An Efficient Congestion Control Scheme for VANET

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***Abstract*— Vehicular ad hoc networks (VANET), which is a subclass of Mobile ad hoc networks, have recently been developed as a standard means of communication among moving vehicles because it has tremendous potential to improve vehicle and road safety, traffic efficiency. The Congestion control remains the major issue that can restrict the network performance for VANET applications due to its characteristics such as bandwidth limitation, fast change of topology and lack of central coordination. Number of solutions proposed to overcome these challenges and to reduce congestion on VANET. These solutions include congestion control algorithms, some of them based on maintaining the beacon load below certain threshold value by adjusting transmit power or transmit rate or both. Moreover, others based on utility function, carrier sense threshold or combination of them. This work proposes the congestion control scheme, which is based on beacon rate control approach for efficient use of available bandwidth. Performance of proposed algorithm is evaluated over different scenarios using network simulator NS2 and it shows that the proposed method outperforms existing methods in terms of packet delivery ratio and end-to-end delay.**

Keywords—VANET, Beacon messages, Event driven messages, Congestion control, IEEE 802.11p

I. INTRODUCTION

The networks with the absence of any centralized or pre-established infrastructure like access points in managed wireless networks or routers in wired networks called Ad hoc networks. Such wireless ad hoc networks can be categorized via their application, such as Wireless Mesh Networks (WMN), Mobile Ad Hoc Networks (MANET) Wireless Sensor Networks (WSN), and Vehicular Ad hoc Networks (VANETs). VANET is a particular type of MANET, that vehicles play the role of nodes in it. As opposed to MANET, vehicles move on predefined roads and velocity depends on the speed signs. Considering providing comfort and safety to the road users, VANET also regarded as one of the influencing areas in advancement of the intelligent Transportation System (ITS).

The basic target of VANET is to increase safety of the road users and comfort of the passengers. There are many challenges in VANET that have to be resolved to offer reliable services such as routing, security, and quality of service. Due to many issues such as inaccurate state of information, dynamically varying network topology, absence of central coordination, hidden terminal problem, limited resource availability error prone shared radio channel, and insecure medium, therefore, supporting Quality of Service (QoS) is a challenging task.

VANET belongs to wireless communication networks area. The Federal Communication Commission (FCC) allocates the frequency spectrum for VANET's wireless communication. Then the Commission in 2003 established the Dedicated Short Range Communications (DSRC) Service. The DSRC is a communication service, which utilized for public and private safety and uses the frequency range of 5.850-5.925 GHz [1].

The DSRC designed into multi-channel system. The DSRC spectrum divided into seven channels by the FCC so that each of them has 10 MHz bandwidth. Six of them were identified as Service Channels (SCH), and one of them is identified as the Control Channel (CCH), as shown in Fig. 1.2.The CCH channel is used for safety messages, while SCH channels are used for non-safety as well as WAVE-mode messages or services [3]

II. NEED OF DESIGNING CONGESTION CONTROL ALGORITHM FOR VANET

There are two types of messages in VANET to enable safety applications. On the one hand, cooperative awareness messages (CAMs), also known as beacons, that broadcasted periodically by all nodes on the control channel, in order to receive and provide status information on presence, geographical position and movement of neighboring nodes, and service announcements to/from those nodes. On the other hand, emergency messages that are event-driven will transmitted in the case that an abnormal or hazardous condition noticed, in order to inform surrounding nodes about it. In high traffic, a large number of vehicles broadcast beacon messages at a high frequency, which can easily congest the control channel. The periodic messages are broadcast may lead to broadcast storm flooding problem in VANETs. It is very important to keep the control channel free from congestion in order to ensure timely and reliable delivery of event-driven safety messages. Though several routing protocols are available for ad hoc networks, these protocols do not have the special mechanism to reduce channel congestion. So there is need to design efficient congestion control policies that guarantee stable and reliable communication between vehicles and roadside units, these policies should reduce load on communication channel.

