Design Traffic Light Control System based on Location Information and Vehicle Density in VANET

Balasubramani S, D. John Aravindhar

Abstract--- Now days, the number of vehicles has increased by around the world, especially in urban areas. For this vehicle increment causes accidents and polluted the environment. The accidents mostly happened in road junctions. To avoid these accidents the traffic lights were implemented. In every traffic signal the number of vehicles is arriving and waiting for some time to cross the roads. In this time interval the vehicles are omitted the CO2 gas. Compare to roadway the traffic signal area has to be more polluted. To recover this problem, reduce the vehicle waiting time at a traffic signal. In this method, Traffic Light Control System to be designed based on the Vehicle density in VANET.

Keywords: VANET, Traffic Light, VANET Density, VANET Communication.

I. INTRODUCTION

Ever day the population has increased, based on the population, the number of vehicles also increased. Everybody travelling in cars and their own vehicles. In a recent survey, the global car sales in 2012 were 52.57 million it has been increased to 75.24 million in 2016. For these growths affect the environments. In this growth of the number of vehicles there is not much improvement in roadways. So that the traffic will be occurring and air will be polluted. To solve this problem the Intelligent Transport System (ITS) [1] has been introduced traffic management models. The traffic management model includes the Vechile detection, traffic surveillance, vehicle classification, vehicle sensor networks and advanced traffic management system.

The advanced traffic management system manages the traffic, especially on road junction points. At road junctions have more traffic and accidents appended. To avoid the accidents the traffic lights were implemented. In an earlier traffic management system was in manually, Now days many researchers have introduced an automatic traffic light system to avoid the traffic in urban areas.

Vehicular communication plays a major role in ITS. Vehicular communication is used to send the data’s like traffic information, accident alert messages, environment information and toll payment alerts from one vehicle to another. This communication process is made upon WAVE/ 802.11p device which attaches to all the vehicles [2]. Based on the communication the Vehicular model has been classified as Vehicle -to-Vehicle model, Vehicle-to-Infrastructure model and Hybrid model. In Vehicle -to-Infrastructure model is used for designing the Traffic Light Control System. Vehicle -to- Infrastructure model is sending the data from one vehicle to infrastructure, here the infrastructure as a traffic light. This system is used to collect the all information like vehicle density and emergency vehicle notifications. The Traffic light control system was designed based on the vehicle density and emergency vehicle alert messages.

In VANET the vehicles are communicating using IEEE-802.11p. Based on the communicating methods VANET has classified in three methods. There are Vehicle-to-Vehicle communication (V2V), Vehicle-to-Infrastructure (V2I) and Hybrid Communication[3]. To design the Traffic Light Control System the V2I communication method is used.

In four way junction the each signal post has attached to the communication device that is acting as infrastructure model. Using these devices we have to calculate the vehicle density and signal priority. In each vehicle has to send the location, vehicle id and direction. The infrastructure node to calculate the vehicle density based on this information.

The traffic signals are working based on the vehicle priority algorithm. This algorithm describes the priority levels for the traffic signal. This system has three priority levels, there are emergency vehicles, vehicle density and location information. Using the priority levels we compute the traffic light control system. In emergency vehicle priority level is to allow the vehicles such as ambulance, fire services and VIP vehicles immediately pass the signal. The vehicle density priority model has to give the priority maximum numbers of vehicle lane to allow the maximum time signal to pass the road and the small numbers of vehicle lane have small time intervals.

II. RELATED WORK

Last few years, many researchers have contributed to design the various traffic light control systems [4][5], these traffic lights are basically designed using following methodologies,

- Mathematical model
- Machine learning and Artificial Intelligence
- VANET Communication

Mathematical models:

The traffic lights are designed using the various mathematical methodologies like Markov process and

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Graph theory. A traffic light controller based upon the intersection of traffic dynamic and probability model to optimize the efficient traffic light controller. Here the probability model describes the Markov chain method to define the number of vehicles and road intersection points as a state to optimize the traffic dynamics.

