Optimization of garbage transport routes in West Medan using Clarke & Weigh saving and Floyd Warshall algorithm

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Abstract. Problems of Medan City is the city with the third highest population density in Indonesia. This results in a large quantity of waste generation in the Medan city that must be managed. Limitations of waste transport equipment resulting in the accumulation of waste in various polling stations in the city of Medan so that it needs to be carried out distribution route optimization. Optimization is done by Clarke & Weight Saving and Floyd Warshall Algorithm. Saving matrix method is one method used to schedule the quantity of vehicles taking into account the maximum quantity of vehicles. The Floyd–Warshall algorithm is a simple and widely used algorithm to compute shortest paths between all pairs of vertices in an edge weighted directed graph. It can also be used to detect the presence of negative cycles. Routes generated using the Saving Matrix method successfully save of travel distance of 33.65 km, and using Floyd Warshall successfully save the travel distance of 25.89 km.

1. Introduction

Waste transportation is closely related to adequate transportation activities. The waste management process ends at the Final Waste Disposal Site (TPA). The landfill referred to in this study is TPA Falls. The Medan City Sanitation Department carried out the transportation of waste from several Temporary Waste Disposal Sites (TPS) to be taken to the TPA. The process of transporting the waste is required for a waste transport truck. A problem that is often encountered is the process of transporting waste from the TPS to the TPA, where the process is the most time-consuming process due to the different volume of waste in the TPS, and the number of transports available in the Medan Barat Sub-district are six trucks and the number of transport equipment there are seven trucks available in Medan Kota Subdistrict with limited vehicles it is necessary to design the route for waste transportation from Temporary Waste Disposal Sites to the Final Waste Disposal Site [1, 2, 3].

There are many factors that influence the process of waste transportation from the starting point to the end point, namely the landfill, among others, the capacity of the conveyance, the waste volume in each Temporary Waste Disposal Sites and the distance traveled in the transport process. The waste transport process must pay attention to the capacity of each vehicle and demand capacity (waste) on each route. The problem of waste distribution involves several main considerations including vehicle routes, vehicles up to the minimum cost of distribution, so that it can expand the service area from waste collection with a limited fleet) [4].

Technically operational, the cause of inefficiency in waste transportation is the lack of a transport fleets quantity, the emergence of obstacles in addition to travel and the absence of certain scheduled routes in waste trucks transportation from Temporary Waste Disposal Sites to Final Waste Disposal Site. Waste transportation is influenced by accessibility (travel time), transportation pattern, transportation mode, transportation frequency and service level of transportation [5]. What can be done to accelerate the process of waste transportation is to find the shortest route to transport waste to the Final Disposal Site (TPA). The use of the shortest route in waste transportation is expected to save travel time and minimize the cost of fuel spent.
According to the Medan City Sanitation Office, Medan Kota and Medan Barat Subdistricts are sub-districts with the highest levels of waste volume in the city of Medan. Waste transportation in Medan Barat District and Medan Kota Subdistrict is carried out once a day when the truck is filled with waste immediately taken to the Disposal Site Final (TPA) and this condition resulted in all the waste in each polling station not being able to be lifted because the truck capacity was only 8M3 and the volume of waste from each pool exceeded the capacity of the truck. This condition resulted in the accumulation of rubbish at each polling station because the waste transport trucks lifted the waste from each polling station once in two days. Determining the route of travel from TPS to TPA is not easy so it must be considered so that the transportation process can be carried out appropriately which will provide the best route.

In this study the Clarke & Weight Saving method and the Floyd-Warshall method were used. The specialty of the savings matrix method is one of the methods used to schedule a vehicles quantity with regard to the maximum vehicle capacity. One part of Saving Matrix is Clarke & Weight Saving. This algorithm is based on the concept of savings. This method is essentially a method to minimize distance or time or cost by existing constraints consideration.