III. DFPAV ALGORITHM

Distributed Fair Transmit Power Adjustment for VANET (DFPAV) proposed the optimization criterion for improving safety that has built upon the concept of fairness. Which means, to make safety applications capable of detecting an unsafe situation and taking the right decisions to avoid a danger in case of emergency, it is very important that every vehicle has a good estimation of the state of all vehicles in its closer surrounding. In other words, if a vehicle has not assigned a fair portion of the resources, it cannot announce itself to its closer neighbors, and becomes a danger itself. Thus, the available channel capacity must share among nodes in a fair way. This is needed for maintaining relevance of safety messages, balancing event driven messages, keeping beacon load below maximum beacon limit. Distributed fair transmit power adjustment scheme uses FPAV algorithm for computing power. It helps to solve BMMTxP problem maximizing the minimum power used by nodes and maintaining network load below MBL.

Algorithm D-FPAV: *(algorithm for node ui)*
INPUT: status of all the nodes in CSMAX(i)
OUTPUT: a power setting PA(i) for node ui, such that
the resulting power assignment is an optimal solution to BMMTxP
1. Based on the status of the nodes in CSMAX(i),
compute the maximum common tx power level Pi s.t. the MBL threshold is not violated at any node in CSMAX(i)
2a.Broadcast Pi to all nodes in CSMAX(i)
2b. Receive the messages with the power level from
nodes uj such that ui € CSMAX(j); store the received values in Pj
3. Compute the final power level:
PA(i) = min_Pi, minj:ui€ CSMAX(j){Pj}

IV. THE PROPOSED CONGESTION CONTROL ALGORITHM

The proposed work mainly concentrates on one of the major issues in VANET i.e. network congestion. Due to certain characteristics of VANET, such as limited bandwidth, fast changing topology and high mobility, congestion remains a major problem. In dense traffic scenario, the entire vehicle transmits safety messages over control channel due to which it can easily congest. The proposed congestion control algorithm based on adaptive beacon rate scheme that can reduce the channel load by considerable amount and hence reduce congestion.

The threshold value and beacon rate initialized at the starting. The channel then continuously monitored at each node by considering traffic. Based on calculated channel load, the channel then checked for condition of congestion. If channel load is above threshold, the channel said to be congested. With the detection of congestion state at channel, the congestion control scheme activates. It modifies the beacon rate and checks the channel load status. If channel load is below congestion level, then again channel monitoring takes place. If still channel appears congested, the beacon rate updates again. The updated beacon rate then sent back to initial stage.

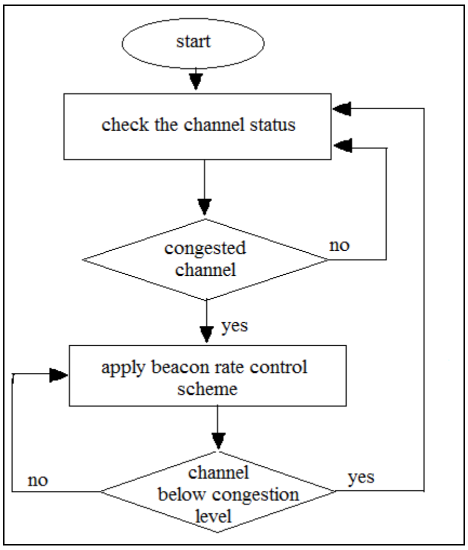

Fig 1. Flowchart of proposed algorithm

V. EXPERIMENTATION

In the evaluation of the wireless communications, the aspect of using suitable mobility models and their accurate configuration plays important role. Since NS2 is extensively used network simulator, we have used NS2.34 version for out experimentation.

Table given above shows different simulation parameters used in our experiment. Two scenarios created as vehicle-to-vehicle (V2V) and vehicle to roadside unit (V2R). The packet size taken is 1000 bytes. Packet delivery ratio and end-to-end delay selected as metrics for evaluation of proposed algorithm.

