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Numerical Experimentation Research in Optimizing the Signal Rate & other Related Factors on Traffic Flow

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Abstract: ***Traffic congestion is one of the current issues faced by the major cities constantly, since past few years. A well organized traffic system and its infrastructure can make a positive impact in reducing the block and thereby affecting the social strata and hence, the economy. Considering the current scenario in the city of Thiruvananthapuram, this study is conducted to forecast the optimal delay time of the signals, such as it reduces the congestion problem effectively. Similar to other cities, Thiruvananthapuram is also prone to the traffic jam in roads on a regular basis. This affects the social system immensely by consuming a large amount of time and fuel. The primal objective of this paper is to optimize the delay time provided for the vehicles that could make the system more systematic, by reducing the wastage of idle time.***

Keywords: Traffic flow, signal rate, cycle time, T phase and Y phase, congestion, delay time.

I. INTRODUCTION

Transportation is the movement of humans, goods or vehicles from one location to another location. There are different modes of transport as air, water, land, cable, pipeline and spaces. A good infrastructure is essential and it provides the vehicles to operate easily, which consists of fixed installation in all modes of transport such as airports for airways, railway station for railways, bus stations for buses etc. It must also include fueling docks and fuel stations. The terminals may be used to interchange the passengers, cargo and also for their maintenance. The operation and the ownership of the infrastructure can either be public or private. With the expansion of the railway system in India, the roads were also renovated simultaneously. Presently, India has the second largest road network in the world (4.87 million kilometer). Kerala, the southernmost state in India has a wide road network of 145704 km. The number of vehicles is having an increasing pace every year, thus causing higher possibility of congestions on roads. The traffic signals are almost placed in all major junctions of thecities and are offering a maximum control to any roads intersections (bottleneck of the trafficjam). The primary function of the traffic flow is to assign the right way to the contradictory movements of the traffic at the intersections. Mainly it allows separating the traffic into different phases by setting time to each phase. In this paper we consider a junction in Thiruvananthapuram-Uppidamoodu junction, a prime location that makes the connection to the main cities in Thiruvananthapuram with the maximum number of commuters regularly. The traffic congestion problem of this signal is subjected to study as a sample, which represents the whole traffic scenario of the capital city and thus, a sample of other heavily commuting areas too.

II. LITERATURE REVIEW

The signals are one of the most effective, flexible active controls of the traffic and it is widely used in many cities all over the world. It is essential to determine the relation betweenthe qualities of service, system and the flow of traffic. Observing the system and modulating it from the collected data, the paper provides a clear glimpse to the problem faced by the system and how the solution could be approached[1]. A better path to improve the efficiency of traffic system and thereby a safe transportation in the society is ensured by altering the timings of the traffic signals. The signal retiming reduces the delay time and the fuel consumption of the vehicles. To design a traffic congestion free city it is necessary to evaluate such retiming of the signals and its effectiveness [2]. Another paper on traffic flow analysis gives an outline of how to reduce the consumption of fuel during the idle time of the vehicles. The paper analyses the sum-of-squares programming method [3]. Applying the nonlinear forms, the impact of the look-ahead vehicles on the stability of the traffic is determined through controlled invariant sets. There are many reasons that effectuate traffic congestion. Repairing works of the damaged roads, the weather conditions, social activities and traffic accidents are the major areas to be focused on. Improvement of road infrastructure, yielding more of the public transport to the society and reducing the outnumbering of the private vehicles -are the better ways to avoid congestions. By forecasting the traffic congestion we can make the current system more effective andefficient[4].

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III. DATA

The traffic flow is generally considered as a reciprocal action of the travelers and the infrastructure. The traffic flow can also affect the economic, personal and day-to-day activities of the citizens. The city administration has to balance the traffic flow by creating a good infrastructure.

The major problems faced in traffic flow are congestions, delay time, cost and also the accidents. The word 'traffic stream' is also coined for the same. Basically, the main function of a traffic signal is to control the vehicles passing through the road intersections by giving a visual indication to the drivers, so that they could reckon when to proceed, when to slow down, turn, or to stop the vehicle. The pedestrians are also taken into consideration. The signals may operate with electric power whereas some may work with solar energy. The traffic flow is the total number of vehicles passing a given point at a specified time period (expressed as vehicle per hour in general). The speed, density, volume, headway, timing, vehicle flow, capacity of the road, breaking of vehicle, road intersections etc., are taken into consideration. The traffic flow varies depending upon the time – the peak hours and also the weekends when compared to the normal days. The road intersections are divided into different phases. The objective of the phases is to separate the conflicting moments at the intersection into different sub phases. The phases and the sub phases are designed such that it reduces the congestion in the stream.

