Congestion Control Scheduling Scheme for Vehicular Networks

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***Abstract*— The vehicular Ad hoc network is new emerging technology to enhance traffic safety and comfort for automotive users. Most of the safety applications in this field need real time information with high reliability and in time delivery. In dense network a large number of vehicles nodes disseminate the messages to all accessible nodes with high frequency and control channels will be easily congested and cause of broadcast storm. There is a need to prevent control channels from these types of storms and ensure the reliable and in time devilry of messages for safety applications. The congestion control mechanism is one of the most popular approach to control the load and ensure in time and efficient delivery of messages. We proposed a congestion control scheduling scheme to provide an efficient operation, congestion avoidance or mitigation. The performance of proposed scheme is evaluated in different congested scenarios and compared with existing congestion control scheduling schemes and improve packet loss rate and packet delay.**

Keywords*— *VANET; Control Channel; Safety Applications

INTRODUCTION

Recently, road accidents and road injuries represent a major cause of death, and economic burden from road crashes is 3% of gross domestic product noticed. One of the most promising technology is vehicular Ad hoc network and their safety applications use for prevent vehicles from accident [1]. The vehicular Ad hoc network (VANET) is a sub class of mobile Ad hoc networks (MANET) but with their own unique characteristics. The high node mobility and dynamic nature and unreliable channel conditions differentiate VANET from MANET [2]. Most of the application relies on the broadcast messages to all reachable nodes within a geographical area rather than a route. The VANET applications are categorized into two main types: beacon and event driven. In beacon based applications the vehicles periodically broadcast the message to alert other vehicles about speed, direction and positioning. The event driven applications need high priority and reliability. These applications are based on reliability of broadcast information such as alerting and detection applications. The alert massages are always on priority and need to broadcast effectively and quickly as possible. The messages broadcast periodically to alert other vehicles to avoid potential dangers [3]. The broadcasting of these messages in high vehicle density areas may lead to broadcast storm issue in VANET and wireless communication channel will be congested. If there are many vehicle nodes with the same priority to transmit, collision may occur. The control channel must be free from congestion for event driven safety messages [4, 5].

In section 2 we will discuss the related work on communication channels and in section 3 illustrates the proposed model and in last section the proposed scheme compare with existing approach.

RELATED WORK

The different approaches have been proposed to prevent broadcast storm problem and to address the degradation of wireless channels communications. The congestion control mechanism has been extensively studied by several authors [4-7]. The main purpose of congestion control mechanism is to best exploit the available network resources to preventing vehicles nodes from overload and provide efficient operation. There are several challenges in development of congestion control mechanism such as dynamic nature of network, high mobility of nodes, rapidly changing topology, node density [8, 9]. Most of the proposed congestion control mechanisms are not suitable for event driven safety messages. The authors Wischhof & Rohling [4] focused on infotainment applications like provision of internet, audio and video. The author [10] focused on emergency electronic brake light with forwarding (EEBL-F) to provide reliable congestion control mechanism but this is only one type of event-driven safety message. The author neglected some other applications such as pre-crash sensing, lane change warning, signal violation etc. In another approach [10] author proposed to reschedule and reorders the messages according to their new computed priorities. The proposed method needs context exchange between neighbor vehicle nodes and cause of communication overhead.

Generally the congestion control mechanism divided into four mechanisms such as brute force queue freezing method, measurement based mechanism, MAC blocking, and transmit power control. Many researchers included brute force queue freezing method in their proposed congestion control mechanisms [8, 10-12].

In Brute Force Queue Freezing the every vehicle node applies brute force queue freezing for all MAC (media access control) transmission queues without high priority messages. When a vehicle node receive a high priority message then the node immediately launch the congestion control and freeze all other beacon messages in CCH (control Channel) and lower priority messages can be avoided. This mechanism triggered only on the time of event driven message detection. In another approach the author use this method when a node receives beacons notifying the presence of event driven message then the first message in its queue will be send [11]. The event driven message freezes its transmission even though the CCH (control Channel) is free. This technique is better for high priority messages in VANET and give delivery guarantee.

The second main category is measurement based detection, in this approach every device periodically senses the channel and this sense is based on predefined threshold. The threshold will measured by channel usage, occupancy time and event validation. The author [10] uses this technique in their proposed approach where every device sense the channel usage, level and detects congestion when measured channel level exceeded the predefined threshold. It has been proposed that the channel usage threshold is just an intuitive and approximation of channel busy level and link with overall traffic load. The proposed approach reduced the channel bandwidth and when the communication channel usage is higher than the event driven messages will be considered invalid. In another [13] approach the channel set the occupancy time as a predefined threshold. If the channel occupancy time measured at the node in the CCH (control channel) communication channel interval is longer than a given threshold, all event driven messages will be blocked. Although measuring the channel communication is so difficult because it need a proper rate control design and more time for measure the congestion.

The third method is MAC (media access control) blocking detection and used for the immediate control of the beacon message transmission for congestion [13]. The MAC blocking happens at a node because of excessively long channel occupancy time and channel is considered congested for high priority messages.

