Transportation Network System Analysis Using Ford-Fulkerson Algorithm in Medan City

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Abstract. Transportation is a major component of life, government, and social. This study aims to analyze the maximum capacity of roads in overcoming congestion using the Ford-Fulkerson Algorithm Network Model in Medan city. To get the output, several stages were needed, namely collecting the data tobe analyzed in the form of the number transportation routes in Medan city and the area which city transportation passes. Analyzing the capacity of transportation roads in Medan city used the Ford-Fulkerson algorithm, forming a model using the Ford-Fulkerson algorithm and Matlab software. The analysis results showed that there were transportation routes that exceeded the road capacity and also low transportation routes.

INTRODUCTION

Several applications such as transportation, routing, communication, economics and so on can be used by graphs as mathematical models of problems observed in the world [1]. A lot of problems can be formulated as finding a path between two points in an optimal graph with a number of specific criteria [2]. The maximum flow problem is a problem involving a directional network by flow carrying an arc to find the maximum flow can be sent through the network arc from some given vertex S, called by the source, to defined second T vertex, called by the destination. The maximum flow problem in Ethiopian Airlines is solved by using the Ford-Fulkerson algorithm [3].

The common problem found in traffic both in big cities and other developing areas is the congestion problem caused by improper traffic management and inadequate road infrastructure which adds to the severity of congestion. Congestion can also be caused by traffic volume exceeds the existing capacity. A certain road or road segment has a capacity which is not always the same as well as the current volume that passes through it, especially in Medan City. The ability to add roads is more difficult than adding vehicles.

Medan City's government has prepared a number of transportation development program plans. They are carrying out traffic management, developing and revitalization of public transportation and regulating various non-motorized transportation matters, such as building parking lots for public transit when they want to use public transportation. Public transportation operates on fixed routes in Medan City consist of public passenger cars (city transportation), small buses, medium buses, and large buses. For public transportation which does not have a route, it is served by taxis, motorized rickshaws and online transportation. In residential areas with large population, business centers, and office complexes, congestion often occurs at intersections, and in the market area it needs to be described so that congestion does not occur [4].

The regulation of traffic direction which has been carried out so far does not consider the number of vehicles flow, while the growth of vehicles in Medan City cannot be controlled. Therefore, it is necessary to analyze the vehicle network based on road capacity so that vehicles and congestion can be controlled. This analysis is used to find the total capacity of the land transportation network, in this case angkot in several majors in Medan City. The Ford-Fulkerson Algorithm network model was analyzed using the Matlab Software program to obtain a solution to the above problems.

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METHODS

The method of collecting data and information related to the problems would be discussed using documentation method. Reading, understanding, and studying books published by offices related to this research, articles, journals, and books that have related to the issued in this research were used to collect data and information. Before applying the maximum flow algorithm, a network graph would be formed. And to form a network graph, it took some data, including the name, direction and selected transportation route. The intersections were vertices in the network graph. The path connecting the intersection was the edge, with the direction and capacity of road section determined according to the travel route.[5]

The Ford-Fulkerson algorithm is a greedy algorithm that calculates the maximum value of flow in a network. As long as there is a path from the initial vertex to the final vertex with available capacity at all edges, then a stream is sent along one of the paths [6].

Let $G(V,E)$ be a graph, and for the arc $e=(u,v)$, let $c(u,v)$ be the capacity and $f(u,$ be the flow. We want to find the maximum flow from the source s to the sink t. The ford-Fulkerson algorithm has two main steps. The first is a labelling process that searches for a flow augmenting path $i.e.$, a path from s to t for which $f<c$ along all backward arcs. If this step finds a flow augmenting path, the second step changes the flow. Otherwise, no augmenting path exists, then we get the maximum flow. The detail step is as follows: The algorithm begins with any feasible flow $(e.g., f=0)$. In general, a node is in one of three states: unlabeled, labelled and scanned, or labelled and un-scanned. Upon entering Step 1, all nodes are unlabeled. The first step renders the source labelled and un-scanned [7].

