of value saving

Step 5: Forming of the first route $t = 1$

Step 6: Determining the first customer which assigned route by choosing customer combination with value of saving biggest

Step 7: Counting to the number of consumers which have is chosen. If the request amount still fulfills vehicle capacities, then proceed to step 8. If the amount of request exceeds vehicle capacities hence continued to step 9

Step 8: Selecting a customer to be assigned to chosen last customer combination with the value of saving biggest, return to step 7

Step 9: Vanishing the chosen last customer, continue to step 10.

Step 10: Including chosen customer previously to be assigned into route hence route t have been formed and if customer which there is still not yet chosen hence continuing to step 11. If all customers have been assigned then the process of working on this algorithm has been completed

Step 11: Forming of a new route $t = t + 1$, continue to step 6

Step 12: All delivered material requisition to the customer has fulfilled, stop this procedure

The Sequential Insertion Algorithm steps: [6], [8]

Step 1: Determining customer data, amount of request, vehicle capacities and matrix apart as required input

Step 2: Determination of the first route started from depot go to the consumer and then return again to depot, selected nearest consumer with depot

Step 3: Counting request and a total of traveled distance of customer at the route

Step 4: Selecting customer with smallest traveled distance with the depot to be selected to be assigned into the route. If amount of request less than vehicle capacities hence continued to step 5. If the amount of request more than vehicle capacities hence continued to step 6

Step 5: Customer then assigned into route and route t formed. Go back to step 4

Step 6: If all customer have chosen hence the process of algorithm of Sequential Insertion have. If customer which there is still not yet chosen hence continuing to step 7

Step 7: Forming of the new route $t = t + 1$, continue to step 8

Step 8: Including customer which not chosen to be assigned into the route to be formed, continue to step 4

Step 9: All delivered material requisition to customer have fulfilled, stop this procedure

RESULTS AND DISCUSSION

PT. Tirta Investama Medan has one driver to travel in each region of Medan city. The data collected is delivery route one of the driver travels in region of Medan city. The driver once every two days (Monday, Wednesday, and Friday) distributing mineral water at 7 address to 15 customers with a note of multiple trips where delivery by considering planning horizon which have been determined, if when the condition of payload vehicle have empty in delivering goods but planning horizon there still hence vehicle will return to the depot to take goods that will be delivered again to customer until the planning horizon time runs out. Table of distance matrix for Clarke Wright and Sequential Insertion Algorithm and figure explained passed below.

Table 1. Distance Matrix Clarke Wright and Sequential Insertion Algorithm

	Z	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Z	0	6,9	7,0	7,9	8,7	7,7	5,7	7,6
1		0	1,8	2,0	2,8	1,8	0,55	4,7
2			0	2,3	0,55	0,85	1,3	4,1
3				0	1,5	1,8	1,5	5,1
4					0	2,6	2,3	4,5
5						0	1,2	3,3
6							0	4,5
7								0

Calculate the saving value using the equation $S_{ip} = h_{ij} + h_{op} - h_{ip}$ for each customer to find out the value of savings. The value of $S_{ip} = h_{ij} + h_{op} - h_{ip}$ for $i = 1, 2, 3, ..., n+1$ and $j = i+1, ...n$ is given:

For $i = 1$
If $j = 2$ then $S_{12} = h_{10} + h_{02} - h_{12} = 6,9 + 7,0 - 1,8 = 12,1$
If $j = 3$ then $S_{13} = h_{10} + h_{03} - h_{13} = 6,9 + 7,9 - 2,0 = 12,8$
If $j = 4$ then $S_{14} = h_{10} + h_{04} - h_{14} = 6,9 + 8,7 - 2,8 = 12,8$
If $j = 5$ then $S_{15} = h_{10} + h_{05} - h_{15} = 6,9 + 7,7 - 1,8 = 12,8$
If $j = 6$ then $S_{16} = h_{10} + h_{06} - h_{16} = 6,9 + 8,7 - 2,8 = 12,8$
If $j = 7$ then $S_{17} = h_{10} + h_{07} - h_{17} = 6,9 + 7,6 - 4,7 = 9,8$

