An Architecture for VANETs

V. B. Vaghela
Jashodaba Polytechnic Institute,
Sidhpur, Gujarat, India

D. J. Shah
Shruj LED Pvt. Ltd.
Ahmedabad, Gujarat, India

Abstract- Vehicular Adhoc Networks (VANETs) are known for providing safety on the road and day by day became popular to provide value added services like entertainment and internet access on the wheel. The basic idea behind this paper is to provide information for avoiding accidents using vehicle-to-vehicle (V2V) communication and make the journey more pleasant. We have suggested an architecture for broadcasting the messages which contains information such as position of the vehicle with reference to one-another, estimation of range and the information regarding road conditioning as well as parking space. This also facilitates some new parameters to avoid injuries, provide convenience to park vehicles and also provide infotainment applications for the drivers and passengers. With this paper, a new architecture is proposed to provide minimum delay in various situations in VANETs and ultimately take care for the best usage of available bandwidth.

Keywords – V2V, service, entertainment, VanetMobiSim

I. INTRODUCTION

In this decade, the research communities of automotive industries and wireless networking have given more attention Vehicular Adhoc Networks (VANETs). VANETs have some special characteristics which derives them different then Mobile Adhoc Networks(MANETs). Specifically could be said as vehicles in VANETs follow the lane directions; vehicles also move at very high speed; the number of nodes (vehicles) are more comparatively so VANETs are required to be scalable; the nodes need not to worry about energy because they are always fitted with dynamo. All the vehicles in VANETs communicate each-other wirelessly with Dedicated Short Range Communication (DSRC) [1], via a device mounted on vehicles called On-Board Unit (OBU).

The major objectives of VANETs can be stated as following [2]:

- Provides quick solution in case of car accidents, obstacles on road, bad weather conditions and emergency problem on the road via broadcasting warning messages to neighboring vehicles.
- Immediate sharing of traffic information with the drivers.
- Drivers get the information about parking space in fraction of time at dense areas.
- Drivers get online help through mechanic in case of car breakdown or can locate itself for maintenance.
- People can get entertainment through multimedia, online gaming etc.

In VANETs, alert message propagation is sensitive to per-packet delivery delays. In order to achieve faster propagation of multi-hop broadcast message generated by the applications requires the deployment of specific solution, which should be able to avoid redundant transmission and other message propagation delays. In the proposed solution, we have modified the layered architecture as shown in Fig. 1, with the use of NS2[4] for range estimation. We have generated mobility for urban scenario using VanetMobiSim [5], which gives collision free vehicle movement with high road density.

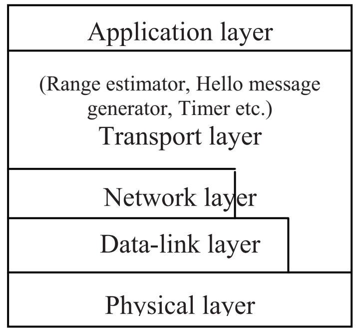

Figure 1. New architecture

This technique is to be used in vehicles to estimate the transmission range for effective propagation of broadcast messages with as few hops and transmissions as possible. Analysis of the data that we have received for the State of Gujarat reveals that there were over 1,11,431 people injured in the year 2012, in 2013 it was 1,05,273 and the same trend continued for 2014, giving nearby one lac injured in Gujarat state. Out of these more than 4000 people got injured in accidents every year in Gandhinagar city only. Considering the above facts, using the proposed research we are positive to provide a solution that can provide the information about number of vehicles on road in particular area, traffic jam or congestion in particular area, vehicle speed, road conditions, parking space etc. As the message can be propagated in a very short time, the proposed solution can be used for cities like Gandhinagar.

The rest of the paper is organized in following parts: section 2 gives a brief discussion of the work related to the VANETs. Then after our proposed architectural solution is explained in Section 3 with best practical example. The experimental results are presented and discussed in section 4 while final conclusions are derived in the last section.

II. Related Work

The work proposed in [6] shows back-off mechanism which has ultimately tried to reduces the frequency of message transmission and retransmissions due congestions and collisions. While in [7], the procedure to detect the repeated transmission is mentioned. So in this way unnecessary message forwarding can be decreased by a car. It is felt that, both of these schemes have not considered a very important parameter which determines the final propagation delay. The parameter is the number of hops a broadcasted message required to cover the whole targeted area.

