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A Smart Traffic Communication Protocol in VANET

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ABSTRACT: VANETS are upcoming and promising applications of Mobile Ad-Hoc Networks. They promise vehicle to vehicle interactions for safer transportation, emergency update services during unexpected calamities, efficient traffic routing in urban areas and on freeways for faster transport, routing of packets for infotainment services and much more. In this paper, concept of the IEEE 802.11p MAC protocol in vehicular environments is presented. Firstly, the existing evaluation of 802.11 with headway based segmentation upto 10 segments is presented and classified, and subsequently, the enhancements up to the 12 segments which has been proposed for 802.11p MAC, is presented and discussed. Based on the mentioned evaluations and enhancements, a conclusion is reached regarding the present situation of this protocol. Headway based segmentation is used for lanes so as to provide effective broadcasting. The probability of collision is reduced using headway based segmentation. Through these ideas a protocol and few simulative models have been developed on MATLAB platform that possesses minimum latency, minimum probability of collision in the acknowledgment messages and unique robustness at different speeds and traffic volumes.

I. INTRODUCTION

"A Vehicular Ad-Hoc Network" or VANET is a self-organized network which is a special type of MANET. The term VANET was adopted to reflect the ad hoc nature of highly dynamic network. Researches for introducing the wireless communication in vehicles had started in 1980s. Two types of communications scenario exist in vehicular ad hoc networks: vehicle-to-vehicle (V2V) and vehicle to infrastructure (V2I). Dedicated short range (DSRC), an enhanced version of the Wi-Fi technology, is employed by VANETs to supports the data transfer in an environment that frequently changes. DSRC also supports high data rates and time critical response in VANETs. The major goal of VANET is to increase the road safety and transportation efficiency. VANET helps in reducing the road accidents and traffic jams. IEEE 1609 has introduced trail use standard for WAVE (Wireless access in vehicular environment) for VANET. IEEE 802.11p is the standard name for VANET.

1.1 Communication In VANET

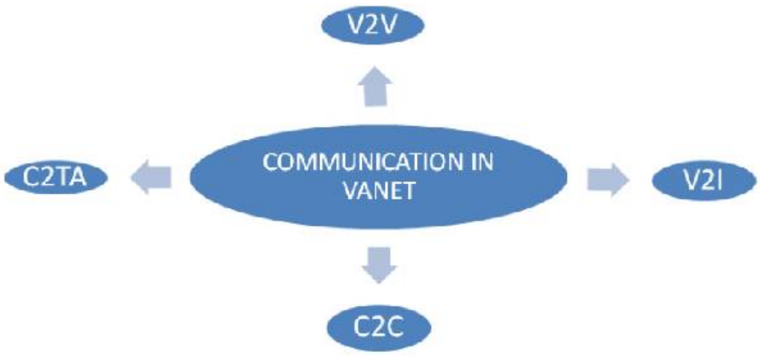

Figure 1: Communication in VANET

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- **Vehicle To Vehicle Communication**: It refers to inter vehicle communication. Vehicles or a group of vehicles connect with one another and communicate like point to point architecture. It proves to be very helpful for cooperative driving.
- **Vehicle To Infrastructure Communication**: Number of base stations positioned in close proximity with a fixed infrastructure to the highways is necessary to provide the facility of uploading/downloading of data from/to the vehicles. Each infrastructure access point covers a cluster.
- **Cluster To Cluster Communication**: In VANETs network is split into clusters that are self managed group of vehicles. Base Station Manager Agent (BSMA) enables communications between the clusters. BSMA of one cluster communicates with that of other cluster.

II. HEADWAY BASED SEGMENTATION

If vehicles are running at different speeds, distance-based segmentation logically fails in simulating the dangerous situation. Hence, the 2nd proposed approach is to include the effect of speed through time headway based segmentation to assign segment numbers. The time headway or headway for short: is the time interval between two vehicles passing a point. Fig.2 shows a 3-lane highway with three following vehicles running at different speeds, (30,60,120 Km/h) with reference to distance (meter). Fig.3 shows the same situation after calculating the headway for each vehicle to produce an imaginary calculated image. This image reveals that headway-based segmentation mimics dangerous situations better than distance-based one, as it puts the 120Km/h-vehicle in the 1st priority, consistent with the intuitive analysis of the situation. So, the algorithm elects the nearest vehicle (in time) by a plain uniform headway-based segmentation method.