For $i = 2$
If $j = 3$ then $S_{23} = h_{20} + h_{03} - h_{23} = 7,0 + 7,9 - 2,3 = 12,6$
If $j = 4$ then $S_{24} = h_{20} + h_{04} - h_{24} = 7,0 + 8,7 - 0,55 = 15,15$
If $j = 5$ then $S_{25} = h_{20} + h_{05} - h_{25} = 7,0 + 7,7 - 0,85 = 13,85$
If $j = 6$ then $S_{26} = h_{20} + h_{06} - h_{26} = 7,0 + 5,7 - 1,3 = 11,4$
If $j = 7$ then $S_{27} = h_{20} + h_{07} - h_{27} = 7,0 + 7,6 - 4,1 = 10,5$

For $i = 3$
If $j = 4$ then $S_{34} = h_{30} + h_{04} - h_{34} = 7,9 + 8,7 - 1,5 = 15,1$
If $j = 5$ then $S_{35} = h_{30} + h_{05} - h_{35} = 7,9 + 7,7 - 1,8 = 13,8$
If $j = 6$ then $S_{36} = h_{30} + h_{06} - h_{36} = 7,9 + 5,7 - 1,5 = 12,1$
If $j = 7$ then $S_{37} = h_{30} + h_{07} - h_{37} = 7,9 + 7,6 - 5,1 = 10,4$

For $i = 4$
If $j = 5$ then $S_{45} = h_{40} + h_{05} - h_{45} = 8,7 \_ 7,7 - 2,6 = 13,8$
If $j = 6$ then $S_{46} = h_{40} + h_{06} - h_{46} = 8,7 + 5,7 - 2,3 = 12,1$
If $j = 7$ then $S_{37} = h_{40} + h_{07} - h_{47} = 8,7 + 7,6 - 4,5 = 11,8$

For $i = 5$
If $j = 6$ then $S_{56} = h_{50} + h_{06} - h_{56} = 7,7 + 5,7 - 1,2 = 12,2$
If $j = 7$ then $S_{57} = h_{50} + h_{07} - h_{57} = 7,7 + 7,6 - 3,3 = 12$

For $i = 6$
If $j = 7$ then $S_{67} = h_{60} + h_{07} - h_{67} = 5,7 + 7,6 - 4,5 = 8,8$

Distance Routing Graph Using Algorithm of Clarke Wright

Based on Table 1, by solving with the Clarke Wright Algorithm after several iterations obtained:
Forming of the first route $t = 1$

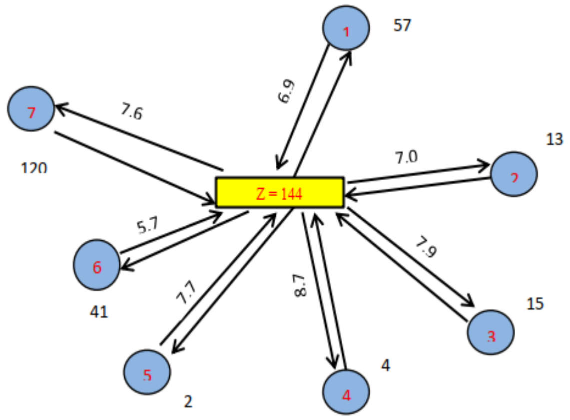

Figure 1. Initial Solution for Distance and Routing Graph

Determine of the first customer assigned to the route with choose of the customer combination with the biggest saving value. The biggest saving value is (2,4), the arcs (2,4) on the graph can be joined.

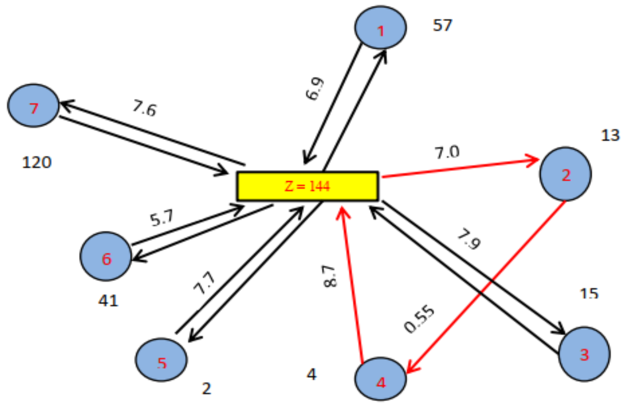

Figure 2. Distance Graph $t = 1$ (Z-2-4-Z)

Select the next customer to be assigned based on the last selected customer combination with the biggest saving value, back previous step. The biggest saving value is (3,4), the arc (3,4) on the graph can be joined to graph $t = 1$.

