A Model To Reduce Traffic Congestion In Colombo City

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Abstract: -Traffic congestion is an adverse problem in the world and Colombo city incurs a huge negative impact from traffic congestion. The number of vehicles drive into the Colombo city increasing day by day and the roads are congested most hours of the day. Among several techniques, which can use to reduce traffic congestion, this research aims to give a solution by reducing the number of vehicles enter to the city. Therefore, motive of this research is to introduce a model to reduce traffic congestion in Colombo city by establishing parking locations in critically congested areas. In order to fulfil this objective, concept of cut in graph theory is applied. Furthermore, to analyse the traffic situation and to evaluate traffic measurements, multimodal traffic simulation software PTV Vissim 9 is used.
Colombo city entry points and area inside the Colombo city periphery are considered when constructing the model within some defined limitations.
This study is mainly based on identifying critically congested roads by traffic measurements and introducing cuts as parking locations to control the vehicle flow in to the city.
As the outcome of this research, three locations are identified to establish parking areas. This concept can be initiated by motivating people to use parking locations to park their private vehicles and by providing public transportation more conveniently and comfortably.

Key words: Graph theory, cut-set, traffic model, queue delay

1. INTRODUCTION

1.1 Background

Over the past few decades, transport demand has highly increased, notably in the Colombo Metropolitan Area. With the growth of traffic demand, traffic congestion has increased resulting many negative impacts. It causes for the economic loss, by travel time cost and by increasing vehicle operating costs such as fuel consumption. Even though many actions have been taken to reduce traffic congestion in the Colombo city, most of them have not succeeded. Therefore, the necessity of a better solution is provisional and significant.

In this project, a traffic model is introduced to control the congested traffic situations by calculating traffic measurements, using a traffic simulation software. PTV Vissim 9 is the traffic simulation software used to obtain traffic parameters and it is a leading microscopic simulation program for modelling multimodal transport operations. Vissim is a microscopic, time step oriented, and behaviour-based simulation tool for modelling urban and rural traffic.
The concept of Cut-Set in graph theory is used to identify the locations to establish parking areas by reducing number of vehicles enter to the city from entry points.

2. METHODOLOGY

2.1 Introduction

Graph theory is used to model the road network into a graph considering class A and class B roads according to Level of Service. Then the network is constructed in the PTV Vissim 9 software according to the developed graph and considering the number of lanes in road segments and distance between two nodes in the graph. The modelled graph and the considered entry points are shown in the figure 2.1.

By locating data collection points, traffic simulation results are obtained. By analysing simulation results, congested road segments can be identified and cuts are introduced as parking locations to reduce the number of vehicles enter to the city. Then again simulation results are analysed to check the effect of introducing cuts by calculating the reduced percentage of queue delay.

2.2 Developing the network

In order to develop the traffic network in PTV Vissim, the links (i.e. the roads) were traced. Each link is traced considering the number of lanes, distance between the junctions and their directions. Width per lane is taken as 3.50m considering standard road conditions.

In this model, cycle time of the signal controlling systems are defined as follows.
Junctions formed by intersection of three roads: 90 seconds
Junctions formed by intersection of four roads: 120 seconds
Junctions formed by intersection of five roads: 150 seconds
The movement of vehicles are defined as follows. When one route allows to move through the intersection, other routes has red signs. Figure 2.2 shows the first 30 seconds of the cycle time in a

