Algorithm to Manage Traffic Light Control to Prioritize Emergency Vehicles

Maheshkumar V. Makwana[1] Hitesh C. Patel[2]
[1]PG-Student [2]Assistant Professor
[1,2]Department of Information Technology
[1,2]Kalol Institute of Technology and Research Centre, Kalol

Abstract— Rapid increase in number of vehicles on the roads as well as growing size of cities have led to a plethora of challenges for road traffic management authorities such as traffic congestion, accidents and air pollution. This work focuses on the particular problem of traffic management for emergency services, for which a delay of few minutes may cause human lives risks as well as financial losses. The goal is to reduce the latency of emergency services for vehicles with minimum unnecessary disruption to the regular traffic, and preventing potential misuses. In this work, we propose STLO (Short Time Less Obstacles) algorithm, which itself describes to bring the patient in a short time to hospital by avoiding unnecessary or necessary stops/halts. Proposed system specially designed for an emergency vehicle, thereby introducing Application Unit (AU), messages passing and also by assigning a specified region or boundary. Whenever an emergency vehicle enters into specified area, the Application Unit detects presence of emergency vehicle. Emergency vehicle passes Vehicle ID, its direction related to traffic signal, average speed, and destination location to AU. Then AU passes massage to the traffic signal controller. Traffic signal control is already equipped with historical data and road patterns to calculate shortest path. Traffic signal turns the traffic light to green so that emergency vehicle passes through the traffic signal intersection. Pre-emption is active until the emergency vehicle passes through the intersection.

Key words: Vehicular Ad-hoc Network (VANET), Traffic lights, Emergency Vehicles, Application unit (AU), Vehicle to Infrastructure communication (V2I), MOVE, SUMO, NS2

I. INTRODUCTION AND MOTIVATION

The term VANET as an acronym for vehicular ad-hoc networks was originally adopted to reflect the ad-hoc nature of the highly dynamic networks. First, consider the opportunities. If vehicle can directly communicate with each other and infrastructure, a new paradigm for vehicle safety applications can be created. Other non-safety applications can greatly enhance road and vehicle efficiency. Second, further challenges are created by high vehicle speeds and highly dynamic operating environments. Third, new requirements include new expectations for high packet delivery rates and low packet latency. Further, customer acceptance and governmental oversight bring very high expectations of privacy and security [(1)]. Driving means constantly changing location. A very important category is driver assistance and car safety. Another category is infotainment for passengers [(2)]. VANET communication is based on two types. (1) Vehicle-to-Vehicle (V2V) communication, (2) Vehicle-to-Infrastructure (V2I) communication. In V2V communication, VANET communication can be done directly between vehicles as 'one-hop' communication, such as car-to-car communication. In V2I communication, VANET communication can be done between vehicles and road side infrastructure as 'multi-hop' communication.

Recently increasing the number of cars on city roads has created many problems, such as traffic congestion, the huge number of people who get killed in car accidents, fuel consumption, emissions, etc. Emergency vehicle such as police cars, fire trucks, and ambulances are special vehicle designated to respond to emergency. Thus, reaching their destination as fast as possible is their primary concern. Thus, reaching their destination as fast as possible is their primary concern. Due to traffic congestion, emergency vehicles response time increases. Emergency vehicles should be able to respond to emergency calls for an incident with minimum delay. So we motive and avoid this problem by prioritizing emergency vehicles at the traffic signal intersection.

The rest of the paper is organized as follows: Literature Review is written in Section 2. The proposed algorithm in section 3. Section 4 describes the simulation environment and presents the experiment results. In Section 5 conclusion and future work is illustrated.

II. LITERATURE REVIEW

K. Udhayakumar, S.V. Manisekaran and R. RamKumar represent a paper on A Smart Traffic Management System using the Spatio-Temporal Relationships for an Emergency Vehicle [(3)]. This paper uses the sensor node to detect the presence of emergency vehicle. Whenever emergency vehicle enters into specific area, sensor detects the emergency vehicle and pass message to the traffic signal intersection to turn traffic light to green so that emergency vehicle pass through intersection. Soufiene Djahel, Mazeiar Salehie, Irina Tal and Pooyan Jamshidi represent a paper on Adaptive Traffic Management for Secure and Efficient Services in Smart Cities[(4)]. In this paper adaptive TMS is choosen. TMS consists of set of Traffic Management Controller (TMC) each of them controls and manages traffic in given area. TMC requests the corresponding authority to authenticate the vehicle. Once the emergency vehicle identity is authenticated and its emergency level is confirmed, driving policies should be approved by the road network authority. Finally, the TMC should provide to the emergency vehicle the best route to speed up its access to the emergency area. This route must be updated during the vehicle journey. Hamed Noori represents a paper on Modeling the Impact of VANET-Enabled Traffic Light Control on the Response Time of Emergency Vehicles in Large-Scale Urban Area [(5)]. This paper deals with decreasing the response time of the emergency cars by using communication between emergency cars and traffic lights. It