There are two types of traffic flow- mainly Interrupted Flow, where the vehicle flow is obstructed due to some reasons such as traffic signals or sign boards; and Uninterrupted Flow, where the flow of vehicle does not require stopping by any external cause to the stream.

The traffic signals works electrically or by solar power and it can be classified as follows,

1. *Fixed timesignals*
   It is set mode such as it has to repeat regularly. The time of each phases are predetermined. Simply it is called as automated signals
2. *Actuatedsignals*
   The timing of these phases and cycle are changed according to the traffic demand
3. *Manually OperatedSignals*
   The traffic police change the timings for each phase based on the flow of vehicles.

A. *Cycle Time*

The total time period from the beginning to the end of the process in each signal is called the cycle time. For each signal, it is the sum of the processing time, inspection time, moving time and also the waiting time. Congestion Traffic congestion in the road network arises due to the insufficiency of the infrastructure such as narrow roads or badly maintained roads, double parking and other factors like rushed vehicles, longer queue etc. It is commonly termed as traffic jam. The congestion in the traffic occurs mainly during the peak hours(morning and afternoon or evening). The flow of vehicle in the peak hour and non peak hour (approx. about 15 minutes) can determine the flow of vehicle for a day, such that the vehicle count of the particular junction can be determined or the demand of the junction can be estimated. If there are more number of vehicles, the commuters are bound to wait until the other vehicles pass by, resulting in an increased waiting time. This increased waiting time can also be a reason for the congestion.

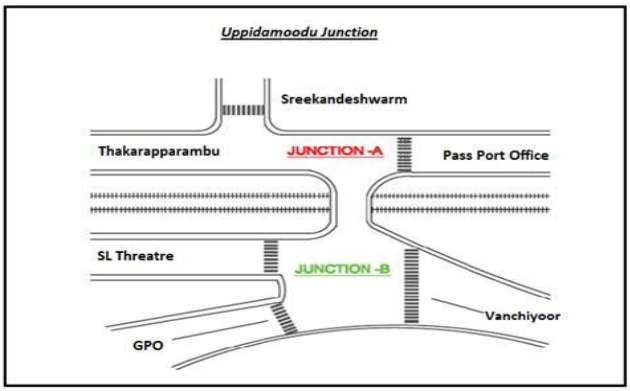
Recordically, it is noted that many of the accidents arise due to congestions.

IV. METHODOLOGY

The major factors that affects the traffic and creates congestion in the area is considered and a primal problem is formulated. It may include factors like the nature of the road, frequency of the incoming and outgoing vehicles, infrastructure etc. The problem is analysed and solution is forecasted for the same.

For this study, the data was collected with the duration of time period ranging from 8.30 AM to

5.30 PM at Uppidamoodu Junction that connects the two junctions. The junction A with the three phases, Thakarapparambu, Sreekandeshwaram and Passport office and the junction B with Vanchiyoor, GPO and SL Theatre. Since it connects two heavy streams -junction A and B, the congestion in the bridge is enormous.



The number of vehicle passing through the junction are considered. The green light and the red light timings for each phase is reckoned to differ based on the vehicle flow. The amber time is set about 3 seconds in all the phases. Here we also consider the number of vehicle passing through and its Passenger Car Unit (PCU), where the mode of traffic variables are converted to a single passenger car.The PCU table is as follows.

V. TABLE 1- PER CAR UNIT CONVERSION VALUES

Sl.No.	Type of Vehicle	PCU
1.	Motorcycle	0.25
2.	Auto Rickshaw	0.60
3.	Car	1
4.	Truck/Lorry	3.60
5.	Bus	3.60

Each arm in the signal is set with a specific time limit from the given cycle time based on the vehicle flow.

We tune the signal time with a small change in each arm by preserving the cycle time that can make a marginal variation in the contemporary flow of vehicle.

