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Distributed Priority based channel access for VANET (DPBCA)

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Abstract— IEEE 802.11p vehicular network supports various applications with different transmission priorities and QoS requirements. It classifies the access categories into four priority levels to ensure the successful transmission of higher priority traffic compared to lower priority traffic in a vehicle. But the external collision between traffic of same priority from different vehicles is not considered. Based on such consideration, this paper proposes a distributed priority based channel access scheme. In this proposed work, the priority of each vehicle is calculated based on its stature on the road and access category. The proposed approach can ensure successful transmission reducing collision leading to overall throughput improvement.

Keywords- VANET; MAC; IEEE802.11p; Challenges in VANET;

I. INTRODUCTION

Vehicular ad hoc network (VANET), a network created by vehicles on the road serves as the foundation of Intelligent Transportation System (ITS). ITS enables vehicles to communicate with each other (V2V) as well as with the road side unit (V2R). The idea of intelligent transportation system (ITS) built on VANET is to reduce road accidents and causalities. It has a range of applications from cooperative collision warning to providing internet on road. The high degree of node mobility leading to frequent topology shifts makes it different from the traditional networks. This unique feature of VANET makes the design of an efficient VANET system challenging. Different applications in VANET have different QoS requirements which in turn shifts the interest of researchers to develop efficient channel access mechanisms.

In 2006, IEEE 802.11p [1] is amended with Wireless Access in vehicular environments (WAVE) operational mode which suits for vehicular environments [2]. WAVE enables communication among high speed vehicles or between a vehicle and a roadside unit. WAVE mode also includes IEEE 1609 standard suite for resource management, security services, network services and multi channel operations [3][4][5][6].

The multi channel operation in WAVE mode operates in the licensed ITS band of 5.9 GHz which includes one control channel (CCH), the two channels at the end are reserved for safety applications, a high data rate channel for critical safety and three other service channels (SCH) for non safety applications. For every channel interval, a station remains in control channel for 50ms, switches to service channel and remains for 50ms. The channel switching occurs in 4ms.

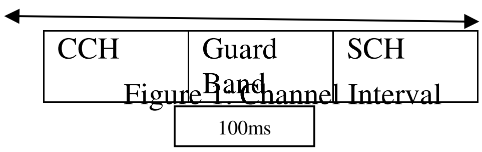

Figure 1: Channel Interval

The standard MAC layer of VANET, the IEEE 802.11p is found to perform poorly in broadcasting [7][8]. It lacks in providing an acknowledgement for broadcast messages. In a congested network, there is a chance for the broadcast packets to get collided and due to the lack of acknowledgement sent to the transmitter, no retransmission happens. Thus IEEE 802.11p fails in providing reliable broadcast support in a congested highway [9][10]. MAC layer of IEEE 802.11p uses Enhanced Distributed Channel Access (EDCA) based on IEEE 802.11e and supports four different access categories with different priority levels. It tries to avoid internal collision inside a vehicle but fails to prevent external collision among vehicles. As the network becomes denser the probability of external collision will be increased and thereby decreases the system throughput. Therefore, a congestion control approach is desirable to decrease the number of collisions between stations. In this paper, prioritization of vehicle considering its stature on the road, its average velocity and the access category is proposed. The remainder of this paper is organized as follows. Large number of writings is available based on the performance improvement of IEEE 802.11p. Section II provides a brief overview of these works. Section III deals with the proposed distributed priority based channel access scheme. Simulation results and the analysis results are briefed in Section IV followed by conclusion remarks in Section V.

II. RELATED WORK

In IEEE 802.11p network, MAC protocol coordinates operations on CCH and SCH. RTS/CTS is employed to reduce packet collisions due to hidden terminals. A back off algorithm called 802.11+ based on adaptive contention window is proposed in [11]. It shows that the 802.11+ algorithm is able to reach the theoretical throughput limit. Bianchi[12] used probability and statistics to analyze the throughput and utilization. This method also solves the hidden node problem. Gannoune[13][14] used the network performance details to adjust the minimum and maximum contention window sizes to adapt IEEE 802.11 EDCF to network changes.

Vehicular channel access scheme [15] is used to optimize channel throughput. In VCAS, all on board units listen to control channel for WAVE Service Announcement information embedded in WAVE announcement frames broadcast by road side unit during control channel interval. Thereafter, on board units with similar data rates are grouped into one SCH by screening them based on their transmission distance available in WSA frame. The simulation results show that VCAS provides a flexible method to handle versatile vehicular scenarios. However, VCAS requires a road side unit which will not suit for a distributed system. An improved channel access scheme [16] allows a station to stay on the service channel for as long as it requires before returning to the control channel. This is done in order to improve the service channel utilization by cutting CCH to avoid the frequent channel switching between SCH and CCH. However, in vehicular networks the safety messages transmitted during CCH enjoy high priority and therefore CCH interval must be guaranteed. Moreover, only one user is considered in the paper and the effects on neighbors incurred by changing the channel intervals are not analyzed.

Detection based MAC protocol discussed in[17] used an RTS/CTS to detect network congestion through message exchange to predict the number of competing nodes. Once the number of competing nodes is available, the nodes dynamically adapt to the contention window based on the network status. Even though the system outperforms IEEE 802.11 base access and RTS/CTS in total throughput and delay, how the nodes guarantee the predicted number of competing nodes is accurate is not clearly discussed. In this paper, priority of each vehicle based on its location on road and access category is calculated to regulate the congestion in the network.

