Determination of trash hauling routes using floyd warshall algorithm in medan barat district

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Abstract. Medan Barat District have many environmental problems includes unoptimal waste management which is resulted by a large number of trash. The large number of trash is not well transported and the area serviced by waste managements are 9 points of temporary landfill which is the waste volume of each temporary landfill point is different, this study applies Floyd Warshall method to determine the waste transport route in Medan Barat District. This method allows the determination of routes by taking into vehicle capacity and volume of waste at each polling station. The data used is the distance between the pool with the temporary landfills point and the distance between the temporary landfills points. The results obtained in this study that total distance of all trucks carried out in Medan Barat District is 415 km and after using Floyd Warshall method, a total distance has been 387,11 km and total saving distance is 6,7%. Total cost has spent in Medan Barat District about Rp.712,000 per day and after using Floyd Warshall method, total cost has been Rp. 664,000 per day and total cost saving 6,7%. Based on the result, it indicates that the route made using Floyd Warshall method produces a better trash hauling route.

1. Introduction
The high activity of the people, one of them has an impact on the presence of waste generation as the rest of the activity. The increasing number of residents in Medan Barat also increase the volume of waste. Based on the results of the recapitulation at the Medan City Public Works and Housing Regional Infrastructure, the volume of waste in the Medan Barat from year to year has also increased. and proper waste management is needed. The process of waste transportation is carried out by waste transportation from garbage bins which are spread on every public road. Limited number of transport vehicles, the process of waste transportation only carried out as much as one round in one day, from the base to each particular service area and then taken to the temporary landfills and ending at the base and not optimal route of waste transportation trucks resulting in waste accumulation in several region [1].

One of the problems happens in waste transportation is the problem of determining the route of waste transport trucks, especially for Stationary Container Systems use wooden bathtub trucks and dump trucks in their operations. The specified route must be the shortest route it can makes efficient of distance, cost and time. From these conditions, it is necessary to do research to improve the efficiency of the garbage transportation truck route [2]. In addition, it is also necessary to categorize the service area of waste transportation based on the amount of waste per length of service area and calculate the predictions of the amount of waste based on the population growth of the sub-district. Meanwhile for
waste transportation facilities, it is necessary to determine the age of waste trucks and the number of trucks recommended to be replaced according to economic life/operational age and truck capacity [3].

The increasing number of residents in the Medan Barat District, the number of waste volume also increase. Based on the results of the recapitulation at Medan City Public Works and Housing Regional Infrastructure, the volume of waste in Medan Barat District from year to year also increased and proper waste management is needed. The process of waste transportation is carried out by waste transportation from waste bins which are spread on every public road. Limited number of transport vehicles, the process of waste transportation only carried out as much as one round in one day, from the base to each particular service area and then taken to the temporary landfills and ending at the base and not optimal route of waste transportation trucks resulting in waste accumulation in several region [4].

There are many factors influences the process of waste transportation from the starting point in this case the Medan City Public Works and Housing Regional Infrastructure to the end point of the temporary landfills, including transportation capacity, the volume of waste in each polling station and the distance time in transportation process. The process of waste transportation must pay attention to the capacity of each vehicle and the capacity of demand (garbage) on each route. The problem of garbage distribution involves several main considerations including the route of vehicles, vehicles to minimize distribution costs, and expands the service area from waste collection with limited fleets) Problems related to the distribution of waste including making decisions to the route of waste collection. The choice of vehicle route determine the total distance of the fleet transportation [5].

In general, transportation is the transfer of goods and humans from the place of origin to the destination. The need for transportation services is very qualitative and has different characteristics such as function of time, destination, frequency, type of cargo transported, and etc. In the selection of transportation for people or goods there are several factors are considered, namely: time, distance, efficiency, cost, security, and comfort. There are four basic elements compiler the physical form of the transportation system, namely: link facilities, vehicles, terminals, and management and labor. While in route selection, there are several key determinations, namely: distance time, time value, distance cost, and vehicle operational cost [6].

The transportation system category for waste transportation classified according to the operation method consists of: Hauled Container System (HCS) and Stationary Container System (SCS). HCS is a waste collection system with collection containers can be moved and taken to temporary landfills. While SCS is a system of waste collectors with collecting containers cannot be carried out and moved (fixed) and is a living container system to serve residential areas. The transport vehicle usually used for HCS is Amroll truck and for SCS is a wooden truck and Dump Truck [7].