Table 1 Simulation parameters

PARAMETERS	VALUE
Simulator used	NS 2.34
Channel Type	Wireless Channel
Propagation model	Two Ray Ground
Antenna used	Omni
MAC protocol	802.11
Area	300*300
Number of nodes	10, 30, 50, 100
Source type	UDP
Packet size	1000 bytes
Simulation time	10 sec
Observation parameters	Packet delivery ratio, End to end delay

A. Simulation results

Various performance metrics are to be considered as Packet delivery ratio and end-to-end delay for evaluation of congestion control algorithm.

i. Packet Delivery Ratio

It is defined as the ratio of number of delivered data packets to the destination to the total sent packets.

ii. End to End Delay

It is the average times it taken by the packet to reach to destination in seconds. End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination.

iii. Relative Improvement in PDR

It is defined as percentage difference between the packet delivery ratios for proposed and implemented work.

iv. Relative Improvement in end to end delay

It is defined as the percentage difference of end-to-end delay between implemented and proposed work.

B. Result Analysis

i. Packet Delivery Ratio for V2V Scenario

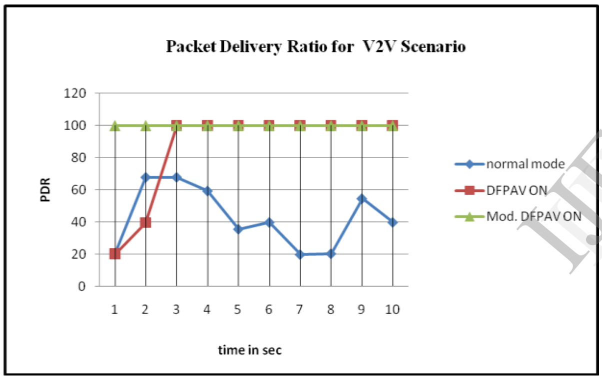

Fig.2 PDR for V2V Scenario

The above figure shows the proposed algorithm gives better performance as compare to normal mode when DFPAV is on. The average value of PDR over whole simulation time for normal mode is 42.43%, for DFPAV it is 85.95% and for modified DFPAV it is 100%. Hence, the average PDR increased by 14.05% in case of modified DFPAV.

ii. End to end delay for V2V Scenario

Fig.2 shows the average end-to-end delay for normal mode is 1.51ms, and for DFPAV it decreased to the value of 0.80ms. When calculated for modified DFPAV modes, the delay found to reduce by 25.92% as compare to DFPAV mode. This shows that the modified DFPAV performs better than rest of two modes.

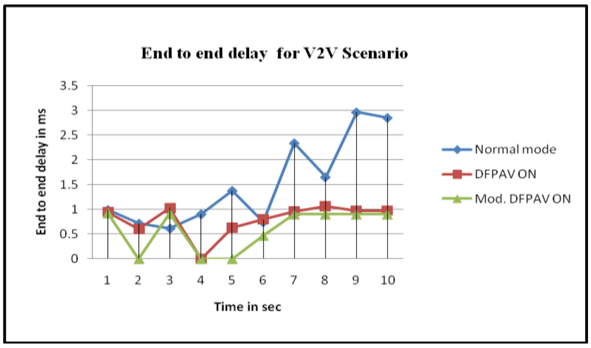

Fig.3 End to end delay for V2V Scenario

iii. Packet Delivery Ratio for V2R Scenario

Fig. 4 gives Packet Delivery Ratio for V2R scenario.