The power transmit control is another approach for maximizing the overall system capacity and connectivity for point-to-point communication [7]. The author [14] proposed the congestion control mechanism and power control strategies to attain the optimal broadcast efficiency.

A. *High Priority Applications*

The high priority applications are used to improve the safety level and transportation efficiency. These applications are further divided into two categories: periodic or beacon and event driven. The main aim of periodic applications is to avoid the dangerous situations and on the other hand the event driven applications are used after any accident or danger to alert other vehicles in time.

These applications have different features and characteristics, frequencies and transmission range as well. The stop sign assists application is used for vehicle position, warning and for velocity, the forward collision application is for speed, acceleration, etc. One popular application is traffic signal violation, which is used for timing, road geometry, and direction. Below Table 1, shows some popular event driven applications with their features.

TABLE 1. EVENT DRIVEN SAFETY APPLICATIONS

Application	**Parameters**		
	Frequency (Hz)	***Range in meters***	***Communication Type***
Stop sign assists	10	300	V2V (Vehicle-to-vehicle) and V2I (Vehicle-to-infrastructure)
Forward Collision	10	150	V2V (Vehicle-to-vehicle)
Curve speed warning	1	250	V2I (Vehicle-to-infrastructure)
Traffic signal Violation	10	250	V2I (Vehicle-to-infrastructure)

PROPOSED MODEL

The proposed rescheduling scheme controls the channel congestion mechanism from congestion in high traffic density. There are some assumptions to test our approach such as the vehicles are equipped with GPS receiver, wireless radio communication and facilitate multi-hope communication and periodically broadcast the position and direction information. The proposed approach monitored and detects the control Channel communication, if channel congested and beacon messages exceed the predefined threshold then launch the congestion control.

The proposed method focused on event driven messages and if channel receive the comfort application messages then these packets will be passed via SCHs (service channels). If the event driven message is more than one it will start the scheduling algorithm. The major aim of proposed approach is to monitor the communication channel (CCH) and detect congestion, we use event driven detection method. The event driven detection method freeze the lower priority packets if the node detected an event driven message. The congestion control method launch queue freezing method for media access control (MAC) transmission queues and not take event driven messages. When vehicles nodes have to send/generate two or more same priority event-driven packets the proposed scheduling scheme will reschedule these packets. The packets with the same priority are scheduled using FIFO (first in first out) scheduling approach. The Fig. 1, shows the flowchart of proposed method.

The main purpose of this scheduling scheme is to schedule same priority event-driven safety packets to determine which packet transmitted first. This scheduling is based on priority and deadline packets. The proposed scheduling scheme is defined in below Equations.

$$\text{Packet Queue (Pq)} = \text{Priority (P)} + \text{Deadline (D)} \tag{1}$$

$$\text{Deadline (D)} = \text{Packet Arrival (Pt)} + \text{Max Latency (Mx)} \tag{2}$$

The packet value for the lane change warning is 107 Pq, the forward collision is 109 pq and pre-crash sensing is 29 pq. The lower packet value application has more critical message content and should be transmitted first like in below Table 2, the re-crash sensing is lower than lane change warning and in last forward collision.

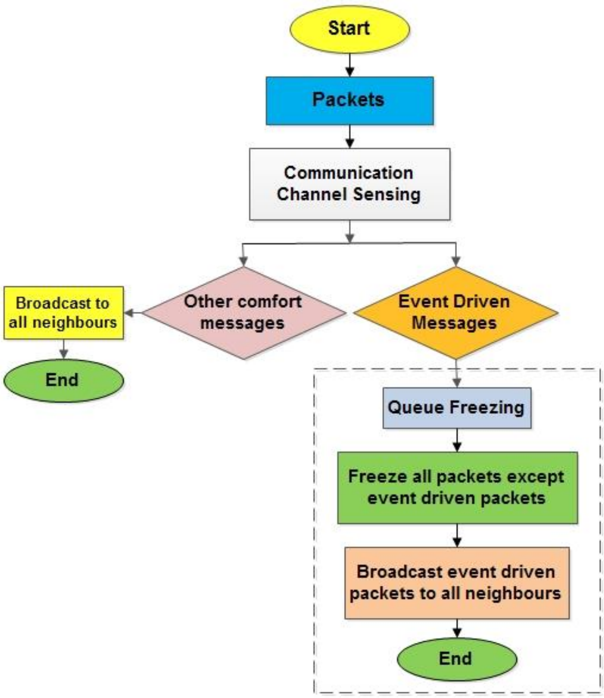

Fig. 1. Proposed method flowchart

The flow chart of proposed scheme Fig. 1, clearly shows that the vehicles disseminate the safety messages after this the channel sensing and monitor these messages. The messages are divided into two types safety and comfort messages. Further the safety messages can be divided into event-driven and beacon messages. If the event driven messages are detected then launch the queue freezing method for all MAC transmission queue and broadcast event driven packets to all neighbors. If the event driven messages are more than one it start the scheduling algorithm.