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uses beaconing concept for this purpose. Fang-Yie Leu, Miao-Heng Chen, Yi-Li Haung and Chung-Chi Lin represent a paper on Controlling Traffic Lights for Ambulances [6]. In this paper Ambulance Traffic Control System (ATCS) use in which when accident occurs, RTA searches the most suitable ambulance; compute the shortest path from the current location of the ambulance and controls traffic lights on the path so that the ambulance can rush to the accident scene. Wantanee Viriyasitavat and Ozan K. Tonguz represent a paper on Priority Management of Emergency Vehicles at Intersections Using Self-organized Traffic Control [7]. This paper uses the VTL-PIC (Virtual Traffic Light- Priority Intersection Control) protocol to detect the presence of an emergency vehicle and assign priority to the emergency vehicle at the intersection. Yi-Shun Weng, Yi-Sheng Huang, Shun-Feng Su and Chi-Shan Yu represent a paper on Modeling of Emergency Vehicle Preemption Systems Using Statecharts [8]. This paper focuses on the use of statecharts to model the preemption of emergency vehicles system. The advantage of the proposed approach is the clear presentation of traffic lights' behaviors in terms of conditions and events that cause the preemption phase. This paper also proposes a new emergency vehicle preemption policy that provides the emergency vehicles can pass through the intersections with minimal delay.

III. PROPOSED ALGORITHM

A. *Assumptions*

- AU is held at 2km away from the traffic signal intersection.
- Traffic signal (Green/Yellow/Red) will be scheduled by seconds like 70/90/120 Sec respectively.

B. *Control Parameters.*

- EV's Direction related to the traffic signal
- Average speed of EV
- Vehicle ID
- Destination location & distance

C. *Constraints*

- $T_{curwait}$ = current waiting time on one intersection
- T_{wait} = Total waiting time on one intersection
- T_{next} = Average waiting time on next intersection
- T_{tot} = Total time from next intersection to the destination
- D_{cd} = Distance from current node to destination
- Z = Average speed of vehicle
- T_{sn} = Shortest time on the next node

