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Congestion Control in MAC Layer of VANET using Gradient Decent Algorithm

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Abstract: Vehicular Adhoc Networks (VANETs) is growing as an enormous technology in wireless network that making communication possible between vehicles. VANET consists of vehicles, GPS, road side units, radio transceivers and internet connection. It attracts lots of researchers and industries towards itself due to its application in road safety, traffic control management and entertainment. United State Federal Communications Commission (FCC) has allocated 75MHz of bandwidth spectrum in 5.9 GHz band. VANET is a part of Mobile Ad Hoc Networks (MANETs). To provide a reliable and safe communication between the vehicles with minimum delay an efficient MAC protocol is required. Many of existing MAC protocols for VANETs are not efficient. Currently VANET is working on contention-based scheme IEEE 802.11p. Contention based MAC protocols are not suitable for VANET environment due to high collision rate of messages and delay in delivery to receiving node. The contention free MAC protocols for challenging environment of VANET. The major reason for this research area is to provide safety to the vehicles and human lives. Safety messages and related information should reach at its destination with minimum latency and collision. Millions of people lost their life due to road accidents in the world. To provide safety on the road with increased vehicular traffic, smart vehicles which can communicate with other vehicles and RSUs are required to prevent accidents. Vehicular Ad-hoc Network (VANET) provides this flexibility to the vehicles, but VANET are not just limited to road safety, it can be used for comfort and entertainment purposes as well. Slot assignment technique to vehicles to send the safety messages plays an important role in safety in VANET but it also poses a major challenge. Self-sorting-based MAC convention is proposed to enhance the execution of wellbeing application in high congestion (VANETs). In this gradient descent algorithm is used for the optimized queue resources. During used slot of a queue handshakes for service application are also transferred through the queue members.

Keywords: VANET, MANET, Congestion Control.

I. INTRODUCTION

Vehicular Ad hoc Networks (VANets) are employed by Intelligent Transport Systems (ITSs) to operate wireless communications in the vehicular environments. VANets are designed to provide a reliable and safe environment for users by reducing the road accidents, traffic jams, and fuel consumptions, and so on. The VANets' users can be informed of hazardous situations by vehicular communications and exchanging the information about surrounding environments [1], [2]. VANets are a type of Mobile Ad hoc Networks (MANets). The vehicles in VANets are similar to the mobile nodes in the MANets. Although VANets inherit most of the characteristics of MANets, VANets have some unique characteristics such as high mobility, high rate of topology changes, and high density of the network, and so on. Thus, VANets have different characteristics in comparison with MANets [7].

Congestion occurs in the channels when these channels are saturated by the nodes competing to acquire the channels. Indeed, by increasing the vehicle density, the number of channel collisions increases occurrence of congestion in the network. The occurrence of congestion increases the delay and packet loss (especially for safety messages) leading to mitigation of the VANets' performance [8]. To guarantee the reliability and safety of the vehicular communications, and to improve the performance of VANets, Quality of Service (QoS) should be supported. Controlling congestion is an effective way that should be employed to support the QoS [2], [4]. By controlling the congestion, the delay and packet loss and consequently the performance of VANet can be improved that help have a safer and more reliable environment for VANets' users [12]. Due to the special characteristics of VANets, the congestion control strategies are different compared to the congestion control strategies proposed for MANets [12]. T

he congestion can be controlled in VANets in different ways such as by tuning the transmission rate, tuning the transmission power, determining the contention window size and Arbitration Inter-Frame Spacing (AIFS), and prioritizing and scheduling the messages [13]. However, congestion control strategies in VANets face some problems including high transmission delay, unfair resource usage, inefficient bandwidth usage, communication overhead, and computing overheads, and so on [10], [13]. Therefore, new strategies, considering these problems, should bedeveloped to control the congestion in VANets, especially in critical situations where the safety messages should be transferred without any significant delay and packet loss.

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II. CONGESTION CONTROL

Generally, in each network, there are some resources that are shared between the users of the network competing to acquire those resources. Adjusting the data rate used by each user is essential to control the network load and prevent the channel overload. When the packets arrive to a router node and the router cannot forward them, the router drops the new packets, whereas these packets consumed a significant amount of resources for arriving to this node. One of the main reasons, which results in dropping the packets by the router nodes, is the congestion. Indeed, when the capacity of the network is less than the networks load, the packets are dropped due to the congestion occurrence in the networks. The throughput of the network significantly reduces due to the network congestion. Therefore, congestion control should be performed to prevent the congestion occurrence and increase the successful delivery of data in the networks. In addition, controlling the congestion enhance the bandwidth utilization, responsiveness, and fairness usage of network resources.

