An Assessment on Multi Channel Mac Protocol in Vanet using Markov Models

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Abstract-To improve the safety and efficiency of vehicles in road many researchers are designed medium *access* control protocol. Safety applications usually demand to disseminate the safety message to be prompt and reliable. VANEs which are created by moving vehicles, have specific properties, such as high mobility and quick topology changes. Due to vehicle density in VANET environment the MAC protocol is designed to adapt the changing data traffic. A lot of researchers deliberated various MAC protocol to solve the chronicle problem of the IEEE802.11p. The latest multichannel related MAC protocol IEEE802.11p EDCA broadcast scheme in Dedicated Short Range Communication (DSRC) have a higher performance. Moreover the multichannel MAC protocol which adapt themselves to different vehicular collision, that can promise the transmission delay of real time safety application an increased packet delivery ratio for non-safety applications. In this paper, we focus on the three subsequent viewpoint: First we studied the multi- channel MAC protocol under the saturated and no saturated data traffic condition; Second, we studied multi-dimensional Markov models (up to three dimensions) under the MAC protocols; and Third, we considered the Nakagami channel fading with and without fading effect to improve the reliability and latency performance in vehicular environment. To conclude, we review our findings and discuss the open issues concerning MAC protocol for VANETs as a part of Intelligent Transportation System.

INDEX TERMS: VANET, MAC protocol, Markov model, Safety application, Non safety application.

I.INTRODUCTION

Nowadays the road safety is increasing more attention due to growing number of vehicles and injuries caused by road accidents. Vehicular communication is called vehicle- to – everything (V2X) communication, is among the main pillars of the imminent era of Intelligent Transportation System (ITS) . Safety is the very important thing for Intelligent Transportation System which is an advanced application aiming to provide safe and comfort drives in VANET environment. Vehicular - Ad –hoc Network (VANETs) are used to develop the vehicular traffic management and supply onboard unit infotainments such video streaming internet access etc. High mobility and with constrained movements and quick topologies are main challenges in VANET. The difficulty in VANET is maintaining the connectivity under the continuous topology changes due to high mobility.

To develop VANET, vehicles are equipped with communication devices are On – Board Units (OBUs) and Road Side Unit (RSUs), which are disseminated among the road for connection between each RSU and Internet. Based on the OBU and RSU, there are two possible types are available in VANET environment such as Vehicle-to- vehicle (V2V) communication and Vehicle- to- Infrastructure (V2I) communication. To use V2V and V2I communications, the Dedicated Short Range Communication (DSRC) spectrum is arranged in seven 10MHz channels. The six channels are service channels (SCH) for the residual application and regular communication. Even though the control and safety messages are short, assigning only one CCH for transmitting high priority messages is either reliable or efficient for high vehicle density and high safety message traffic. Moreover according to the coordination schemes, the Wireless Access in Vehicular Environment (WAVE) standard set the fixed value 50ms for both CCH Interval CCHI and SCH Interval SCH. In the DSRC architecture every layer practices different protocols. For the PHY and MAC layers, the IEEE 802.11p is adopted, while at the top layers the IEEE 1609.2, 1609.3, and 1609.4 protocols are implemented, each of which deals clearly with several services. In particular, they are respectively: security services (1609.2), network services (1609.3), and channel switching (1609.4). In the network layer, the WAVE Short Message Protocol (WSMP) is employed, but, depending on the application, it is also allowable to make use of other protocols, such like IPv6TCP and UDP.

According to the physical division spectrum of resources, in VANET the MAC protocols are divided in to single channel MAC protocol and multichannel MAC protocol. The single channel MAC protocol solve resources allocation problem for multiple nodes by using the carrier sensing mechanism. Compared with single channel MAC protocol, the multi-channel MAC protocols can concurrently support packet transmission for multiple channels in vehicular environment. In low MAC layer the IEEE 802.11 tow different medium access method such as Distributed Coordination Function (DCF) and Point Coordination Function (PCF).PCF can able to support collision free and time bounded services are real time audio and video. The DCF is Used Carrier Sensing Multiple Access with Collision Avoidance (CSMA/CA) to avoid collision among multiple nodes in VANET environment. VANET standardized IEEE802.11p with Enhanced Distribution Channel Access (EDCA), which is improved modification of DCF. The different between EDCA and DCF are duration of Arbitration Inter-Frame Space (AIFS) and size of contention windows (CWs) shown in table.

