

An Enhanced VeMAC Protocol

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An Enhanced VeMAC Protocol

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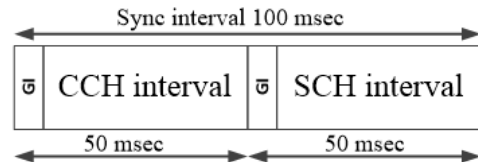
요 약

VeMAC protocol is a medium access control protocol based on the direction of moving vehicle. VeMAC reduces the transmission collision and supports higher throughput on the control channel (CCH). However, the number of time slots in a frame is limited and affects the time slot reservation on the CCH. In this paper, we propose an enhanced VeMAC protocol to expand the number of time slots by reducing the length of the control frame.

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

1. Introduction

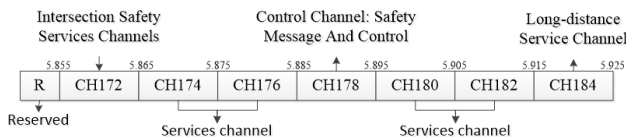
Vehicle Ad hoc NETwork (VANET), one of special types of Mobile Ad hoc NETworks (MANET), consists of many vehicles. The essential applications are Vehicle-to-vehicle (V2V) and Vehicle-to-infrastructure (V2I). The goal of VANETs is to provide safety applications and non-safety applications for more driving efficiency, comfort and safety. Dedicated Short Range Communications (DSRC) spectrum [1] is divided into seven 10-MHz channels: six Service CHannels (SCHs), 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, as shown in Fig. 2.



(그림 2) The CCH interval and SCH interval.

Various MAC protocols [2-5] are proposed to improve the reliable of safety message broadcast. VER-MAC [2] utilizes the SCHI on the CCH and employs retransmission mechanism for safety message broadcast. ADHOC MAC [3] employs a Dynamic TDMA mechanism, which is achieved by the Reliable R-ALOHA protocol. Vehicle node knows the time slot occupancy of its two-hop neighbors and can avoid collisions (hidden and exposed terminal problems and reliable broadcasting). Like ADHOC MAC, some TDMA-based MAC protocols [4-5] are proposed to provide the collision free and delay-bounded transmissions for safety messages. The Dedicated Multi-channel MAC (DMMAC) [4] adopts the Basic Channel reservation from RR-ALOHA.

VeMAC protocol [5] clarifies a set of vehicles moving direction (associated with left or right direction) and a set of Road Side Units (RSUs). The VeMAC provides a smaller rate of transmission collisions (access collision and merging collision), and higher throughput



(그림 1) DSRC spectrum allocation.

on the CCH than ADHOC MAC and ADHOC-enhanced protocols.

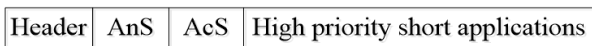
In this paper, we propose an enhancement to the VeMAC protocol for extension the number of time slots. The paper is organized as follows. Section 2 discusses about the VeMAC protocol. Section 3 presents a modified frame format of each packet transmitted on the CCH. Section 4 analyses this enhancement and conclusions are given in section 5.

2. The VeMAC protocol

In the VeMAC protocol, 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 RSUs, the VeMAC protocol divides each frame into three sets of time slots, as shown in Fig. 3. \mathcal{L} and \mathcal{R} are associated with vehicles moving in left and right directions, respectively whereas \mathcal{F} is associated with RSUs. Each node is equipped with Global Positioning System (GPS) receiver to determine its position and moving direction. Based on the moving direction, each node acquires one time slot of the corresponding set. If node cannot acquire a time slot, its accessible set is extended to the opposite set. Node still cannot acquire a time slot, node will start to acquire any available time slot. Each packet transmitted on the CCH includes four fields: Header, Announcement of Service (AnS), Acceptance of Service (AcS), and high priority short application, as show in Fig. 4 (refer [2] for detail). Based on the overheard packet, each node is provided with full knowledge of the channel access of its one and two hop neighbors.



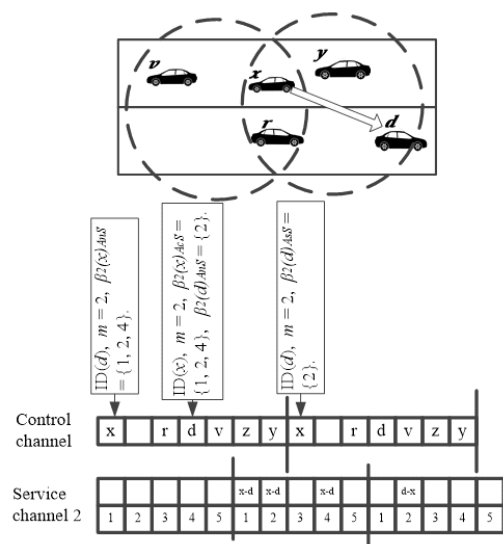
(그림 3) The \mathcal{L} , \mathcal{R} and \mathcal{F} sets on the CCH.



(그림 4) Format of each packet transmitted on CCH.