Transmission Control Protocol (TCP) employs the slow-start algorithm as the main part of the congestion control process in the networks. In the slow-start algorithm, the congestion window size is initially set to 1, 2, or 10. When an acknowledgment is received, the congestion window size is doubled. Once a packet is lost or the congestion window size exceeds the predefined slow-start threshold, TCP considers that the congestion occurred in the network. In this situation, TCP increases the congestion window size by one unit in each Round Trip Time (RTT) to reduce the channel loads and control the congestion.

Various congestion control strategies accomplish based on TCP to avoid the congestion occurrence in the networks. TCP-Tahoe is a congestion control strategy referred by many congestion control strategies. Using the TCP-Tahoe strategy, the congestion is detected by determining the timer for acknowledgments. In the TCP-Tahoe strategy, when congestion occurs in the network, the slow-start threshold is set to half of the current congestion window size and the slow-start algorithm is reset to the initial state. In TCP-Reno strategy, however, when three duplicate acknowledgements are received, the congestion window size is set to the half of the current value, and the slow-start threshold is set to the current value of congestion window size.

The packet losses are considered to detect the channel overloading in the traditional TCP congestion control strategies. However, when the bandwidth is available, the packets losses may still occur due to the random bit corruption, channel error, and route failure. Also, using the packet losses is not a sufficient for determining the level of contention in the channels. Therefore, in addition to packet losses, other parameters of network conditions should be considered for controlling the congestion in the networks.

Although TCP congestion control strategies efficiently carry out on the Internet, these strategies are not efficient for MANets due to the unique characteristics of these networks. Indeed, the standard TCP faces many issues in MANets due to unique characteristics of these networks, different environments, different protocols, and different architecture. The unique characteristics of MANets include the shared wireless channels, node mobility, and multi-hop wireless communications and so on. Due to the node mobility in MANets, the frequently routes break or change lead to increasing the packet loss or delay for delivering the packets. In the Internet, congestion occurs in a single router node, while, in MANets, the congestion occurs in an area because of employing the shared medium in these networks. Moreover, TCP congestion control strategies consider that all packet losses are caused by congestion, while, in wireless mobile networks, the packet can be lost due to the congestion occurrence, channel errors, and route failures. Therefore, TCP congestion control strategies are not efficient in mobile ad hoc networks and result in a performance reduction.

The EDCA mechanism is used in the IEEE 1609 WAVE protocol for determining the priorities for different types of messages generated in VANets. In EDCA, the high priorities are assigned to the safety messages to occupy the channel and transfer with less delay compared to the other low priority messages. Indeed, EDCA determines a smaller contention window size and AIFS for high priority safety messages to acquire the channels quickly.

The congestion detection part employs some information from the application layer to detect the congestion occurrence in the network. In addition, the congestion can be detected by sensing the channel in the physical layer and measuring some parameters like channel usage level. The congestion control can be conducted in different ways in different network layers. The application layer can contribute to congestion control by tuning the message generation rates of different applications, and reducing the traffic loads as well as congestion in the networks. The network layer can control the congestion by smart routing algorithms that efficiently rebroadcast the messages and mitigate the congestion. The prioritizing and scheduling messages at MAC layer can significantly help control the congestion in VANets. Moreover, the control and service channels can employ to transfer the prioritized safety and non-safety messages, respectively.

In VANets, congestion control strategies can be classified based on the means and parameters employed for controlling the congestion. Thus, the congestion control strategies can be classified into the rate-based, power-based, CSMA/CA-based, prioritizing and scheduling-based, and hybrid strategies. The rate-based strategies adjust the transmission rate based on the channels conditions to reduce the collisions in the channels. The power-based strategies dynamically tune the transmission power (range) to control the channels loads. The CSMA/CA-based strategies control the congestion by adjusting parameters of CSMA/CA protocol such as the contention window size and/or AIFS. In prioritizing and scheduling-based strategies, the priorities are defined for the message, and then the prioritized messages are scheduled to transfer in the control and service channels. Finally, in the hybrid strategies, all or some of the means or parameters used in previous categories are employed to avoid or control congestion occurrence in the netwconnectork [13].

III. PROPOSED ALGORITHM

In the existing approach the following algorithm is used for Packet Delivery enhancement and reduction in Packet Drop Rate.
Step 1: Queue Formation: Division of nodes into groups / queues based on their physical location and collection of security messages of queue members.
Step 2: Channel reservation: reserving the control channel for the entire queue.
Step 3: Forwarding security messages and WSA handshaking: forwarding of all-queue security messages and exchange of WSA handshake for service messages of queue members. This step is performed during the slot TDMA on the control channel.
Step 4: Transmission of service data: transmission of service messages on service channels.