A final scheme trying to statistically achieve a minimum number of hops when propagating a broadcasted message is discussed in [8, 9]. Both the schemes allot different CWs to each car. The cars communicating with V2V communication randomly select a waiting time within its CW before forwarding the message, because their respective CWs are inversely proportional to the distance from the previous sender. In all way, the mentioned schemes are affected by the assumption that there is a unique, constant, and well-known transmission range for all cars. This is somewhat unrealistic. So as an alternative, we propose a new broadcasting scheme that is aware with vehicle positioning and can reduce the basic parameter i.e. number of hops based on the proposed algorithms.

III. Proposed Algorithm

We have proposed a new architecture in which the messages generated by generic application will be broadcasted via multi hop transmission. It is assumed that all the vehicles are fitted with OBUs and Global Positioning System (GPS). They will process the packets at their levels with modified code at MAC layer, Network layer and Transport layer. Ultimately, the proposed solution gives V2V communication between vehicles in a targeted area of cars, and the most important features are listed below.

- It acts as a special solution, which provides rapid propagation of messages generated from various applications of any type and any rate for all of V2V communication applications.

- An algorithm is developed for providing competent system to select the next-hop vehicle for forwarding. A message is rebroadcasted based on (i) the distance from the previous dispatcher (ii) the calculated communication range. It reduces unwanted retransmissions, which at the end reduces propagation delays.
- Transmission range is estimated that represents a fundamental feature for the vehicular ad-hoc networks: a highly dynamic network. Though there is a small overhead.

However, if there isn't any intelligence applied to the scheme, all the nodes in the area will simply transmit received message. The subsequent effect will lead to congestion, increase in collisions, higher delays, and will tend to transmission problem in the vehicular network. Such phenomenon is known as broadcast storm problem in networking literature [10].

In our proposed solution, as mentioned, vehicles are fitted with OBUs for vehicle-to-vehicle (V2V) communication, monitoring, entertainment and location awareness . Also we have considered a cluster of cars that move at various speeds ranging from 40-140km/h on a multilane highway road. It is understood that V2V communication may have frequent variations in terms of available bandwidth and transmission range. This we can assume because of the availability of the DSRC, which promises to provide vehicles with communication capabilities. Also in our proposed architecture we have considered two practical case studies like road safety (accident alert communication, road conditioning, congestion etc.) and networked interactive entertainment[11].

The developed mechanism is used to broadcast quickly, even through multi-hops, send alert messages from a vehicle behaving abnormally to all following vehicles in a range. or video triggering messages to activate a video stream sent in a certain geographical location back to a requesting vehicle (e.g., first responders travelling toward an emergency area). All these schemes made use of hello messages from which each vehicle can compute the transmission range and utilize the same to reduce the number of hops, the total transmitted messages, and hence the delay to cover the whole area-of-interest till destination.

If we consider one of the networked interactive entertainment applications such as online gaming, REMBP is intended to quickly transmit some events to the users in a certain area. All vehicles, which are engaged in the online session are having this common protocol and one of the most important feature of this protocol is transmission range estimation in both the directions i.e. forward and backward. The information of current range estimations of vehicles are kept in every event sent by those vehicles so as to have all other vehicles in range aware of them. Ultimately, the vehicles who receive broadcast message can use this information to estimate its position with respect to the sender's transmission range and get a chance of becoming the next hop forwarder. To understand the concept clearly, consider the Fig. 2, mentioning a group of cars running on highway.

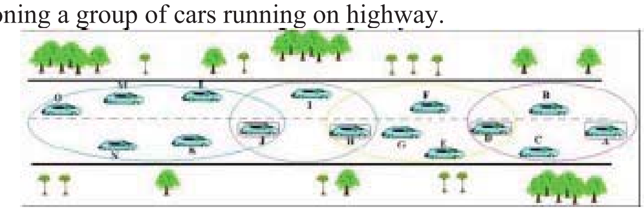

Figure 2. The message forwarding procedure: an example

For ease of understanding, we assume that the cars in the shown area are positioned 20m apart and also the transmission range of each car is assumed variable due to different surrounding conditions. The direction of the cars is assumed from left to right and each elliptical area characterize the transmission range towards the back in the area. It is assumed that car A has a transmission range of about 400m, and can reach the cars B, C and D by one hop. Similarly, car D is assumed to have range of 600m and can reach directly to cars E, F, G and H; in same way the car H and J are having particular transmission range and one hop recipients. With this all assumptions, if we desire that car A sends out a message that has to reach all vehicles in the targeted area, then the optimal solution would be represented by having cars D, H, and J forwarding it. On the other hand, this most excellent way can be thought only if cars can be aware of their positions with reference to time within the sender's transmission range. Also cars D, H and J find a mechanism that they are the farthest car in that particular area have heard the last message. To realize this they have to take on themselves the task of being the next forwarders. This can be achieved via a mechanism called transmission range estimation, explained below.

