Transmission of Safety and Non-Safety Messages in Multihops Wireless Vehicular Environments

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Abstract- To provide safety and comfort of transportation system, the emerging wireless vehicular communication technologies should be used. In VANET, two types of channels are used such as Control Channel (CCH) and Service Channels (SCHs) to transmit the messages from vehicle to vehicle (V2V) or vehicle to infrastructure (V2I) communications. These channels are used to transmit the safety messages and non-safety messages respectively. The protocol was developed for channel coordination such as Variable Control Channel Interval Multichannel Medium Access Control (VCI MAC) scheme based on the standards such as IEEE 802.11p and IEEE 1609.4 and the messages between nodes are transmitted in a multihop wireless environment with potential hidden terminals. The detection of transmission range based on the parameters and message transmission is involved in the Multihop wireless environments. The VCI MAC scheme is to help IEEE 1609.4 to deliver real-time safety packets and accommodate multichannel coordination mechanism and variable intervals of CCH and SCHs. To derive the optimal interval, the Markov chain model is applied which is used to examine the nodes and obtain the stationary probability. A contention model is to analyze the average time consumed on the CCH for the negotiation of service packet transmission. The VCI MAC scheme is used to provide the efficient channel utilization with higher saturation throughput and low service packet delay when transmitting large service packets in multi-hop wireless environment.

Keywords — Control Channel (CCH), IEEE802.11p, IEEE 1609.4, Multichannel coordination, Service Channel (SCH), VCI MAC Scheme.

I. INTRODUCTION

A Vehicular Ad-Hoc Networks (VANET) is a special kind of Mobile Ad Hoc Networks (MANET), which uses moving cars as nodes in a network to create a mobile network. The main works involved in the VANET are developed for enhancing the driving safety and comfort of automotive users. VANET are required real-time communication with high reliability to build the many of safety applications. The main benefit of VANET communication is seen in active safety systems, which target to increase the safety of passengers by exchanging warning messages between vehicles.

Fig. 1 Message transmission among number of vehicle nodes on the road segment

Two types of communication are used in the VANET. One is Vehicle to Vehicle (V2V) communications and the other one is Vehicle to Infrastructure (V2I) communications. In the Vehicle to Vehicle (V2V) communication approach the safety and non-safety message transmitted between numbers of vehicles. V2V communication is most suited for short range vehicular networks and it is fast, reliable and it provides real time safety. In the Vehicle to Infrastructure (V2I) communication provides solution to longer-range vehicular networks and it makes use of preexisting network infrastructure such as wireless access points (Road-Side Units called as RSUs).

Some of the VANET applications such as safety warning applications, life-critical safety applications, Internet access, group communications, electronic toll collections, etc.

Fig. 2 Communication types in VANET
VANET contains two types of channel that allows the drivers to communicate with each other as well as with roadside infrastructure. The channels are control channel (CCH) and service channel (SCH), which transmits the safety messages and non-safety messages between number of vehicles and roadside units. The CCH transmits the safety messages such as collision information, accident information, and emergency messages and so on. The SCH transmits non-safety messages such as efficiency of comfort driving, traffic messages and so on. The VCI MAC (Variable Control Channel Interval Medium Access Control) Scheme was developed based on the IEEE 802.11p and IEEE 1609.4 which can dynamically adjust the length ratio between CCH and SCH.

A. RELATED WORK

1.1.1 An Adaptive Multi-Channel MAC protocol with Dynamic Interval Division in Vehicular Environment [2]

In this method, the CCH interval is divided into Service Announcement Phrase (SAP), Beacon Phrase (BP) and Peer-to-peer reservation phrase (PRP). The distribution algorithm is used to calculate the duration of low-priority PRP according to the real-time traffic load in every synchronization interval based on the several dynamic parameters. This system mainly focuses the safety and vehicle status frames and non-safety applications. Adaptive MAC protocol, named Dynamic Interval Division Multi-Channel MAC to maximize the utilization of CCH interval and increase the duration of SCH Interval. In this paper the theoretical analysis only provided.

1.1.2 IEEE 1609.4 DSRC Multi-Channel Operations and its Implications on Vehicle Safety Communications [3]

The IEEE 1609.4 provides the standard for multi-channel operations over the 5.9GHz Dedicated Short Range Communications (DSRC) spectrum. IEEE 1609.4 defines a time-division scheme for DSRC radios to alternately switch within these channels to support different applications concurrently and it describes the operation of control channel and service channel interval timing, and channel switching and routing. It is generally envisioned that a DSRC onboard unit should, by default, be tuned to the CCH to send and receive safety messages continuously. If it is engaged in some non-safety application communications in a SCH, then it is expected to actively switch between CCH and SCH channels for the duration of the service session. In this paper, the simulations conducted to study vehicle safety communications under stressful but realistic. From this paper the following conclusions are made.