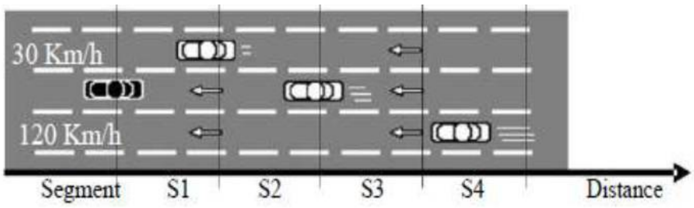

Figure 2: Distance Based Segmentation

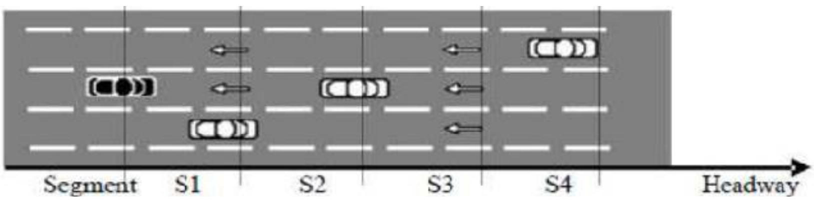

Figure 3: Headway Based Segmentation

III. PROPOSED MODIFIED 802.11P MAC ALGORITHM

In this Paper, an attempt has been made to propose an Improved Algorithm for the Transmitting Node. In case an On Board Unit(OBU) of the vehicle has a message to broadcast, the MAC layer of the system has to proceed with the following steps as described below:

STEP 1: RSU send Beacon frame periodically with the free slots available in the TDMA frame. OBU scan for RSU beacon. Beacon frame is one of the management frames in IEEE 802.11 based WLANs. It contains all the information about the network. Beacon frames are transmitted periodically to announce the presence of a wireless LAN.
STEP 2: If more than one RSU respond, compare their (received signal strength indicator) RSSI's and select the best one.
STEP 3: Put the other RSUs as first, second, etc candidates according to their RSSI. OBU uses the beacon for synchronize its frame with the RSU.

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STEP 4: OBU sends the data in the free slots (in the coming uplink frame). Check the RSSI < threshold then compares the RSSI's again and selects the best RSU.
STEP 5: TDMA frame encapsulates 802.11 frames in the payload subsection. The frame is repeated periodically every 20msec (which is the length of the frame).
STEP 6: Each frame contains beacon field i.e. broadcast control channel (BCCH) which comprises of timestamp, SSID, BS-node capabilities. The frame also contains frame control channel which carries information about the structure and format of the ongoing frame i.e. slots scheduler which contains the exact position of all slots and Tx/Rx times and guard times.
STEP 7: GACH and RACH are used for random access channel when the OBU want to join the WBSS. RACH is the channel that OBUs use it for association request. GACH is the grant access channel contain all the OBUs accepted for transmit in the next frame.

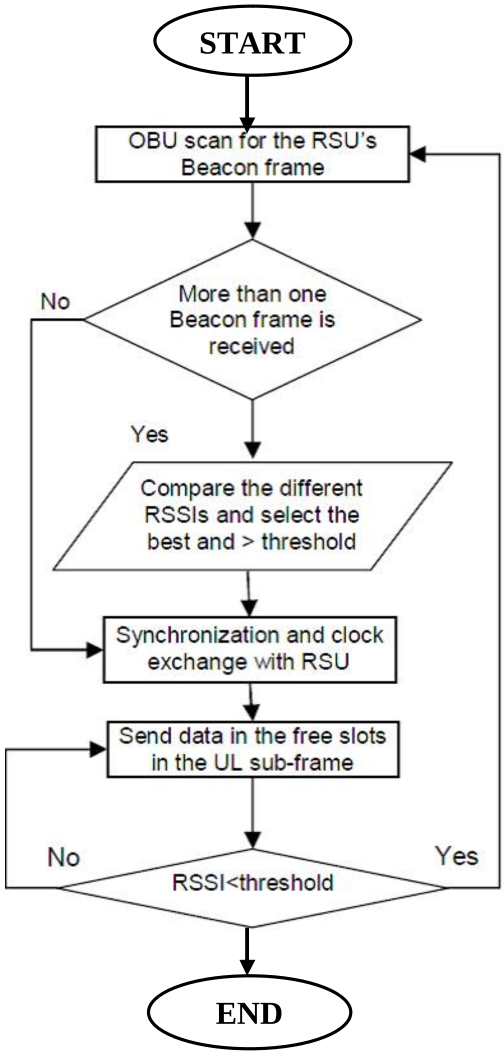

Figure 4: Flowchart of communication between OBU and RSU.