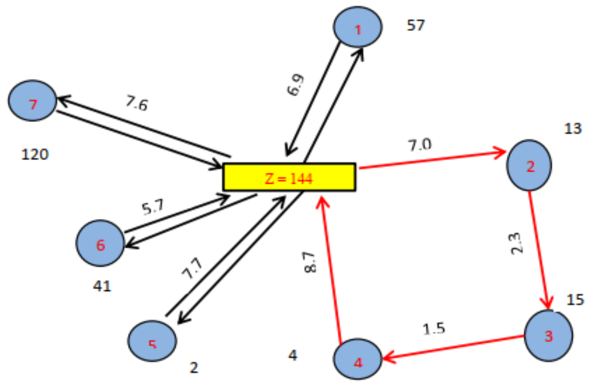

Figure 3. Distance Graph $t = 1$ (Z-2-3-4-Z)

The biggest saving value is (2,5), the arc (2,5) on the graph can be joined to graph t = 1.

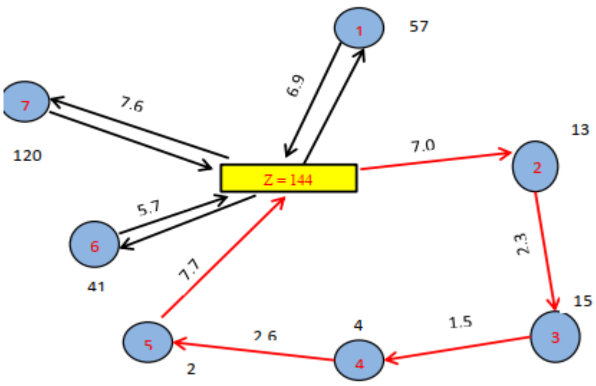

Figure 4. Distance Graph t = 1 (Z-2-3-4-5-Z)

The biggest saving value is (1,3), the arc (1,3) on the graph can be joined to graph t = 1.

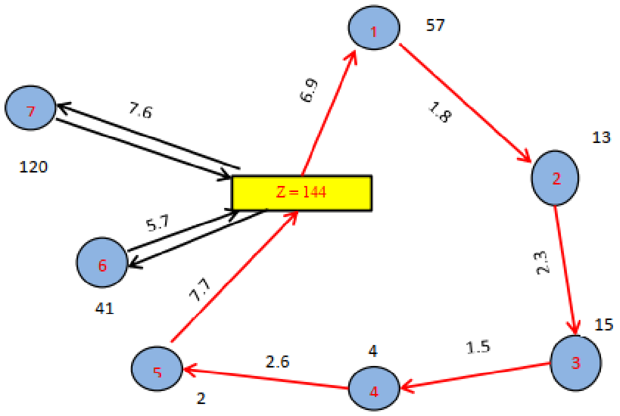

Figure 5. Distance Graph t = 1 (Z-1-2-3-4-5-Z)

The biggest saving value is (5,6), so the arc (5,6) on the graph can be joined to graph t = 1.

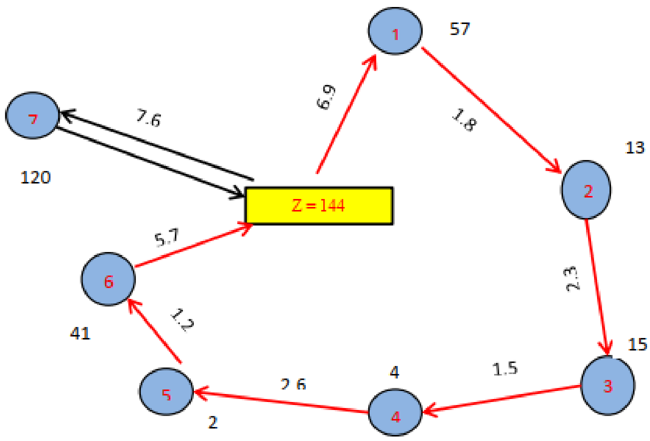

Figure 6. Distance Graph t = 1 (Z-1-2-3-4-5-6-Z)

The biggest saving value is (6,7) and the arc (6,7) cannot be joined to graph t = 1 because exceeding the capacity. Then a new route will be formed namely $t = t + 1$.