Step 1. Initially, label the source $(s, l(s)=1)$;

Step 2. Select any node u, that labelled and un-scanned (if there are not nodes that is labelled and un-scanned, then the current flow is the maximum flow). For all nodes $v \in N(u)$ (where $N(u)$ is the set of all the neighbor nodes of $u, i.e.(u,v) \in E$ or $(v,u) \in E$). If v is unlabeled, then :

- If $(u,v) \in E$ and $f(u,v)<c(u,v)$, then assign the label $(u,+,l(v))$to node v. Where $l(v)=min(l(u), c(u,v)-f(u,v))$;
- If $(v,u) \in E$ and $f(v,u)>o$, then assign the label $(u,-l(v))$ to node v. Where $l(v)=min(l(v), f(v,u))$;

Then let u be labelled and scanned, mean while let v be labelled and un-scanned. If the sink node t is labelled then go to step 3, else return to step 2.

Step 3. Let $x=t$, then do the following work until $x=s$.

- If the label of x is $(y,+,l(x))$, Then let $f(y,x)=f(y,x)+l(t)$
- If the label of x is $(y,-,l(x))$, Then let $f(x,y)=f(x,y)-l(t)$
- Let $x=y$

Then go to step 1

The Ford-fulkers algorithm is simple to implement but its time complexity is high and it's a pseudo-polynomial time algorithm. By adding the flow augmenting path to the flow already established in the graph, the maximum flow will be established in the graph. The maximum flow will be reached when no more flow augmenting paths can be found in the graph. However, there is no certainty that situation will ever be reached, so the best that can be guaranteed is that the answer will be correct if the algorithm terminates. In the case that the algorithm runs forever, the flow might not even converge toward the maximum flow.

RESULTS AND DISCUSSION

This study used secondary data with an observation in 2021. This data was obtained by observing and analyzing data from the Medan City Transportation Department. The required data includes:

a. The number of routes from urban transportation in Medan City

b. Areas traversed by city transportation

c. Number of angkot that operate in a day per unit)

The simulation was carried out on the road segment based on the number of public transportation that passed from Jl. Rivai A Manaf to Jl. Yos Sudarso. There were 8 angkots observed through this route, namely angkot no. 113, 30, 53, 81, 82, 122, 25, and 135. Furthermore, the data was in the form of a graph where the intersection of the street names was a vertex and the route that connected each crossroads as edges. The weighting on each edge was given according to the data obtained from transportation departmen, the weighting was done by looking at the public transport route from the source point to the destination point.

TABLE 1. Transport Network Simulation of Several Angkots in Medan City

No Angkot	Angkot Route
113	V_{21} - V_{23} - V_{36} - V_{37} - V_{38} - V_{25} - V_{17} - V_{16} - V_{26}
30	V_{21} - V_{23} - V_{60} – V_{13} - V_{15} - V_{213} - V_{66} - V_{67} - V_{68} - V_7
53	V_{21} - V_{38} - V_{102} - V_{103} - V_{104} - V_{105} - V_{13} - V_{45} - V_{44} - V_{43} - V_{59} - V_{11} - V_9 - V_7
81	V_{21} - V_{23} - V_{119} - V_{58} - V_{110} - V_{111} - V_{67} - V_{68} - V_7
82	V_{21} - V_{23} - V_{109} - V_{58} - V_{110} - V_{120} - V_{116} - V_{117} - V_{214} - V_{94} - V_{56} - V_{55} - V_{54} - V_{73} - V_{97} - V_{121} - V_{123} - V_{124} - V_{125} - V_{126} - V_{127} - V_{106} - V_6 - V_{128} - V_5 - V_4 - V_{129} - V_7
122	V_{21} - V_{23} - V_{119} - V_{58} - V_{110} - V_{111} - V_{67} - V_{68} - V_7
25	V_{21} - V_{19} - V_{20} - V_{18} - V_{132} - V_{89} - V_{15} - V_{133} - V_5 - V_{13} - V_{12} - V_{40} - V_{32} - V_{33} - V_7
135	V_{21} - V_{23} - V_{57} - V_{56} - V_{55} - V_{54} - V_{73} - V_{146} - V_{97} - V_{122} - V_{106} - V_6 - V_7

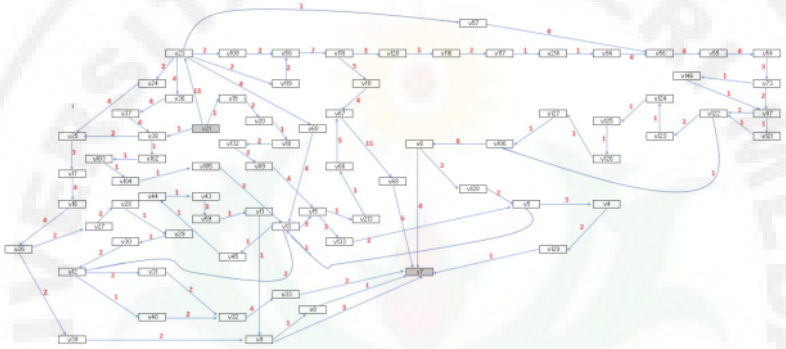

FIGURE 1. Transport Network Simulation for several angkot routes in Medan City

Figure 1 is a transport network simulation from Jl. Rivai A Manaf to Jl. Yos Sudarso which is presented in a graph.