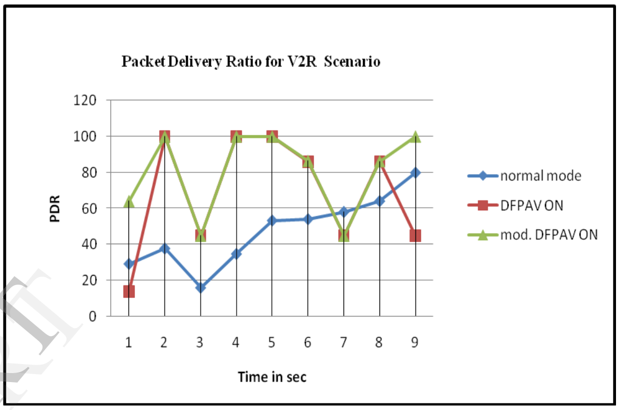

Fig.4 PDR for V2R Scenario

Figure above shows modified DFPAV performs better than DFPAV mode. For normal mode, the average PDR over complete simulation time is 47.66%, where for DFPAV mode it is 80.77%. When modified DFPAV is applied, the average PDR increased by 14.54% than in case of DFPAV.

iv. End to end delay for V2R Scenario

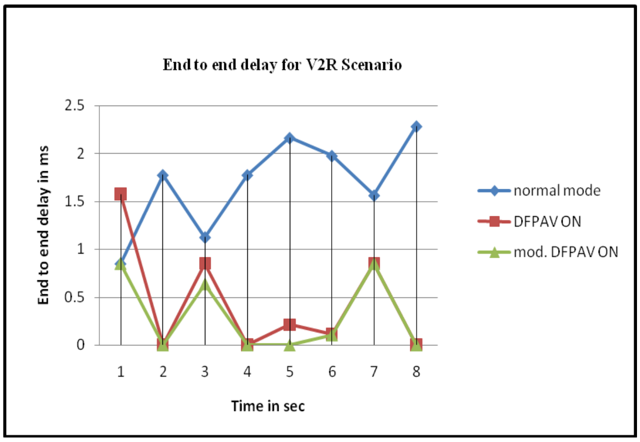

Fig.5 End to end delay for V2R Scenario

Fig. 5 shows the average end-to-end delay for normal mode is 1.68ms. When DFPAV is applied, the average end-to-end delay decreased to 0.45ms. With modified DFPAV, the end-to-end delay further reduced to 0.30ms. It shows that modified DFPAV decreases the end-to-end delay by 32.11% hence performs better than DFPAV mode.

v. Relative Improvement in PDR for V2V Scenario

Result shows there is improvement in PDR during first half of simulation time. However, for rest of duration, the performance of both DFPAV and modified DFPAV is same. With less number of nodes, the improvement index is less. As number of nodes increases the improvement index is also increased.

