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An Intelligent V2V Communication Based Traffic Control System

Miss. Sadaf A. Shaikh [1], Prof. L.M.R.J. Lobo [2]

Student, Master of Engineering, Dept of Computer Science and Engineering, Walchand Institute of Technology, Solapur, Maharashtra,India[1]

Associate Professor, Dept of Computer Science and Engineering, Walchand Institute of Technology, Solapur, Maharashtra, India[2]

Abstract: Vehicular Ad-Hoc Networks (VANETs) technology is the most promising technology to increase traffic security and proficiency, and to enable various other related applications in the domain of vehicular communication. Applications using VANETs have diverse properties. Applications such as clearance to emergency vehicles (e.g. Ambulance, Fire Trucks), Vehicle-to-Vehicle (V2V) Communication is important to properly manage traffic situations. Using V2V communication, warns a driver about instances like crash, before it happens .This takes into account distance between each vehicle and speed adjustment for avoiding collision and better traffic flow has been developed. Based on experiments conducted it is found that the efficiency of HardBrake Vehicle System is 57.13% more than Smart Vehicle System and accuracy is found to be 21.6% more than Smart Vehicle System. These applications are classic models of what we call an Intelligent Transportation System (ITS) which aims to enhance security and efficiency in road transport using new technologies for information and communication. VANETs target to offer a high data rate and at the same time minimize latency within a small communication zone.

Keywords: Ad hoc network, communication, Traffic Control, Vehicles, Vehicle Safety.

I. INTRODUCTION

India is a highly populated country and the fastest growing economy in the world. It is experiencing awful road congestion problem in its cities [13]. Around million people are killed every year in road accidents. Road traffic safety has been an interesting problem in traffic management. One possible way is to deliver the traffic information to the vehicles to analyse the traffic situation. It can be accomplished by exchanging the information of traffic state amongst vehicles.

All the vehicles are traveling into a versatile environment, hence a mobile network is needed which can be self-organized and capable in operating without infrastructure support. With the evolvement of microelectronics, it becomes possible to add nodes and network devices into single units and wireless interconnection, i.e. an ad-hoc network. Additionally this network is evolved as mobile ad hoc network. MANET is composed of groups of self-organized wireless stations without a need to exploit any preinstalled infrastructure Vehicular ad-hoc networks (vanets) are a sensational and growing field of study.
The existence of such networks opens the way for a wide range of applications. Two of the most important classes of applications are those associated with route planning and traffic safety. Route planning aims to provide real-time traffic information to drivers, which in the absence of a VANET, would require an expensive infrastructure. But the VANET approach is scalable and cost effective.

Safety applications involve broadcasting vital information, which is missing from driver's sight, or it is difficult to notice for reasons such as fog or other vehicles blocking headway. A lot of accidents happen in foggy conditions because drivers could not notice the traffic in front of them. Safety at intersections could also be increased, since the risk of collisions could be spotted in advance and the driver could be warned seconds before accident happens.

The evaluation of VANET protocols and applications could be made through real outside experiments, which are time costly and claim for a large number of resources in order to obtain significant results. Instead there are many possibilities of using ad-hoc communication between vehicles for information dissemination, safety, or even entertainment. These likelihoods, driven in the United States by the Department of Transportation, Intellidrive initiatives, have launched many different lines of research. Due to the budget of vehicles and equipment, nearly all of this research has been done using simulation. However, the current collection of simulators widely available either wholly splits the vehicle and network stages of the simulation or overgeneralizes either the vehicle or networking simulation. The German Aerospace Centre (DLR) ongoing the development of the open source traffic simulation suite SUMO back in 2001. Since then SUMO has progressed into a full featured suite of traffic modelling utilities including a road network capable to read different source formats, demand

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generation and routing utilities from various input sources (origin destination matrices, traffic counts, etc.), a high performance simulation usable for single junctions as well as whole cities including a "remote control" interface (traci) to adapt the simulation online. SUMO is not only a traffic simulation, but rather a suite of applications which help to implement the simulation of traffic. As the traffic simulation "sumo" needs the representation of road networks and traffic to simulate in an own format, both have to be imported or generated using different sources[10]. After experimentation it is verified that the efficiency of developed hardbrake system is 57.13% more than and the accuracy of the system is increased by 21.6% as compared to Smart vehicle system mentioned in existing literature.