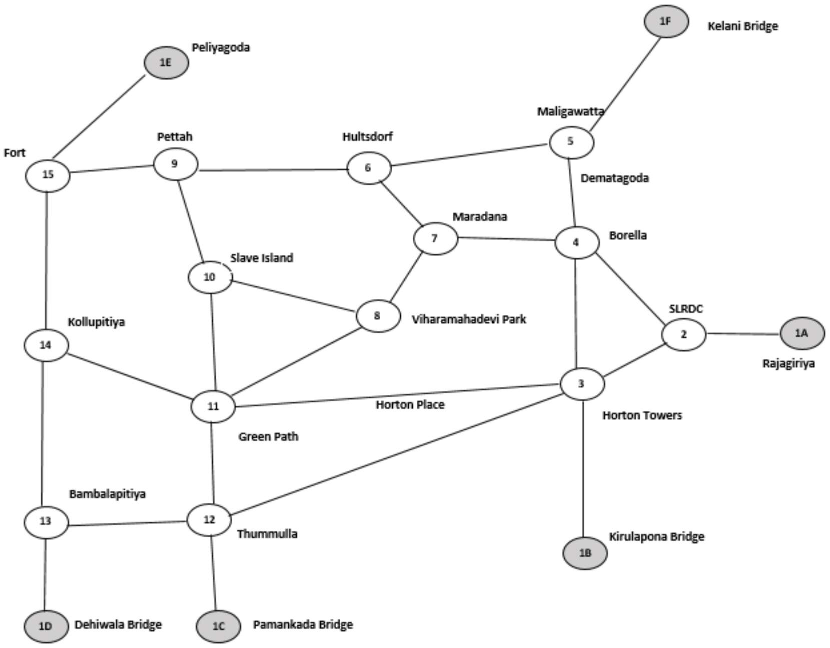

Figure2.1 Developed graph of the road network

The network is constructed for the scale 1:10. In other words, 1m link in the network represents 10m of the road. After designing the network, vehicle routes are constructed in a junction. Then the vehicle types and vehicle classes are added. For the simulation vehicle compositions are defined at each entry point.
Signal heads are set to control the flow, to avoid vehicle crashes, and to simulate the real situation.

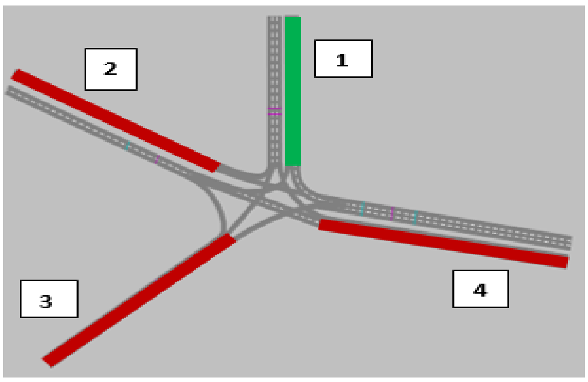

Figure 2.2: First 30 seconds under signal controllers at a junction

junction with 4 roads. In next 30 seconds, road 2 allows green light and road 1, 3 and 4 get red light and so on.
Apportionment of green time is set by allocating 30 seconds to each route. In the modelled network, signal heads are located at 43 points. In every road segment, signal heads are located for each lane towards the junction.

To evaluate traffic parameters, data collecting method is selected and 120 data collection points are
located at signal heads. Queue delay is considered as the traffic evaluation parameter and it gives the average time vehicles has spent is a congested state in seconds. After the simulation, simulation results of the traffic parameter are collected.
Critically congested road segments in the network were identified by analysing simulation results of the traffic parameter, to introduce cuts. The locations where the cuts were introduced are the places where the parking locations should be established.

To analyse the results and to introduce cuts, following criteria is defined.
1. Queue delay of the lane with maximum queue delay is considered as the queue delay of the link.
2. Links which have queue delay greater than or equal 300 seconds are considered as the roads with critical traffic congestion by observing traffic simulation results for several input values.
3. Vehicle input volumes are reformed by the consideration of links with critical traffic congestion.
4. Vehicle input volumes and compositions are reformed by introducing cuts to the network system.
5. Parking locations are introduced to limit MCL (Motor Cycle), CAR and TWL (Three Wheeler).
6. BUS are introduced to fill the gap of passengers which are reduced when reducing the number of MCL, CAR and TWL.
7. When introducing a cut in a link (for the first time), number of MCL, CAR, TWL were reduced by 50%.
8. When introducing another cut in the same link (for the second time), 1/3 of the remaining number of vehicles is reduced from MCL, CAR and TWL.
9. Composition of HGV (Heavy Good Vehicle) and LGV (Light Good Vehicle) remained unchanged after introducing cut, since the change in relative flow is negligible.

3. RESULTS AND DISCUSSION

3.1 Simulation and introducing cuts

First simulation is done by setting the volume of vehicle inputs in each entry point according to the data collected from Road Development Authority. According to the data, vehicle entry volumes are counted for 24 hours. In this study, those values are modified regarding peak hour vehicle entry volume, by considering 10% of the total number of vehicles counted for 24 hours. In the graphed model, entry points at SLRDC(Sri Lanka Land Reclamation and Development Corporation) and Near Ayurveda hospital (Borella - Rajagiriya Road) are considered as one entry point. Therefore, average value of number of vehicles have used as the sample input values.

