Cluster-Based Broadcast Mechanism for Inter-Vehicular Communication

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***Abstract*- Broadcast plays a significant role in VANET, especially in public safety applications, such as routine messages which are periodically broadcasted to announce the state of a vehicle to its neighbors and emergency messages which are generated when the behavior of a vehicle is abnormal. However, rapid and reliable broadcast of emergency messages is still a challenge to current protocols. This paper presents a broadcast mechanism which aims to reduce control messages in the network by broadcasting packets between nodes arranged in cluster formation and communicating through cluster heads, thereby improving the efficiency of packet transmission.**

***Keywords* : VANET, Cluster.**

I. INTRODUCTION

Intelligent transportation and ad-hoc technology have been rapidly developing and being widely used in recent years. VANET (Vehicle Ad-hoc Network), a special kind of MANET (Mobile Ad-hoc Network) which has been attracting more and more attention, emerges in various applications, including traffic management and sharing messages such as accidents and vehicle congestion information delivery, electronic navigation. In VANET, emergency information should be broadcasted in whole network rapidly. Thus, reliable and efficient routing algorithm is crucial. Real systems of intelligent transport will not exist without the existence of the communication networks that make it possible to collect the necessary data for operation [2].

There are mainly two approaches of communication in the network of vehicles. They are Vehicle-to-Infrastructure (V2I) communication and Vehicle-to-Vehicle (V2V) communication. V2I approach is based on infrastructure installed on the roads through which the vehicles communicate. This ensures the reliability of management of communications. This type of communication approach is expensive as the installation and maintenance costs of the equipments are high and they also do not readily adapt to new circumstances. The Vehicle-to-Vehicle (V2V) approach deals with communication between vehicles without the use of any already deployed infrastructures.

The main advantage of this is that it reduces the setup cost drastically as well as can be implemented in any existing topology or adapt to a scalable environment. But the problem of secure and reliable propagation in wireless environment persists.

II. INTER-VEHICULAR COMMUNICATION (IVC)

This kind of communication uses a direct transmission of information between vehicles without the use of fixed infrastructure. Thus, it adapts quickly and easily to several circumstances. An IVC network is considered as an ad hoc network, which consists of a set of nodes (vehicles) that communicate through radio frequencies, without the use of a beforehand-deployed infrastructure and without the use of a centralized administration. This type of network is used to exchange various kinds of vehicular information, in order to avoid collisions between vehicles and to ensure accurate automatic driving.

In IVC, the topology changes frequently and the vehicles communicate between them using radio channels. Since the bandwidth is limited and the topology of the network can generate bottlenecks, it is necessary to reduce the useless transmissions in order to decrease the traffic and to guarantee high QoS in the network.

III. CLUSTERING

It is defined as the division of network into different virtual groups, based on certain rules in order to differentiate the nodes allocated to other sub-network [1]. Or in simple words we can say that clustering is defined as virtual partitioning of nodes into sub networks according to geographical area. A typical cluster structure consisting of a cluster head node and gateway node designated in each cluster is shown in Figure 1. This setup helps in organizing the packet flow to the destined node (in any cluster) through gateway nodes.

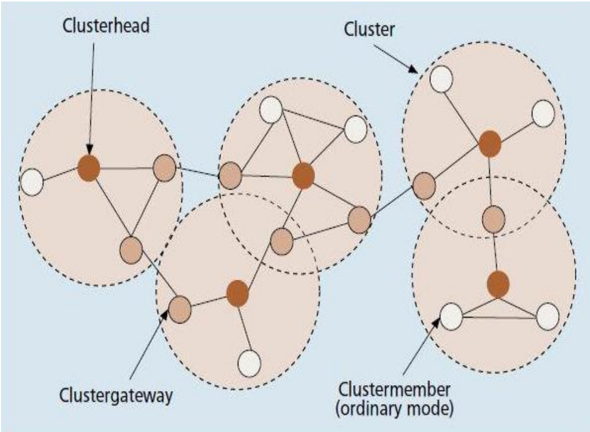

Figure 1: A typical Cluster structure

IV. Proposed Mechanism

We propose a mechanism in which vehicles of a road network are grouped into clusters, depending on the radio range of each vehicle. All the vehicles initially ping their neighbors i.e., send Hello packets, which contains the speed, distance from each neighbor, transmission rate and velocity of the vehicle. Each node which gets the Hello packet analyzes it and checks how many neighboring nodes are in its range (based on the distance) and how many it can be connected to. The nodes retransmit this data to all its neighbors and finally choose the node with maximum neighbors in its range, as their cluster head. Similarly, depending upon the vehicle density, clusters and therefore cluster heads are formed [3]. Now, any communication within a cluster is possible through the cluster head, hence minimizing the route overheads to every node. For communicating with a node in another cluster, a gateway node is selected from the nodes farthest to the cluster head in a cluster range. The Gateway node is responsible for inter-linking clusters by maintaining a handshake understanding with gateways of other clusters [5]. Thus, unnecessary overheads from the control messages are avoided during handshake with members of different clusters, hence allowing efficient utilization of bandwidth.