Our proposed protocol are having two phases. (i) Transmission Range Estimation Phase and (ii) Message Broadcast Phase as explained below.

A. Transmission Range Estimation Phase

In this phase, each car estimates its transmission range by the use of hello messages. For updating the transmission range of individual car, time is divided into turns. All the data collected during a particular turn are stored for the whole duration of the next turn, then after discarded if they are of no use. Current Front Maximum Transmission Range (CFMTR) and Current Back Maximum Transmission Range (CBMTR) represents collected information for the current turn. CFMTR represents the estimated maximum forward distance from which the considered car can hear another car along the road and CBMTR represents estimated maximum backward distance at which the considered car can be heard. There is a mechanism to keep both the variables updated continuously via an event called hello messages receiving procedure, at this stage, their values are stored in the Latest Front Maximum Transmission Range (LFMTR) and the Latest Back Maximum Transmission Range (LBMTR), respectively. We keep up to date record of both a last-turn and a current-turn value because the former guarantees to have a value computed with large number of hello messages, while the latter considers fresh information.

The transmission range estimation phase is best explained with the help of flow diagram given in Fig. 3 and Fig. 4. We explain behavior our scheme during the procedures for sending hello messages (Fig. 3) and receiving hello messages (Fig. 4), respectively. In hello message sending procedure, each car determines a random waiting time in every turn. After the waiting time, if no other transmission is heard or collision happened, it proceeds with transmitting a hello message, which contains estimation of maximum forward transmission range.

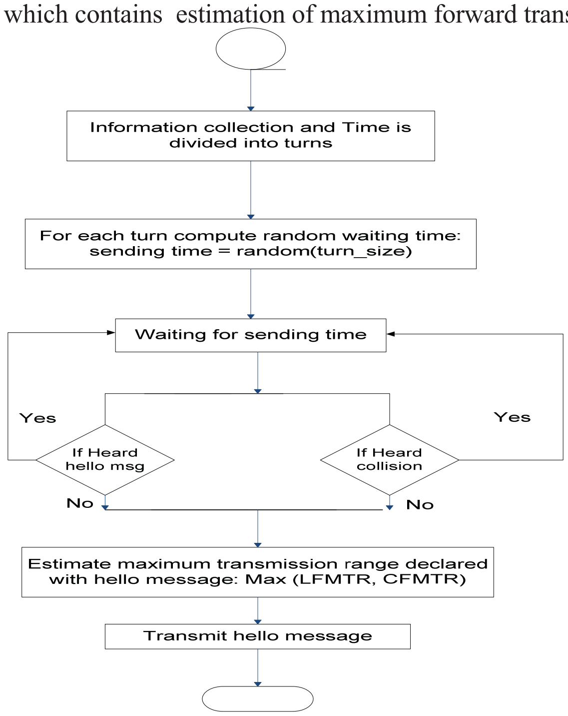

Figure 3. Hello message sending procedure

A hello message received at each car includes position of car, hello message sender car's position, hello message declared maximum range and the distance between message receiving car and hello message sender car. The generated messages cause minimum overhead.