D. *Control Flow Diagram*

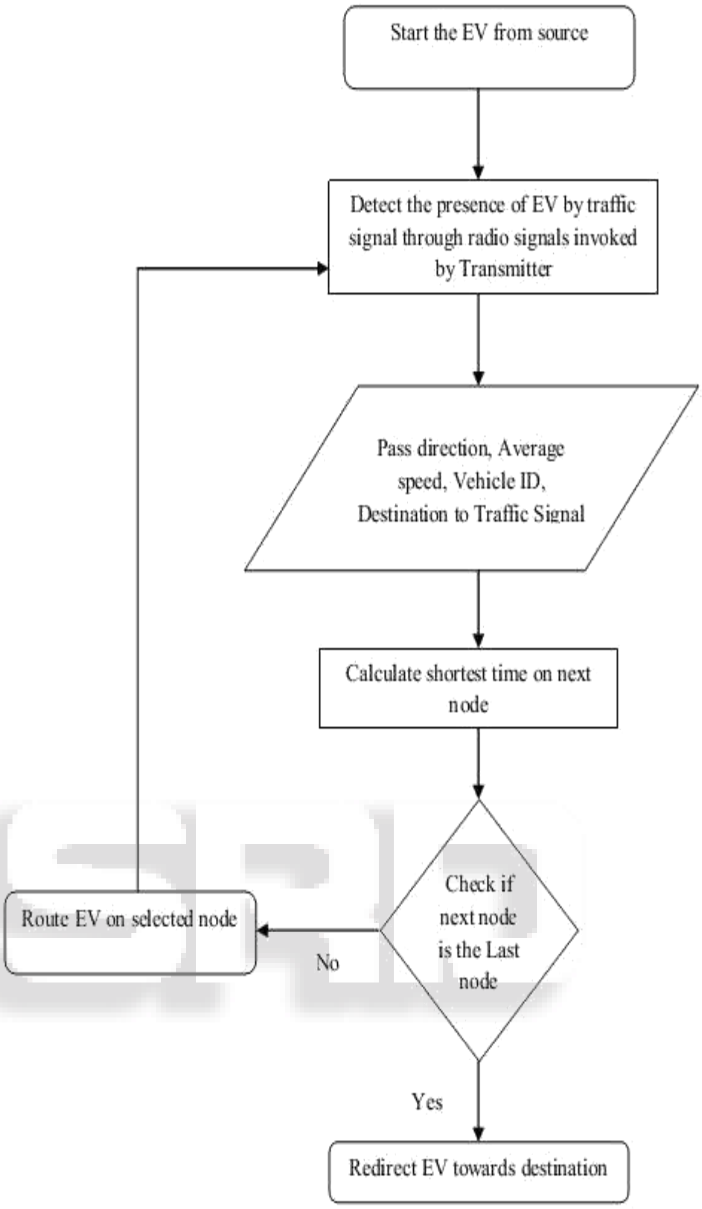

Fig. 1: Control Flow Diagram

In metropolitan city traffic is a terrific problem and sometimes it is really difficult to carry the patients to destination in a quick time. To overcome this situation we can implement STLO (Short Time Less Obstacles) algorithm, which itself describes to bring the patient in a short time to hospital by avoiding unnecessary or necessary stops/halts. Start the emergency vehicle from the source. The presence of Emergency Vehicle is detected by application unit & Emergency Vehicle passes Vehicle ID, its direction related to traffic signal, its average speed, and its destination location to the AU. AU then passes massage to the Traffic Signal Controller. Then we calculate the shortest time on next node. After that we check if next node is the last node. If no, then route the emergency vehicle on selected node. Otherwise redirect emergency vehicle towards the destination. Traffic signal control is already equipped with historical data and road patterns to calculate shortest path.

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Based on the data, algorithm will be working step by step.

1) *Step 1*

Start the Emergency Vehicle (EV) from source.

2) *Step 2*

Detect the presence of EV by Application Unit (AU) and Give the Vehicle ID, Direction to the traffic signal, Average speed, and Destination to the AU.

3) *Step 3*

Application Unit (AU) then passes massage to the Traffic Signal Controller.

4) *Step 4*

Route the vehicle to the node from which the lowest time will be taken to reach the destination.

(1) Current waiting time will be half.
$T_{curwait} = T_{wait}/2$

(2) At the same time the parameters provided by Emergency Vehicle will be passed to next nodes of traffic signal by current traffic signal.

(3) On each next traffic signal $\mathbf{T_{tot}}$ will be calculated.

For every traffic intersection:

$T_{tot} = T_{next} + (D_{cd} / Z)$

Lowest Ttot will be considered as shortest time on the next node,

T_{sn} = Lowest T_{tot}

5) *Step 5*

Check if next node is the last node. If true redirect emergency vehicle towards the destination, else route the emergency vehicle on selected node and go to step 2.

Last node will be calculated on base of following condition,

$T_{last} = 0$
// Find the next traffic node from current node
while (next node exists) {
if ($D_{cd} < x$)
{
Current node = last node;
$T_{last} = 1$;
break;
}
}

Here,

Distance between two traffic signal intersection = x meters

IV. Simulation and Results

We use simulation tools like MOVE, SUMO and NS-2 to perform simulation. MOVE is implemented in Java and runs on top of an open source traffic simulator SUMO. "Simulation of Urban Mobility (SUMO)" is an open source, microscopic, multi-modal traffic simulation. It allows to simulate how a given traffic demand which consists of single vehicles moves through a given road network. NS-2 is an object oriented simulator written in C++ with an OTcl interpreter as a frontend. The simulator supports a class hierarchy in C++, and a similar class hierarchy within the OTcl interpreter. Table 1 shows the simulation parameters. Fig. 2 shows the movements of vehicle on the road. Fig. 3 indicates that massage from emergency vehicle can be passed to the traffic signal intersection. And once the massage was received by traffic signal intersection, it assign priority to the emergency vehicle.

