AE-VeMAC: An Enhanced VeMAC Protocol for Vehicular Ad hoc Networks

VanDung Nguyen, Duc Ngoc Minh Dang and Choong Seon Hong*

Department of Computer Engineering, Kyung Hee University

ngvandung85@khu.ac.kr, dnmduc@khu.ac.kr, cshong@khu.ac.kr

Abstract

VeMAC, a novel TDMA MAC protocol, is proposed for vehicle ad hoc network. Based on TDMA scheme and direction of moving vehicles, the VeMAC protocol supports higher throughput and decreases the rate of transmission collisions. However, the overhead of the packet transmitted on the control channel is high in VeMAC protocol. In this paper, we propose an enhanced VeMAC protocol (AE-VeMAC) by modifying the header and acceptance of service fields. As the results, the number of time slots increases and it helps to decrease the collision rate.

Key word: VeMAC, medium access control, control channel.

1. Introduction

Vehicle Ad hoc NETwork (VANET), one of special types of Mobile Ad hoc NETworks (MANET), consists of many vehicles. The essential applications are Vehicle-to-vehicle (V2V) and Vehicle-to-infrastructure (V2I). The goal of VANETs is to provide safety applications and non-safety applications for more driving efficiency, comfort and safety. Dedicated Short Range Communications (DSRC) spectrum [1] is divided into seven 10-MHz channels: six Service CHannels (SCHs) for safety and non-safety related applications, and one Control CHannel (CCH) for transmitting the control information and high-priority short safety messages (CCH), as shown in Fig. 1. A Sync Interval (SI) consists of a the CCH Interval (CCHI) - 50 ms and SCH Interval (SCHI) - 50 ms. There is a Guard Interval (GI) – 4 ms for switching between the CCHI and the SCHI.

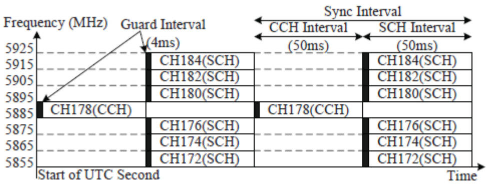

Fig. 1: Frequency channel layout of a 5.9GHz WAVE systems.

Various MAC protocols, such as VER-MAC [2], ADHOC MAC [3], DMMAC [4] and VeMAC [5] are proposed to improve the reliability of safety message broadcast and utilize the SCH resources efficiently. VeMAC protocol [5] has the advantages: the reduction of the access and merging collision rate by portioning the frame into three sets, and the Slot Release Prevention (SRP) condition which prevents the node from unnecessarily releasing their time slots when they just enter the communication range of each other.

*본 연구는 미래창조과학부 및 정보통신산업진흥원의 대학 IT 연구센터 육성지원 사업의 연구결과로 수행 되었음" (NIPA-2014-(H0301-14-1003)). Dr. CS Hong is corresponding author

In this paper, we propose an enhanced VeMAC protocol to reduce the overhead of the packet transmitted on the CCH the number of time slots on the CCH.

2. The AE- VeMAC protocol

Like the VeMAC [5] protocol, AE-VeMAC requires each node has to acquire exactly one time slot in a frame on the CCH. It keeps accessing the same slot in all subsequent frames on the CCH. Based on a left (right) direction of vehicles and Road Side Units (RSUs), the VeMAC protocol divides each frame into three sets of time slots, as shown in Fig. 2. $\mathcal{L}$ and $\mathcal{R}$ are associated with vehicles moving in left and right directions respectively, whereas $\mathcal{F}$ is associated with RSUs. Each packet transmitted on the CCH includes four fields: Header, Bit Identified Status (BIS), Announcement of Service (AnS) and high priority short applications, as show in Fig. 3. Based on the overheard packet, each node is provided with full knowledge of the channel access of its one-hop and two-hop neighbors.

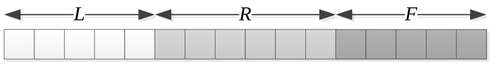

Fig. 2: The $\mathcal{L}$, $\mathcal{R}$ and $\mathcal{F}$ sets on the CCH.

We define a new bit - Bit Identified Status (BIS) to replace AcS field, which shows the status of communication between source and destination. BIS is set to 1 if and only if the destination accepts communication.

In the header field of the packet transmitted on the CCH, we reduce payload by using Status Field (SF). The SF shows the time slots occupancy of one-hop neighbors on the CCH and it can be either 0 or 1. Bit 1 means occupied slot otherwise empty slot. The number of time slots, s0, in a frame on the CCH is presented by log2s0 bits, as shown in Fig. 3b.