Gaps in the previous Method

1) In Previous research queue length follow the poison distribution which only express the retry of packet not show drop ratio of packets.
2) In previous research the queue length depend on safety packet (that packet acknowledgement but not monitor the behavior of vehicles which indicate drop packet by its connectivity.
3) In previous work give the channel according to queue but ignore its connectivity to other nodes or channel available in range of particular vehicle or not.

Gradient descent is an optimization algorithm which is used to identify the values of constraints of a function which minimize the cost function. This algorithm provides the continuous optimization for a long time. Basically it is an iterative algorithm which is based on the alue of cost function which decreases fast in the direction of negative gradient.

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Algorithm Used
Input : Y, θ, X, α, tolerance, Max iteration
Here, Y← Number of Queues
θ← Queue length
X← Vehicles
α← Variance in queue Length
Output: θ
Step 1: $for\ i = 0; i < \max iteration; i++\ do$
Current cost= Cost(Y,X, θ) {Current cost← Number of drop Packet}
If current cost < tolerance of variance
else
gradient = Gradient (Y,X, θ)
$\theta j \leftarrow \theta j - \alpha.\ gradient$ {Update the variance on the basis of variance change the queue length}
Here α is learning rate.
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The Gradient descent is working effectively by plotting the cost function and put the iteration on the x-axis and y-axis contains the value of cost-function. This method provides the value of the cost function after each iteration of the gradient descent. This enables you to see the value of your cost function after each iteration of gradient descent. This lets you easily spot how appropriate your learning rate is. You just try different values for it and plot them all together. When Gradient Descent can’t decrease the cost-function anymore and remains more or less on the same level, we say it has converged. Note that the number of iterations that Gradient Descent needs to converge can sometimes vary a lot. It can take 50 iterations, 60,000 or maybe even 3 million. Therefore the number of iterations is hard to estimate in advance.

V. RESULTS

The parameters used in this work represent the efficiency of the proposed work in the vehicular network. Following are the parameters that are used for analysis process in the next section:-

(a). Vehicle Coverage Ratio: It is defined as the vehicles in the particular range. No. of Collision Occur: it is the ratio between the total packet transferred from a nodes and their delivery rate. If the packet delivery is successful then network is working properly if the nodes does not receive message due to failure is case of accident.
(b). Channel Busy Ratio: This parameter defines the network ratio when the data packet delivered on the network is more than its efficiency and data transmission between vehicle goes slow.
(c). Packet Delivery Ratio (PDR): It is defined as the ratio of total number of packets delivered successfully and the total number of packets sent from source to destination. Higher PDR signifies more efficiency in the network.

Existing Approach results

The below given table 1 represents the existing approach results values. The parameters used in this shows the changes according to node.

Table 1. Existing approach results

No. of Nodes	Vehicle Coverage ratio	No of Collision Occur	Channel Busy Ratio	PDR
50	0.0257	0.00222	0.7	0.08
100	0.019	0.0021	0.75	0.15
150	0.019	0.002	0.73	0.26
200	0.025	0.0020	0.76	0.29
250	0.029	0.0020	0.74	0.30

Proposed Approach Results

The below given table 2 represents the proposed approach results values. The parameters used in this shows the changes according to node.

Table 2. Proposed approach Results

No of nodes	Vehicle coverage Ratio	No of Collision occur	Channel busy ratio	PDR
50	0.04	0.0019	0.801	0.36
100	0.029	0.0019	0.791	0.41
150	0.025	0.0019	0.803	0.48
200	0.03	0.00191	0.817	0.50
250	0.034	0.00192	0.819	0.51

Comparison of Existing and Proposed Approach

The table 3 depicts the values of the existing and proposed approach. The values of the parameters are changed according to the nodes.

Table 3. Comparison Values of existing and proposed approach

No. of Nodes	Vehicle Coverage ratio		No of Collision Occur		Channel Busy Ratio		PDR	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
50	0.0257	0.04	0.00222	0.0019	0.7	0.801	0.08	0.36
100	0.019	0.029	0.0021	0.0019	0.75	0.791	0.15	0.41
150	0.019	0.025	0.002	0.0019	0.73	0.803	0.26	0.48
200	0.025	0.03	0.0020	0.00191	0.76	0.817	0.29	0.50
250	0.029	0.034	0.0020	0.00192	0.74	0.819	0.30	0.51

VI. CONCLUSION

This work describes various MAC protocols for VANETS. It incorporates point by point discourse of TDMA based MAC protocols that perform superior to anything whatever is left of contention based protocols. We proposed Novel Self sorting based MAC protocol. Self-sorting based MAC convention is proposed to enhance the execution of wellbeing application in high congestion (VANETs). In this gradient descent algorithm is used for the optimized queue resources. During used slot of a queue handshakes for service application are also transferred through the queue members. The performance evaluation of this work is done by enhancing the packet delivery ratio.

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