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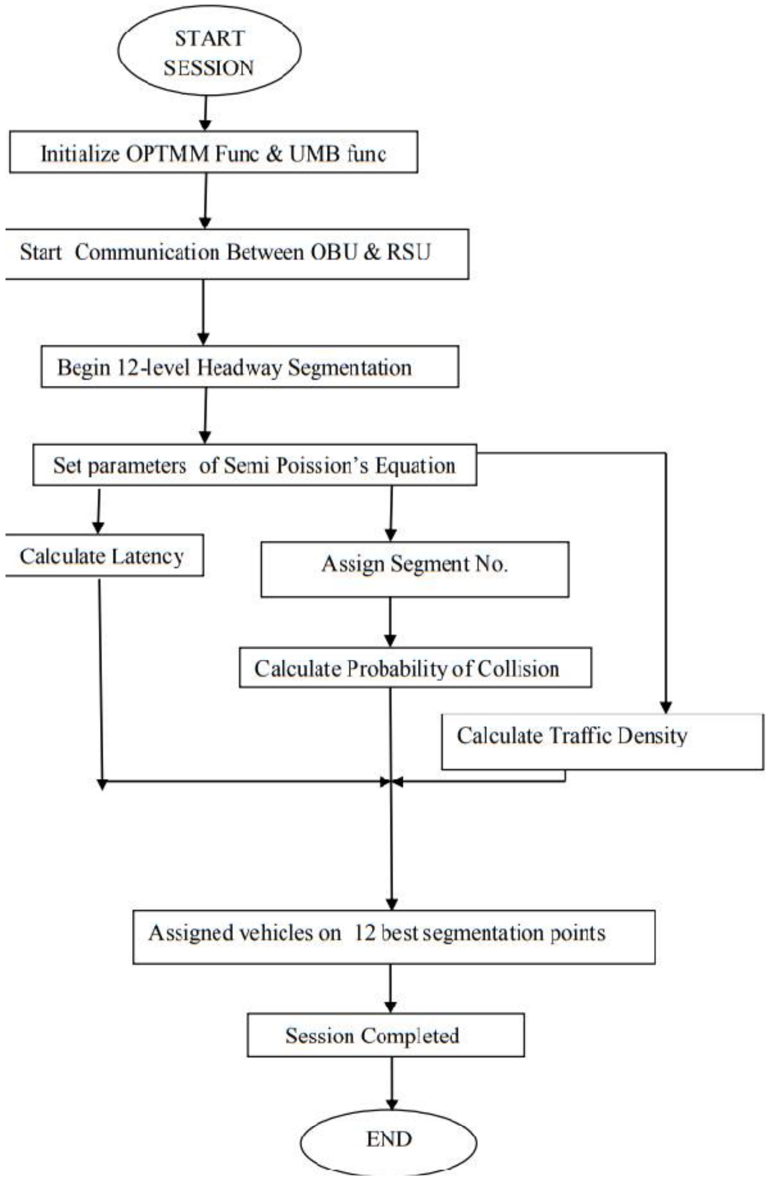

Figure 5: Flowchart of Proposed Algorithm.

3.1 Analysis of Flowchart

For starting the communication, the Road Side Unit(RSU) sends the beacon frame periodically, the On Board Unit(OBU) scans the RSU beacon. If more than one RSU respond then it selects the best one by compared the RSSI. The OBU uses the RACH for request and GACH for acceptance to transmit the message within limited time frame, then the source vehicle and Road Side Unit(RSU) connects to communicate. After this time slots nodes will not start a new session until the end of the current broadcast. Then it finds the segment number for all the vehicles, Through this process the source node sends the detail to other vehicles about the locations, speed and other information of the vehicles that are used to manage traffic, avoid collision, control accidents etc. After the complete broadcast the session is terminated.

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IV. SIMULATION RESULTS

The main goal of this work is to build a new transmission protocol with simulative models of various VANET system model-cases that are generally built using network simulators without proper GUI support. MATLAB offers rich set of functionalities which reduces the development time for the framework necessary for carrying out model tests.