Consider that node x has a reliable service to offer to node d in time slots numbered 1, 2 and 4 on the SCH 2. Node x includes $\beta_2(x)$ = {1, 2, 4} in AnS field and sets

BIS(x) = {0} of its packet broadcasted on the CCH, as shown in Fig. 4. Once node d accepts the service and includes $\beta_2(x)$ in AnS field of its packet transmitted on the CCH, node d sets BIS(d) = {1}. Upon receiving the packet transmitted by node d, node x starts offering the service on the SCH 2 in time slots {1, 2, 4} as announced in $\beta_2(x)$. When nodes y and r (neighbors of node d) receive the packet transmitted by node d on the CCH, they check BIS(d). If BIS(d) is 1, they will update $\beta_2(x)$ to $T_2(y)$ and $T_2(r)$ to avoid using the same time slots on SCH 2. After node d receives the last packet on the SCH, it will send an ACK packet in its time slot on the CCH to node x to announce the successfully received packets.

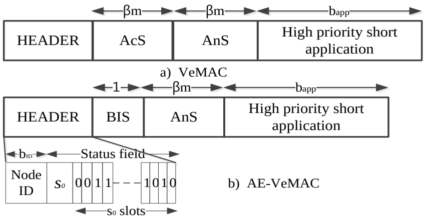

Fig. 3: Format of each packet transmitted on the CCH.

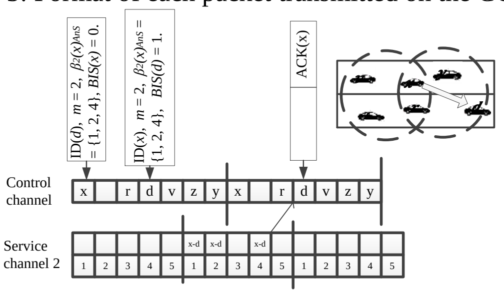

Fig. 4: Operation of AE-VeMAC protocol.

3. Performance and Simulations

Based on VeMAC protocol [5], we have parameters:

- N(x): the number of one-hop neighbors.
- si: the length of frame, i = 0, 1, 2, ..., M.
- bextra: the number of bits for all other information in the packet.

From Fig. 3a, the total packet size of the VeMAC protocol (in bits)

$$S = |N(x)|(b_{ID} + \lceil \log_2 s_0 \rceil) + |\beta_m(x)|\lceil \log_2 s_m \rceil + |\beta_n(x)|\lceil \log_2 s_n \rceil + b_{app} + b_{extra}$$

In our proposal, total protocol packet size (in bits)

$$S_{enhancement} = b_{ID} + \lceil \log_2 s_0 \rceil + 2^{s_0} + 1 + |\beta_n(x)|\lceil \log_2 s_n \rceil + + b_{app} + b_{extra} + ACK$$

We use Matlab version 7.10 to compare the performance between the AE-VeMAC and VeMAC protocols with parameters shown in Tab. 1. In this simulation, we set $\log_2 s_o = \log_2 s_i = n$. We vary the parameter n and compare our proposal with VeMAC protocol.

Table 1: Simulation parameters

Parameter	Value	Parameter	Value
N(x)	100	b_{app}	200 bytes
b_{ID}	8 bits	b_{extra}	30 bytes
β_m	100	ACK	14 bytes
β_n	50		

In Fig. 5a, the maximum number of time slots on a frame of our scheme is higher than VeMAC protocol. At n = 10 (maximum is 210 = 1024) the time slots of our proposal is 293 time slots. Meanwhile, VeMAC protocol is 209 time slots.

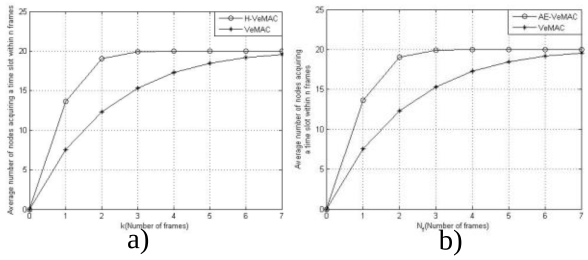

Fig. 5: a) Maximum number of time slots on a frame. b) Average number of nodes acquires a time slot within k frames. We keep the constant number of contending nodes (K=20) and choose the number of time slots in VeMAC is less than AE-VeMAC protocol.

In Fig. 5b, based on the higher number of time slots of our scheme, we choose the same K denoted the number of contending nodes, each node needs to acquire a time slots on the CCH (refers [5] for detail). The average number of nodes acquiring a time slot within Nf frames is higher than VeMAC protocol.

4. Conclusions

In this paper, a novel protocol is proposed for VANETs to design a vehicle ad hoc networks. Based on the simulation, AE-VeMAC protocol performs a higher number of time slots and average number of nodes acquiring a time slots on the CCH compared with VeMAC protocol.

5. Reference

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