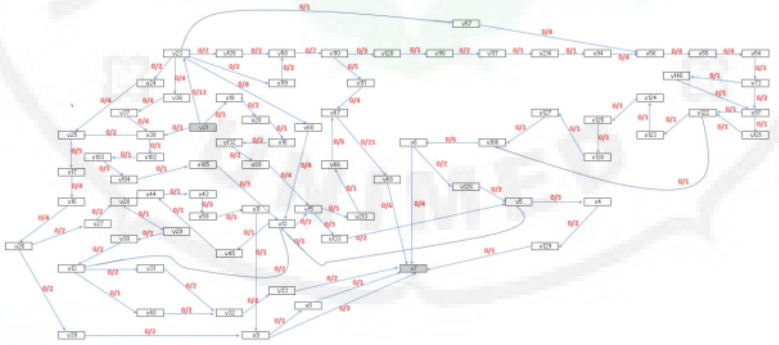

FIGURE 2. Transport Network Simulation with the Maximum Flow is Zero

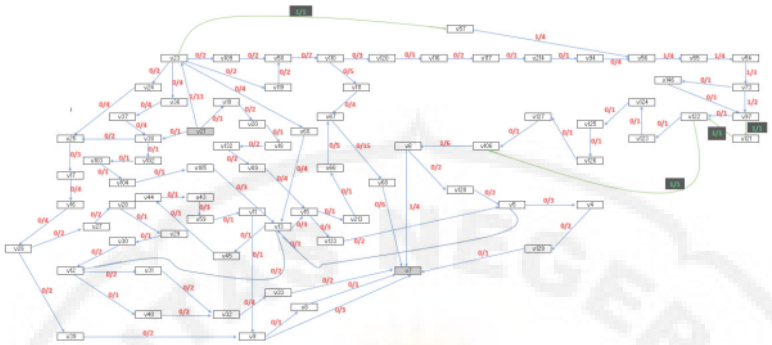

FIGURE 3. Transportation Network Simulation of the 1st iteration

From Figure 3. The maximum flow is 1, with a maximum flow of $V_{21} - V_{23} - V_{57} - V_{56} - V_{55} - V_{54} - V_{73} - V_{97} - V_{121} - V_{122} - V_{106} - V_{6} - V_{7}$

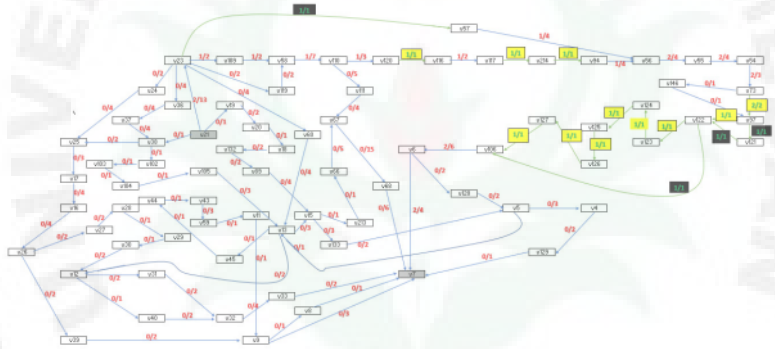

FIGURE 4. Transport Network Simulation of 60th iteration

From Figure 4. the maximum flow is 1, with the maximum flowV_{21} - V_{23} - V_{109} - V_{58} - V_{110} - V_{120} - V_{116} - V_{117} - V_{214} - V_{94} - V_{56} - V_{55} - V_{54} - V_{73} - V_{97} - V_{122} - V_{123} - V_{124} - V_{125} - V_{126} - V_{127} - V_{106} - V_{6} - V_{7}