- The time division oriented channel switching approach is inefficient in channel utilization.
- This design forces upper layer applications to be aware and implemented around the details of IEEE 1609.4 mechanisms.
- Even if upper layer applications are optimized for IEEE 1609.4 operations, the simulation results show that a realistically stressful scenario quickly renders the effort moot.

1.1.3 Performance Analysis of the IEEE 802.11 Distributed Coordination Function [4]

Recently, the IEEE has standardized the 802.11 protocol for Wireless Local Area Networks. The primary medium access control (MAC) technique of 802.11 is called distributed coordination function (DCF). DCF is a carrier sense multiple access with collision avoidance (CSMA/CA) scheme with binary slotted exponential backoff. It provides a simple, but nevertheless extremely accurate, analytical model to compute the 802.11 DCF throughputs, in the assumption of a finite number of terminals and ideal channel conditions. The proposed analysis applies to both the packet transmission schemes employed by DCF, namely, the basic access and the RTS/CTS access mechanisms. In addition, it also applies to a combination of the two schemes, in which packets longer than a given threshold are transmitted according to the RTS/CTS mechanism.

1.1.4 Performance Analysis of A Multi-channel MAC with Dynamic CCH Interval in WAVE System [5]

To improve the throughput performance of the Wireless Access in Vehicular Environment (WAVE) system, we propose a multi-channel MAC protocol that is able to adaptively adjust the intervals of Control Channel (CCH) and Service Channel (SCH) according to the probability distribution of the reservation time for service packet in CCH interval. WAVE system is a radio communications system intended to provide seamless, interoperable services to transportation. IEEE802.11p defines a single channel MAC for WAVE vehicles. Recently, the IEEE1609.4 is considered as a default multi-channel MAC standard for WAVE system, which defines the general framework for multi-channel management. This WAVE MAC adopts the split phrase mode to coordinate multiple channels. Channel access time is divided into Synchronization Intervals (Sync Interval) with a length of 100ms, consisting of a CCH Interval and a SCH Interval, 50ms of each. During CCH Interval, all the devices have to monitor CCH, where safety frame, vehicle status frame, and WAVE service announcement (WSA), are delivered. When SCH Interval arrives, devices can optionally switch to SCHs, which are used for non-safety applications.

1.1.5 A dedicated Multi-channel MAC protocol design for VANET with adaptive broadcasting [6]
Dedicated Multi-channel MAC protocol is based on the hybrid channel access mechanism. Adaptive broadcasting provides collision-free and delay-bounded transmissions for safety messages. It enhances the adaptability of the MAC protocol to different traffic density conditions. It doesn’t focus the non-safety applications on the transmission for communication.

1.1.6 Design of 5.9GHz DSRC-Based Vehicular Safety Communication [7]
In the communication-based safety applications the DSRC Spectrum is used. The U.S Federal Communication Commission allocated 75 MHz of dedicated short range communication spectrum at 5.9GHz to be used. The overall DSRC communication architecture in the draft IEEE 1609 standard contains two parallel stacks: one for TCP/IP-based communications and the other one for safety messaging. Three key challenges, namely, channel congestion control, broadcast performance enhancement, and concurrent multichannel operation, are defined. To address these challenges, a coherent set of protocols, grounded on differentiating routine and event safety messages, is proposed.

B. EXISTING SYSTEM
In the existing system, the VCI MAC Scheme was implemented in single hop wireless environment to transmit the safety and non-safety messages. The following are the some of the disadvantages found in the existing system,
- In a congested vehicular traffic condition, the limited length of CCH is unable to provide sufficient bandwidth to deliver a large amount of safety packets and control packets.
- If the node density is sparse, the occasional transmission on the CCH channel will waste the channel resource, whereas some large bandwidth consuming applications, such as video download and map update, cannot obtain sufficient bandwidth resources on the SCHs.
- The coordinative multichannel access techniques outlined in the IEEE 1609.4, we can find one limitation, i.e., the ratio between CCH interval and SCH interval is a fixed value.
- In a dynamically changing vehicular traffic condition, the restricted CCH and SCH intervals are unable to provide proper bandwidth to deliver both safety/control packets and application streams.