Some algorithms can be used to solve the shortest route problems, including Dijkstra's algorithm, Bellman-Ford algorithm, Greedy algorithm, Floyd-Warshall algorithm and others. The Floyd-Warshall algorithm is one of the easiest algorithms to implement, because this algorithm is part of a dynamic program search for all the shortest paths between each possible pair of different places (All-pairs Shortest Path Problems) and is very effective to use in deal with the optimum route problem [6]. The Floyd-Warshall algorithm was discovered by Warshall to find the shortest route/path. This algorithm is an algorithm that is simple and easy to implement. This algorithm is very efficient from the point of view in data storage because it can be implemented by simply modifying a distance matrix and calculate the smallest weight of all points connect a pair of dots and do it all for all pairs of dots [7]. The Floyd–Warshall algorithm is a simple and widely used algorithm to compute shortest paths between all pairs of vertices in an edge weighted directed graph. It can also be used to detect the presence of negative cycles [8].

This research presents a general model in a mixed integer program that integrates regional design and distribution route planning, striving to minimize the Total distance covered by vehicles in each region. The results of the study showed that the model used in addressing the distribution issues was quite effective and efficient which should provide a process with enough information to optimize the use of the distribution (limited) available [9].

2. Methodology

The study was conducted in the area of waste collection services carried out in the Medan Barat district where the objects examined in the form of garbage transport routes in the district. The study is conducted by observing directly the garbage transport route to the TPA. Then the collection of data needed in the study. The data used is the number of vehicles or fleet of garbage transport, capacity of the vehicle or fleet of garbage transport, number of temporary dump sites, number of consumer requests or volume of trash dumps, location of consumers or temporary dump, garbage disposal location, transportation costs namely in the form of fuel costs. Based on the data, the optimization of the garbage transport route is suitable for the purpose to be achieved is minimizing travel time. Optimization is done by Floyd-Warshall algorithm dan Clarke & Weight Saving. The steps in determining the route using the Clarke & Wright Savings method are as follows [10]:

1. Identify the distance matrix between Disposal Site Final to each Temporary Waste Disposal Sites and distance between Temporary Waste Disposal Sites and Temporary Waste Disposal Sites.
2. Identify savings matrix between customer using this formula:
   \[ S_{(x,y)} = J_{(x,y)} - J_{(x,y)} - J_{(x,y)} \]  
   (1)
3. Allocate Temporary Waste Disposal Sites to vehicle or route
4. Sort the destination in a defined route. The principle of this sorting is to minimize the distance travel of truck
Floyd–Warshall algorithm that finds both the shortest costs and the shortest routes between every pair of nodes on this network, and develop a new efficient algorithm for this problem that reduces the required computational effort of the Floyd–Warshall algorithm substantially [11]. Algoritma Floyd–Warshall to find the shortest path is as follows:

1. \( W = W_o \)
2. For \( k = 1 \) to \( n \), do :
   - For \( i = 1 \) to \( n \), do :
     - For \( j = 1 \) to \( n \), do :
       - If \( W_{i,j} > W_{i,k} + W_{k,j} \) then changes \( W_{i,j} \) with \( W_{i,k} + W_{k,j} \).
3. \( W^* = W \)

In its iteration to find the shortest path, the Floyd Warshall algorithm forms \( n \) matrices, according to \( k \)-iterations. This will cause the process to slow down, especially for large \( n \) values. Although the processing time is not the fastest, the Floyd-Warshall algorithm is often used to calculate the shortest path because of its simplicity. In addition, the implementation of the Floyd-Warshall algorithm is very easy to make. The connectedness matrix \( W \) which is used to express weighted directed graphs is the same as the matrix used to express weighted graphs, i.e. the elements express line weights.