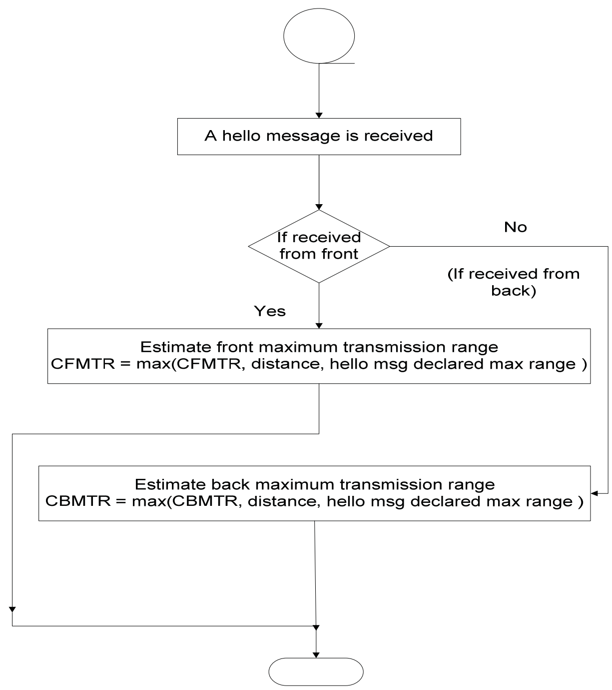

Figure 4. Hello message receiving procedure

In Fig. 4, a car receiving a hello message determines its own position. After extracting the information of sender's position and the included estimation of the maximum transmission range, it determines the distance between itself and the sender. If the hello message is received from front the value of CFMTR is updated, otherwise CBMTR is changed.

B. Message Broadcast Phase

The transmission range estimation phase is used for making cars aware of their transmission range via sending and receiving hello messages, while message broadcast phase is used to reduce transmission time and achieve a quick receipt of message as shown in Fig. 5. Each of the cars uses this transmission range to get a priority for forwarding the broadcasted message based on its distance from the message sender. The logic for the case is higher the relative distance, the higher the priority. The broadcast phase is triggered via the ongoing application in vehicles and generates a broadcast message which has to be spreaded over the interested area of the sender. This broadcast message contains information related to the supported applications as well as data utilized by the broadcast algorithm, which includes, the fields: Sender_Position and Max_Range().

Max_Range() is a typical parameter that corresponds to how far the transmission is expected to go backward/forward before the signal becomes noisy and undetectable. The same is used by following cars to determine which one among them will become next forwarder. Ultimately this will minimize the number of hops, and in other way propagation delay. We want the farthest car to do this task of forwarding, so higher the relative distance of the considered car from the sender, the higher the priority of the considered car becoming the next forwarder.

Depending on the distance from the sending/forwarding car (Distance) and on the estimated transmission range (Max_Range()) declared in the broadcasted message, the contention window of each car is varied between a minimum value (CWMin) and a maximum value (CWMax). This is summarized by equation (1) and is used to determine which car will propagate the broadcast message on the next hop.

$$\left\lfloor \frac{(MaxRange - Distance)}{MaxRange} \times (CWMax - CWMin) \right\rfloor + CWMin$$

....(1)

After receiving a broadcast message from the front, a car uses equation (1) to determine its CW [12] and then computes a random waiting time based on it. If, during waiting time, the same message has been heard again coming from behind, it will not forward the message. If the car receives same broadcast message from front, meaning that a preceding car has already forwarded it. The procedure will restart with the new parameters included in the last heard message. If the waiting time expires without having heard any other car forwarding the same message then the considered car will broadcast it with estimated transmission range.

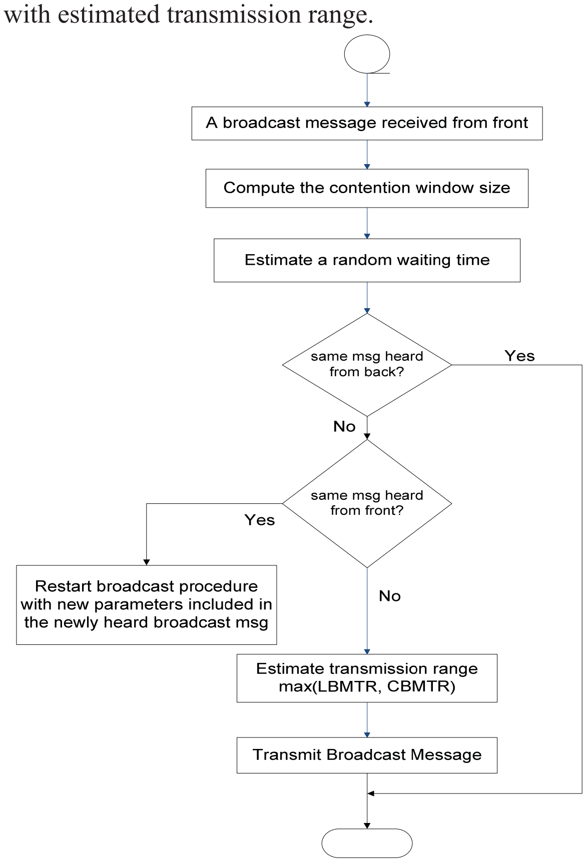

Figure 5. Broadcast message forwarding procedure

IV. RESULTS AND DISCUSSIONS

We have modified the MAC layer by changing some of the parameters according to the requirements of DSRC. The hello message generation rate is 100ms. The following Fig. 6 shows the throughput of the system.