Table 3.1: Initial vehicle input volumes

Vehicle Input Points	Volume
1A	7000
1B	5000
1C	5500
1D	5500
1E	6000
1F	9000

After the first simulation, following output is obtained. Since a link consists with 2 or more lanes and output results of the parameter is received for each lane of the link, queue delay of the lane with maximum queue delay is considered as the queue delay of that particular link.

Table 3.2 Maximum Queue Delay after first simulation

Data Collection Measurement	Queue Delay	Maximum Queue Delay of the link
9-6 (Lane 1)	216.7	
9-6 (Lane 2)	254.6	
9-6 (Lane 3)	300.0	300.0

After the first simulation, congested road segment can be identified between Pettah - Hultsdorf with maximum queue delay of 300.0 seconds.
In order to reduce number of vehicles flows to the link 9-6, a cut was introduced at 1E-15 link by changing the composition as in the following table.

Table 3.3 Changed compositions in the link 1E-15

Vehicle Type	Current Percentage (%)	No. of vehicles Before the cut	No. of vehicles after the cut	New Percentage (%)
MCL	25.5	1530	765	20.7
TWL	30.5	1830	915	24.7
CAR	21.2	1272	636	17.18
BUS	2.15	145	274	7.4

After introducing the cut in the link 1E-15, volume of that link is reduced by reducing the number of MCL, TWL and CAR by 50% and adding the corresponding percentage to loss of passengers to number of BUS and simulation is done again. New percentages are introduced as follows. Average number of passengers in MCL, TWL, CAR and BUS are considered as 2, 3, 3, and 75 respectively. Total number of vehicles after introducing the cut is calculated by reducing the sum of reduced number of vehicles from the total number of vehicles before introducing the cut. The vehicle input volume in link 1E-15 for the second simulation is rounded off to 3700 after reducing MCL, TWL, CAR and adding BUS.
Simulation results after the second simulation is in the table 3.4 below.

Table 3.4 Maximum Queue Delay after second simulation

Data Collection Measurement	Queue Delay	Maximum Queue Delay of the link
3-4 (Lane 1)	208.9	
3-4 (Lane 2)	221.9	
3-4 (Lane 3)	303.5	303.5

It can be noticed that the queue delay of the link 9-6 is reduced by 15% after introducing the cut in the link 1E-15. After the second simulation, link 3-4 has 303.5 seconds as the queue delay. In order to control the vehicle flow in that link, a cut is introduced in the link 1B-3 since it affects the link 1B-3 most.

The vehicle input volume in link 1B-3 for the third simulation is rounded off to 2900 after reducing MCL, TWL, CAR and adding BUS. Number of passengers to fill the gap of reducing vehicles were calculated using the same criteria mentioned above when introducing the first cut an added BUS accordingly. Vehicle compositions before and after introducing the cut in the link 1B-3 are listed in the table 3.5 below.

Table 3.5 Changed compositions in the link 1B-3

Vehicle Type	Current Percentage (%)	No. of vehicles before the cut	No. of vehicles after the cut	New Percentage (%)
MCL	19.7	959	480	16.55
TWL	25.28	1264	632	21.79
CAR	40.96	2048	1024	35.31
BUS	2.15	125	205	7.06

After the third simulation, queue delay of the link 3-4 is reduced by 11.4% and link 6-5 and link 7-6 has 325.6 seconds and 319.0 seconds of queue delay respectively. In order to control the number of vehicles flow to the links 3-4 and 7-6, 2 cuts are introduced simultaneously. Since link 1E-15 affects the link 7-6 another cut is introduced in the link 1E-15. Current vehicle volume of link 1A-2, 1B-3 and 1C-12 are 7000, 2900, 5500 respectively. The second cut is introduced in the link 1A-2 and 1A-2 link is selected out of 1B-3 and 1C-12 by considering the maximum vehicle flow.

Table 3.6 Maximum Queue Delay after third simulation in 6-5 link

Data Collection Measurement	Queue Delay	Maximum Queue Delay of the link
6-5 (Lane 1)	325.6	
6-5 (Lane 2)	255.3	
6-5 (Lane 3)	288.2	325.6

Vehicle flow and the compositions of the entry points in the links 1A-2 and 1E-15 are reformed according to the criteria mentioned above. Table 3.8 and table 3.9 display the changes of the links which should be made when introducing the new cuts.

