Optimal Vehicle Routing Problem (VRP) For The Distribution Of Medical Devices By Applying The Clarke-Wright Algorithm

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Abstract.
In the current era of modernization, the development of the need for medical devices is increasing,g so that the companies need goods distribution system with criteria that have speed, safety, and convenience to distribute various kinds of products according to optimal distribution routes. The aim of this study is to overcome the problem of the distribution route for medical devices from PT Alkes Medan because the number of demand for goods varies for each consumers, vehicle capacites, delivery time limits, average speed that can be reached on certain routes and times and the existence of the different conditions of multiple trips at the customer's location. A heuristic algorithm named Clarke-Wright Algorithm is applied in this problem. This algorithm will be later provide an optimal solution to route problem in the distribution of medical devices and provide effectiveness in finding the shortest optimal route of medical device goods distributed to consumers. The optimal route will be described in the results section of this study.

Keywords: *Distribution, routes, medical devices, multiple trips, and optimality of the Clarke-Wright Algorithm.*

I. INTRODUCTION

Distribution is one aspect of marketing. For compete, every company must be able to meet the needs of customer demands with the right amount and time. This relates to determining the distribution system to each customer [1]-[2]. Distribution is an activity to move products from suppliers to consumers in a supply chain. Distribution in the distribution of products and services must be in accordance with the resources and capabilities possessed by a company to achieve the economic size expected by a company. In the distribution activities, the distribution process will be seen by the use of vehicles as a means of transporting goods that have different load capacities and distances in determining the routes that vehicles pass in one way [3]-[4].In the current era of globalization, business development has accelerated, companies are increasingly competing to use information technology to support processes their business. Business will never be separated from the need for strategic information. Companies will be able to compete and survive only by producing as much information so that it can be used for strategic decision making. Same with the business in the distribution of medical devices, especially product profile information [5].PT. Alkes Medan is one of the largest medical devices and hospital equipment supply companies in Medan City. Because people's demand continues to grow, high for health services, and according to needs. PT Alkes Medan is an official medical device company in Medan City that sells a variety of health products such as the Littmann Stetoscope, Autocheck health test kits, Beurer, Onemed, OPPO, Gea, Laica, General Care and many more.

This company also provides medical devices that meets service standards, quality requirements, security and safety for the community.PT. Alkes Medan has a random arrangement of routes 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. One of the causes of delays in product delivery at PT. Alkes Medan is an error in setting the route for delivery, there is a multiple trips condition and there is no parking space available at the consumer's location. If the travel route is not determined beforehand, then the target that has been determined will not be implemented optimally.The problem of the distribution of goods is an aspect that must be considered because these problems have a considerable influence on costs and the level of service to consumers. There are 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 limit, average speed that can be reached on certain routes and times, the existence of multiple trips conditions and different consumer locations different anyway [6]-[7]. Its need a way so that the distribution process can run smoothly and on time.

One way that can be done in the distribution process is to optimize vehicle routes so that the time used to serve consumers is more efficient and goods can reach consumers in a timely manner [8],Routing problems are included in the Vehicle Routing Problem (VRP) namely the problem of determining vehicle routes to serve several customers [5], [9], [10], [11]. The basic form of VRP is generally concerned with the problem of determining a vehicle route serving a customer associated with a point with known demand and a route connecting the depot with the customer, and between other customers [5], [9].One of method that can be applied to solve this VRP and its variations is the heuristic method [4], [12]-[13]. The heuristic method is a technique for solving problems with more emphasis on simple computational performance [14]-[15]. According to Laporte [16], one example of a heuristic method is the Clarke-Wright Algorithm. The Clarke-Wright algorithm is suitable for solving problems that are quite large, in this case a large number of routes [17]-[18]. The Clarke-Wright Algorithm also performs savings calculations that are measured by how much distance traveled and time used can be reduced by connecting existing points and making it route based on the largest saving value, namely the distance traveled between the point of origin and the point of destination [3], [19]-[20]. So that, the effectiveness of the Clarke-Wright Algorithm will provide an optimal solution to the optimal route problem in distributing medical devices to consumers.

II. METHODS

The method used to determine the distribution of health equipment is the Clarke-Wright Algorithm. The procedure of the algorithm [4], [16], [18]:

Step 1: Determine customer data, number of demand and input vehicle capacity

Step 2: Creat of distance matrix between depots to consumers and consumers

Step 3: Calculate the saving value using $S_{ij} = c_{i0} + c_{0j} - c_{ij}$ for each customers

Step 4: Sort the customer pairs based on the saving value from the largest savings matrix to the smallest saving value. Iteration will be stop when all entries in rows and columns have been selected

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

Step 6: Determine the first customer assigned in the routing by selecting the customer combination with the largest saving value

Step 7: Calculate the number of demand from the selected consumers. If the number of demand still satisfy of the vehicle capacity, then to step 8. If the number of rdemand exceeds the vehicle capacity then to step 9

Step 8: Select the next customer to be assigned based on the last selected customer combination with the largest saving value, return to step 7

Step 9: Delete the last selected customer, then to step 10

Step 10: Enter the previously selected customers to be assigned in the routing, the route (t) has been formed. If there are still customers who have not been selected, then proceed to step 11.