Parameter	Value
Street's Length	5 km.
Number of vehicle	80
Interface	Wireless Interface
Transmission Range	300 m.
Vehicle Speed	5 m/s
Lane	2

Table 1: Simulation Environment

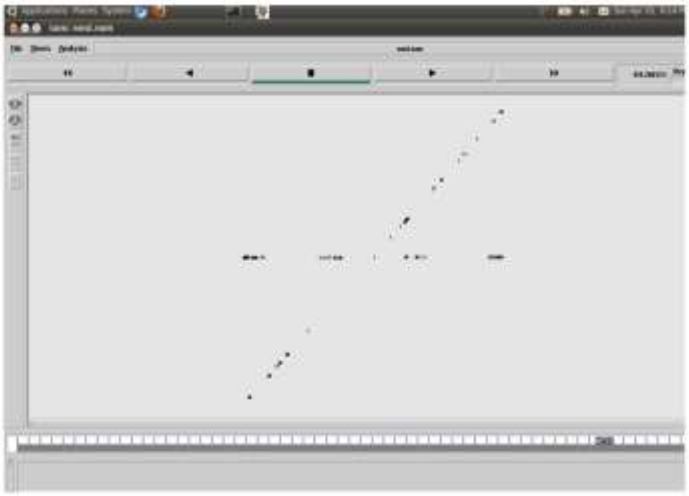

Fig. 2: Vehicle Movements

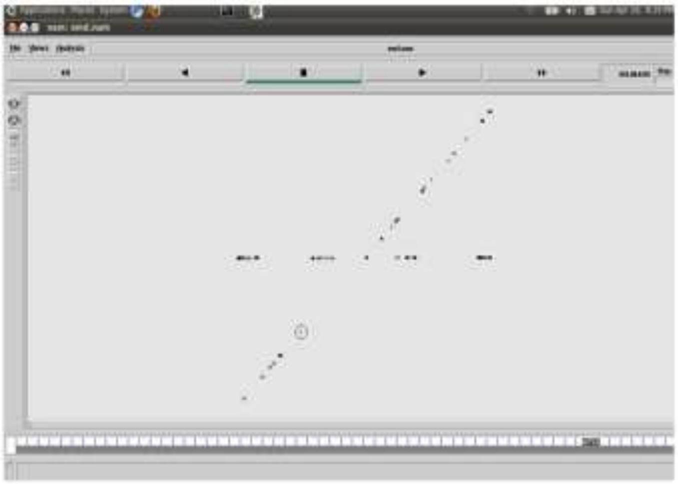

Fig. 3: Massage Passing to the Traffic Signal Intersection

Fig. 4 shows STLO Algorithm with Best Case. Emergency vehicle takes approximately 25 minutes while Emergency vehicle with STLO algorithm takes 16-17 minutes for reaching to destination. It indicates that up to 32% performance effected.

Fig. 5 shows STLO Algorithm with Worst Case where traffic is too much. In Worst case STLO algorithm takes 19-20 minutes for reaching to destination. It indicates that up to 24% performance effected. STLO Algorithm Worst case degrades up to 8-10 % performance in comparison to Best case.

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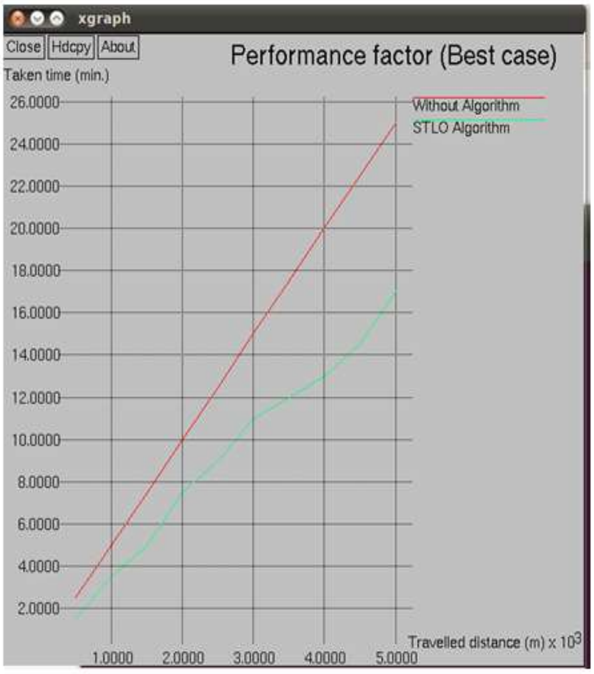