II. SYSTEM ARCHITECTURE

Fig.3 System Architecture
The architecture diagram represents the whole system process. The overall process is that the sending packets to V2V or V2I, Selecting the control channel and service channel, Analysis of control channel and service channel, optimize the intervals and broadcasting the safety and non-safety messages. The performance such as the throughput is increased and the transmission delay is decreased.

The Service information are transmitted among number of vehicles in multihop wireless environment, in which the messages are transmitted in different transmission ranges. The main parameters for the transmission range are distance between sender and receiver, transmission power, transmission rate and vehicular traffic density.

The following processes are used to implement the VCI MAC Scheme in multihop wireless environment for hidden potentials.
1. Frequency Channel Layout of a 5.9 – GHz Wave System
2. Movement Generation for Vehicle Nodes
3. Detection of Transmission Range in Multihop Wireless Environments and Message Transmission
4. Analysis of Control Channel
5. Analysis of Service Channel
6. Markov Chain Model for WSA or Transmission Probability
7. Contention Model for Time Analysis in WSA or RFS Transmission

A. FREQUENCY CHANNEL LAYOUT OF A 5.9 – GHz WAVE SYSTEM
Based on the standard draft of IEEE 802.11p, VANETs employ the technique of dedicated short-range communication (DSRC) for the enhancement of driving safety, as well as comfort of automotive drivers. The U.S. Federal Communication
Commission allocated 75 MHz of the DSRC spectrum at 5.9 GHz to be exclusively used for vehicle-to-vehicle and infrastructure-to-vehicle communications.

**Fig. 4 Frequency Channel Allocation in 5.9 GHz Spectrum**

The overall bandwidth is divided into seven frequency channels. CH178 is the control channel (CCH), which is used as a public channel for safety-relevant applications on the road. The other six channels are service channels (SCHs) for non-safety service applications for the comfort of driving.

**B. MOVEMENT GENERATION FOR VEHICLE NODES**

In this module, the vehicle nodes are created and the messages are transmitted from one node to all other nodes. To create the vehicle nodes, the following parameters are used. They are, channel type, radio propagation model, network interface type, MAC type, interface queue type, link layer type, antenna model, queue size for the node, number of vehicle nodes, routing protocols used, topography, time to start simulation and time to end simulation are defined. After creating nodes, the configuration for the vehicle nodes should be defined. The generation of movements for the vehicle nodes is defined based on the moving position.

**C. DETECTION OF TRANSMISSION RANGE IN MULTIHop WIRELESS ENVIRONMENTS AND MESSAGE TRANSMISSION**

The TCP or UDP protocol is used to transmit the packets. The source node and destination nodes are defined. The source node sends the packet or data to all other nodes within the coverage area. Based on the protocol used, the source node detects the transmission path and coverage area and it transmits the messages through the detected transmission path in a multihop wireless environment. In the Multihop wireless environment, the collection of mobile nodes connected together over a wireless medium. To detect the transmission range the following parameters such as distance between sender and receiver, transmission power, transmission rate and vehicular traffic density should be used. The messages are transmitted in a different transmission ranges. The NAM window is used to visualize the node movements and path for transmitted messages.

**Fig. 5 Detection of Communication Range**

**D. ANALYSIS OF CONTROL CHANNEL**

The control channel (CCH), which is used as public channel for safety-relevant applications on the road. The CCH interval is further classified into Safety interval and WSA interval. The new CCH interval begins from the safety interval, during which WAVE nodes transmit safety information and broadcast the VCI packets. During the WSA interval, service providers broadcast WSA packets and piggyback with service information and the identities of SCHs to be used. Nodes that need the service can optionally respond to the WSA packet with an acknowledgement (ACK). Furthermore, a service user can initiatively send a request for service (RFS) packet to make an agreement with a service provider. After the end of the CCH interval, nodes tune to certain SCHs to transmit service packets.

**E. ANALYSIS OF SERVICE CHANNEL**

VCI MAC Scheme adopts a new coordination mechanism to provide contention-free SCH by the channel reservation on CCH. At the beginning of the WSA interval, service providers broadcast WSA packets, containing the identities of SCHs to be used, as well as other information. The other nodes that need the service can optionally compete to respond with an ACK. The node that successfully sends the response can make an agreement with the service provider on data transmission resource with a specific SCH ID and transmission duration.

Considering that too many service providers may share an SCH in a dense node environment, each service provider can only transmit one service packet for successful contention. All nodes will store the channel reservations for SCHs in the dedicated queues by monitoring the successful reservations. During the WSA interval, nodes that act as service users can initiatively start a reservation. An RFS packet will be sent by a service user with the ID of service provider and the service type. Then, the service provider will accept or reject the service request based on the channel conditions. If the service request is accepted,
the ACK packet from the service provider will contain
the ID of the SCH to be used in the upcoming SCH
interval.

