A Multi-channel MAC Protocol for VANETs

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Abstract

In the IEEE 1609.4 [2], nodes are allowed to transmit non-safety messages only during service channel (SCH) interval. In this paper, we propose a Multi-channel MAC for Vehicular Ad Hoc Networks (VANETs) which allows nodes to transmit non-safety messages in both the control channel (CCH) and SCH intervals to improve the non-safety traffic throughput. Moreover, nodes have to broadcast safety message twice to increase the reliability of safety message transmission.

Key word: Multi-channel, MAC protocol, Vehicular Ad hoc networks.

1. Introduction

Wireless Access in Vehicular Environment (WAVE) is designed for the Intelligent Transportation System on 5.9 GHz frequency with the IEEE 802.11p [1] and IEEE 1609 standard family. The IEEE 1609.4 [2] is a MAC extension of IEEE 802.11p to support multi-channel operations. In the IEEE 1609.4, the channel access time is divided into sync interval of the 50 ms CCH interval and 50 ms SCH interval. Nodes have to be on CCH during the CCH interval for exchanging safety messages and other control messages. During the SCH interval, nodes switch to SCHs to exchange non-safety data. The IEEE 1609.4 wastes the channel resources during the CCH interval.

A variable CCH interval (VCI) multi-channel MAC scheme is proposed in [4] to dynamically adjust the CCH interval. This scheme tries to improve the saturation throughput and provide the reliable transmission for safety messages. The AMCMAC is an Asynchronous Multi-channel MAC scheme which is proposed in [5]. A clustering-based multi-channel MAC protocol is proposed in [6]. The cluster head uses one transceiver to collect and deliver emergency messages and control messages within its cluster, and uses another transceiver to exchange consolidated safety messages among cluster head.

In our previous work, we proposed a synchronous multi-channel (H-MMAC) for wireless ad hoc network. The E-MMAC protocol adopts the H-MMAC [3] which allows nodes to exchange non-safety data on service channels while other nodes exchange safety messages or control messages on the control during the CCH interval.

2. The Proposed E-MMAC protocol

In our proposal, each node has a half-duplex transceiver. Node chooses either Normal Transmission (N-Tx) or Extended Transmission (E-Tx) mode. N-Tx mode is within the SCH interval while E-Tx mode is within the SCH interval and the next CCH interval.

A. Neighbor Information List – NIL

Each list entry keeps the information of neighbor nodes: Channel, Tx mode and Next_CCH. Channel field shows which service channel the node is going to use. Tx mode is either N-TX or E-Tx mode. Next_CCH is how many sync intervals the node will be on CCH. Node has to keep the NIL updated in order to exchange data. Table I shows the example of NIL.

TABLE I. Node A's NIL

Node	Channel	Tx mode	Next_CCH
B	1	N-Tx	1
C	2	E-Tx	2
E	3	E-Tx	2

B. Preferable Channel List – PCL

The state of each channel is either Selected or Not_Selected state. Selected channel means that this channel has already been chosen by the node, otherwise Not_Selected channel. The counter of a channel shows how many node pairs already reserved that channel. Node uses the PCL to select the “best” service channel for non-safe data transmission.

TABLE II. Node A's PCL

Channel	State	Counter
1	Not_Selected	1
2	Selected	1
3	Not_Selected	0

C. The operation of E-MMAC protocol

1) A node contends the control channel to broadcast each safety message twice in both the CCH and SCH interval.