4.1 MODEL1: VANET Nodes At Intersection Of Roads

This model plots intersection of a road with nodes on both the stretches. The nodes on each segment can interact with each other. This model can be used to calculate the Doppler effects due to relative motion between the nodes. This can also be used to estimate the window margins for communication between two nodes on separate roads. This model assumes random points of origin for both the nodes and the nodes can assume independent velocities.

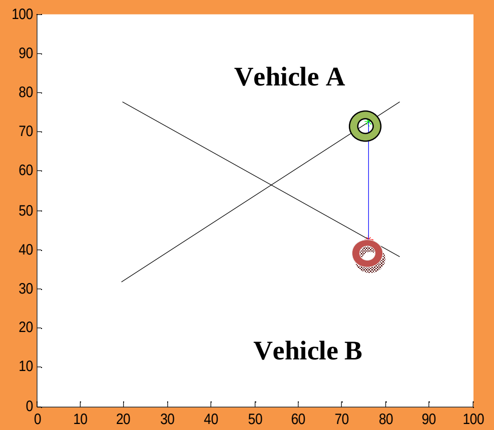

Figure 6 Model-1 Frame A

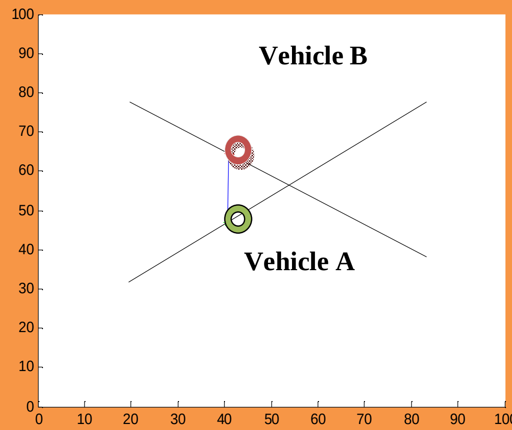

Figure 7 Model-1 Frame B

4.2 MODEL2: VANET NODES At Single Road-Side Unit

This model is similar to a cellular base station trying to provide range for travelling mobile node. The model allows user to configure the range of the Road Side Unit(RSU). The communication platform facilitated by this model can be used to test the connection mechanisms between mobile VANET nodes and the stationary Road Side Unit(RSU) which will act as hub or central controller for the given region. This also marks the second type of interconnection in the VANET system which is Vehicle-to- Infrastructure unit.

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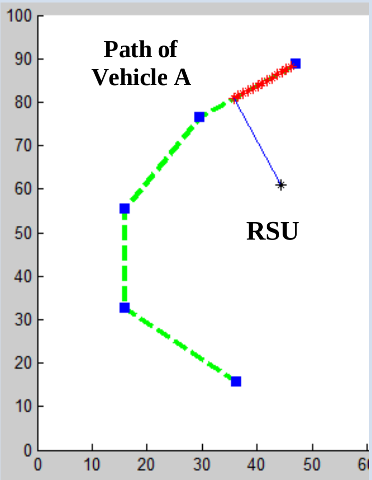

Figure8. Node entering RSU range

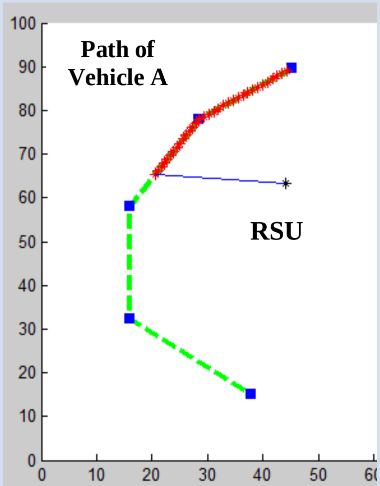

Figure 9. Node existing RSU range

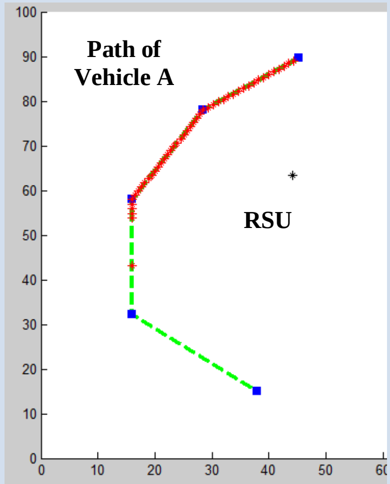

Figure 10. Node Out of RSU range

4.3 MODEL 3: VANET Nodes Passing Across RSUs

This is analogous to handover of mobile nodes from one base station to another in cellular networks. However, there are significant differences. There is no central Mobile Switching Center to coordinate the transfer of mobile VANET node from one roadside infrastructure unit to another roadside infrastructure unit. This model could be used to study mechanisms that involve continuous connection maintenance over large distances in VANET systems. The analogous handoff of VANET nodes could be studied using this model.