AC	Traffic Type	CW min	CW max	AIFSN
AC0	Background	15	511	9
AC1	Best effort	7	15	6
AC3	Video	3	7	3
AC3	Voice	3	7	2

TABLE 1. Comparison between EDCA and DCF

	Distribution Coordination Function	Enhanced Distributed Channel Access
Contraction	DCF	EDCA
Standard Comparison	IEEE 802.11b	IEEE 802.11p
Channel Access Method	CSMA/CA	CSMA/CA
Operation	-Clear slot required for counter decrement.	-There is no empty slot needed for the counter decrement -Based on access category (AC) Packets are classified. -Every ACs has its own transmission queue within a station.
Slot Time	20µs	16µs
SIFS	10 µs	32 µs
CWmin/ CW max	31/1023	Voice Queue (VO): 7/15 Video Queue (VI) : 15/7

In multichannel operation to enable the single radio transceiver, IEEE 1609.4 access scheme, which allows a vehicle to switch between CCH and SCH every 50ms.on the other hand, if there are two antennas, one transceiver is always tuned to CCH, while another transceiver can be tuned to any service channel, which will reduce the need for any channel switching operation, thus enabling every vehicle to broadcast safety messages during the 50ms of the CCHI not including a Guard Interval [8]. In this survey, we focus on multi-channel MAC protocols and their function and latest drafts of the IEEE 802.11p standards.

Single concern of multi-channel MAC protocols is that the fixed CCH Interval (CCHI) and SCH period (SCHI) are used for access in a given sync interval (SI). On the one hand, for the duration of high density data traffic, the fixed interval for CCHI does not promise all vehicles to broadcast their Safety messages. On the other hand, throughout low density data traffic, the fixed interval for CCH will be underutilized. Therefore, a fixed interval between CCH and SCH is not enough to supply appropriate bandwidth to distribute equally safety and non-safety applications. Therefore various multi-channel MAC protocols were proposed to different vehicle density.

TABLE 2. EDCA Access Category Parameter

The Markov model has a efficient tool to analyze the IEEE 802.11p Enhanced Distributed Channel Access (EDCA) broadcast scheme in Dedicated Short Range Communication (DSRC) with influence of hidden terminals. Under different data traffic densities, the Markov model can calculate the throughput and delay with high precision in comparison with the simulation results. The Markov model complements the design of adaptive MAC protocols, which can calculate and adjust control intervals according to the vehicle density to develop throughput and packet delay.

In our survey, MAC protocol using the IEEE 802.11p EDCA method can calculate the channel access. In DSRC elementary is a one of the single hop broadcasting service on the CCH, which is an effective way to spread the safety message for vehicular nodes. Therefore, by employing Markov models, vehicles can dynamically regulate the duration of CCHI to develop the system throughput on SCHs in MAC protocols. We formulate the following explanation.

- Emergency information has the highest priority and broadcast the VANET environment without need for positive ACK.
- They represent interval until a winning reservation, which is made by a WAVE Service Advertisement (WSA) packet, can be computed using a Markov model.

In MAC protocol using Markov model not only guaranteed the delay for the safety packet transmission, and also optimize the Q os for not- safety message application.

The common adaptive MAC protocol use Markov models have the following assumptions,

- The channel is ideal
- N number of vehicles in fixed network
- The packet collision probability is stable and independent of each vehicle

MARKOV MODEL IN MAC PROTOCOLS

The MAC protocols that allow Markov model to adjust the length of interval use contention based channel access method such as IEEE802.11. The IEEE 802.11 access the medium of Distributed Coordination Function (DCF).Generally CSMA/CA access use the binary exponential back off technique, that can be regarded the Markov chain. The re-transmission collided packets managed according to binary exponential back off rule. The assumption of ideal channel condition the Markov chain calculates the suitable back off window size.