The following table gives a vehicle count and passenger car unit (also known as Per Car Unit) of Uppidamoodu junction. There are two main junctions A, B with six phases, the signals of each phase are distributed with unique time limit (with the cycle time of 90 seconds). The signals are also labeled with direction to every phase, where the commuters can use all the arms in the junction without any restriction. To illustrate with an example, the number of vehicles passing from Thakarapparambu to Bridge is of 1084 with its PCU count is about 591.3 and there are 2132 vehicles moving from vanchiyoor to SL theatre with its PCU count as 1231.5

A. Table 2 - Vehicle Count and Passenger Car Unit of Uppidamoodu Bridge

SNo.	From	To	Vehicle Count	Per Car Unit
1.	Thakarapparambu	Bridge	1084	591.3
2.	Thakarapparambu	Passport office	918	497.05
3.	Thakarapparambu	Sreekandeshwarm	390	174.35
4.	Sreekandeshwarm	Thakarapparambu	898	564.4
5.	Sreekandeshwarm	Bridge	3335	2037.2
6.	Sreekandeshwarm	Passport office	1657	1012.1
7.	Passport office	Bridge	2572	1557.9
8.	Passport office	Thakarapparambu	1134	648.15
9.	Passport office	Sreekandeshwarm	1128	647.8
10.	Vanchiyoor	GPO	976	534.95
11.	Vanchiyoor	SL Theatre	2132	1232.5
12.	Vanchiyoor	Bridge	3617	2089.9
13.	GPO	SL Theatre	946	523.65
14.	GPO	Bridge	2326	1406.05
15.	GPO	Vanchiyoor	2094	1312.15
16.	SL Theatre	Bridge	430	237.4
17.	SL Theatre	Vanchiyoor	616	326.2
18.	SL Theatre	GPO	325	183.8

Table 3: Actual Timing (obtained from the collected data)

Junction A		Junction B	
Signal Rate	**No. of Vehicles**	**Signal Rate**	**No. of Vehicles**
25	2392	27	6725
15	5890	31	5366
50	4834	32	1371
Cycle Time:90 sec	Total: 13116	Cycle Time:90 sec	Total: 13462

The cycle time for each junction A, B is given by 90 seconds. But in both cases, the signal rate and the vehicle count differs. Here, we examine peak hours and non peak hours, based on the number of vehicles moving to and fro from each phases.We consider changes in the signal rates without affecting the cycle time. Using the software MATLAB, we predict an optimal outcome for the given data, so that we can avoid the obstacles over the junction to produce a congestion free movement to the vehicles. Here, by customizing the signal rate, the outflow of the vehicles has increased from 13116 to 17482 vehicles in the junction A and 13462 to 16026 vehicles in the junction B with the same cycle time (as shown in Table 2).

Hence, it can reduce the congestion in the junction with the maximum outflow in the same signal time limit.

I.

I. TABLE 4: ADJUSTED TIMING

Junction A		Junction B	
Signal Rate	**No. Vehicle**	**Signal Rate**	**No. Vehicle**
20	2002	34	8857
30	11780	36	6312
40	3700	20	857
Cycle Time:90 sec	Total: 17482	Cycle Time:90 sec	Total: 16026

The cycle time for the junction A is of 90 seconds and by using the software to the collected data we consider it as the exact values and by plotting them we obtain the figure-1, where it shows the signal rate and its corresponding movement of vehicles from the junction A in both peak hour and non-peak hours.