II. LITERATURE SURVEY

After the survey it was identified that traffic congestion is a main problem in cities of developing countries like India. Evolution in urban population and the middle class sector contribute ominously to the rising number of vehicles in the cities [1]. Congestion on roads eventually results in slow moving traffic, which escalate the time of travel, thus stands out as one of the key issues in metropolitan cities. In [3] an intelligent traffic control system to pass emergency vehicles smoothly is developed. Each individual vehicle is equipped with distinct radio frequency identification (RFID) tag (placed at a strategic location), which makes it difficult to remove or destroy.
Md. Abdus Samad Kamal,Junichi Imura, Tomohisa Hayakawa [2] worked on a vehicle driving system in a model analytical control structure that efficiently improves traffic flow is presented. The vehicle driving system regulates safe inter vehicle distance under the bounded driving turning condition by predicting the preceding traffic. It also focuses on improving the effect of braking on the vehicles that follow. Traffic is a perilous issue of transportation system in most of the cities of various countries. In [4] the use of RFID traffic control to avoid problems that usually arise with standard traffic control systems is presented, specifically those related to image processing and beam interruption techniques are discussed. This RFID technique deals with multivehicle, multilane, multi road junction areas. It provides an efficient time management scheme, in which, a dynamic time schedule is worked out in real time for the passage of each traffic column.
Michael R. Hafner, Drew Cunningham, Lorenzo Caminiti, and Domitilla Del Vecchio [5] worked on vehicle-to-vehicle (V2V) communication technology to implement computationally efficient decentralized algorithms for two-vehicle cooperative collision avoidance at intersections. Vehicular Ad hoc Networks (VANETs) are the promising approach to provide safety and other applications to the drivers as well as passengers. It becomes a key component of the intelligent transport system. A lot of works have been done towards it but security in VANET got less attention. In [6], we are introduced to VANET and its technical and security challenges. We also are introduced to some major attacks and solutions that can be implemented against these attacks. They have compared the solution using different parameters. Nafi, N.S.Khan, R.H[7] Presented a predictive road traffic management system (PRTMS) based on the Vehicular Ad-hoc Network (VANET) architecture. The proposed PRTMS uses a novel communications scheme to estimate the future traffic intensities at different intersections based on a modified linear prediction algorithm. Based on the prediction, a central controller reduces the congestion level by rerouting the vehicles and adaptively changing the signalling cycles. In [8] they collect envisioned application from various sources and classify the unique network characteristics of vehicular networks. Based on this analysis they propose distinct communication patterns that form the basis of almost all VANET Applications. Communication patterns like Beaconing, Geobroadcast, Unicast Routing, Advanced Information Dissemination, and Information Aggregation out of these communication patterns using geobroadcasting and information aggregation are dealt with.

Michael Behrisch, Laura Bieker, Jakob Erdmann, Danniel Krajzewicz [9] developed a client to make SUMO and NS3 work parallel by TraCI (Traffic Control Interface) in NS3. It helps NS3 get SUMO's information and sends instructions to change the states of vehicles and traffic lights. They present a realistic road traffic model with kinds of vehicles and intelligent traffic lights. The model is built in SUMO (Simulation of Urban Mobility). We use Open Street Map to generate a realistic map near the bund in Shanghai. The traffic flow is built according to a survey which makes us get meaningful and reliable statistics. A mechanism of changing the traffic lights dynamically is introduced to minimize traffic jams and give high priority to emergency vehicle. In 11] we studied about SUMO simulator i.e. how to install it, basic needs to run simulators, also studied about how to build network. After this we decided to use SUMO simulators as platform.