3. Result and discussion

The Research on determining waste disposal routes in the Medan Barat sub-district with waste transport trucks with 8 \( m^3 \) capacity using Clarke & Weight Saving is:

| Pool | Route | The volume of waste transported \( M^3 \) | Distance (Km) | Total |
|------|-------|----------------------------------------|----------------|-------|
| A    | A0-A1-A2-A3-X-A0 | 5,75 | 42,4 | 81,25 |
|      | A0-A4-A5-A6-X-A0 | 7,5 | 38,85 |       |
| B    | B0-B8-B6-B7-X-B0 | 6,5 | 40,8 |       |
|      | B0-B4-B9-B5-X-B0 | 7 | 44,4 | 123,8 |
|      | B0-B2-B1-B3-X-B0 | 5,5 | 38,6 |       |
| C    | C0-C1-C2-C5-X-C0 | 7 | 33,3 | 63,7 |
|      | C0-C3-C4-X-C0 | 4,5 | 30,4 |       |
| D    | D0-D4-D7-X-D0 | 6 | 36,9 |       |
|      | D0-D5-D6-D3-X-D0 | 6,5 | 38,1 | 112,6 |
|      | D0-D1-D2-X-D0 | 6 | 37,6 |       |

Table above shows that the total travel time produced varies. This is due to the different distances for each route in each pool. Research on determining waste disposal routes in the Medan Barat sub-district with waste transport trucks with 8 \( m^3 \) capacity using floyd algorithm is:
Table 2. Waste disposal routes in the West Medan sub-district using floyd algorithm.

| Pool | Route                  | The volume of waste transported M³ | Distance (Km) | Total   |
|------|------------------------|-----------------------------------|---------------|---------|
| A    | A0-A3-A1-A5-X-A0       | 6,25                              | 40,96         | 85,96   |
|      | A0-A2-A4-A6-X-A0       | 7,00                              | 44,8          |         |
| B    | B0-B2-B3-B1-X-B0       | 7                                 | 38,9          |         |
|      | B0-B4-B7-B8-X-B0       | 7                                 | 39,8          | 124,15  |
|      | B0-B9-B5-B6-X-B0       | 5,5                               | 45,45         |         |
| C    | C0-C1-C2-C3-X-C0       | 7,5                               | 33,2          | 64,8    |
|      | C0-C4-C5-X-C0          | 4                                 | 31,6          |         |
| D    | D0-D4-D5-X-D0          | 6                                 | 38,6          |         |
|      | D0-D1-D3-D7-X-D0       | 7,5                               | 37,5          | 114,2   |
|      | D0-D2-D6-X-D0          | 5                                 | 38,1          |         |

The process of transportation in West Medan and Kota sub-districts is carried out once a day, if the truck is full of waste, it will go to the TPA and TPS where the waste has not been lifted will be lifted the next day. Comparison of actual route distances with routes using Clarke & Weight Saving and Floyd Warshall algorithm can be seen in Table 3.

Table 3. Distance comparison.

| No | Pool | Total distance (km) | Actual | Clarke & Weight Saving | Floyd Warshall |
|----|------|---------------------|--------|-------------------------|----------------|
| 1  | A    | 85,7                | 81,25  | 85,96                   |                |
| 2  | B    | 137,8               | 123,8  | 124,15                  |                |
| 3  | C    | 74,5                | 63,7   | 64,8                    |                |
| 4  | D    | 117                 | 112,6  | 114,2                   |                |
|    | Total | 415                | 381,35 | 389,11                  |                |
|    | Saving | 33,65              | 25,89  |                         |                |

The formation of waste transport routes using the Clarke & Weight Saving can reduce the distance of 33,65 km, and using Floyd Warshall algorithm can reduce the distance 25,89 km.

4. Conclusion
The process of transporting waste in Medan Barat sub-districts is carried out once a day, if the truck is full of waste it will go to the TPA and the TPS where the waste has not been lifted will be lifted the next day. This condition causes the waste in each TPS to be lifted once every two days. The result using clark & weight saving and floyd warshall algorithm is shows that can be reduced 25,89 and 33,65 km from before.

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