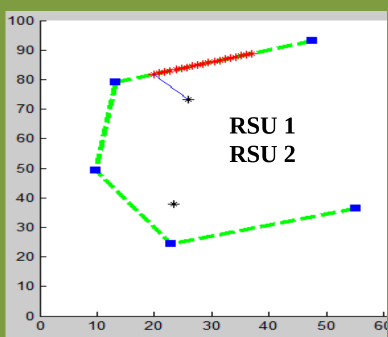

Figure 11. Model 3 - Node moving away from RSU1

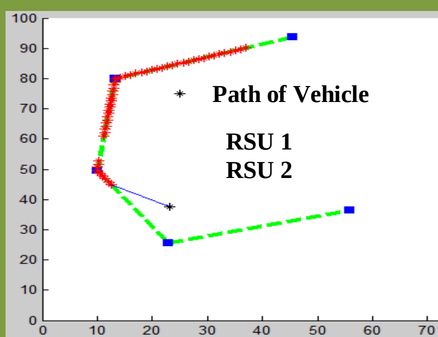

Figure 12. Model 3 - completing transfer from RSU1 to RSU2

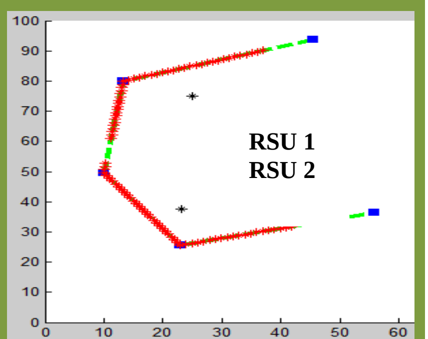

Figure 13. Model 3 - Node out of the system

Following parameters are quoted from the 802.11p standard. It is assumed that the length of ACK message is the same as the original broadcast. The ACK message is a mere repeat of the original broadcast setting the ACK field, which is considered as compensation to the expected collisions at far range nodes. The headway distribution is considered at a traffic volume of 400 vehicles/hr and 1400 vehicles/hr.

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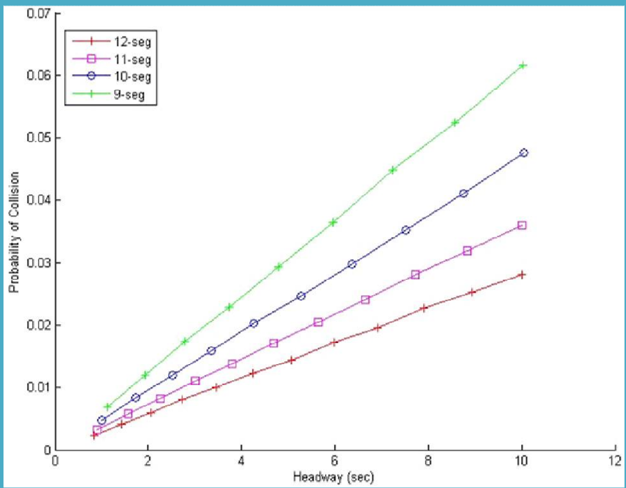

Figure 14: Simulated calculation for PC for best segmentation for 400 vehicles/hr