Each node will broadcast its packet (header, Ans, AcS, high priority short application) in its time slot on the CCH even if it does not have information to transmit or receive. In Fig. 5, 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 announces for the service

and includes time slots $\beta_2(x) = \{1, 2, 4\}$ in AnS field of its packet broadcasted on the CCH. Once node d accepts the service, it specifies the time slot which is used to transmit ACK packet $\beta_2(d) = \{2\}$. Node d includes $\beta_2(d)$ in the AnS field and $\beta_2(x)$ in the AcS field of its packet transmitted on the CCH. When nodes y and r (neighbors of node d) overhear the packet transmitted by node d on the CCH, they will update $\beta_2(x)$ to $T_2(y)$ and $T_2(r)$ in order to avoid using the same time slots. Once node x accepts the service, it adds $\beta_2(d)$ to AcS field of its packet broadcasted on the CCH. Nodes v, y and r (neighbors of node x) receive the packet transmitted by node x on the CCH, they will update $\beta_2(d)$ to $T_2(v)$, $T_2(y)$ and $T_2(r)$ in order to avoid using the same time slot.

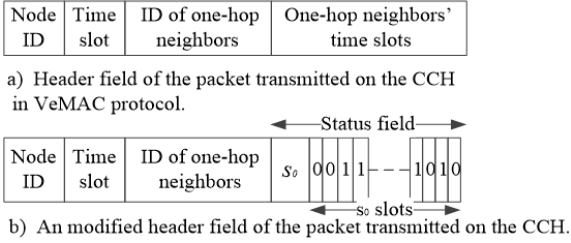


(그림 5) Operation of VeMAC protocol.

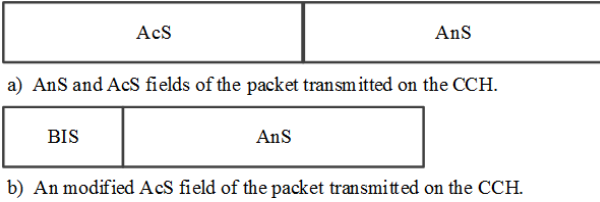
3. The enhanced VeMAC

In the header field of the packet transmitted on the CCH, we reduce payload by using status field (SF). In SF, each bit corresponds to the status of a time slot on the CCH. Bit 1 means occupied slot, otherwise bit 0 means empty slot. The number of time slots in a frame on the CCH, s_0 , is presented by $\log_2 s_0$ bits, as shown in Fig. 6.

We define a new bit, Bit Identified Status (BIS), which shows the status of communication between source and destination as shown in Fig. 7. BIS is set to 1 only if the destination accepts communication.

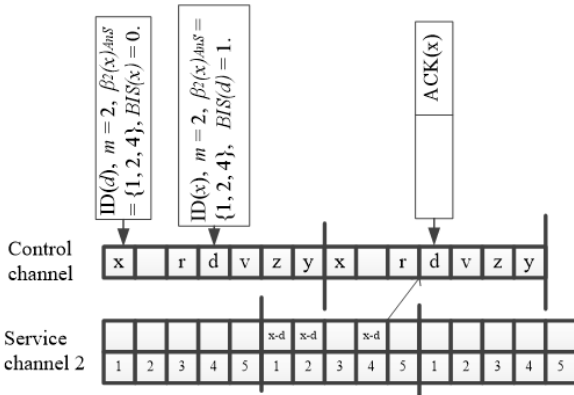


(그림 6) A modified header field of the packet transmitted on the CCH.



(그림 7) An modified AcS field of the packet transmitted on CCH.

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. 8. Once node d accepts the service and includes $\beta_2(x)$ in AnS field. In 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. After node d receives the last packet on the SCH, node d will send ACK packet to node x for the successful received packets in its time slot on the CCH.



(그림 7) Operation of the enhancement with modified header and AcS fields.

4. Performance evaluation

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

- $N(x)$: the number of one-hop neighbors.
- b_{ID} : the number of bits used to represent node ID.
- s_i : the length of frame of channel (control and service channel) $i = 0, 1, 2, \dots, M$.
- β_m and β_n : the number time slots on the SCH c_m and c_n , respectively.
- b_{app} : the number of bits for the high priority application field.
- b_{extra} : the number of bits for all other information in the packet.

The total packet size of the VeMAC protocol (in bits) is

$$S = |N(x)| (b_{ID} + \lceil \log_2 s_0 \rceil) + |\beta_m(x)| \lceil \log_2 s_m \rceil + |\beta_n(x)| \lceil \log_2 s_n \rceil + b_{app} + b_{extra} \quad (1)$$

In this enhancement, total protocol packet size (in bits) is:

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

We assume that $N(x) = N_{max}(x) = 100$ (as assumption in [3]), $b_{ID} = 1$ byte, $\log_2 s_0 = \log_2 s_i = 9$ bits, $b_{app} = 200$ bytes, $b_{extra} = 30$ bytes, $|\beta_m| = |\beta_n| = 10$ and $ACK = 14$ bytes [1]. From Eq. 1, we have $S = 3720$ bits ≈ 465 bytes. In this paper, from (2), we have $S_{enhancement} = 3373$ bits ≈ 422 bytes. Considering the transmission rate of 12 Mbps, the transmission time of packet in the VeMAC and enhanced VeMAC are 0.31 ms and 0.29 ms, respectively. By adding guard interval and taking account of physical layer overhead, the slot duration of the VeMAC and enhanced VeMAC can be assumed as 0.36 ms and 0.34 ms, respectively. For the 100 ms frame, the number of time slots in the VeMAC and enhanced VeMAC are 275 slots and 290 slots, respectively. When the number of time slots increases, the successful probability of acquiring time slot increases.

5. Conclusions

We propose an enhancement to VeMAC protocol by modifying header and AcS fields of the packet. Our scheme provides a higher number of time slots and lower collision rate of acquiring time slots on the CCH

compared with VeMAC protocol.

6. Acknowledgement

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