As shown Fig. 1, In MAC layer IEEE 802.11p is extended the different application in vehicular environment. The having four different access categories (ACs). Every access categories has a unique queue where the packets from the different application that are stored in queue based on their priority. Each ACs has different Arbitration Inter-Frame Space Number (AIFSN) to ensure the time based on high priority packets. The highest priority is granted AC [3] for the MAC protocol in vehicular environment.

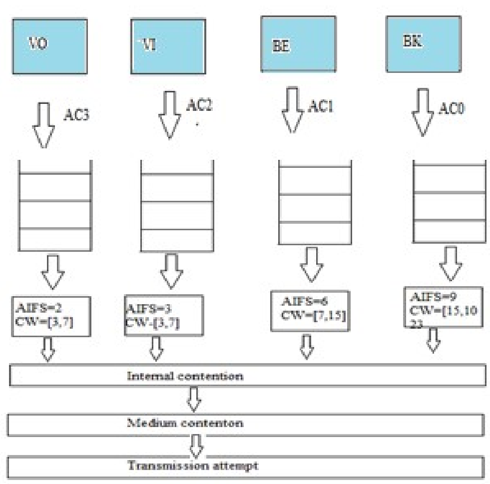

FIGURE 1. Access Categories at MAC layer.

The second priority [ACs] is established to basic safety message (BSM) that advertises the vehicles being there within the access point. In vehicular environment the non-urgent message, are asking for help these kind of information using the lower priority [AC1] who are not a danger to other vehicles. The lowest priority is given to the solicited message starting new non safety related conversation over the SCH.

In vehicular environment there are two types critical packets are transmitted in CCH. The Safety message and WSA packets are sent according to IEEE 802.11p. And also the safety messages have their own properties, such as delay and no positive ACK and WSA packets are used to exchange the information about DSRC for the offered area. Moreover the WSA contains the all information about the WAVE service and network parameter to join the Basic Safety Service (BSS), The SCH where they provide service like timing information and EDCA parameter set. The Markov chain designed for safety and their classified according to their state dimensions.

a. ONE DIMENSION MARKOV CHAINs

In one dimensional Markov chain is sufficient to broadcast safety packets transmission in without the back off stage. In contention window is represented by W_e, is fixed for the safety information. The safety transmission is described {k : k €[0, W_e -1} λ_{e} – arrived safety packets