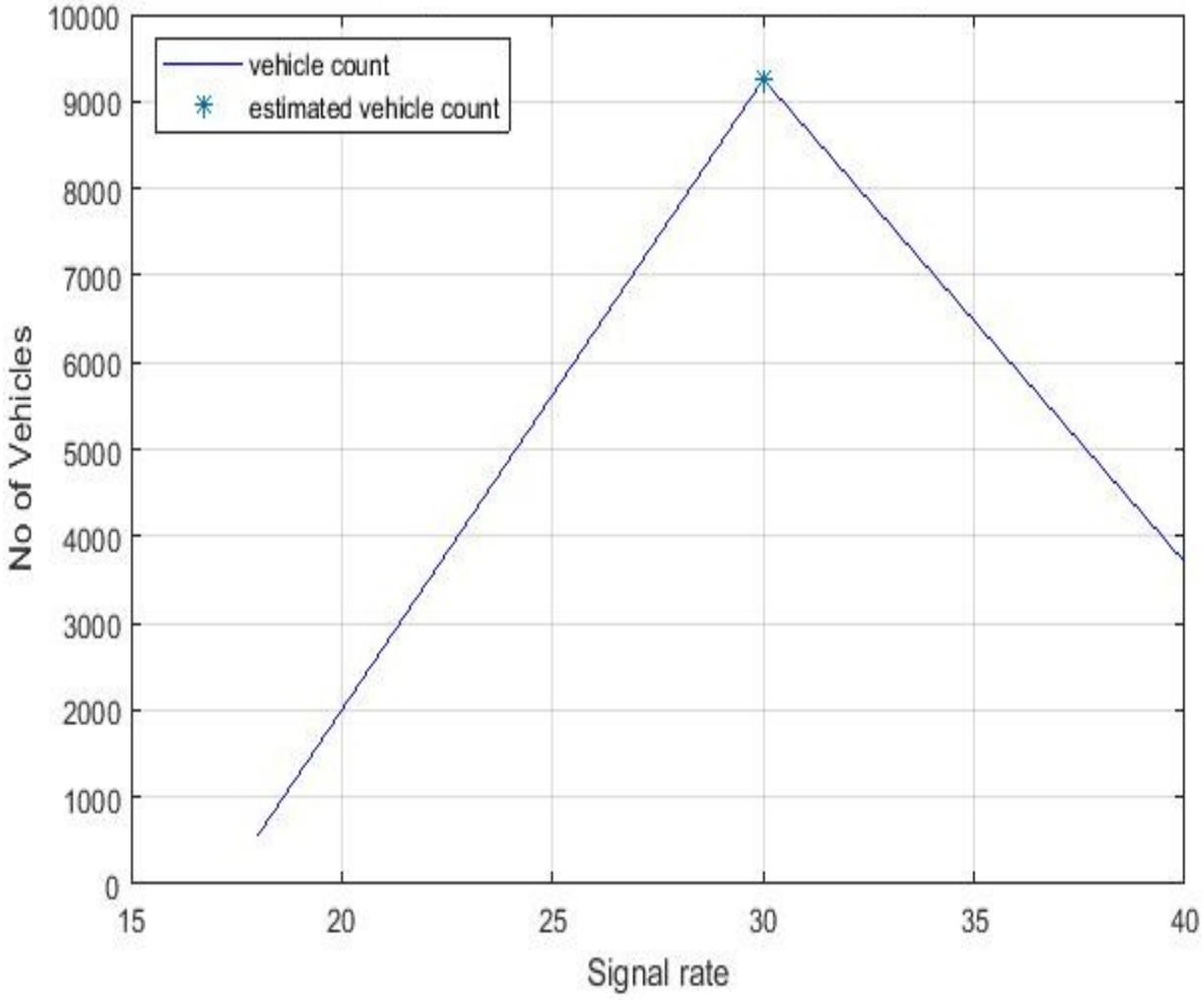


Fig 1- Exact data values (Junction A)

By decreasing the cycle time by 3 seconds and also increasing by 7 seconds to the given data we could find that there is a waiting time for more number of vehicles in the phases in junction A. The output obtained are negative in values, which indicates that the absolute value gives the number of vehicles which could be traversed. Respective plots are given below as figure-2 and figure 3. Thus it is obvious that the obtained output is not a feasible solution.

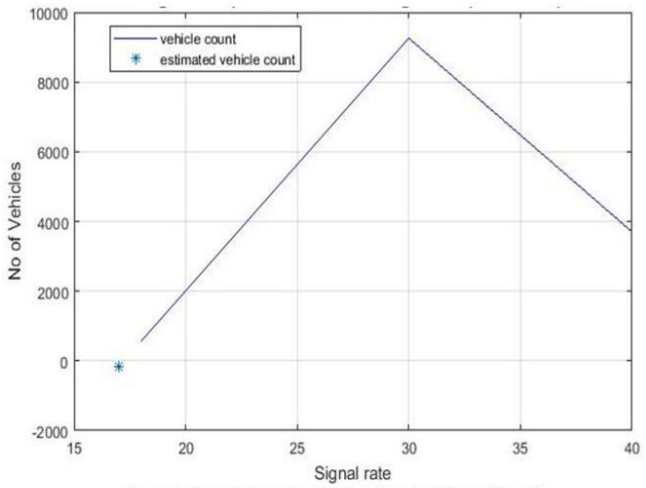


Fig 2. Extrapolated value-lower signal rate(Junction A)

