Adaptive Message Passing in Vehicular Ad-hoc Networks
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ABSTRACT
A Vehicular Ad-Hoc Network, or VANET, is a form of Mobile ad-hoc network, to provide communications among nearby vehicles and between vehicles and nearby fixed equipment, usually described as roadside equipment. VANET defines protocols for intelligent way of using vehicular network. A vehicle in VANET is a mobile node which is intelligent enough to communicate with other vehicles in the network and also with the static Road Side Unit (RSU). In the current project we focus on hybrid model consisting cluster based VANET and infrastructure based VANET. In adhoc mode, only clusters are present. Each cluster will be having its own cluster head. Also cluster members of each cluster communicate with their respective cluster head. The cluster head will communicate with other cluster heads. In infrastructure mode, RSUs are already present. Each and every vehicle communicate with these RSU. In this approach if RSU is present in the coverage area, it works ininfrastructure mode. If RSU is not available, then adhoc mode will be activated.

Key words: VANET, Cluster, RSU, Infrastructure, Vehicle safety, Adhoc

1. INTRODUCTION
Vehicular Ad-hoc NETworks are a subset of the MobileAd-hoc Networks MANETs which provide wireless communication capabilities between devices in a certain range. In a VANET environment this devices are either stations (STAs)installed in vehicles as on board units (OBUs) or accesspoints (APs) strategically located in fixed points along the road, and hence usually referred to as road side units (RSUs). The vehicles equipped with an On Board Unit (OBU) in the VANET will be able to receive and transmit messages [1].

In MANET the nodes are moving at random and their speed is normal. In VANET, nodes are vehicles moving in a high speed of maximum 250 km/hr in a predefined road which depends on the road structure, traffic and traffic regulation[2]. For this reason IEEE 802.11 standard is not well suited for VANET Environment. Instead of using IEEE 802.11, the modified version IEEE 802.11P is used in VANET [3].

In VANET, there is no need to implement handover scheme, because it would imply overhead and also incur delay in communication. However, goal of VANET is not only limited to secure communications. There are many applications which require continuous communication when mobile node is traveling through the service area of a given RSU, such as voice over IP (VoIP), video streaming, etc. [4]. The applications can be classified into four categories:

1. Safety Warning: The VANET promises more safety features.
2. Traffic Management: The VANET offers more efficient driving.
4. Maintenance: VANET offers vehicles to send messages to the workshop in case the vehicles face any problems. Also firmware of vehicles can be upgraded from car manufacturer’s server.

The aim is the study of the available simulation environments for VANETs, the modeling of the simulation environment and the analysis of the results in order to design hybrid model that will reduce end-to-end delay and improve packet delivery ratio.

2. IEEE 802.11 AND IEEE 802.11 P
The protocol IEEE 802.11p is an amendment of the IEEE 802.11-2007 protocol for wireless networks which focuses on the improvement of the performance of the CSMA/CA networks in highly mobile ad-hoc networks. Currently the IEEE organization is working hard on defining the Standard WAVE 1609/IEEE 802.11p (Wireless Access in Vehicular Environments) [5], a specific protocol architecture for communications in scenarios of vehicular traffic.

The wireless communication standard IEEE 802.11 operates in the centralized mode. Here the mobile nodes communicate through the infrastructural unit and in Adhoc modes [6].

A. PHY LAYER
The physical layer of the IEEE 802.11p protocol is based on the one of IEEE 802.11a: orthogonal frequency-division multiplexing (OFDM) based modulation is used and the frequency allocation at the 5GHz band. The Federal CommunicationCommission (FCC) of the U.S. approved 75 MHz bandwidth in 5.850-5.925 GHz frequency band. The available band is divided into seven 10 MHz bandwidth channels (CHs 172 to 184), of
which CH 178 is designated as the Control Channel (CCH). CCH usage is limited to broadcast of safety-related data and transmission of control and management messages. The remaining channels are Service Channels (SCHs) which are available for non-safety related data transmission like sending multimedia message, video streaming, etc.

B. MAC LAYER
The IEEE 802.11 protocol is based on CSMA/CD and interframe spaces, which is used in both IEEE 802.11b and 802.11g [7]. The IEEE 802.11p proposal for MAC layer is a limited subset of the IEEE 802.11p, where only CSMA/CA random access scheme is available for the contention based phase (CBP), with no collision-free phase (CFP). To prevent privacy issues for the users, who can be easily traceable when using the standard IEEE 802.11 MAC permanent addressing approach, an OBU in a VANET frequently changes its MAC address. At startup time, the system randomly generates a new MAC address. It may change it during operation, as long as there are no ongoing communication sessions.