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*This research was supported by the KCC (Korea Communications Commission), Korea, under the R&D program supervised by the KCA (Korea Communications Agency) (KCA-2012-10921-01305) *Dr. CS Hong is corresponding author.*

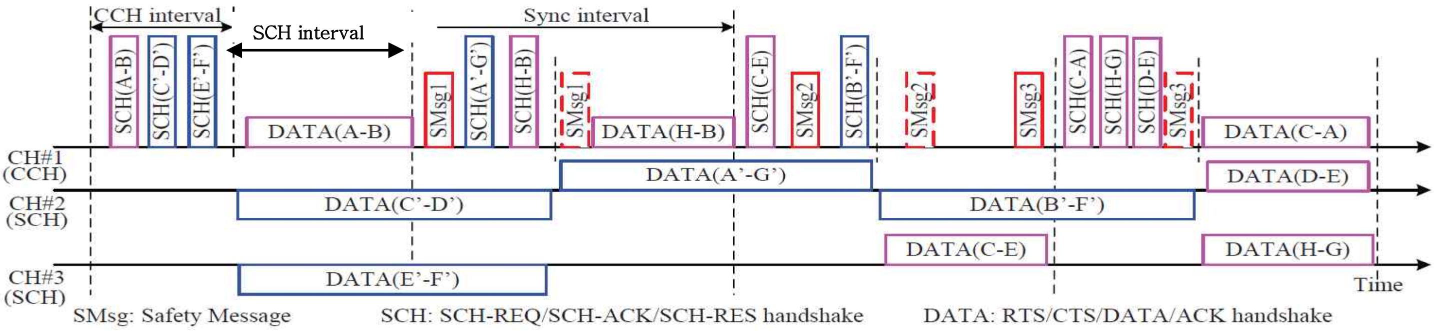

Fig. 1. The operation of E-MMAC protocol.

2) When a node has non-safety messages to send, the sender decides which transmission mode is used based on the traffic load,
3) The sender sends the SCH-REQ including its PCL and Tx mode to the receiver.
4) Upon receiving the SCH-REQ, the receiver selects the "best" channel from its PCL and the sender's PCL. Then, the receiver sends the SCH-ACK with the selected channel to the sender.
5) The sender confirms the service channel selected by the receiver by sending the SCH-RES.
6) After the CCH interval, the sender and receiver switch to the agreed service channel and start their data transmissions.

3. Performance Evaluation

In this section, we compare the performance of the IEEE 1609.4, AMCMAC and E-MMAC. There are 50 nodes (10 nodes broadcast safety messages of 20 packets/second and 40 nodes transmit the non-safety traffic of 1 to 1000 packets/second). Safety and non-safety packet size are 100 and 512 bytes.

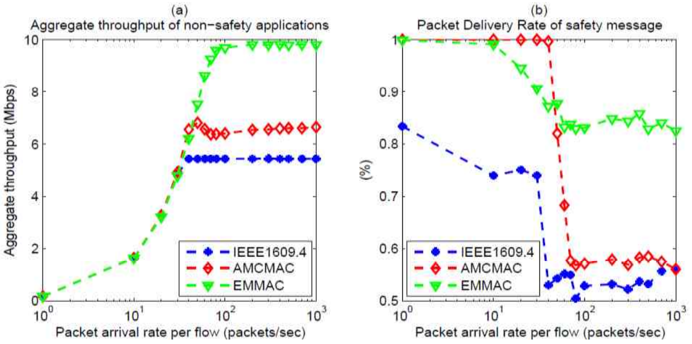

Fig. 2. The performance comparisons.

Fig. 2(a) shows the aggregate throughput of the non-safety traffic. By exploiting the service channels during the CCH interval, the E-MMAC achieves twice as much throughput compared to IEEE 1609.4. Although the AMCMAC has higher throughput than IEEE 1609.4, its control channel may become bottleneck. So, the service channels can not be fully utilized and the throughput is lower than E-MMAC.

The safety message broadcast efficiency is shown in Fig. 2(b). Since the safety message is broadcast twice in the E-MMAC, it is more reliable than IEEE 1609.4. However, when the network load is low, the E-MMAC's broadcast reliability is lower than AMCMAC because of high collision probability. When the network load is high, there is a congestion on the control channel, the broadcast efficiency of AMCMAC is lower than E-MMAC.

4. Conclusions and Future work

In this paper, we have proposed a Multi-channel MAC for VANETs, E-MMAC, which fully utilizes all channel resources to improve the network performance. The simulation results show that the E-MMAC has higher throughput for non-safety traffic and more reliability for safety message transmission.

5. Reference

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