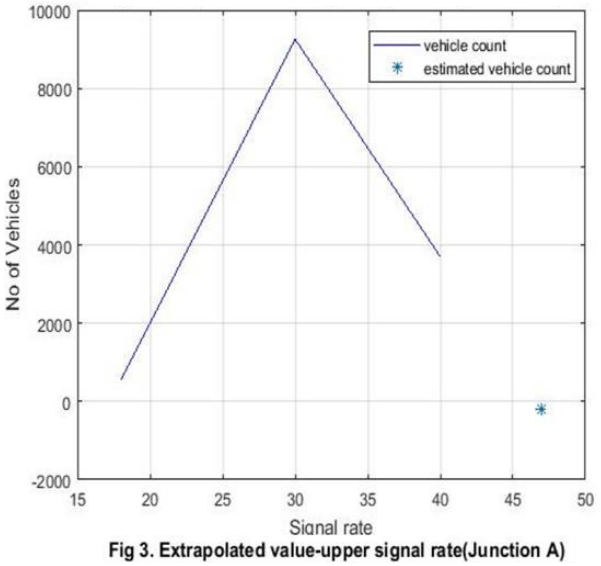


Fig 3. Extrapolated value-upper signal rate(Junction A)

Now to find a appropriate solution, we increase the time by 6 seconds, so we could get an optimal solution since there will be a maximum outflow in a minimum time period, where it reduces the waiting time to the vehicles at each phases in the junction A. Figure-4 displays the optimal solution possible in junction-A.

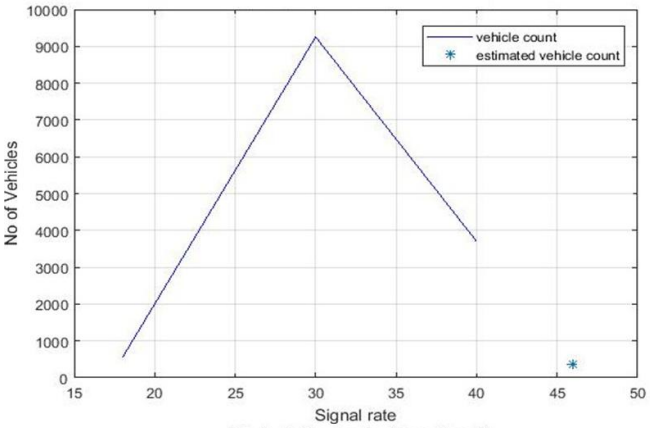


Fig 4. Optimal value(Junction A)

The cycle time for the junction B is of 90 seconds and from the collected data we consider it as the exact values and by plotting them we obtain the figure-5, where it shows the signal rate and its corresponding movement of vehicles from the junction B in both peak hour and non-peak hours.

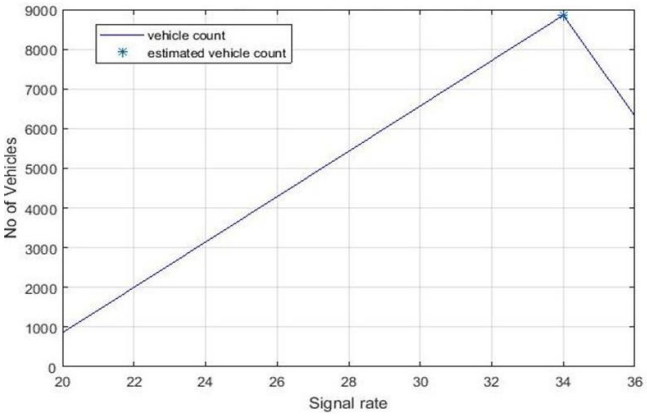


Fig 5- Exact values (Junction B)

By decreasing the cycle time by 3 seconds and also increasing by 5 seconds to the given data we could find that there is a waiting time for more number of vehicles in the phases in junction B. The output obtained is negative in values, which indicates that the absolute value gives the number of vehicles which could be traversed. Respective plots are given below as figure-6 and figure 7. Thus it is obvious that the obtained output is not a feasible solution.