Problems of distribution routes in done by several methods, one of which is the floyd warshall algorithm. [8] The Floyd-Warshall algorithm is a graph analysis algorithm to find the minimum weight of a directed graph. In one execution of the algorithm, distance obtained as the number of weights from the shortest path between each pair of vertices without information about the pass nodes. This algorithm is also known as Roy-Floyd. In another sense, Floyd-Warshall Algorithm is a method performs problem solving by looking at solutions obtained as a related decision. This is means that the solutions are formed from solutions originating from the previous stage and there is the possibility of more than one solution. This Floyd-Warshall algorithm choose one of the shortest and safest paths from several alternative paths generated from the calculation process. The Floyd-Warshall algorithm compares all possible paths to the graph for each side of all vertices. Interestingly, this algorithm is able to work on this comparison process of \( V^3 \) times (compare the possibility of the number of sides as \( V^2 \) (square of the number of vertices in the graph, and each side combination tested). This is happen because there is an estimate of decision making (the shortest path selection) at each stage between two vertices, until the estimate is known as the optimal value.

The problem of garbage hauling routes has been widely investigated in previous studies. [9] Lisye et.al is done a research by making the draft route to collecting and transport the waste in the city of Bandung. This research aims to determine the route collection and transport of waste. The condition of
the garbage collection may be analogous with the model Vehicle Routing Problem by adding intermediate facility at the end of the route, i.e. landfills. This model is called Vehicle Routing Problem with Multiple Trips and Intermediate Facility (VRPMTIF). The determination of the route of the garbage collection VRPMTIF solved using sequential insertion algorithm. The algorithm is applied to the determination of the route of the garbage collection in the city of Bandung with the following results: 28 tour to West Bandung, Bandung tour to 41 middle, and East Bandung tour to 68 with different settlement time for each scenario other research is also done by Dody et.al in 2005 [10]. This research was conducted for the knowing causative accumulation of junk that often occur in landfills in several locations on the edge of the roads in the city of Depok and some like crowd the place seen from the mall management system the garbage. The results showed that the policy needs to be applied in dealing with these problems is to shift the time depart from landfills, collection system from door to door container system, the addition of personnel and the development of the SPA is the right recommendation to increase the volume of waste is transported. The same study is done by Rizka et.al [11] to analyzes the transportation of garbage in Surabaya. This research aims to provide information about the condition of the existing system of garbage transport which include routes and distance hauling garbage, garbage hauling speed, time transporting garbage and trash the tinbuman number of terangkut from TPS Surabaya North heading to the landfill. The result of this study is an alternative road (motorway or ordinary road) does not give significant effects against time hauling garbage because the median speed – average freight of junk that is used is the same. Junk hauling offroute factor in Surabaya i.e. 0.07<0.15, however the remaining work time which pretty much lets do the addition amount of rotation. The mean density – flat truck hauling trash in trash in North Surabaya is 229.29 kg/m3 for the container there is still close and 361.85 kg/m3 for containers that are already off the lid. However, research on the problems of garbage hauling routes still very rarely done for the region surrounding in Medan city. To that end, this research aims to analyze the trash hauling route in the West of Medan so that retrieved the garbage hauling routes that are optimal.

2. Methods

The study begins with a direct observation to see and observe the situation at the study site. The study was conducted in the waste collection service area carried out in the Medan Barat District. From the results of observation, determined the formulation of the problem accordance by what is happen. After the formulation of the problem is determined, determined the purpose of research on the problems that occurs. The purpose of the study determined is a solution of the existing problems. Furthermore, collecting the data needed in conducting this research. Data used is the number of vehicles or fleet waste transportation, the capacity of vehicles or fleets waste transportation, the number of temporary landfills, the number of consumer demands or the volume of temporary landfills, consumer locations or landfill sites, the location of temporary landfills, transportation costs in the form of fuel costs.

In this study the data collected consist of Primary Data and Secondary Data. Primary data collected includes: truck transportation routes for waste at operational time and location of service areas; truck capacity; and the amount of waste generated in each service area. Secondary data collected include: the number and type of waste transportation trucks, truck data (type, police number, and year of output); data on the average speed of the truck (distance speed), the time of loading and unloading of waste, waste transportation vehicles in Medan Barat District number 7:

- In pool 1 there is 1 unit of capacity waste truck 8m³
- In pool 2 there are 2 units of truck capacity 8m³
- In pool 3 there is 1 unit of truck capacity 8m³
- In pool 4 there are 2 units of truck capacity 8m³