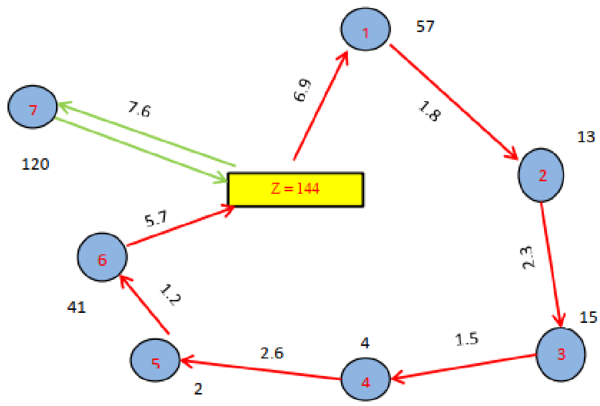

Figure 7. Distance Graph t = 1 (Z-1-2-3-4-5-6-Z) and $t = t + 1$ (Z-7-Z)

The optimal routing distance start and stopping in PT. Tirta Investama Medan with Clarke Wright Algorithm is at t = 1 (Z-1-2-3-4-5-6-Z) = 22 km and at $t = t + 1$ (Z-7-Z) = 15.2 km.

Distance Routing Graph Using the Sequential Insertion Algorithm

The basic principle of the Sequential Insertion algorithm is trying inserts the customer between all arcs (directed sides) on the route now. This arc is defined as the side that connects in a manner directly from one location to another location. Based on Table 2, by solving with the Sequential Insertion Algorithm after several iterations obtained:

Determination of the first route t = 1 starting from the depot leading to the customer then returns to the depot, which one is selected closest to the depot.

Figure 8. Distance Graph t = 1 (Z-6-Z)

Choose the customer with the smallest mileage with depot for selected are assigned into the route. If the number of requests is less from the vehicle capacity then proceed to the next step.

Figure 9. Distance Graph t = 1 (Z-6-1-Z)

The customer is then assigned to the route and route t is formed. Back to the previous step.

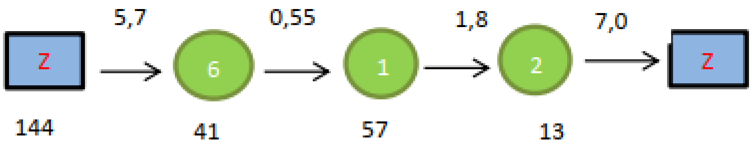

Figure 10. Distance Graph t = 1 (Z-6-1-2-Z)

The closest distance from Z is (Z-7) then (Z-7) is inserted into the graph t = 1.

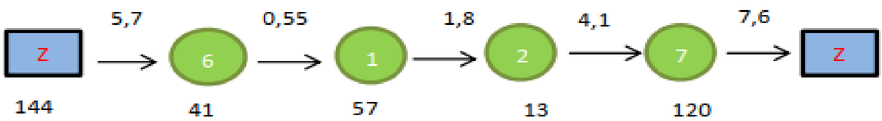

Figure 11. Distance Graph t = 1 (Z-6-1-2-7-Z)

Forming a new route $t = t + 1$ and go to the next step. The closest distance from Z is (Z-7) then (Z-7) becomes a graph $t = t + 1$.

Figure 12. Distance Graph $t = t + 1$ (Z-7-Z)

Include customers who have not been selected to be assigned to the route that will be formed next, go to the previous step.

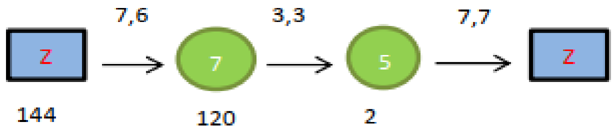

Figure 13. Distance Graph $t = t + 1$ (Z-7-5-Z)

The closest distance from Z is (Z-3) then (Z-3) is inserted into the graph $t = t + 1$.