III.METHODOLOGY

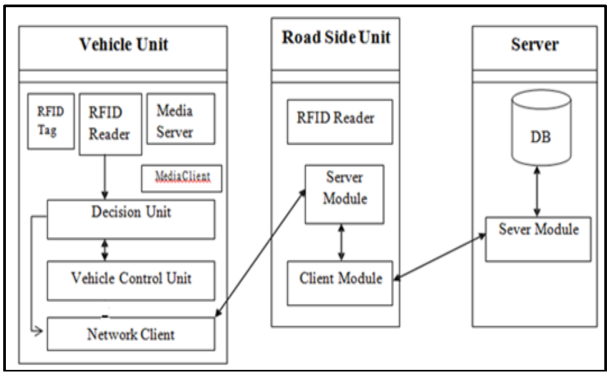

Fig 1: System Architecture of Proposed Concept

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The block diagram of the proposed methodology to be used is explained in Fig1 above.

Vehicle Unit

Vehicle Unit is a device usually mounted in a vehicle used for exchanging information with Road side units and other Vehicle units. It Consist of RFID Tag, RFID Reader Media Server Media Client, Decision Unit,
Vehicle Control Unit, Network Client. RFID Reader is used to read RFID signals these signals send to the decision unit to take the decision according to that Vehicle will perform the action. This information will be shared with Road side unit through Network client. It also includes Media Server and Media Client for entertainment purpose egg to watch YouTube videos, Google Map etc. The main function of Vehicle Units is wireless radio access, ad-hoc and geographical routing, network congestion control, reliable message transfer, data security and IP mobility.

Road Side Unit

The RSU is a wave device usually fixed along the road or in dedicated locations Such as at junctions, at Traffic signal, or near parking spaces dedicated for short range communication based on IEEE 802.11p radio technology, and can also be equipped with Infrastructure Network. Main function of RSU is 1) Extend the Communication Range 2)Providing Safety application such as accident warning 3)Provide internet connectivity to Vehicle Units.

Server Unit

Server contains a database (memory database) and a Server Module. It will store RFID Tags of Each vehicle. This also helps to track the stolen vehicle. Server module fulfils the request coming through Client Module from a road side unit.

1] V2V Communication:

This implemented work describes an intelligent V2V-based traffic management system. The goal is to coordinate traffic in limited urban cities, in which different driving scenarios can coexist. All Vehicles are in charge of assessing the traffic conditions to prevent collisions well in advance and improve traffic flow. To this end, a Driving state indicator representing a trade-off between safety and fluidity in driving is sent to the drivers with a recommended action to adjust the vehicle's direction and speed toward an optimal state. Given the key role that communications play for the operation of this system, an evaluation of their requirements was carried out. The performance of the V2V communication system was tested in SUMO simulator.
Each vehicle start communicates with other vehicles when vehicle enters in its communication zone. Each vehicle is capable of receiving all information and analyses the information coming from the other vehicles to send each driver information about how they are driving and an alert and recommended action to avoid any critical situation. Vehicle control unit (in Fig.1) is responsible for determining the Driving state on the basis of the vehicle's location, direction, speed, and the road layout.
The whole communication is done by exchanging packets between vehicles. A Packet contains all information related to the vehicle such as, vehicle speed, vehicle angle, distance form current vehicle to neighbour vehicles, type of Vehicle, lane in formation etc. This Packet has a specific data structure.

Data Structure of Packet:

TABLE –I Communication Packet Data Structure

Vehicle-to-Vehicle	
Field	Type(Size)
Vehicle ID	Short(2B)
Vehicle Speed	Double(8B)
Vehicle Angle	Double(8B)
Vehicle Type ID	Short(2B)
Lane Index	Integer(4B)
Warning Message	Short(2B)
Vehicle Position	Double(8B)
Reserved	X(6B)

Table I lists the fields to send and their sizes. This Packet is exchanged among vehicles .The fields considered correspond to an identification number for each kind of vehicle, vehicle angle, vehicle speed, vehicle position ,warning message, and a space reserved for future variables that may be interesting to transmit, e.g., the vehicle's intentions. Once this information is received at the Vehicle Unit, it will be forwarded to the vehicle control unit to pass on to the decision unit. The decision unit (see Fig. 1) uses this information and takes the decision according to the situation and gives warning to a driver to avoid collisions or improve traffic flow.
Once the information is exchanged successfully between vehicles, following problems have been tackled at the designation and this helps to diminish the traffic congestion.