Fig. 4: STLO Algorithm with Best Case

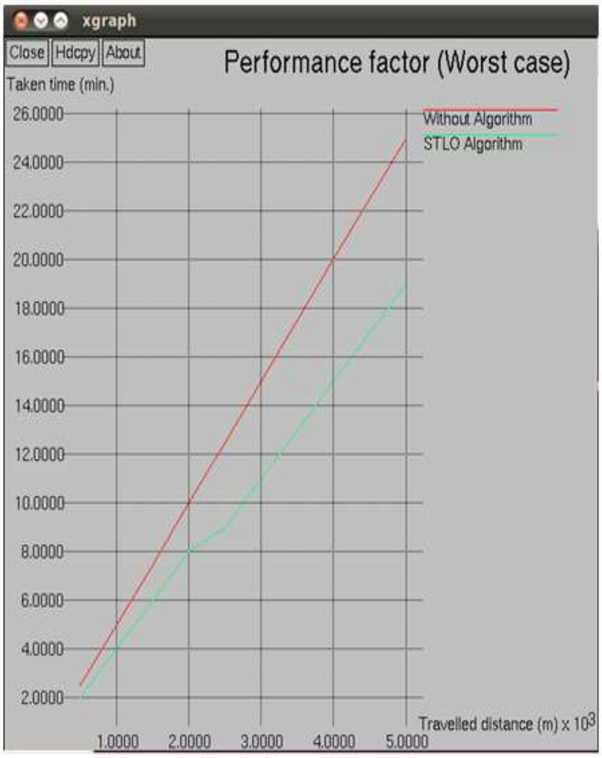

Fig. 5: STLO Algorithm with Worst Case

V. Conclusion and Future Work

From the above studies we conclude that the Proposed System helps in decreasing the response time of emergency vehicle, minimizing traffic jam and reducing the fuel consumption and emission. Message passing between vehicles to traffic signals and in-between traffic signals should be improved in such a way that less times should be taken to pass the messages. Thus, Proposed System will help us to prioritize emergency vehicle at the traffic signal intersection.

In the future, if more than one emergency vehicle is coming from different roads towards same traffic signal in that case, we try that the node which has more emergency vehicles should be prioritizing first.

Acknowledgment

The accomplishment of this work is not only due to my efforts. In fact, I stand on the shoulders of many people. So, with great pleasure I take this opportunity to express my gratitude towards all the individuals who have helped and inspired me in my work. I would like to thank my family as well, for their continuous support and encouragement. I would like to express my gratitude towards my guide for his kind co-operation and encouragement which helped me to understand the vast topic of Vehicular Ad-hoc Network's.

Reference

[1] Hannes Hartenstein and Kenneth P Laberteaux, VANET: Vehicular Applications and Inter-Networking Technologies, A John Wiley and Sons, Ltd, Publication.
[2] Rainer Baumann, Master's Thesis in Computer Science, "Vehicular Ad hoc Networks (VANET)", ETH Zurich 2004.
[3] K. Udhayakumar, S.V. Manisekaran, R. RamKumar, "A Smart Traffic Management System using the Spatio-Temporal Relationships for an Emergency Vehicle", IJARCST 2014, PP 178-183.
[4] Soufiene Djahel, Mazeiar Salehie, Irina Tal and Pooyan Jamshidi, "Adaptive Traffic Management for Secure and Efficient Services in Smart Cities", IEEE , March 2013, PP 340-343.
[5] Hamed Noori, "Modeling the Impact of VANET-Enabled Traffic Light Control on the Response Time of Emergency Vehicles in Large-Scale Urban Area", IEEE, International Conference on Communications 2013, PP 526-531.
[6] Fang-Yie Leu, Miao-Heng Chen, Yi-Li Haung, Chung-Chi Lin, " Controlling Traffic Lights for Ambulances", IEEE, Seventh International Conference on Communication 2012, PP 462-467.
[7] Wantanee Viriyasitavat and Ozan K. Tonguz, "Priority Management of Emergency Vehicles at Intersections Using Self-organized Traffic Control", IEEE, 2012.
[8] Yi-Shun Weng, Yi-Sheng Huang, Shun-Feng Su, Chi-Shan Yu, "Modeling of Emergency Vehicle Preemption Systems Using Statecharts", IEEE 2011, PP 556-561.
[9] S.Kwatirayo, J.Almhana, Z.Liu, "Adaptive Traffic Light Control using VANET-A case study", IEEE 2013, PP 752-757.
[10] Maythem Kamal Abbas, Mohammad Noh Karsiti, Madzlan Napiah, Brahim B. Samir, "Traffic Light Control via VANET System Architecture", IEEE 2011, PP 174-179.
[11] N.Maslekar, M.Boussedjra, J.Mouzna, H.Labiod, "VANET based Adaptive Traffic Signal Control", IEEE 2011.
[12] Jeff R. Bycraft, "Green Light Pre-emption of Traffic Signals for Emergency Vehicles"
[13] Vaishali D. Khairnar, Dr. S.N.Pradhan, "Mobility Models for Vehicular Ad-hoc Network Simulation", International Journal of Computer Applications (0975 – 8887), Volume 11– No.4, December 2010.s

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