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Beacon based Accident Prevention System

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Abstract — *The main focus of Accident Prevention System is to reduce number of road accidents. The foremost scope of the system includes regions with fog and roads with blind turns. The system fulfills its aim by calculating distance between two nearby vehicles. For this purpose GPS, beacons, ultrasonic sensor, magnetometer and microcontroller is used. The APS works in a peculiar radius. The GPS module finds the location which is traded with other vehicles through beacons. A plausible threat is realized by this. Then the ultrasonic sensors are used to get better affirmation of threat. After confirmation of threat the driver is notified about it using LEDs, buzzers and display. A small screen is installed on which the surrounding region is exhibited. Along with this appropriate instructions are provided for better assistance. The system starts on ignition and works in a continuous loop till ignition is on.*

Keywords- *Vehicular Ad-Hoc Networks, Broadcast Storming, Adaptive Beacon Control, VANET, LIDAR*

I. INTRODUCTION

Vehicular ad-hoc networks (VANET) has become a trending topic for research in the recent years. VANETs are different from other networks as they present some noticeable differences like rapid changes in network topology and variable network density. It also provides wide variety of applications such as critical safety services to infotainment applications. A recent traffic safety fact of US in 2015 is that there were 22,144 and 2.18 million people approximately who died or got injured respectively during a road accident [3]. Inability of the drivers to react in time is one of the major reasons, which motivates to build active driving safety applications.

VANETs use the periodic broadcasting of beacons or messages, which contain information like location, speed, direction and other information if required which is analyzed to determine the potential threats and broadcasting warning messages. The transmission rate of beacons should be controlled to avoid congestion in the network and avoid broadcast storming.

One major challenge in VANETs is broadcast storm. Broadcast storm problem occurs when a massive dissemination of messages overloads the transmission channel. This causes many packet collisions and reduces efficiency of message delivery. Dense traffic is prone to the problem of broadcast storm whereas less traffic will not be.

In VANETs, the topology of the network changes rapidly, therefore, to maintain the updated information of the neighbour, the frequency of sending beacons (messages) can be increased. Increased rate of beacons will consume significant amount of bandwidth and can also cause collisions.

Network partition problem occurs when there are not sufficient nodes in the area to disseminate broadcast messages, which means that the warning messages will not be broadcasted to the neighbours which are not present in the area or it can be said that a partition in the network will be created.

II. RELATED WORK

A. *ABDDis scheme*[1]

In Adaptive Beacon-based Data Dissemination (ABDDis) Scheme [1], all vehicles use beacons to exchange local information like location, direction, speed, etc. The main aim of this scheme is to provide some features:

- To be able to operate on various traffic densities.
- To adjust the beacon rate according to the requirements to reduce the channel load while maintaining the updated information about the neighbours.

Beacon Interval Determination: it is an essential issue in VANETs because, if the interval is too short, then lots of packets will be generated causing broadcast storm problem and if the interval is too long, then wrong information of the vehicle may be used which will cause the protocol to fail.

When the traffic is dense, often vehicles will move in a cluster and there will not be major difference in their speeds, which means that the topology will not change rapidly. In this situation, high rate of beacon transmission is not efficient. From observation, it can be seen that the ratio of vehicle speed and average speed of neighbouring vehicles can be used to determine the optimal beacon interval.

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$$ratio = \begin{cases} \frac{v}{\overline{v_{nb}}} & \text{if } v > \overline{v_{nb}} \\ \frac{\overline{v_{nb}}}{v} & \text{otherwise} \end{cases}$$

where:

v is the current speed of the vehicle.
$\overline{v_{nb}}$ is the average speed of its neighbors.

When the ratio is high, it indicates that the vehicle topology is more likely to change, therefore, the beacon interval is required to be small.

Beacon interval can be calculated by:

$$interval = 1 + \frac{max.Interval - 1}{ratio}$$

where *max.Interval* is the default maximum beacon interval set.

Store-Carry-Forward (SCF): to overcome the network partition problem, SCF mechanism is used. A vehicle chosen as an SCF stores the required messages and broadcasts them whenever it detects a new neighbour which did not received the message before.

B. *Adaptive Beacon Control*[2]

In Adaptive Beacon Control [2] protocol design, vehicles leverage beaconing status among neighbours through beacon transmission and detect the congestion in the network. After detection of the congested channel, vehicles reduce the beacons frequency to suppress the congestion in the network. Then a greedy heuristic algorithm is used to determine the optimal beacon rate and other vehicles are informed so that all vehicles can adjust the beacon rates accordingly.

The adaptive beacon control has three major steps:

- Online Congestion Detection
- Distributed Beacon Rate Adapting (greedy heuristic algorithm)
- Informing adapting results

III. PROPOSED METHODOLOGY

In the proposed methodology, the major differences are:

- Every vehicle relies on one-hop neighbour information.
- Ultra-sonic sensors are used to verify the threats.
- Beacon transmission rate is controlled on the basis of incoming beacon rate.