Shiuan et al [6] proposed a Traffic light system using the Graph model. It is working based on the branch and bound model, Genetic algorithm, Practical swarm optimization method and Ant colony optimization algorithm to reduce the traffic waiting time for each vehicle. This system was demonstrated with Kaohsiung city map as a graph model to take the entire road segments as edges and also consider the neighboring traffic lights to design an efficient traffic controller.

Mirchandani et al[7] designed the RHODOES prototype model for traffic light system, It contains the two control systems to optimize traffic signals. The Intersection control system operates based on the dynamic programming model, it response to signal timing. Network flow control model is another model to observe the vehicle movements on road segments. The RHODOES model estimates the vehicle queue size, queue discharge time, turning point and travel time using the above control systems.

Stefan Lammer et al [8] proposed a self control of traffic lights, it is constructed using Optimization strategy. In this strategy given the higher priority, when the vehicles are passes during the green signals. This priority based scheduling to measure the queue length, the traffic light timing set upon the queue length. Where the queue length is stable, there is no change in the traffic model. If it is not stable then the traffic signal time to be altered. So that Lammer maintains the combined strategy for both optimization and stabilization models to reduce the waiting time for the vehicles.

Machine Learning and Artificial Intelligence:

Multi Agent Reinforcement Learning (MARL) model [9] and Synchronized Timed Petric Nets (STPN) Models [10] are designed based on the Machine Learning and Artificial Intelligence technologies. In MARL is calculating the traffic queue using the probabilistic methods. It takes the road intersections as a state, choose one vehicle as an agent and monitoring the other neighbor vehicles movements from one state to another finally finds the maximum expected queue length. MARL model measures the following things during the simulation, the number of vehicles, queue length, average link delay, average link stop time, average link travel time and CO2 emissions.

STPN model first analysis how many traffic lights are required, identify and define the phase transition, construct the STPN model and define master module for each phase after that select complex module to construct the traffic light control system for that module.

VANET Communication:

VANET communication is used to design an adaptive traffic light in various methodologies. In traffic light design, VANET communication is transferring the data from one traffic system to another traffic system. The communication was used at various routing methodologies. Maram Bani Younes et al[11], proposed an Intelligent traffic control algorithm to gather the real time traffic information to all signalized road intersections.

III. TRAFFIC LIGHT DESIGN

In four way junction the each signal post has attached to the communication device that is acting as infrastructure model. In this traffic system has to design using two computational methods. The first method is neighbor signal information and another method is current signal information. The signals are transmitted using the communication devices which are already used in VANET, like 802.11p or WAVE. The neighbor signal information is a first factor to calculation of current traffic signal timing. But the current traffic signal information is a leading factor. In each vehicle has to send the location, vehicle id and direction. The infrastructure node to calculate the vehicle density based on this information.

Vehicle Density Estimation:

Vehicle density estimation was determined in various methodologies uses the data fusion algorithms with GPS, to compute vehicle density based on messages from different sources. Cooperation between vehicles to measure the vehicle density. We are using the vehicle density estimation for each lane density. In this method the density was calculated using a message sent from the vehicle and uniform distribution mean was used to define a time interval for density calculation.

$$V(t)\frac{r+1}{L_L * L_n}$$

Where,
r-messaged vehicles,
L_L-Lane Length
L_n- Number of Lanes.