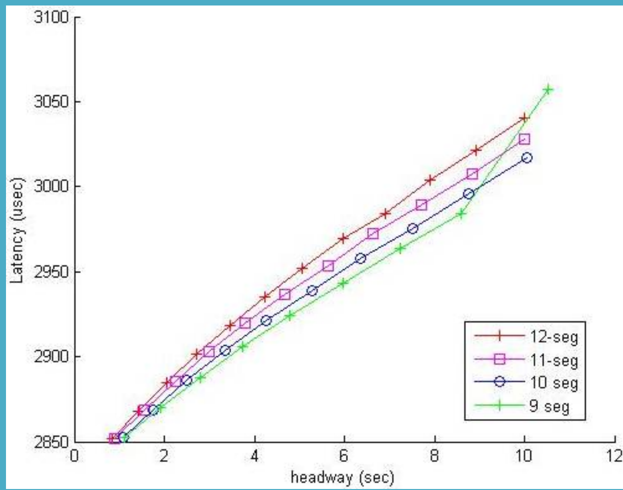

Figure 15: Simulated calculation of latency at best segmentation for 400 vehicles/hr

Using these random variables, a simulation program was conducted for estimating the probability of collisions and the average latency within each segment of the communication range (12 sec). The width of each segment is taken according to parameters. The probability of collision is shown in Figure 14, while the average latency is shown in Figure 15.

In Figure 16, we have seen that for 1400 vehicles/hr, the probability of collision is higher than the 400 vehicles/hr. The latency of the segmentation for 1400 vehicles/hr has given in Figure 17.
In VANETs, the reliability, latency and channel efficiency deteriorate with speed, traffic density and transmission range.

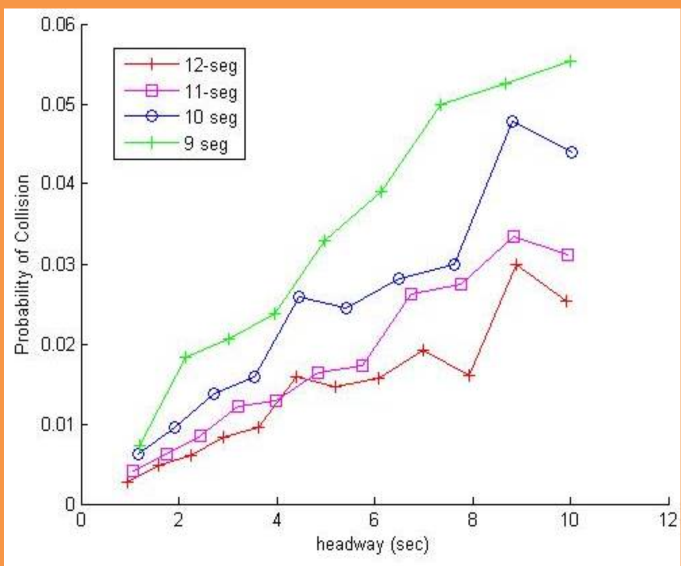

Figure 16: Probability of collision for 1400 vehicles/hr

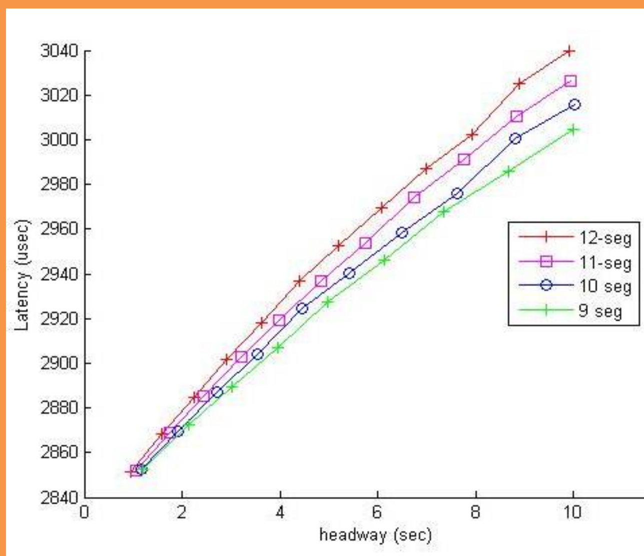

Figure 17: Latency for 1400 vehicles/hr

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The traffic density depends on message rate (messages/ second), size (bytes/message), message range (meters), and density of vehicles producing these messages. It is important to choose system parameters ideally without which VANET will fail to function properly.

For e.g. a message updates slower than once every 500 ms is probably too slow. Driver reaction time to stimuli like brake lights can be of the order of 0.7 seconds and higher. Thus if updates come in slower than every 500 ms, the driver may realise something is wrong before the safety system. This would make the driver think the safety system is not effective.