Services providers will select an SCH when they
require the CCH to broadcast a WSA packet or
response to a service request. Based on the SCH usage
information, a service provider selects the channel
that accommodates the least service data packets in
the next SCH interval. If more than one SCH is
available, the service provider preferentially selects
the same SCH used in the previous service data
transmission. Upon the beginning of the SCH interval,
nodes that have made reservations will switch to
SCHs to perform service transmission according to
the reservations records in the relevant queues in an
orderly way.

Nodes that have not made any reservations can
stay on the CCH. Among these nodes, service
providers can broadcast WSA packets, and service
users record the information contained in the WSA
packets so that service users can join the WAVE [6]
Basic Service Set (WBSS)[1] or initiatively send RFS
in the next WSA interval.

F. MARKOV CHAIN MODEL FOR WSA OR
TRANSMISSION PROBABILITY

A markov chain model is proposed to obtain the
stationary probability τ that a node transmits a WSA
or RFS packet in an arbitrary time slot. The WAVE
nodes are communicated through single hop
environment. Let b(t) and s(t) be the stochastic
process representing the backoff window size and
backoff state for a given node at time t, respectively.

Consider m be the maximum backoff stage and W
be the maximal contention window (CW) of the ith
backoff stage and p be the probability of collision that
more than one node transmits in a single slot. In the
markov chain model, when a node detects the channel
is busy the counter of the backoff timer will be “frozen”
until the channel is detected to be idle again.

When the backoff stage of a node exceeds the
maximal value m, it holds m until the WSA or RFS
packet is successfully retransmitted, rather than being
reset to 0.

The markov chain model is mainly used to obtain
the collision probability when more than one node
transmits at the same time slot. The collision
probability p is obtained from markov chain model
[8],

\[ p = 1 - (1 - \tau)^{n-1} \]

(1)
The condition used to obtain the collision probability
p is 0 < p < 1 and 0 < \tau < 1.

G. CONTENTION MODEL FOR TIME ANALYSIS
IN WSA OR RFS TRANSMISSION

To analyze the average single reservation time on
CCH, the contention model is proposed. The
transmission delay for the control channel should be
defined as Tch_delay [1] and the transmission delay
for the service channel should be defined as
Tsch_delay [1] is calculated to increase the throughput
and reduce the transmission delay for the large service
packets transmitted through the service channel and
control channel.

III. PERFORMANCE EVALUATION

The Analytical model for the proposed VCI MAC
Scheme is validated by simulation parameters. The
main parameters used to validate the Scheme are the
number of nodes and the average length of service
packets.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
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<tr>
<td>Data rate of each channel</td>
<td>3 Mbps</td>
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<tr>
<td>Number of CCH</td>
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<tr>
<td>Number of SCHs</td>
<td>6</td>
</tr>
<tr>
<td>W0</td>
<td>32</td>
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<tr>
<td>Wm</td>
<td>1024</td>
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<td>MAC header</td>
<td>256 bits</td>
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<tr>
<td>PHY header</td>
<td>192 bits</td>
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<tr>
<td>WSA/RFS</td>
<td>160 bits+PHY header</td>
</tr>
<tr>
<td>ACK</td>
<td>112 bits +PHY header</td>
</tr>
<tr>
<td>Slot time</td>
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</tr>
<tr>
<td>SIFS</td>
<td>10 µs</td>
</tr>
<tr>
<td>DIFS</td>
<td>50 µs</td>
</tr>
<tr>
<td>Service packet length</td>
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<tr>
<td>Sending frequency of safety messages</td>
<td>2</td>
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<tr>
<td>Number of nodes</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 1 Simulation Parameters

IV. RESULTS AND DISCUSSION

Compared to the previous system used for Channel
coordination and Message transmission, the VCI
MAC Scheme is very effective to transmit the safety
and non-safety messages in multihop wireless
environment. The graph was plotted for the VCI MAC
Analysis and VCI MAC Simulation.
Fig.6 CCH interval and Throughput on SCHs: Analysis result versus Simulation Result

V. CONCLUSION
The performance of IEEE802.11p and IEEE 1609.4 based WAVE systems are improved depends on the VCI Multichannel MAC Scheme implementation. Both analytical results and simulation experiments to provide efficient channel utilization with higher saturation throughput and low service packet delay when transmitting large service packets in a multihop wireless environment.

REFERENCES