C. QoS
CBP in IEEE 802.11p uses the enhanced distributed channel access mechanism (EDCA). There are ACs which provide four QoS levels. For different medium access priority, there are different arbitrary inter-frame spacing (AIFS) and contention windows (CWs) defined for each QoS level. Within QoS classes the collisions are not prevented by the EDCA. Once packet has collided, a back-off time is randomly chosen from the Contention Window (CW) interval. The size of contention window is also different depending upon the priority level. For high priority packets, the probability for accessing channel after collision will be high. There are two factors: CWmin and CWmax. CWmin will have initial size of the CW. For each failure while transmitting message, the CW size if doubled until the size reaches CWmax parameter. CWmax parameter defines the maximum size of contention window.

3. EXISTING SYSTEM
New safety related mechanisms to reduce the number of car accidents on the roads are associated primarily to the deployment of new information technologies in cars and roadside equipment. Vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications provide a means with which traffic can be regulated to some extent and in this way reduce the risk of accident, increase driving comfort and implement infotainment communications (Internet access, mail service, etc.) on vehicles.

The mechanism provided in [8], is based on one-hop notification delivery scheme for vehicles where message is sent by colliding vehicle. When the collision take place then the vehicle which collides send the notification to the vehicles which are coming behind them. So, the vehicles which will receive the notification, will decrease their speed. So, the basic problem in the above solution is that the transmission range of the vehicle is very less. So, if the message needs to be transmitted to more number of vehicles which are coming behind, then it is not possible for the collided vehicle to send message to that extent. The possible solution for the above problem is Vehicle to Vehicle (V2V) communication. But the number of hops will increase tremendously. Also because of transmission of number of message, wireless traffic will increase which will lead to increase in collision of messages.

B. Ramakrishnan et.al. [9], discusses about Cluster Based Simple Highway Mobility Model (SHWN) where clusters are formed for V2V communication. There are less Road Side Units (RSUs) outside city areas. So the vehicles will communicate with other vehicles when there are no RSUs. In that case, VANET area will be divided into number of clusters where each cluster will have cluster head. So the communication will be possible through cluster heads only. The cluster head can communicate among themselves. The time needed for any vehicle to send message to long distance will be more in case of cluster based model. The end to end delay will also be more if SHWM is used. There are also chances that the packet may be dropped in vehicular network.

4. PROPOSED AMPSV: ADAPTIVE MESSAGE PASSING SCHEME IN VANET
When the vehicles move from the area where there are more RSUs to the area where there are less RSUs, or if the signal strength of RSU decreases, then automatically the cluster should be formed. The proposed Adaptive Message Passing Scheme in VANET will use both V2V communication and V2I communication to decrease end to end delay among vehicles. It will use V2I communication when RSUs are present. And similarly it will use V2V communication when there are no RSUs. So in this proposal we will design the hybrid model which will use both V2V and V2I communication. So in this hybrid model, there are two modes: Ad-hoc mode and Infrastructure mode.

In Ad-hoc mode, there is no RSU. The area will be distributed among different cluster area. Each cluster will have cluster head. Cluster members will communicate with their individual cluster head. Cluster head will be able to communicate with other cluster heads. Also cluster head should store message received from cluster
members. And depending upon the type of message it would transmit the message to other cluster heads which in turn would transmit that message to their cluster members. The cluster head would buffer the message received from their cluster members. If the buffer space is full, then in that case non-safety related messages should be deleted.

In infrastructure mode, RSUs are present. So all the vehicles will communicate with RSU.

A. Assumptions
- All the vehicles have onboard units
- If accident have taken place then the on-board unit automatically detects accident and send the message to either cluster head or RSU. The OBU detects accident by any mechanism.
- Also there is an emergency/manual button which driver can press if the vehicle have broken down in middle of the road may be because of any reason other than accident.

B. PROPOSAL
Based on the assumptions mentioned above, proposal for the application under consideration is:

- First of all the vehicle will try to establish the connection with Road Side Unit (RSU). If the vehicle is successful in establishing connection with the RSU then infrastructure mode is activated. In infrastructure mode, the vehicle directly communicates with RSU.
- By default infrastructure mode is enabled. If the onboard unit present in the vehicle does not receive the acknowledgement from the RSU, then it can be assumed that there is no RSU in the range.
- In case the OBU on vehicle does not receive the acknowledgement from RSU, the Ad-hoc mode will be enabled.
- In Ad-hoc mode, the vehicles will form cluster. For each cluster a cluster head is elected. All vehicles in cluster communicate with its cluster head. All cluster head communicates with each other.
- Also cluster head are required to buffer data i.e. store the communication messages received from the other members of cluster. There is a threshold value for how many number of messages cluster head can store in case RSU is not detected.
- Once RSU is detected and if currently it is in Ad-hoc mode, then the cluster head will transmit all the buffered data to the RSU. Also OBU will change its mode from Ad-hoc to Infrastructure.
- While deleting the buffered data, the OBU will not delete any priority data from the available data i.e. any accident related information or any break-down related information.