The traffic lights are sending the traffic information like vehicle density, emergency vehicle and lane information. In particular area (Traffic light surrounded area) the vehicle density has to measured, it is measured in each lane. Using this information we have to assume the average number of vehicles has to arrive in the next traffic signal. Sometimes, the emergency vehicles are coming to next traffic signal. When the emergency vehicles are moving to one traffic signal to another traffic signal the message to be transmitted to the next traffic signal. The traffic signals are already computing the travelling time from one traffic signal to next traffic signal. Based on this travelling time the traffic light automatically adopts the green signal for a particular lane, whose lane is having the emergency vehicle.

```
Precondition<Emergency vehicle id, lane information, vehicle density, neighbor traffic signal information>
Postcondition<Compute the traffic signal timing>
Begin
Neighbor signal ()
{
Measure the lane information
        Begin forloop
                Calculate each lane vehicle density
        End forloop
```

```
        Measure the emergency vehicle with lane id
        Sends the message to Current signal.
    }
    Current signal ()
    {
        Measure the current lane information
        Begin forloop
            Calculate each lane vehicle density
        End forloop
        Measure the emergency vehicle with lane id
        Get the neighbor signal information and compute the total priority level.
    }
    Signal Priority ()
    {
        Priority level 1:
            Emergency vehicle → Green signal
        Priority level 2:
            Compute the final vehicle density with current traffic signal with neighbor traffic signal

            Based on the vehicle density, assign the traffic signal timing.
    }
```

The traffic signals are working based on the vehicle priority algorithm. This algorithm describes the priority levels for the traffic signal. This system has two priority levels, there are emergency vehicles and vehicle density. Using the priority levels we compute the traffic light control system. In emergency vehicle priority level is to allow the vehicles such as ambulance, fire services and VIP vehicles immediately pass the signal. The vehicle density priority model has to give the priority maximum numbers of vehicle lane to allow the maximum time signal to pass the road and the small numbers of vehicle lane have small time intervals. Using this method the vehicle waiting time become reduced and the emission of CO_2 to be minimized.

IV. SIMULATION RESULTS

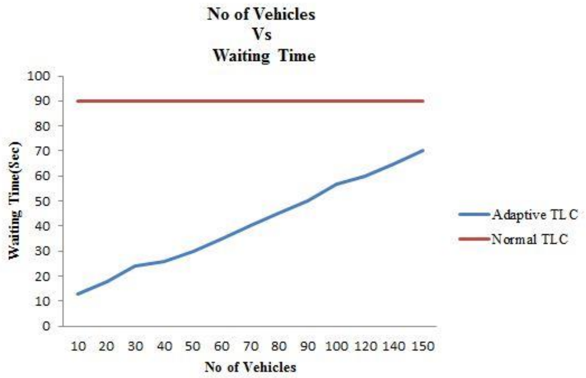
In proposed system, mainly focused on reducing the waiting time while vehicles are crossing a traffic signal and also avoid the accidents at road intersections. The Adaptive traffic control model was computed using SUMO (Simulation of Urban Mobility) and NS3 (Network Simulator). The SUMO is a simulation tool to create a VANET environment like real time manner. Using this tool, to create a vehicle's movement, emergency vehicles and traffic lights. NS3 is used to maintain the communication in between vehicles and traffic signal. The vehicles and traffic signals send the data using CLWPR (Cross-Layer, Weighted, Position-based Routing) Protocol in NS3. Table() shows the simulation parameters.

Parameters	Value
Simulation Time	360 Seconds
Number of Vehicles	700
Vehicle Communication Range	1000meters
Vehicle Speed	0-100Km/hr
Data packet Size	512 bytes
MAC Protocol	802.11p

Table 1:Simulation parameters

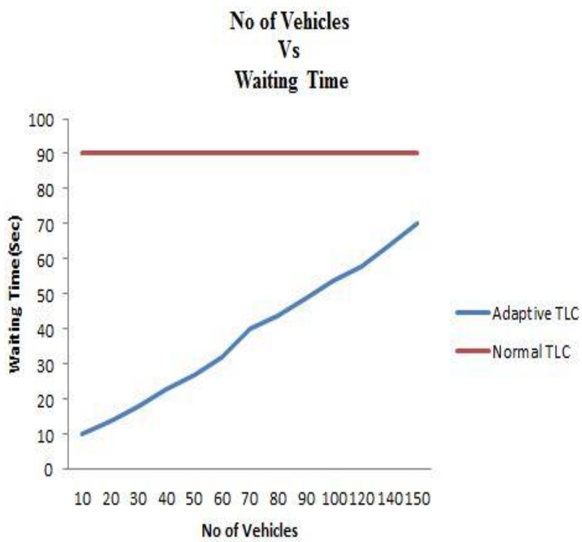
In this simulation results analysis the idle time of vehicle while crossing the signals. The simulations are done in two scenarios. The scenario 1 is to calculate the idle time within the range involved in the two traffic light system. The second scenario involved the three traffic lights in analysis the performance.