1) When crash is predicted the vehicle will provide warning to driver. Driver must remain in control all the time.
2) When vehicle with highest priority like Emergency Vehicle (e.g. Ambulance, Fire Trucks) detects coming in same lane. All the vehicles should provide the smooth or clear way by moving to other lane if possible.
3) Automatic speed control when hard breaking vehicle detected.
4) When a driver intends to change lanes into a zone that will soon be occupied by a faster moving vehicle traveling in the same direction, using this V2V communication our vehicle will predict that and gives the warning NOT Safe message to a driver to change the Lane.

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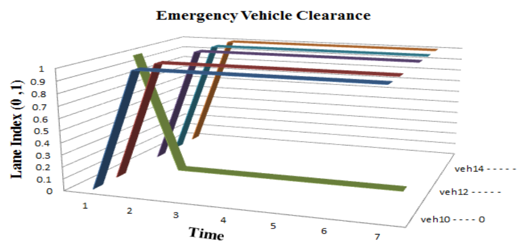
5) Warning is provided to a driver if it is unsafe to enter into the intersection and maintain the safe distance among themselves to avoid the crash at intersection.

IV. EXPERIMENTAL SETUP AND RESULTS

The System is developed using Java platform and SUMO simulator .SUMO simulator is an open source traffic simulator .It uses TraCI(Traffic Control Interface)for Java implementation. TraCI gives the access to a running road traffic simulation, it allows retrieving values of simulated objects and to manipulate their behaviour "on-line".TraCI4J is the Java implementation of TraCI.

Experiment 1:-Emergency Vehicle Clearance:
The implemented emergency vehicle clearance is evaluated in this section.While implementing this concept we have given the specific VehicleTypeID for emergency Vehcile.When Emergency vehicle #Veh 12 arrives in the communication zone of other vehicles ,immediatly all the preceding vehicles of the Emergency vehicle will change their lane and provide the clearance to that emergency vehicle.Peroformance of the vehicle on appearance of Emergeny vehicle is shown in following Fig.2. Here LaneIndex and the Time is given as an input to form a graph.



	1	2	3	4	5	6	7
veh10 - - - - 0	0	1	1	1	1	1	1
veh11 - - - - 0	0	1	1	1	1	1	1
veh12 - - - - -	1	0	0	0	0	0	0
veh13 - - - - -	0	1	1	1	1	1	1
veh14 - - - - -	0	1	1	1	1	1	1
veh15 - - - - -	0	1	1	1	1	1	1

(a)

(b)

Fig.2. Performance of vehicles on appearance of Emergency Vehicle i.e #Veh12 a) Graphical presentation of how vehicles change their lane when Emergency Vehicle (#Veh12) Arrived b) Result of same in SUMO simulator

In Fig.2 a) Shows graph which is derived from table values .This gaph Shows Lane index (0,1)of vehicles and emergency vehicle, with respective time in seconds.Veh12 is the emergency Vehicle in a graph. As the communication is omnidiretcional, so preceding vehicles and following vehicles of emergency vehicle will get the signal of emergency vehice.In this graph we can see when emergency vehicle at time 2sec enters in to lane-'0' the all other vehicles change their lane to '1' and provide the clearance to that emergency vehicle. The graph having only 2D values but shown in 3D graphical format because with 2D graph display we can not get the proper display of lane index .

Fig.2.b) Shows these results in simulator.As we are using SUMO simulator for testing .In this figure the purpule color vehicle is the emergency vehicle. when that vehicle arrives in the communication zone of Veh 10 and Veh 11 both changed their lane an allows the emegency vehicle to pass ahead.