Troubleshooting trash hauling routes in the study carried out using the method of floyd warshall's algorithm. Floyd-Warshall algorithm is one variant of dynamic programming, which is a method that performs the breakdown with regard to a solution that would be obtained as a decision. This means that the solutions was formed from the solutions originating from the previous stage and there is more than one possible solution [12]. The algorithm implementation invented by Warshall is to find a
simple and easy the shortest route 13]). The Floyd-Warshall algorithm here compares all possible lines in a graph for each side of all vertices. This happen because there is an estimate of decision making (the shortest path selection) at each stage between two vertices, until the estimate is known as the optimal value. Floyd Warshall algorithm checks each path and compares the middle path to get the shortest path. The middle path is the between two vertices which are the vertices between [14]. The calculation used by Floyd Warshall Algorithm to find the shortest path is to use a recursive method has the advantage of having all pairs type where the shortest path determination by determining all pairs of vertices can be determined quickly if applied in a system, stable performance, and decisions to be interrelated taken. Floyd Warshall algorithm calculates the smallest weight of the side has a negative weight. The negative weight in the calculation of the Floyd Warshall Algorithm can be found in the cost calculation process [15].

The use of floyd warshall algorithms this can be done in several stages [16]. The first stage of the determination of the shortest path algorithm Flyod Warshall is gathering data on the number of polling stations, the distance between the existing polling stations in Medan. Next determine the distance between the nodes obtained from Google Maps and based on a field survey. After that, the next step is a weighted graph already formed represented into the matrix of weights size \( n \times n \) (with \( n \) is the number of vertices). Then specify a predecessor matrix is the matrix representation of the initial problems were taken. After it's done as much iteration \( n \) node to determine the weight of the shortest path. Once the calculation is done until the last iteration then obtained the matrix matrix end result of the process of calculation algorithm Floyd-Warshall which shows the shortest path between any point [17]. Based on the results of the calculation of the matrix, then the shortest path can know is to process the transport of waste to landfills in Medan. The results obtained from the results of calculations using the Floyd Warshall algorithm give a more optimum route in terms of distance and cost.

3. Result and Discussion

3.1. Route of Waste Transportation Truck in Medan Barat District

Research on temporary landfills routes determination in Medan Barat District with the capacity of 8m$^3$ waste transportation trucks where the actual route of waste collection in the Medan Barat District. Recapitulation of the actual route that is applied at this time can be seen in Table 1.

| Pool | Route         | Distance (Km) |
|------|---------------|---------------|
| Pool A | A0-A2-A6-A3-X-A0  | 45,7          |
|       | A0-A1-A5-A4-X-A0  | 40,0          |
| Pool B | B0-B9-B2-B6-X-B0  | 50,6          |
|       | B0-B7-B1-B8-X-B0  | 44,6          |
|       | B0-B5-B3-B4-X-B0  | 42,6          |
| Pool C | C0-C5-C2-C4-X-C0  | 41,5          |
|       | C0-C3-C1-X-C0     | 33,0          |
| Pool D | D0-D6-D3-D5-X-D0  | 36,9          |
|       | D0-D7-D4-X-D0     | 41,1          |
|       | D0-D1-D2-X-D0     | 39,0          |

The actual route of the waste truck in each pool only runs at each temporary landfills once a day and if the volume of waste meets the capacity of the truck then the temporary landfills waste has not been lifted continued the next day, using Floyd Warshall algorithm, the proposed route can be applied of
waste in the Medan Barat District. Recapitulation of the route proposed by using algorithm floyd warshall can be seen in Table 2.

### Table 2. Proposed Route.

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

3.2. **Comparison of the Total Actual Distance and Propos**

After the calculation of the distance from the start point to the start of each polling station and the calculation of the distance between the polling stations in Medan Barat uses actual methods with the application of the proposed algorithm and floyd will do next, warshall comparison for see the best method. Based on the total distance of the waste transportation truck route using the Floyd Warshall method, then compared between the actual route and the proposed route. Comparison of total actual distance with the method proposed can be seen in Table 3.

### Table 3. Comparison of Total Distance and Propos.

| No | Pool | Distance Total (km) |
|----|------|---------------------|
|    |      | Actual              | Propos              |
| 1  | A    | 85,7                | 84,96               |
| 2  | B    | 137,8               | 124,15              |
| 3  | C    | 74,5                | 64,80               |
| 4  | D    | 117                 | 113,20              |

From the table it can be seen that the total distance using the Floyd Warshall method is smaller than the actual distance where the difference in distance between the actual system with the method of this proposal looks significant.