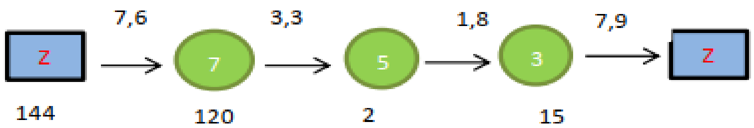

Figure 14. Distance Graph $t = t + 1$ (Z-7-5-3-Z)

The closest distance from Z is (Z-4) then (Z-4) is inserted into the graph $t = t + 1$. All requests for goods sent to customers have been fulfilled, stop this procedure.

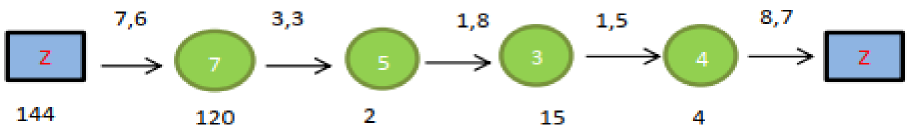

Figure 15. Distance Graph $t = t + 1$ (Z-7-5-3-4-Z)

The optimal routing distance start and stopping in PT. Tirta Investama Medan with Sequential Insertion is at t = 1 (Z-6-1-2-Z) = 15,05 km and at (Z-7-5-3-4-Z) = 22,9 km.

Based the calculations above, the comparison of the route using the Clarke Wright Algorithm and Sequential Insertion Algorithm is obtained in multiple trip conditions with a planning horizon. With the holding of the planning horizon, the delivery of goods carried out by the driver according to the working hours given. If the planning horizon still exists and the load on the motor has run out, so the driver can take the goods back to the depot to be delivered to unserved customers up to the horizon planning ends. The result of comparison of routes with Clarke Wright Algorithm and Sequential Insertion Algorithm in multiple trips conditions are given in Table 2.

Table 2. The Comparison of Effective Route Clarke Wright and Sequential Insertion Algorithm

Algorithm	**Tour**	**Route**	**Capasity (gallon)**	**Distance (km)**
Clarke Wright	1	t = 1 (Z-1-2-3-4-5-6-Z)	132	22
	2	$t = t$ + 1 (Z-7-Z)	120	15,20
Total			252	37,20
Sequential Insertion	1	t = 1 (Z-6-1-2-Z)	111	15,05
	2	$t = t$ + 1 (Z-7-5-3-4-Z)	141	22,90
Total			252	37,95

Based on Table 2, the results show that the Clarke Wright algorithm solution obtained a total distance of 37.2 km. Whereas in the Sequential Insertion solution, the total distance is obtained amounting to 37.95 km. It can be concluded that the route was formed using the Clarke Wright Algorithm in this case is more effective then routes formed using Sequential Insertion Algorithm.

CONCLUSION

The distribution problem of goods is an aspect that must be considered because these problems have effect on costs and level of service to consumers. Several obstacles that must be faced in the distribution process, such as the number of requests for goods that are different for each consumer, vehicle capacity, delivery time limits, the average speed that can be traveled on a certain path and time, multiple trips conditions and different consumer locations. It is necessary for distribution process to run on time, the way can be done in the distribution process is by optimize the route of the vehicle so that the time is used to serve consumers are more efficient and the goods can arrive to consumers on time. From the case above, Based on the Clarke Wright Algorithm with multiple trips, the route taken is t = 1 (Depot - Jl. Diponegoro - Jl. Suka Mulia - Jl. Imam Bonjol - Jl. Pemuda - Jl. Pulau Pinang - Jl. Kapten Mulia - Depot) = 22 km and at t = t + 1 (Depot - Jl. Pimpinan - Depot) = 15.2 km. Based on the Sequential Insertion Algorithm with multiple trips, the route is t = 1 (Depot - Jl. Kapten Mulia - Jl. Diponegoro - Jl. Suka Mulia - Depot) = 15.05 km and at t = t + 1 (Depot - Jl. Pimpinan - Jl. Pulau Pinang - Jl. Imam Bonjol - Jl. Pemuda - Depot) = 22.9 km. It can be concluded that the route formed using the Clarke Wright more effective than using the Sequential Insertion Algorithm.

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