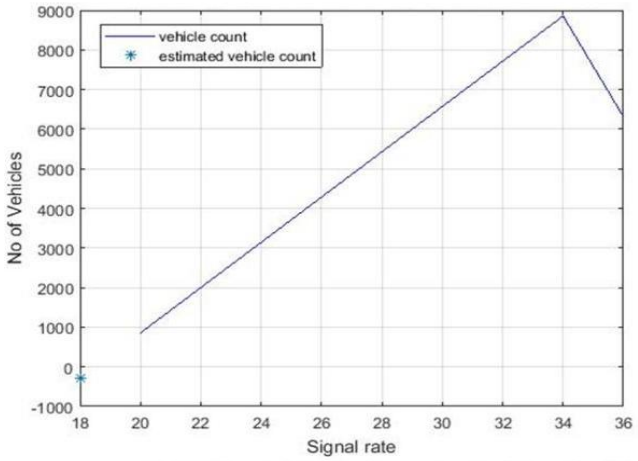


Fig 6. Extrapolated value-lower signal rate(Junction B)

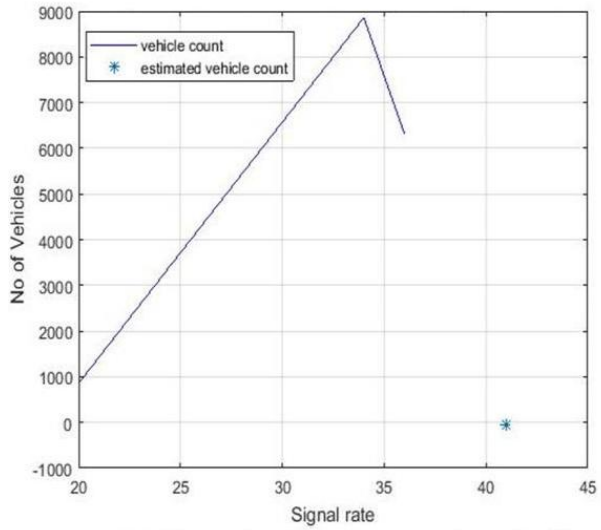


Fig 7. Extrapolated value-upper signal rate(Junction B)

Now to find a appropriate solution, we increase the time by 4 seconds, so we could get an optimal solution since there will be a maximum outflow in a minimum time period, where it reduces the waiting time to the vehicles at each phases in the junction B. Figure-8 displays the optimal solution possible in junction-B.

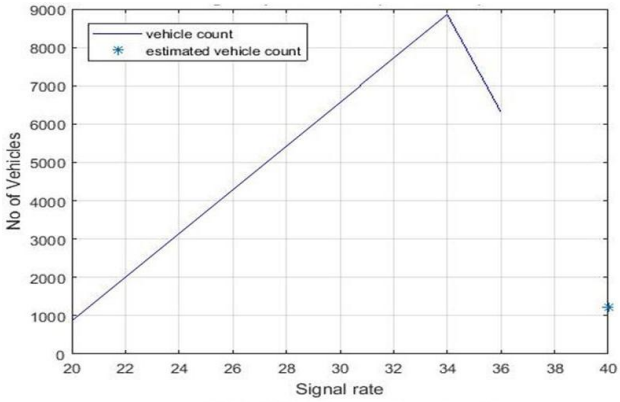


Fig 8. Optimal value (Junction B)

While considering both the junctions –A and B, we find that the optimal solution is obtained, which helps the system to work more effectively, by decreasing the congestion. From the given cycle time we shuffle the timing of each arms to find the variation in the movement of vehicles in the junctions. By providing more time to the arm where there is a maximum flow, we can reduce the waiting time of the vehicle in each phases, that helps in reducing the congestion to a great extent. Thereby making some changes in the cycle time we can make the system more efficient than before.

I. CONCLUSION

In this paper, we contemplate a high traffic junction where congestion has become very common. This creates commotion on a daily basis which has to be addressed seriously. The Uppidamoodu junction, aforesaid, connects six main cities in Thiruvananthapuram. From the given data, we alter the signal rate and also making some changes to the cycle time that is by decreasing and increasing the cycle time to an extend will generate a waiting time to some vehicles in the junctions and by optimizing from that we have a congestion free junction to the city. Hence by moving larger number of vehicles between the phases, we can reduce the congestion at this junction that can also reduce the waiting time. Thus, it makes the system more efficient.

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