Experiment 2:-Hardbrake Vehicle:
The proposed HardBrake vehicle concept is implemented in this section. Imagine a situation when three vehicles are driving in same lane and we are driving in third vehicle, we can't see the first vehicle because it is blocked by the vehicle directly in front of us. So as we are using V2V communication because of it our vehicle aware about HardBrake Vehicle. Here Hardbrake vehicle's speed suddenly reduces to 0.

The HardBrake Vehicle warning will lets the driver know that there is vehicle that is stopped or hardbraked and may not be visible positioned . As it provides warning ahead of time so that you can safely slow our vehicle before reaching the stopped vehicle ahead. Due to this hardbrake vehicle all the following vehicles speed should not affects so much in dense traffic.

In [2] when the current vehicle speed gets reduced; It will badly effects on the all following vehicle's speed up to 15th following vehicle. So due to this; unnecessary delay for following vehicles will happen. As they don't provide V2V communication so that each vehicle will not directly get the signal from hardbrake vehicle; instead they have to predict the situation from the preceding Vehicle.

See Fig.3 we have implemented this concept such that all the following vehicles of hardbrakes vehicle will not affects their speed and which will not leads to the collision. Here Speed (km/h) and Time(s) is given as input.

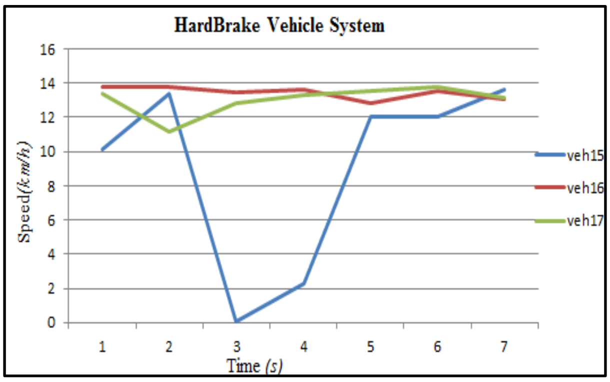


Fig.3.(a)

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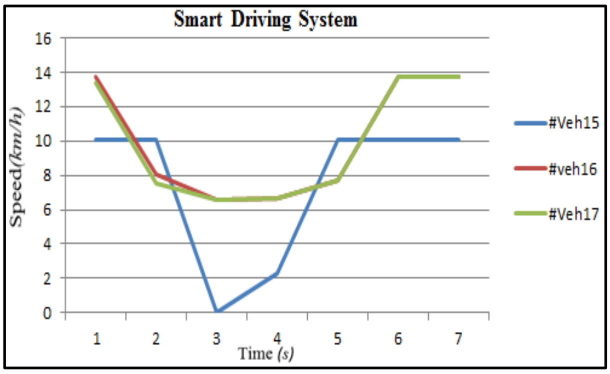

Fig.3(b)

Fig.3(a) and (b)Shows performance of vehicles for two systems when HardBrake vehicle is detected in traffic

Fig.3.a) Graph shows when vehicle Veh15 hard braked. All the following vehicles i.e. Veh16 a Veh17 will slightly reduce their speed without any large reduction in speed. Here speed of immediate two following vehicles will not affected so much that means third following vehicles will not affected by this it will continue to drive with its speed, so from above charts we got efficiency 57.13 % more than Smart Driving System.

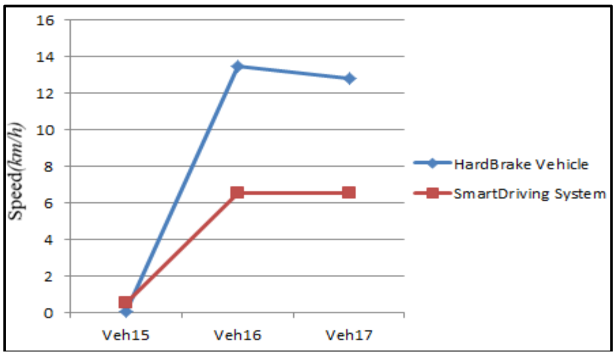

Fig.4

Fig4. Shows accuracy with respect to time and speed. Hardbrake vehicle System using the V2V communication so that we get immediate response from the vehicles instead of relying on preceding vehicle's behavior. So here HardBrake methodology is 21.6% more accurate than Smart Driving System.