Table 3.7 Maximum Queue Delay after third simulation in 7-6 link

Data Collection Measurement	Queue Delay	Maximum Queue Delay of the link
7-6 (Lane 1)	232.2	
7-6 (Lane 2)	233.1	
7-6 (Lane 3)	306.9	
7-6 (Lane 4)	318.9	318.9

Total number of vehicles enter through 1A-2 and 1E-15 was changed from 7000 to 4100 and 3700 to 2200 respectively.

Table 3.8 Changed compositions in the link 1E-15

Vehicle Type	Current Percentage (%)	No. of vehicles Before the cut	No. of vehicles after the cut	New Percentage (%)
MCL	20.7	765	510	23
TWL	24.7	915	610	27
CAR	17.18	636	424	19
BUS	7.4	274	401	13.6

Table 3.9 Changed compositions in the link 1A-2

Vehicle Type	Current Percentage (%)	No. of vehicles Before the cut	No. of vehicles after the cut	New Percentage (%)
MCL	22.14	1550	775	18.90
TWL	22.14	1550	775	18.90
CAR	37.73	2650	1325	32.31
BUS	2.15	297	433	10.5

Finally, after introducing the cuts in the links 1A-2 and 1E-15, queue delay of every link resulted as below 300 seconds. Since every link is removed from congested state, this situation can be identified as an optimum state.

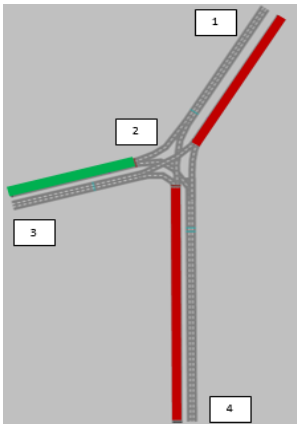

Figure 4.1: Signal-Controlling System 1

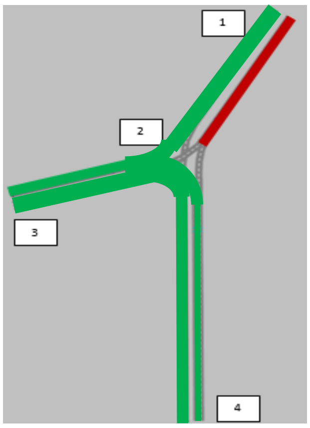

Figure 4.2: Signal-Controlling System 2

3.2 Analysis on traffic signal controlling system

When compare with real situations 300 seconds is relatively high-congested state. These results are obtained since the cycle time of a junction is designed in a way, which restricts two or more movements in the same time.

To analyse this situation, above system is used. A junction is designed for the same cycle time and set the movements at the same time without any crashes of vehicles. (Figure 4.1: Traffic Signal-System 1).
The same junction was used with the equal cycle time but restricting the movements at the same time (Figure 4.2: Traffic Signal-System 2). After simulating the two networks for a same period of time, following results were obtained.

Table 3.10 Traffic Simulation results on comparing Traffic Controlling system

Data Collection Measurement	Delay time for network 1 (s)	Delay time for network 2 (s)	Difference of two results as a percentage (%)
1-2 Link	214.4	158.2	26%
2-3 Link	162.5	143.5	12%
2-4 Link	112.1	48.2	57%

By observing the results obtained, it can be noticed that the optimum traffic controlling system resulting reduced delay time than the system with restricted movements. Therefore, it can be concluded that green time allocation of the traffic controlling system affects the queue delay of the network.

4. CONCLUSION

In this study, the number of vehicles enter to the road network has controlled by introducing parking locations to the system. Traffic parameter, queue delay is used to identify congested road segments. By analysing the simulation results of the network before and after introducing the cuts it can be concluded that the congested situations of the roads can reduce by introducing parking locations.
By the analysis on traffic controlling systems, it can be concluded that the green time allocation of the signal controlling system affects the queue delay in roads.
According to the constructed model and the defined criteria in this study, three locations can be identified to establish parking areas. Three parking areas can be suggested in between SLRDC and Rajagiriya in Kollupitiya-Sri Jayewardenepura route, between Horton Towers and Kirulapona Bridge in Baseline Road and between Peliyagoda and Fort in Puttalam-Peliyagoda Road.

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