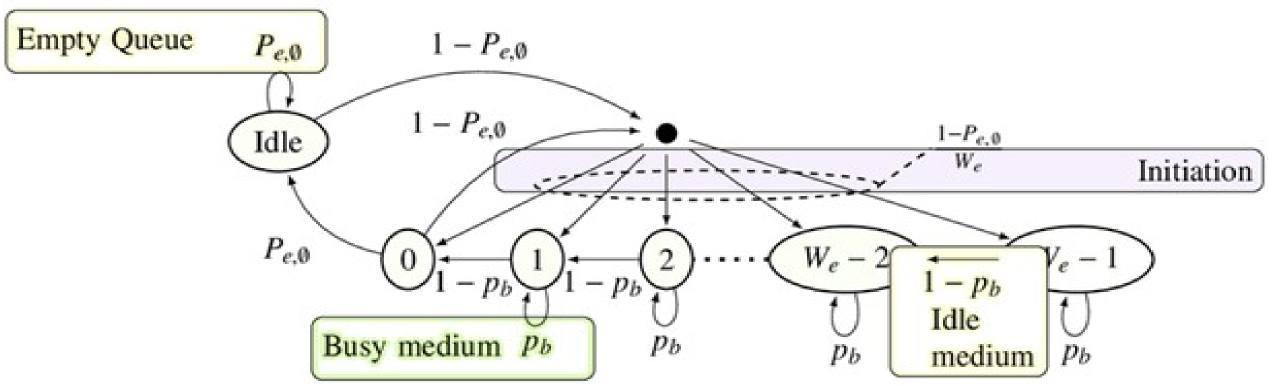

FIGURE. 2, Markov Chain Used For Safety Message

a. TWO DIMENSIONAL MARKOV CHAINS

The state is represent the state of empty queue. The models consider the no ideal transmission channel to prevent the saturated throughput. The maximum re-transmission number and the contention window CW in the 1[th] back off state denoted by m. *CW* is set to the smallest Value *Ws*;0 for the first transmission effort. When the collision is detected, the *CW* is doubled and then re-transmission is started .All Markov model assume that the probability of collision of packet is transmitted to another packet is constant and independent of the station back off stage s (t). the back off timer freezing, the rate of packet arrival rate, the first order memory in queue are taken to account in order to provide a accurate channel access estimation, make use of channel efficiently and analyze the time performance. The back off period and short retry limit for the packet transmission are considered in the model to satisfy the IEEE 802.11p requirement and make sure that no packet is served indefinitely. In addition when the node detects the channel is busy, b (t) the channel is monitoring until the channel is sensed ideal again.

The back off stage m, if the transmission is ineffective, the node is remaining at stage m .According to the IEEE 802.11p standard the size of back off window increases, exponentially, Contention Window is $W_{S,0.}$The 2- D Markov chain model is developed to calculate the probability of frame transmission τ. For given station at time slot t Let s (t) and b (t) is a random variable in the back off operation (0, 1, 2, Wi-1) respectively. The two dimensional s (t), b (t) process are evaluated with discrete- time Markov chain, where the channel status changes. The 2-D Markov chain queuing model broad cast scheme by each node (h, k) conjunction with ideal state that denoted as ideal state. The model occupancy $0\leq h < L$ Where the L is the maximum length of queue. Let *q* be the probability that a packet arrives while in each back off state, *q T* be the probability that a packet arrives while in each transmission position and *p* be the conflict probability for the node.

The top row represents the post back off state and busy state that means there is no packet arrive in the queue. The next row represent the (1,0) and (1, W_0-1) means the back off state when there is one packet in the queue length. The second row indexed the (2, 0) and (2,W_0-1), represent the back off state when there is two packet in the queue.

And the last of the row represented (L,0) and (L,W_0-1) means the back off state when there is a L no of packet the queue length is filled that means the channel become busy.

$$P [(ideal)| (ideal)] =1-q$$

The 2-D Markov chain integrates the IEEE 802.11p the vehicular node follow the back off and the queue system process. The model enables the performance of packet delay, average queue length and queue overflow, throughput and collision probability in vehicular environment.

I. MARKOV CHAIN IN IEEE 802.11P EDCA BROADCASTA SCHEME

The IEEE 802.11p also known as DSRC is WLAN standard deliberated for ITS. The contention based EDCA protocol is support priority based Q os services by setting different parameters. IEEE p borrowed the ideas of enhanced distributed channel access in IEEE 802.11e MAC method which is enhanced version of the basic distributed coordination function (DCF). EDCA use the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism. This is one of most popular MAC control protocol, for the wireless ad hoc network that is designed to reduce the collision due to multiple nodes transmitting at the same time in shared channel. The IEEE 802.11p EDCA protocol deletes all control frames including Request – to –send and Clear – to – send (RTS /CTS) and Acknowledgment (ACK) to work in a vehicular environment with the high density. The EDCA mechanism does not have RTS/ CTS handshake scheme shall be used apart from of the length of the packet, because CTS has the same detonation problem as ACK. When broadcast data units are transmitted from a node, only the basic access method shall be used. Furthermore, since a packet collision cannot be detected, once the size of the contention window, denoted as W0, is indomitable, it will remain continuous despite of whether a packet collides or not. As such, collision can be more serious in broadcast, thus modeling such scheme is important for the success of VANET.