TABLE 2. EVENT-DRIVEN APPLICATIONS

Application	**Parameters**	
	Max Latency	***Formula***
Pre-Crash sensing	20 msec	Pq=4+(5+20)=29 pq
Forward Collision	100 msec	Pq =5+(4+100)=109 pq
Lane change Warning	100 msec	Pq=4+ (3+100)=107 pq

SIMULATION SETUP

The proposed congestion control mechanism is compared with existing solutions and test the stability, reliability, and the delay free for the safety applications. There are some assumptions to test proposed scheme such as each vehicle having its own route, all vehicles broadcast beacon messages and vehicles sending messages multiple times. Further vehicles can receive and generate more than one event-driven message. The Ad hoc On-Demand Distance Vector (AODV) [15] protocol is used as routing protocol. The safety messages are transmit with high power transmission because they can access the CCH channel with short delay and will cover large areas. The proposed approach monitored and detects the control Channel communication, if channel congested and beacon messages exceed the predefined threshold then launch the congestion control.

The proposed mechanism simulated with the Veins module and run with two simulators SUMO (simulation for urban mobility) for mobility generator and OMNeT++. The Linux platform based Ubuntu operating system is used for run the simulator. The below Table 3, shows the parameters used in simulation.

TABLE 3. SIMULATION PARAMETERS

Parameters	***Value***
Simulation Area	1200m x 1200m
Numbers of vehicle nodes	50-100-150-200
MAC protocol	IEEE 802.11p
Packet type	UDP
Speed	50-100 Km per hour
Packet size	512 bytes
Time	200s

The simulation is based on warning packet delay, average waiting time and packet loss. The warning packet delay is defined as the delay between the first time event driven message sent and the end time of receiving the message. The packet loss occurs when the data packet fail to reach their destination especially in congested situations. The average waiting time is described as the time when event driven packets waits in the buffer queue. The proposed approach was compared with the previous proposed method [10] because the approach is also based on event driven messages.

In scenario 1 we test the effectiveness of event driven safety packets in dense network. The Below Fig. 2, shows the previous approach and our proposed approach warning packets delay for the event driven safety packets. Results from these experiments shows that the number of vehicles are crucial and disturb the overall quality of service and network performance. In the dense network, the results shows that the performance of the proposed scheduling scheme is still good compared to the existing approach. The blue line shows the better performance of proposed congestion control whilst red line shows existing previous approach [10]. The existing approach maximum packet delay is 20 ms and 13 ms for the proposed mechanism. The difference of packet delay in both mechanisms is 7 ms. Based on the result, the performance of proposed scheme is very satisfactory.

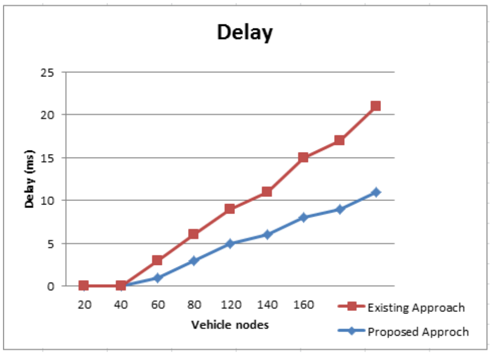

Fig. 2. Warning packets Delay

The second graph shows the measured packet loss for event-driven safety messages versus the number of nodes. If the number of vehicles are increased, the packet loss has also consistently increased, which shows the congestion level in the control channel. If the number of vehicles are more than 20 the event driven messages being losing their packets. In proposed control scheduling mechanism the ratio of packet loss is 10 packets and the maximum packets loss is 12 for the existing approach. The packets loss rate is affected by the number of vehicle nodes. From the results, it is shown that the packets loss rate is affected by the number of vehicles.

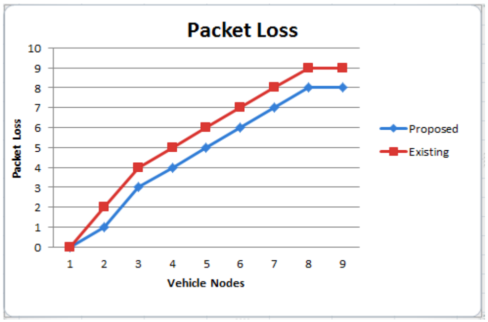

Fig. 3. Packet Loss in network

In Fig. 2 and 3, the results showed the better performance of proposed approach in the terms of delay and packet loss. In dense network our proposed approach is good compared to previous existing approach. An efficient congestion control mechanism is one of the best solution for disseminating the event-driven safety packets. The delay of safety messages and packet loss are caused of serious accidents and loss of life in network. These sensitive and high priority messages need to deliver in time without any delay and loss. The proposed scheme will help the drivers and travelers to avoid from accidents preventions.

Conclusion

In dense network the large numbers of vehicle node disseminate beacon messages at a high frequency, multiple times and cause of congestion in the control channel and affect the performance of event-driven safety packets. The proposed congestion control scheduling scheme use to prevent the congestion of control channel communication in vehicular Ad hoc dense network. The extensive results showed that compared to existing approach our proposed scheme is better in terms of packet delay and packet loss. The VANET environment is highly mobile and dynamic, so there is a need for more intelligent congestion control mechanism and schemes to deal with communication channel. As a result, the proposed scheme will have more impacts especially on accident prevention in vehicular networks.

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