Let us discuss the changes in detail. In the studied methodologies, messages are stored and rebroadcasted to all the neighbours which join the network within the time limit. The location, speed, etc. of the host vehicles is also included in these messages. Thus, to maintain the updated information in the network, the beacon rate and computations to determine the new neighbors are increased. In the proposed methodology, every vehicle broadcasts its information and also warning messages for a particular time-period (e.g. 1 second), with the location updates of the host vehicle. Thus there is no increase in the beacon rates and extra computation for determining new neighbours. On the other hand, the range of the system in the studied papers is approximately 500 m whereas in the proposed strategy the range will be less than 50 m. Small range implies less number of broadcasts required.

In the above studied papers, only the GPS location is used for determining the potential threats. But GPS may not be reliable every time, therefore, in the proposed methodology, the sensors like ultra-sonic sensors are used to verify the threats. Consider an example, a threat is being detected with the use of GPS coordinates, but there is some error in the coordinates and no potential threat is around the vehicle. Without the ultra-sonic sensors, the driver will get false notifications. To avoid these misinterpretation, the sensors are used to verify that whether there is a threat in the predefined threshold radius. In this way, the use of ultra- sonic sensors enhances the accuracy of threat determination.

A magnetometer is employed to derive the direction of threat using relative direction concept. Along with this, the surrounding area is mapped on a screen visible to the driver. This will help the driver to see the situation for himself and make quick decisions. This can prove very beneficial in cases of high fog density and blind turns.

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If the rate of beacon transmission is high, it can lead to broadcast storm and if it is low, it may cause lack of updated information of neighbours which may result in protocol failure. The transmission rate cannot be kept constant as it may either create broadcast storm or protocol failure due to lack of updated neighbour information. Hence, dynamic transmission rate is preferable. In the proposed methodology, the rate of transmission of beacons is decided on the incoming rate of beacons. Rate of incoming beacons is an appropriate variable to determine the transmission rate as when the traffic density is high, the incoming beacon rate will also be high and when the traffic density is low, incoming beacon rate will also be low. When the rate of incoming beacons is high, that means high traffic density, then the vehicles would generally move in clusters where the velocity of all vehicles will be similar. At that moment, the rate of transmission can be reduced. When the incoming rate of beacons is low then the traffic density will be low and the vehicles will have variable speed. To execute the protocol efficiently in such situation, regular and quick updates of vehicles are required. This can be achieved by increasing the rate of beacon transmission.

IV. RESULTS AND DISCUSSION

There are three major changes in the proposed methodology which will have considerable impacts. First, relying on the local one-hop information will reduce rebroadcasting and computations required to find new neighbours which will decrease the processor time used for these computations and all the saved time can be used for main protocol to determine the potential threats. Secondly, the protocol does not rely solely on GPS locations. It uses sensors to verify the threats which reduce the rate of false positives. Third, the beacon transmission rate is controlled with the incoming beacon rate and it requires less computation as compared to the previously studied methods.

Some of the observed output is shown below in the form of tables.

Table 1: Response time of GPS module

Distance Calculated by GPS	Response Time
234.84 m	1.1 sec
11.04 m	0.8 sec
33.34 m	0.9 sec

Table 2: Response time of Ultrasonic sensor

Ultrasonic Sensor Position	Response Time
Left	1.6 sec
Right	1.3
Front	1.2 sec
Back	0.8 sec

Table 3: Values given by Magnetometer

X	Y	Z	Degree	Relative Direction	Response Time
157	-1580	466	-60.43	North-West	2 sec
48	-1555	197	-60.43	North-West	2 sec
726	-1386	360	-60.43	North-West	3 sec

From the above tables we can see that the average response time of distance calculation is 0.9 seconds, that of Ultrasonic sensors is 1.2 seconds and Magnetometer is 2.3 seconds.

V. CONCLUSION

The proposed methodology reduces the processor time required for functions like finding new neighbour, greedy heuristic algorithm to find optimal beacon rate and increases the efficiency and response time of the whole system. It also reduces the probability of broadcast storm.

The hardware used also works efficiently. The minimum response time of distance calculation module is observed to be 0.8 seconds. The response time of Ultrasonic sensors and Magnetometer is 0.8 seconds and 2 seconds respectively. The system is much systematic as well as cost-effective as compared with previous studied systems

VI. FUTURE SCOPE

Machine learning algorithms can be used to determine optimal beacon rates from past experiences which will further reduce broadcast storming. The system can be centralized if all the locations in a particular country are accessible to high-speed internet, which can open gates for using distributed and parallel systems for increasing response time.

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With further use of efficient hardware it can be made usable for regular circumstances. We can use high-cost GPS module, original magnetometer and better sensors for locating the entities precisely.

We can use high-cost technology like LIDAR (Light Detection and Ranging) and circumvent the use discrete hardware. This technology gives us the real-time view of the surrounding area.

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