Infrastructure mode is shown in Figure 1. In Infrastructure mode, all the nodes will communicate with RSU. Initially all the vehicles will send Hello message to RSU. If RSU is in the transmission range, then RSU will receive Hello message sent from all the vehicles and will send Acknowledge message (ACK) to the vehicles. If the vehicle receives the ACK message then it can be confirmed that RSU is in the range and then they can communicate with RSU. If previously it was in Ad-hoc mode, then cluster head will send all the buffered data to RSU. If the vehicle does not receive ACK message then there is no RSU in the transmission range. As a result Ad-hoc mode is initialized and cluster formation will be initialized.
Ad-hoc mode is shown in Figure 2. In Ad-hoc mode, every node will broadcast HELLO message. Neighboring nodes on receiving the HELLO message will reply with Acknowledgement message (ACK). So, on receiving the total number of ACK messages from neighboring nodes, every node will broadcast their total number of neighbors. The node with the highest number of neighbors will become a cluster head. Once an node is elected as cluster head, it will broadcast its MAC address to all its neighboring nodes to inform them about their cluster head. Now every cluster member will communicate with its cluster head. If the cluster member does not receive ACK message from cluster head after sending the message, then it can be concluded that cluster head is out of transmission range and so cluster formation mechanism needs to be repeated again.

Cluster head on receiving the message from cluster member will buffer the received message. The messages are buffered FIFO principles. If buffer space is not available, older message is overwritten. If the message is safety related then it forwards the message to other cluster heads.

There are various parameters which are taken care of while forming cluster. If speed of vehicles is less and density is high then medium sized cluster is created. Similarly if the node density is high, traffic is heavy, and speed is less than that case small size clusters are created. Lower density of vehicles leads to creation of large size cluster. Also cluster head should not exceed the threshold speed as it could cross the cluster boundary early than other members.

5. SIMULATION

The Adaptive Message Passing Scheme in VANET is simulated using NS2.34. The vehicle mobility and traffic model was generated with MOBility model generator for Vehicular networks (MOVE). MOVE is built on top of Simulator for Urban MOBility (SUMO) version 0.13.1 and NS2.34. The simulation scenario was in the area of 652 * 752 meters of highway with bidirectional movements of vehicles. The scenario is designed for various number of vehicles 50, 60, 70, 80 and 90 and various vehicle speeds ranging from 20 m/s to 40 m/s. The simulation time taken is 300 seconds and 400 seconds. There are 5 communication flows i.e. communication between 2 vehicles is considered to be a communication flow. The IEEE 802.11p or 802.11 standards are integrated in the NS2.34 simulator to evaluate the performance of the proposed mobility model. The physical layer uses Orthogonal Frequency Division Multiplexing (OFDM) and MAC layer uses 802.11p which is standard amendment for VANET. The simulation parameters are summarized in Table 1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna Model</td>
<td>Omnidirectional antenna</td>
</tr>
<tr>
<td>Radio Propagation Model</td>
<td>TwoRayGround</td>
</tr>
<tr>
<td>Physical Layer</td>
<td>WirelessPhy/OFDM</td>
</tr>
<tr>
<td>MAC Type</td>
<td>IEEE 802.11p</td>
</tr>
<tr>
<td>Interface Queue Type</td>
<td>priority Queue (50 Packets)</td>
</tr>
<tr>
<td>Routing Protocols</td>
<td>AODV</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>250 second</td>
</tr>
<tr>
<td>Dimension</td>
<td>7973 X 4282</td>
</tr>
<tr>
<td>No. of vehicles</td>
<td>25, 50, 75, 100</td>
</tr>
<tr>
<td>Speed</td>
<td>10 m/s, 15 m/s, 25 m/s</td>
</tr>
<tr>
<td>No. of UDP connections</td>
<td>2, 3, 4, 5</td>
</tr>
</tbody>
</table>