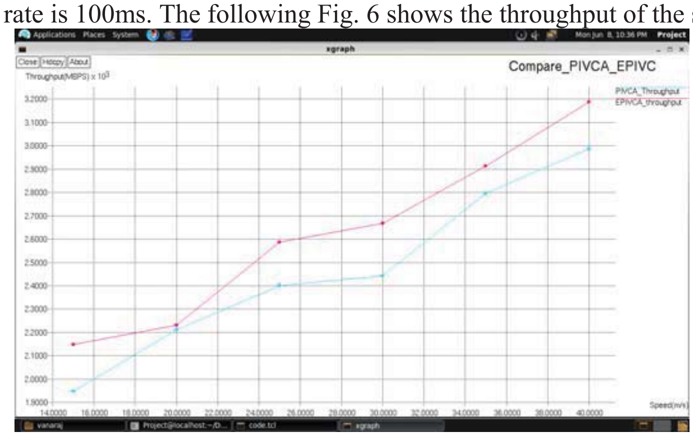

Figure 6. Throughput

We have compared the results with the existing one and found they are better than the existing system.In this study, we have kept the vehicular network length up to 6 Km and vehicles with mentioned assumptions are placed in such a way that minimum distance between the two vehicles remain 20m, thus we can say average 50 to 300 vehicles may be involved in the transmission/forwarding process. The message delivery fraction shown in the Fig. 7 and the estimated delay shown in Fig. 8, also validate the results.

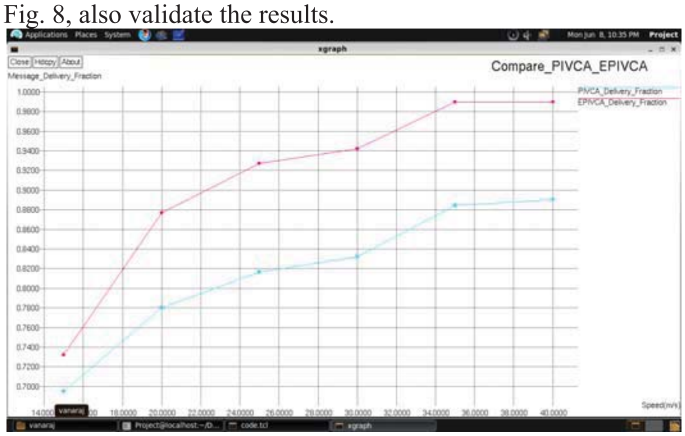

Figure 7. Message delivery fraction

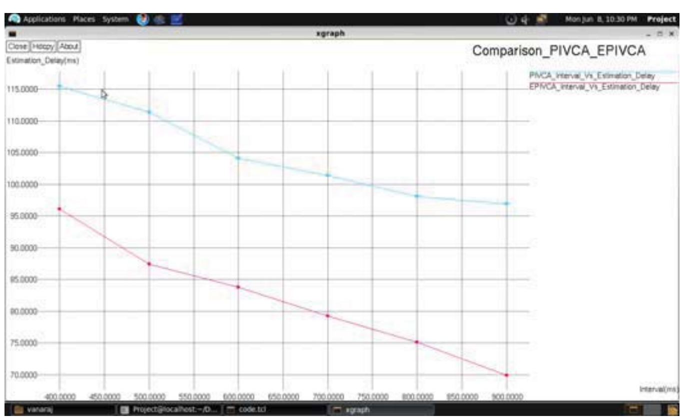

Figure 8. Estimated delay

V.CONCLUSION

We proposed a broadcast protocol and provided a solution to have minimum propagation delay for real time vehicular ad hoc networks. Our solution can be used in 108 ambulance service in Gandhinagar city of Gujarat for vehicle to vehicle communication in urban scenario. We analyzed the performance of REMBP under different parameter to check the reliability of message delivery. We have achieved different results and analyzed to confirm that the messages reach the end of the targeted area with improved message delivery fraction and throughput up to the mark. In future work the performance of this protocol will be analyzed for urban area of other Indian cities.

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