Experiment 3:-Provide Warning

In this section we examine the conditions of safe lane changing and Intersection movement Assist and provide the alert to the driver. Lane change warning is a safety application intended to provide a warning if driver intends to change lanes into zones that will soon be occupied by faster moving vehicle in the same direction. As we send the packets for communication between vehicles .Those Packets contains all information regarding neighbour vehicles Using the data obtained by V2V communication, current vehicle predicts that neighbour vehicle will soon be in this zone by calculating the angle and distance between current vehicle and nearest vehicle .If neighbour vehicle attempt to make a lane change; the warning will be provided; letting neighbour vehicle know that the lane change should not be attempted.

This decision will be taken by the Decision Unit of Vehicle Unit. When vehicle unit receives the information, immediately Vehicle Control Unit start calculating the angle and distance between them, and forward the results to the Decision Unit then decision will be taken as per the results.

Calculations performed by Vehicle Control Unit.

$$nv = atan2(x, y) \qquad (1)$$

nv is the nearest vehicle angle calculated by arctangent function between current vehicle's & nearest vehicle's X,Y coordinates of their position.
The angle between current vehicle and nearest vehicle is calculated as follows

$$C = nv - (\alpha - 90) \qquad (2)$$

$$C = (C\%360) - 360 \quad \text{if } C > 180 \qquad (3)$$

Where α : is the current vehicle angle.
C : is the angle between current vehicle and neighbor vehicle.

According to the value of 'C' Decision Unit will take the decision and send the warning of "DO NOT CHANGE LANE" will be sent to the driver.
Intersection crash avoidance is safety application intended to warn driver when it is not safe to enter in the intersection because of high likelihood of crash with a vehicle on an adjacent approach to the same intersection from left or the right .If the intersection vehicle is detected using V2V communication driver warning is provided if it is unsafe for vehicle to enter the intersection.

Here also Decision Unit uses above equations (1),(2),(3). With these three calculations; distance is also measured between vehicles to avoid crash and maintain safe distance between them.
Distance is calculated as follows.

$$d = x^2 + y^2$$

Where d: is the distance between current vehicle and neighbour vehicle.
x,y : values that are used in equation (1)
This is how intelligent traffic control system ismplemented to diminish road accidents.

Table 2. Results of experiment 3.Angle and Distance are the input for these results.

Condition	**Results**
$C \leq 30$ and $C \geq -30$ and $d \leq 50$	WARNING(e.g. Slowdown, Do Not Change Lane)

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Table.2. Shows the condition when warning message sent to driver to alert about Speed Control, Not safe to change Lane, Intersection crash warning.

V. CONCLUSION

The implemented system aimed to acquire intelligent control over traffic and as vehicle having automotive control over it by emergency speed control, warn before lane change, keep safe distance, etc. it diminishes the roadside accident, providing clearance to an emergency vehicle. The emergency vehicle like an ambulance, fire trucks, needs to reach their destination at the earliest time. If they spend a lot of time in traffic jams, precious lives of many people may be at stake. Providing Warnings to a vehicle when it tries to change the same lane which soon will be occupied by the other vehicle. Maintaining of safe distance among vehicles so that at the intersection point crash should not happen has to be kept in mind .Each time all the vehicles remain in control using V2V communication. Based on experiments conducted it is found that the obtained result's efficiency of HardBrake Vehicle System is 57.13% more than Smart Vehicle System and accuracy is found to be 21.6% more than a Smart Vehicle System mentioned in existing literature.

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