$$T_{AIFSn} = T_{SIFS} + AIFS.\ T\ s$$

$$AIFS [AC] =AIFSN [AC] * a\ Slot\ Time\ \ + ASIFS\ Time$$

When the new packet arrives with in a certain priority time at the MAC layer, that will stored in corresponding queue. The back off window size defined the IEEE 80211p with EDCA including the all types of safety messages. In the EDCA there are four available access categories (ACs) with different priorities according to their criticality for the vehicle safeties in vehicle node. Background traffic (BK), Best effort traffic (BE), Voice traffic (VO), and Video traffic (VI). Different AIFS and contention window (CW) values are chosen based on the access categories (ACs).If the channel is sensed free by the ACs the packet for some time equal to AIFS means the will be transmit. If the channel is detected to busy immediately or during the AIFS means it will keep monitoring the channel status until the channel ideal state. The node starts a back off process and generates the back off counter time and selected uniformly in the contention window (CW) [0, $W_{0,}$ -1]. Then when the back off counter is decremented the channel is sensed is ideal for slot time denoted as σ or frozen when the channel is sensed busy. The channel becomes busy the back off counter is suspended and reactivated only if the channel became idle state for a duration of AIFS. Then the packet will be sent immediately when the back off counted drops 0 zero.

Broadcast service is generally used in various ad hoc network applications like VANET where with relatively high speed vehicles move along with roads. In the WAVE broadcast the urgent messages over the CCH during the important periods, so that they can be receive the message by as many possible devices.

II. MAC PROTOCOL UNSING IN MARKOV CHAIN

The CCHI should be adjusted according to the traffic conditions in order to increase the throughput on SCHs. Based on Markov chain many methodologies in MAC protocol are proposed such as ,in enhance the reliability of broadcast in vehicular network by employing a notion of channelization they proposed the Hybrid Cooperative MAC (HCMAC) protocol. HCMAC protocol every node acquires a time slot in a distributed manner. CTMC, the MAC queue length is unlimited. So that new arrival packets are successfully stored in the queue. The MAC protocol for VANET is separated the CCHI into two main intervals such as fixed interval and dynamic intervals during the fixed intervals the safety packet and ACK packets are transmitted. Otherwise during dynamic interval the safety packets and WSA packets are transmitted.

II.CHALLENGES IN MAC DESIGN USING MARKOV MODEL

We have studied some open issues and possible directions for research related to the dynamic interval division protocol for the vehicular ad hoc network environment.

a. FREQUENT TOPOLOGY CHANGES

In VANET environment the vehicles move with the different speeds and vehicle may join or leave the transmission area at any time. However, MAC protocol using the Markov chain assume that there are fixed number of nodes. So designing the MAC protocols dynamically adapt to frequent changes of topology is important.

B. HIDDEN TERMINAL EFFECTS

The ad hoc networks having advantage that several transmission can take continuously at geographically separated locations. Moreover the capacity gain may be offset by the hidden terminal problem. The Markov models assume that the channel conditions are no exposed terminals or hidden terminals. In fact the both exposed hidden terminal problems are affect the packet delivery ratio of the application messages.

II.CHANNEL FADING AND PATH LOSS IN AD HOC NETWORKS

The assumption about the lack of amplitudes correlation which is series of the implicit narrowband physical channel model discrete and uncorrelated point surfaces on limited on very specific propagation conditions. The difficulty of finding packet distribution of a sum of random vectors, using a parametric gamma distribution-based density function to explain experimental data obtained for ionosphere and tropospheric modes of propagation. The multipath signal's envelope distributions are summarized and enhanced with the more general approach.

CONCULSION

Using the Markov model under the different traffic condition with changing topologies VANET environment the MAC protocol can adjust the length of control channel. MAC protocol can reduce the delay and improve the system throughput of the service channels. Otherwise they can assume that the Qos for different service packet types. In this paper we survey the Markov chain models used to adjust the length of the different traffic conditions and MAC protocols using the N-dimensional Markov chain. We summarized the challenges in Markov models and discussed fading channel in the ad hoc network. Furthermore, we also discussed some research related to dynamic interval division MAC protocols using Markov chains.

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