Step 11: Creat of the new route $t = t + 1$, then to step 6

Step 12: All demand of goods sent to the customer have been satisfied, stop this procedure.

III. RESULT AND DISCUSSION

1. Description Data

Data used is delivery route one of the driver in district of Medan city. Every three days (tuesday, thursday, and saturday) distribute to health equipment for 5 address to 10 customers, with consider planning horizon which have been determined. If when the condition of payload vehicle have empty in delivering goods but planning horizon still contain, so the vehicle will be return to depot to take goods that will be delivered again to customer until the planning horizon time runs out.

Table 1. Distance matrix for data health equipment

Depot to	P	1	2	3	4	5
P	0	6.7	7	7.4	8.2	7.5
1		0	1.5	1.8	2.7	1.7
2			0	2.3	0.6	0.9
3				0	1.4	1.6
4					0	1.2
5						0

2. Calculate data using Clarke Wright Insertion Algorithm

Calculate the saving value using equation $S_{ij} = c_{i0} + c_{0j} - c_{ij}$ for each customer to find the saving value.

For $i = 1$:

If $j = 2$, then $S_{12} = c_{10} + c_{02} - c_{12} = 6.7 + 7 - 1.5 = 12.2$

If $j = 3$, then $S_{13} = c_{10} + c_{03} - c_{13} = 6.7 + 7.4 - 1.8 = 12.3$

If $j = 4$, then $S_{14} = c_{10} + c_{04} - c_{14} = 6.7 + 8.2 - 2.7 = 12.2$

If $j = 5$, then $S_{15} = c_{10} + c_{05} - c_{15} = 6.7 + 7.5 - 1.7 = 12.5$

For $i = 2$:

If $j = 3$, then $S_{23} = c_{20} + c_{03} - c_{23} = 7 + 7.4 - 2.3 = 12.1$

If $j = 4$, then $S_{24} = c_{10} + c_{02} - c_{12} = 7 + 8.2 - 0.6 = 14.6$

If $j = 5$, then $S_{25} = c_{10} + c_{02} - c_{12} = 7 + 7.5 - 0.9 = 13.6$

For $i = 3$:

If $j = 4$, then $S_{34} = c_{30} + c_{04} - c_{34} = 7.4 + 8.2 - 1.4 = 14.2$

If $j = 5$, then $S_{35} = c_{30} + c_{05} - c_{35} = 7.4 + 7.5 - 1.6 = 13.3$

For $i = 4$:

If $j = 5$, then $S_{45} = c_{40} + c_{05} - c_{45} = 8.2 + 7.5 - 1.2 = 14.5$

3. Discussion

Based on table 1, forming of the first route $t = 1$

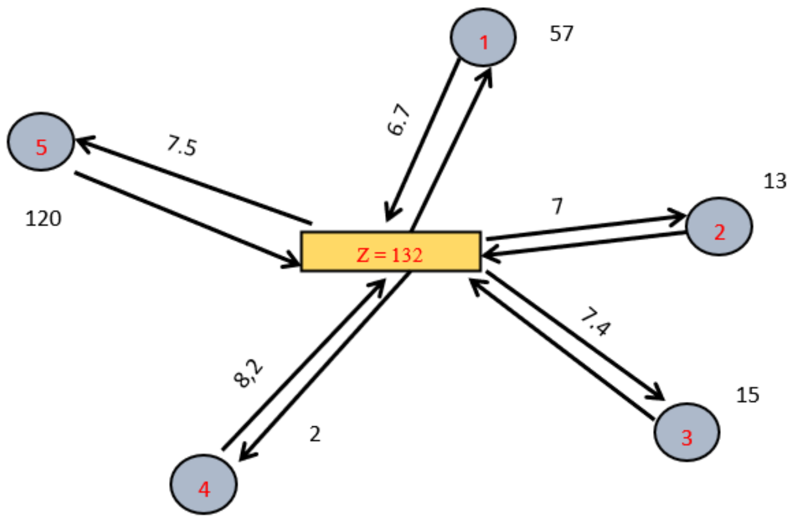

Fig 1. Original solution for distane and route

Determine of the first customer assigned to the route with choose of the customer combination have the biggest saving value in the point (2,4).

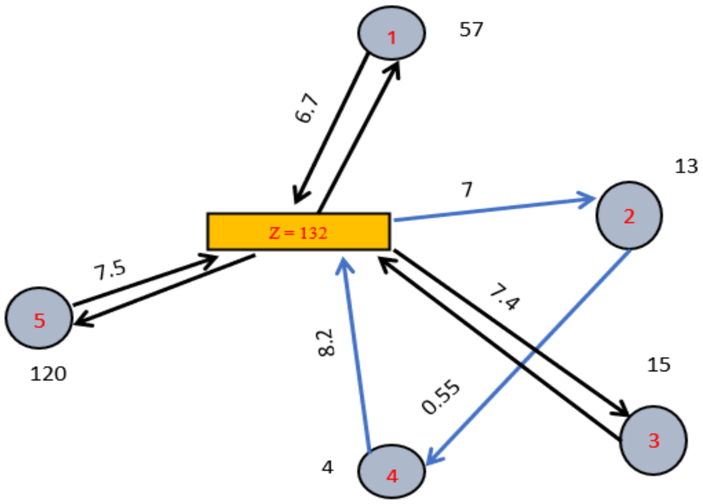

Fig 2. Distance of graph t = 1 (Z–1–4)

After that, select the next customer to be assigned based on the last selected customer combination have the biggest saving value, back to previous step. The biggest saving value in the point (3,4), the arc (3,4) on the graph can be joined to graph t = 1.