Table 1. Simulation Parameters
The results in Table 2 and Table 3 are generated for the existing system. The number of vehicles and speed of the vehicle was varied to measure avg. end-to-end and avg. packet delivery ratio. Table 2 shows the average end-to-end delay for vehicle count ranging from 50 to 90 and speed varied from 20 m/s to 40 m/s. It is clear that for higher speed i.e. 40 m/s, the end to end delay is low. As speed increases, the time needed for V2V communication decreases. But as the number of nodes increases, the end to end delay is higher for high speeds, because of congestion in network. Table 3 shows the packet delivery ratio (PDR) for similar variation. Packet delivery ratio is the percentage of number of packets received to the number of packets sent. The PDR is more in case of higher speed because the number of messages transmitted to destination nodes are more.

<table>
<thead>
<tr>
<th>Speed (ms)</th>
<th>20m/s</th>
<th>30m/s</th>
<th>40m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>50.20 ms</td>
<td>55.89 ms</td>
<td>49.70 ms</td>
</tr>
<tr>
<td>60</td>
<td>51.65 ms</td>
<td>56.54 ms</td>
<td>45.88 ms</td>
</tr>
<tr>
<td>70</td>
<td>54.05 ms</td>
<td>58.33 ms</td>
<td>44.54 ms</td>
</tr>
<tr>
<td>80</td>
<td>55.03 ms</td>
<td>59.50 ms</td>
<td>43.65 ms</td>
</tr>
<tr>
<td>90</td>
<td>56.87 ms</td>
<td>61.65 ms</td>
<td>42.78 ms</td>
</tr>
</tbody>
</table>

Table 2. Average End-to-end delay

<table>
<thead>
<tr>
<th>Speed (ms)</th>
<th>20m/s</th>
<th>30m/s</th>
<th>40m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>67.40 ms</td>
<td>71.59 ms</td>
<td>79.67 ms</td>
</tr>
<tr>
<td>60</td>
<td>71.73 ms</td>
<td>73.20 ms</td>
<td>81.67 ms</td>
</tr>
<tr>
<td>70</td>
<td>83.00 ms</td>
<td>75.45 ms</td>
<td>78.50 ms</td>
</tr>
<tr>
<td>80</td>
<td>79.43 ms</td>
<td>75.19 ms</td>
<td>79.18 ms</td>
</tr>
<tr>
<td>90</td>
<td>84.54 ms</td>
<td>83.86 ms</td>
<td>83.05 ms</td>
</tr>
</tbody>
</table>

Table 3. Average Packet delivery ratio

6. RESULTS

The performance of the proposed solution is compared with basic AODV protocol in terms of Average End-to-End delay and Packet Delivery Ratio. All experiment results presented in this section are average of five simulation runs for all the two different parameters for performance metrics. The performance metrics measurements are with respect to number of vehicles and speed of vehicles. The following metrics were chosen for evaluating the performance of protocols:

**Average End-to-End delay (E2E delay):** It is the calculation of typical time taken by packet (in average packets) to cover its journey from the source end to the destination end.

**Packet Delivery Ratio (PDR):** This metric gives the ratio of the total data packets successfully received at the destination and total number of data packets generated at source.

By analyzing results of Ahmedabad city with varying number of nodes and speeds as shown in Figure 3 performance improvement in Avg. End-to-End delay can be seen. But as the number of vehicle increases, average end to end delay increases in the present system, while in the proposed solution it remains constant.
Similar results were recorded for Ahmedabad city with varying number of nodes and speed. The observations are shown in Figure 4. The Packet Delivery Ratio is less when compared with the current implementation. The PDR decreases because at the time of cluster election, the messages are discarded at MAC layer. When cluster election algorithm works, HELLO messages are broadcasted and so few messages are discarded. As a result PDR is less for new proposed solution.

7. CONCLUSION

Inherent VANET characteristics makes data transmission quite challenging for different type of application and scenarios. The proposed algorithm was tested for Ahmedabad city traffic scenario with variable number of vehicles and speed. Results showed that with help of clustering, better end-to-end delay can be achieved when compared with the existing system. But the time taken to form cluster, clustering algorithm and the periodicity of running cluster election algorithm are major factors which affect the results. Because of cluster election algorithm, the packet delivery ratio decreases when compared with the current system. When cluster election algorithm is executing, because of broadcast message the packets are discarded at MAC layer itself. The use of AMPSV capabilities in vehicular networks is expected to guarantee passengers to drive with a much higher level of safety.

REFERENCES

7. A Survey and Qualitative Analysis of MAC Protocols for Vehicular Adhoc NETworks