The scenario 1 taken two traffic signal systems, one traffic signal is act a current traffic signal and another one is a neighbor traffic signal .In this simulation results contain the each lane vehicle idle time to be analyzed. The simulation results are shown in figure (1).



Fig(1): Number vehicles Vs Waiting Time in Traffic signal

The scenario 2 taken three traffic signal systems, one traffic signal is act a current traffic signal and another two traffic signals are neighbor traffic signal. In this simulation results contain the each lane vehicle idle time to be analyzed. The simulation results are shown in figure (2).



Fig(2): Number vehicles Vs Waiting Time in Traffic signal

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CONCLUSION:

In this paper, mainly contribute the traffic light design based on the vehicle density. The traffic light was dynamically changing the waiting time (Red signal) based upon the priority algorithm and vehicle density. Simulation results compare the Normal traffic light control with Adaptive traffic light control. The results show each and every lane segment vehicle waiting time. Using this adaptive traffic light control system, the vehicles waiting time in traffic signals to be reduced.

REFFERENCES

1. www.itsindia.org
2. Weidong Xiang, Richardson, P, Jinhua Guo, • "Introduction and Preliminary Experimental Results of Wireless Access for Vehicular Environments (WAVE) Systems",. in Proc. 3rd Annual International Conference on Mobile and Ubiquitous Systems - Workshops, 2006,pp. 1-8.
3. Balasubramani, Deepalakshmi V. Karthikeyan L, "Comparative Study on Non-Delay Tolerant Routing Protocols in Vehicular Networks", Procedia Computer Science, vol. 50, pp. 252-257, 2015.
4. RyanFlorin, StephanOlariu "A survey of vehicular communications for traffic signal optimization" International Journal of Vehicular Communications, Vol:2,pp:70-79, 2015.
5. W. Lee, Y. Lai and P. Chen, "A Study on Energy Saving and CO2 Emission Reduction on Signal Countdown Extension by Vehicular Ad Hoc Networks," in IEEE Transactions on Vehicular Technology, vol. 64, no. 3, pp. 890-900, March 2015.
6. P. Mirchandani and Fei-Yue Wang, "RHODES to intelligent transportation systems," in IEEE Intelligent Systems, vol. 20, no. 1, pp. 10-15, Jan.-Feb. 2005.
7. Chen Shiuan-Wen, Yang Chang-Biau and Peng Yung-Hsing. Algorithms for the Traffic Light Setting Problem on the Graph Model.
8. Stefan Lämmer, Dirk Helbing "Self-control of traffic lights and vehicle flows in urban road networks", Journal of Statistical Mechanics: Theory and Experiment,Vol.4, April2008.
9. L. Bus¸oniu, R. Babuska, and B. De Schutter, "Multi-agent reinforcement learning: ˇ An overview," Chapter 7 in Innovations in Multi-Agent Systems and Applications – 1 (D. Srinivasan and L.C. Jain, eds.), vol. 310 of Studies in Computational Intelligence, Berlin, Germany: Springer, pp. 183–221, 2010.
10. Y. Huang, Y. Weng and M. Zhou, "Modular Design of Urban Traffic-Light Control Systems Based on synchronized Timed Petri Nets," in IEEE Transactions on Intelligent Transportation Systems, vol. 15, no. 2, pp. 530-539, April 2014.
11. M. Bani Younes and A. Boukerche, "An Intelligent Traffic Light scheduling algorithm through VANETs," 39th Annual IEEE Conference on Local Computer Networks Workshops, Edmonton, AB, 2014, pp. 637-642.

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