Now in the road network, when a vehicle in the front detects abnormal behavior of a vehicle (e.g., accident, hard brake, abrupt lane changing, overtaking, etc.), emergency message is generated which is broadcasted to all the preceding vehicles. This broadcasting of emergency message is based on the link status of the vehicles [4]. The node which first detects the abnormal event triggers an emergency message to the gateway, which in turn announces the cluster head. The cluster head then determines the link status, which is measured by the probability of packet reception. The analytical estimation of probability of packet reception is shown as,

$$P(x, \delta, r, f) = e^{-3(x/r)^2}\left(1 + \sum h_i(\xi, r)\,(x/r)^i\right)$$

where

$$h_i(\xi, r) = \sum h_i^{(i,k)}\, \xi^i r^k$$

$$i = 1, \ldots, 4, \text{ with } \xi = \delta \cdot r \cdot f$$

and x is the distance between sender and receiver in meters (m); δ is the traffic density in vehicles per kilometer (veh/km); r is the transmission range in meters (m) with certain transmission power, f is the message rate, $h_i^{(i,k)}$ is the empirical coefficient.

With the help of this link status calculation, the emergency messages are transmitted from the cluster head nearest to the event to the incoming vehicles behind.

V. SIMULATION AND PERFORMANCE ANALYSIS

The simulation was done using NS 2.35 with the following simulation parameters as listed,

PARAMETERS	VALUES
Simulation Time	120s
Area	1000x1000
Number of vehicles	30
Speed	30-50 kmph
MAC layer protocol	802.11p
Control packet size	30 byte
Data packet size	1000 byte

The two important metrics of a broadcast mechanism are the Average Delay and Packet Delivery Ratio (PDR), which are the representations of low-latency and reliability in broadcasting of emergency messages. The average delay here is

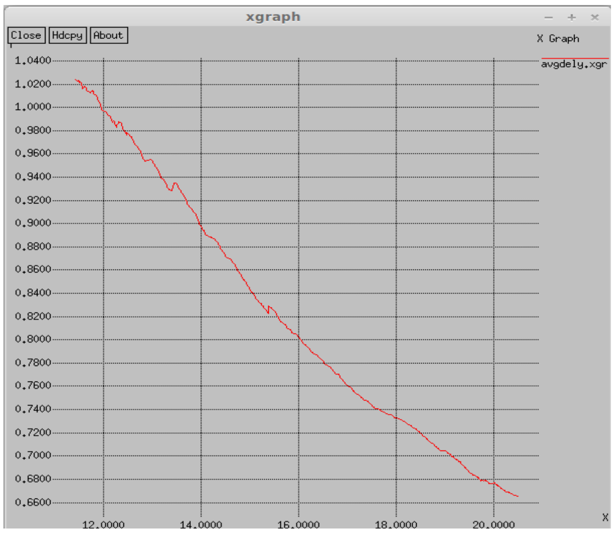

Figure 2 : Average delay for the given traffic density

The Packet Delivery Ratio (PDR) we obtained is shown below,

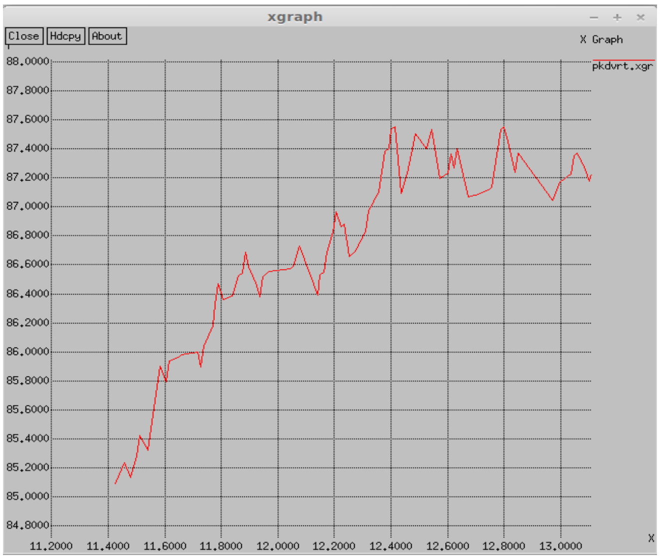

Figure 3 : Packet Delivery Ratio

The results show a better performance as in case of Average Delay, the graph shows a decrease in delay as the traffic density is high. This is because with more vehicles, the range of cluster head will be easier to connect and transmit messages to its neighbors and hence route its way to the preceding vehicles. The packet delivery ratio is also good as this helps in achieving the reliability constraint.

VI. CONCLUSION

In this paper, we divide the road network into clusters and appoint cluster heads so that unnecessary message overheads are avoided during handshake. Also, a broadcasting scheme was designed with which the cluster head could easily broadcast any emergency message to all the impending vehicles behind. Thus, the reliability and delay constraints are minimized by using this broadcast mechanism.

VII. FUTURE WORK

The concept can be further enhanced by applying more stochastic queuing mechanisms in order to minimize the traffic that may arise during high traffic and therefore can effect the overall efficiency and QoS of the model.

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