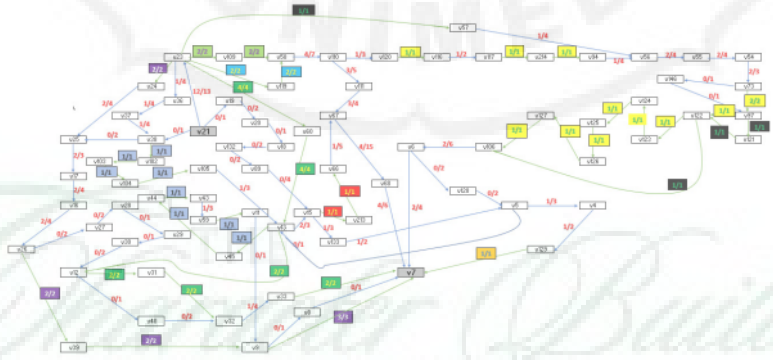

FIGURE 5. Transport Network Simulation of 91st iteration

From Figure 5. the maximum flow is 2, with the maximum flowV_{21} - V_{23} - V_{24} - V_{25} - V_{17} - V_{16} - V_{26} - V_{39} - V_{9} - V_{7}

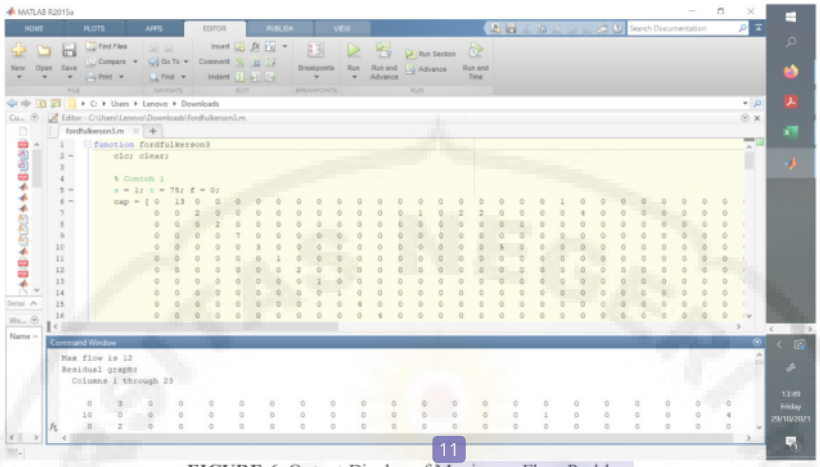

FIGURE 6. Output Display of Maximum Flow Problem

From Figure 6, it is obtained that the solution to the maximum flow problem using Matlab software was obtained. The maximum flow from Medan City vehicle network for the angkot route from Jalan RivaiAManaf to Jalan Yos Sudaraso produces a maximum flow of 12 angkot units.

CONCLUSIONS

From the results of analysis using Matlab Software, the maximum flow from Medan City vehicle network for the angkot route from Jalan RivaiAManaf to Jalan YosSudaraso resulted in a maximum flow of 12 angkot units. The maximum flow of 12 angkot units on the network means that if the network has more than 12 units of flow, there will be a side which in this case a vehicle exceeds the capacity of the road segment.

ACKNOWLEDGMENT

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REFERENCES

1. Lin, K. and Chen, M. The fuzzy shortest path problem and its most vital arcs. Journal of Fuzzy Set Syst, 58, pp. 343-353 (1993).
2. Noraini Abdullah , Ting Kien Hua . Sing Ford-fulkersonalgoritma And Max Flow-Min cut Theorem to Minimize Traffic Congestion in Kota Kinabalu,Sabah. Journal of Information System and Technology Management , pp.18-34.(2017)
3. HaftomGebreanenya,Maximum Flow Problem in Ethiopian Airlines, Journal of Progressive Research in Mathematics(JPRM),ISSN: 2395 – 0218 (2016)
4. M. Husni, dkk , Kajian Terhadap Alat Transportasi Yang Ekonomis, Aman, Nyaman dan Ramah Lingkungan, ISBN: 978-623-7297-02-4 (2019)
5. Aboelela, E. and Douligeris, C.,. Fuzzy reasoning approaches for routing in B-ISDN. Journal of Intell Fuzzy Syst, 9, pp. 11-27. (2000)
6. Biswas, Srijan, dkk.. A Review On Ford-Fulkerson Graph Algorithm for Maximum Flow. International Journal of Scientific & Engineering Research, Vol.**8(3),** 109-112 (2017)
7. Ford.L.R. and D. R. Fulkerson. Maximal Flow Through a Network. Can. J. Math. 8,399-404. (1956)

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