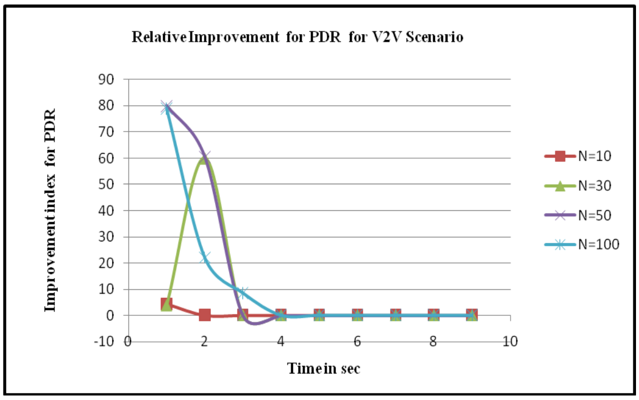

Fig.6 Relative Improvement in PDR for V2V scenario

vi. Relative Improvement in end-to-end delay for V2V scenario

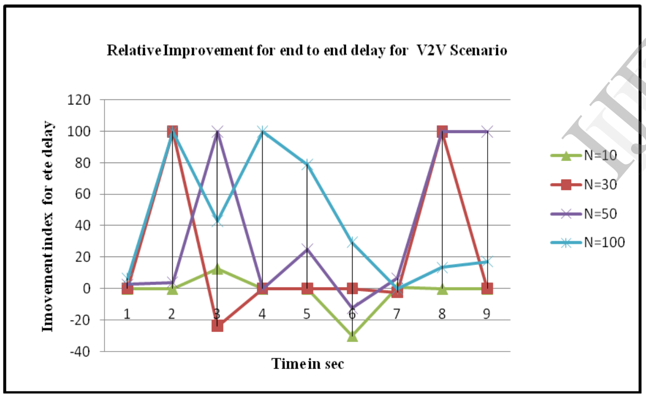

Fig.7 Relative improvement in end to end delay
For V2V scenario

Result shows that at lower number of nodes, the performance of modified algorithm is poor. As number of nodes increases, the improvement index for end-to-end delay increases. This shows that with increase in node number, modified algorithm performs better as compare to DFPAV.

vii. Relative improvement for PDR for V2R scenario

The improvement index for packet delivery ratio for V2R scenario shows that for lower number of nodes packet delivery ratio increases significantly while with increase in node number both the algorithm shows same performance.

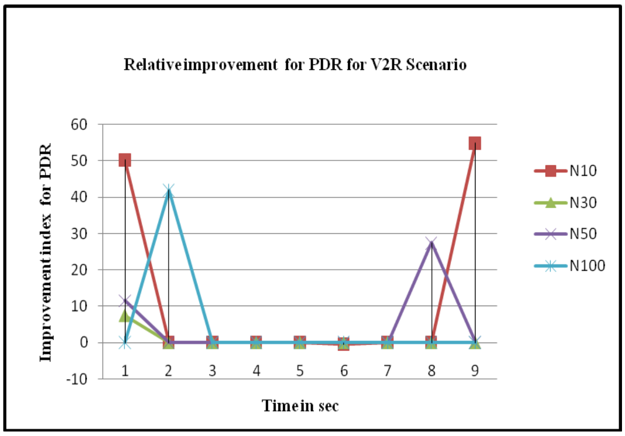

Fig.8 Relative Improvement in PDR for V2R scenario

The improvement index for packet delivery ratio for V2R scenario shows that for lower number of nodes packet delivery ratio increases significantly while with increase in node number both the algorithm shows same performance.

viii. Relative Improvement in end to end delay for V2R scenario

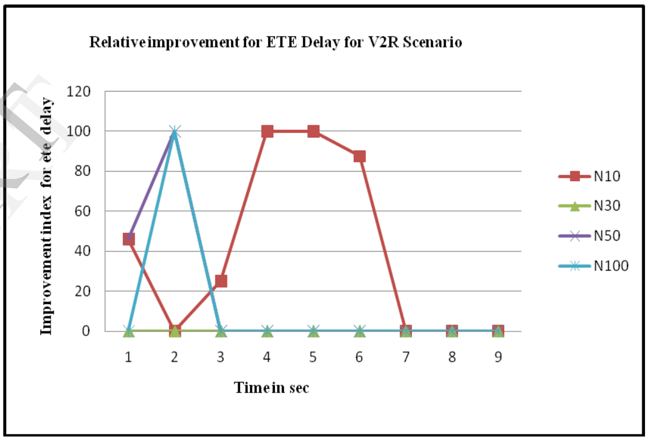

Fig.9 Relative improvement for end to end Delay for V2R Scenario

Figure above shows that for 10-node scenario, the end-to-end delay for modified algorithm gives better result. As number of nodes increases in scenario, there is no significant improvement in end-to-end delay.

CONCLUSION AND FUTURE SCOPE

In this paper, we discussed the implementation and simulation of congestion control algorithm for VANET. Simulation considers two scenarios i.e. V2V Vehicle to Vehicle V2R Vehicle to Roadside unit and three different modes normal mode, DFPAV on and modified DFPAV on. From simulation results, we observed that the modified algorithm performs better in V2R scenario as compare to V2V scenario. The performance of proposed algorithm evaluated also by varying node number; from results, it is observed that as node number increases, the proposed algorithm performs better in V2V scenario but for V2R scenario, its performance degrades with increase in number of nodes. The future study will be on examining the proposed algorithm considering scenarios that are more realistic.

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