3.3. **Comparison of total actual and proposed costs**

The costs are calculated in this study is the fuel costs incurred from travel each truck from the starting point until heading to the landfill and back again to the starting point. Based on the total distance of the route, the total costs spent in each route of waste transportation obtained by calculating how much fuel is spent. A comparison of the total cost of the actual current being applied to the use of the algorithm is proposed as a method of warshall floyd can be seen in Table 4.
From the table it can be seen that with the application of Floyd warshal algorithms in the problems of garbage hauling routes, the average total cost incurred to transport the garbage is lower if compared to the actual system currently still applied.

3.4. Comparison of Actual and Proposed Distance Time
Based on the total distance of the route obtained the total distance time from the pool to the temporary landfills spent in each route of waste transportation by calculating how much the cost of fuel spent. A comparison of the total distance of the actual current being applied to the use of the algorithm is proposed as a method of warshal floyd can be seen in Table 4.

| No | Pool | Total Cost (Rp) | Actual | Propos |
|----|------|-----------------|--------|--------|
| 1  | A    | Rp 147.118      | Rp 145.848 |
| 2  | B    | Rp 236.557      | Rp 213.124 |
| 3  | C    | Rp 127.892      | Rp 111.240 |
| 4  | D    | Rp 200.850      | Rp 194.327 |

Table 4. Comparison of Total Actual and Proposed Cost.

Table 5. Comparison of Total Actual and Proposed Distance.

| No | Pool | Distance Time | Actual | Propos |
|----|------|---------------|--------|--------|
| 1  | A    | 5,10          | 4,19   |
| 2  | B    | 7,84          | 5,71   |
| 3  | C    | 4,46          | 3,41   |
| 4  | D    | 6,96          | 5,29   |

Table 5. Comparison of Total Actual and Proposed Distance.

3.5. The route of proposed trash hauling in Medan Barat District
Based on the results of the analysis using floyd warshal algorithms, obtained that:

- **Truck 1**
  Trash hauling routes that traversed the truck started from the pool (the base), the truck will move towards Protokol street to Masjid street, proceed to Palang Merah street because the garbage was already full of then dump will be taken directly to tpa and back again to the base with total time 2,54 hours. the garbage truck back to collect in Putri Hijau street continued to Merak Jingga street continued to Perintis street and continued brought trash to the landfill and forth return to base with total time 2.38 hours.

- **Truck 2**
  Trash hauling routes that traversed the truck started from the base, the truck will move towards Kartini alleyway continued to Karya dame street and continued to Cilincing street. The garbage will be taken to landfill with total time 2,41 hours and the truck returned to the pool.

- **Truck 3**
  Trash hauling routes that traversed the truck started from the base, the truck will move towards Dame street, continued to kartini alleyway, continued to Amir Hamzah street. After that the truck will move to landfill and returned to the pool with total time 2,57 hours, after the truck arriving at the base, the truck will move back to Danau poso street, continued to
Danau Singkarak street and continued to Gereja street, After that the truck will move to landfill returned to the pool with total time 2.27 hours.

- **Truk 4**
  Trash hauling routes that traversed the truck started from the base, the truck will move towards Yos sudarso street continued to Pembangunan street and continued to pertempuran street. After that the truck will move to landfill returned to the pool with total time 2.14 hours, after that the truck will move back to Budi Kemenangan street and continued to budi kemasyarakatan street and truck will move to landfill and returned to the pool with total 1.90 hours.

- **Truk 5**
  Trash hauling routes that traversed the truck started from the base, the truck will move to Gatot Subroto street continued to sei deli street and truck will move to landfill returned to the pool with total time 2.23 hours and after that the truck will move back to Adam malik street and continued to Guru Patimpus street and truck will move to landfill and returned to the base.

- **Truk 6**
  Trash hauling routes that traversed the truck started from the base, the truck will move to Kelapa street continued to Gatot subroto street continued to Makmur street and after that the truck akan will move to landfill and returned to the pool with total 2.26 hours.

4. Conclusion
The process of hauling trash in Medan Barat was held once a day led to a buildup in some shelters so that needs to be done analysis of the system as soon as possible. Based on research conducted by applying algorithms floyd warshal, obtained that the existence of approximately 6.7% reduction where the total distance of all trucks carried out in Medan Barat District is 415 km and after using Floyd Warshall method a total has been 387.11 km. While the total costs incurred are experiencing savings of 6.7% where the total fuel cost spent by Medan Barat District about Rp. 712,000 per day and after using Floyd Warshall method Rp.664.000, per day. The results obtained indicates that the route made using Floyd Warshall method produces a better trash hauling route.

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