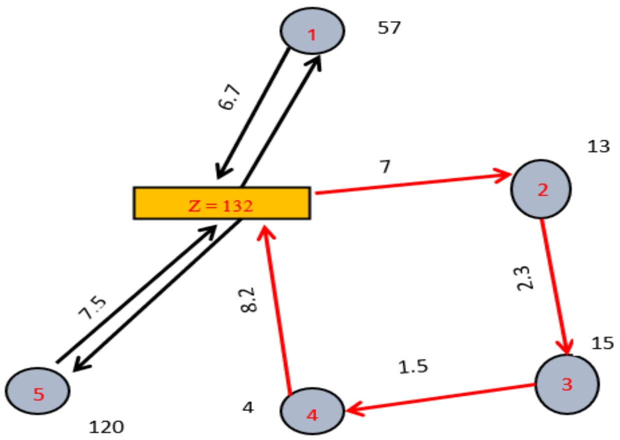

Fig 3. Distance of graph t = 1 (Z–2–3–4)

The biggest saving value in the point (3,4), the arc (3,4) on the graph can be joined to graph t= 1.

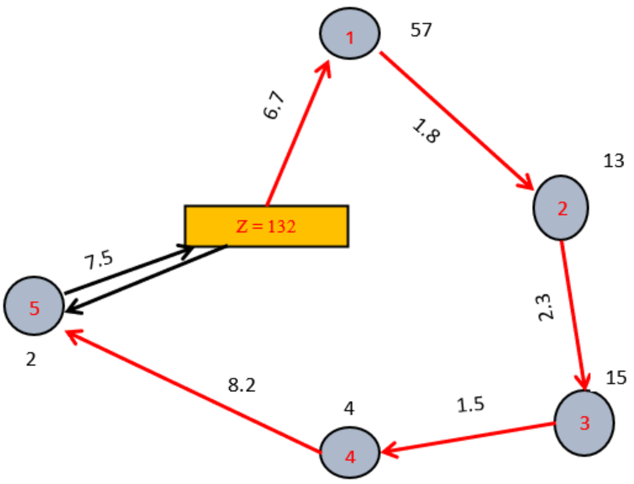

Fig 3. Distance Graph t = 1 (Z–1–2–3–4–5–Z)

The biggest saving value in the point (4,5) and the arc (4,5) cannot be joined to graph t = 1 because exceeding the capacity. Then a new route will be formed t = t + 1.

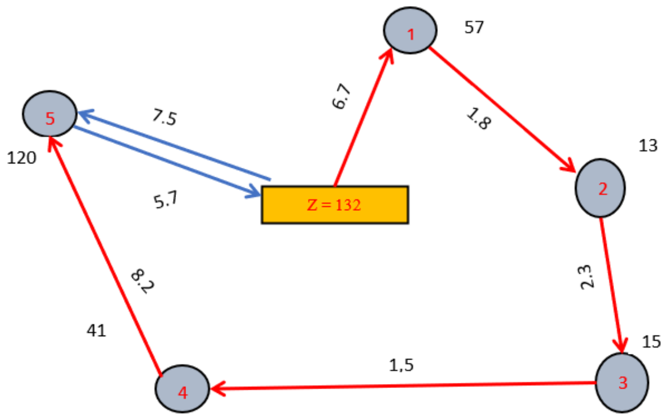

Fig 4. Distance Graph *t* = 1 (Z–1–2–3–4–5–Z)

So that, the optimal route of distance start and stopping in PT. Health Equipment Medan with Clarke Wright Algorithm is at *t* = 1 (Z–1–2–3–4–5–Z) = 21.3 km.

IV. CONCLUSION

The distribution problem of goods is one aspect that must be considered because these problems have effect on costs and level of service to consumers. Some obstacles must be tackled in the distribution process, such as the different number of demand goods for each consumer, vehicle capacity, limits of delivery, the average speed can be traveled on graph and time, multiple trips conditions and different consumer locations. It is necessary for distribution process to run on time, In the distribution process is the way can be done that optimize the route of the vehicle, so the time is used to serve consumersare more efficient and the goods can arrive to consumers on time. The result of Clarke Wright Algorithm with multiple trips, the route taken is t = 1 (PT. Health Equipment Medan, Diponegoro street, Imam Bonjol street, Pemuda street, Pulau Pinang street, Kapten Mulia street and return to PT. Health Equipment Medan), the distance almost 21.3 km.

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