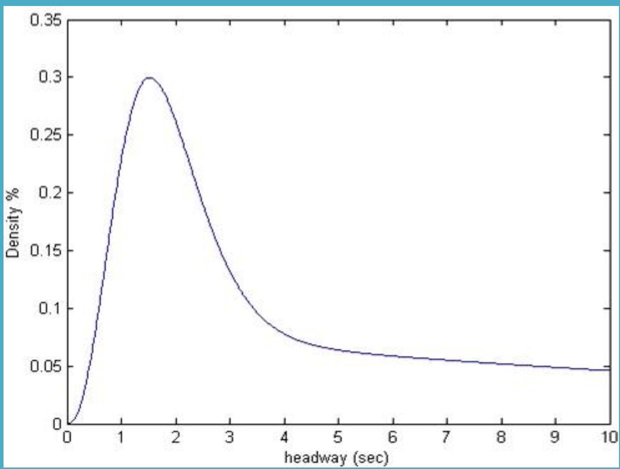

Figure 18: Headway Distribution at 400 vehicles/hr

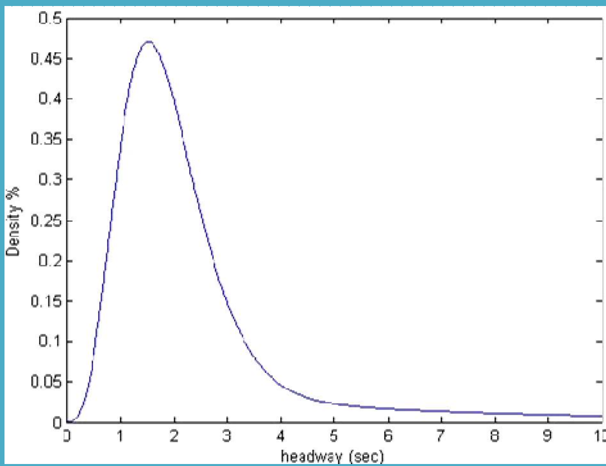

Figure 19: Headway Distribution at 1400 vehicles/hr

The traffic distribution done by the proposed protocol shows that the density of the traffic was reduced to 84 percent at the 12th headway based segmentation. Hence this proposed protocol maintains the traffic density at a low level as compared to previous protocols.The headway distribution at traffic volume of 400 vehicles/hr and 1400 vehicles/hr (very low vs. very high) are shown in Figure 18. and Figure 19. So, as the figure shows, the proposed protocol drastically lowers the traffic density when the segmentation increases to 12th point. This result is one of the achievements of this paper. Figure 18. and Figure 19. represents a comparative graph of change of density with the change in Headway time. The density in these graphs represents the number of vehicles present in given time interval. More the density, more will be the messages per second generated which will increase the response time of the system. But we require response time as low so the proposed protocol lowers the traffic density which decreases message per second and improve response time.

V. DISCUSSION AND CONCLUSION

Mobile Ad-Hoc network research has been gaining stream in last few years. Lot of work has been put into devising routing protocols. With the development 802.11p standard dedicated to DSRC, realizing VANETs is very close. As is the case with any system associated with Vehicular design, VANETs also must be tested thoroughly before they are put in real world as the consequences of failing systems are very high in VANETs. In this paper models of VANET have been simulated in on MATLAB platform to present the concept of the proposed Intelligent Transmitting protocol in VANET. To study this proposed protocol a fleet of 400 vehicles depicting a traffic scenario was introduced and various procedures were implemented to get a better result with respect to the existing protocols in VANETs.

After setting the standard parameters required to simulate VANET on MATLAB, the first procedure was to check the probability of collision, before and after implementing the proposed protocol. The simulation results showed that the probability of collision was reduced by 95 percent as compared to the previous transmitting protocols. Second aim was to calculate the latency of the vehicle communication in the VANET system. The simulation results shows that the latency was reduced after the proposed protocol was executed. The third aim was to study the traffic density in

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VANETs. The traffic distribution done by the proposed protocol shows that the density of the traffic was reduced to 84 percent at the 12th headway based segmentation. Hence this proposed protocol maintains the traffic density at a low level as compared to previous protocols. The majority of tools available at present do not have the ease and widespread reach, using MATLAB offers unique advantage over other systems. Some areas of future work are to imply this proposed protocol in various parts of the country to see the actual effect on the road; To improve latency and effect of headway-based segmentation; To take more public safety measurements using this protocol.

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