In [18] distributed multi-priority congestion control approach for IEEE 802.11p vehicular networks, congestion control is done by studying the queue of different access category. From the observations a congestion threshold is calculated and based on this threshold the contention window size is adjusted. However, the external collision of packets of similar access categories from different vehicles is still unattended. To overcome these collisions and thereby to improve the throughput, a distributed priority based channel access is proposed.

III. DISTRIBUTED PRIORITY BASED CHANNEL ACCESS

The media access of IEEE 802.11p service channel is based on Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA). Different service channels have different contention window sizes. Suppose the contention window size is small, interference may happen. Also the factors like the high degree of mobility, hidden terminal problem, and change of moving direction may create more packet collisions or transmission failures. In IEEE 802.11p each node depending on its access category calculates an arbitration inter frame space (AIFS). The node listens to the channel for AIFS time and if the channel is found free, the transmission happens else it waits for a random back off period.

Inside each vehicle, different access categories exist and there exist an internal contention for the similar access categories. IEEE 802.11p employs a per packet priority scheme for channel access. But the level of internal contention of packets of different access category and the external contention with similar access category packets can lead to an increase in collision of packets in a dense network. To improve the performance of IEEE 802.11p MAC, a distributed priority based channel access approach is proposed in this section.

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DISTIBUTED PRIORITY BASED CHANNEL ACCESS ALGORITHM

1:The node enters a zone of relevance it calculates:
2:The expected time of a vehicle to reach a point of exit on
  The road is calculated based on its distance from the point
  and average velocity at which the vehicle is moving in.
3:Different priority levels are given for different types of
  messages. The size of data message and beacon also varies.
4:Each vehicle determines its priority with respect to other
  vehicles on the road.
    P=(d/vavg)+(type)+ X%SIFS
  Where d is the distance of the vehicle from the point of
  exit, vavg is the average velocity of the vehicle, type is
  the category of message, ie. Beacon, Service, Event. Size is
  to differentiate between a beacon signal and  a data
  request. Event type can be traffic or road. Traffic messages
  can be traffic jam and accidents. Road messages can be
  slippery road, sharp turning etc. X is a unique ID based on
  MAC.
5:Each vehicle waits for the estimated period of time and
  starts transmission.
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IV. SIMULATION RESULTS AND DISCUSSIONS
V.

The proposed priority based channel access scheme exploiting the structure of VANET is evaluated by simulation. The environment is simulated in MATLAB. The number of vehicles on the zone depends on the vehicle arrival rate, vehicle density and vehicle speed. Traffic arrival interval follows the Poisson distribution. The total arrival rate λ can be determined as

$$\lambda = k.\mu \qquad (1)$$

where k is the vehicle density and μ is the mean vehicle speed. The probability of collision increases with the number of nodes on the road. In this scenario, let us assume that each vehicle has at least one packet to transmit and there are no transmission errors in the channel. The successful transmission time is calculated by

$$E[ts]=Tp+Trts+Tsifs+Tcts+Tsifs+Tdata+Tsifs+Tack+4*propagationdelay \qquad (2)$$

The average collision time can be calculated as:

E[tc]=Tp+2*propagationdelay (3)

Where Tp is the calculated priority value of each vehicle. The throughput of the system is calculated based on the number of successful packets transmitted in unit time. It is found to increase with the number of nodes on the road. The percentage of collision is found to decrease with the number of vehicles on the road.

Figure 4 show that the percentage of collision increases and then gets reduced with the number of nodes in the region. Apart from the initial decrease, figure 5 indicates that the throughput remains almost stable with increase in number of node.

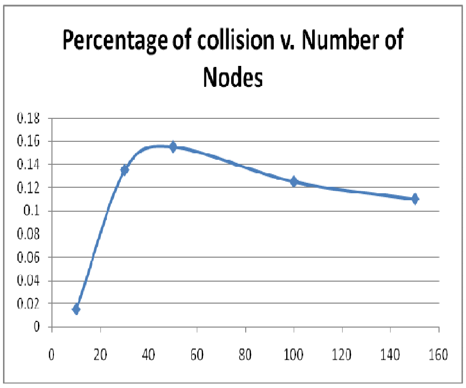

Figure 4: The percentage of collision versus the number of nodes in the region.

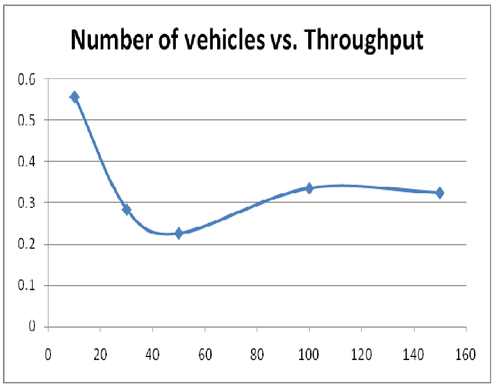

Figure 5: The throughput of the network versus the number of nodes in the region

The simulation results show that the proposed scheme improves the throughput of the system reducing the degree of collision.

VI. CONCLUSION

In a dense network, the CSMA/CA scheme creates high degree of collisions. This is mainly due to the fact that the IEEE 802.11p system considers the access categories in each vehicle and prioritizes them where as the priority between vehicles are never analyzed. The proposed scheme enables the calculation of priority of each vehicle and the different types of traffic in it making it possible to reduce the number of collisions so as to improve the throughput of the system.

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