Parallel transmission problem in the VeMAC protocol

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Abstract

The VeMAC protocol not only supports efficient one-hop and multi-hop broadcast service but also provides significantly higher throughput on the control channel (CCH) than the ADHOC MAC and ADHOC-enhanced protocols. Based on the packet transmitted on the CCH in the VeMAC protocol, the vehicle provided with knowledge can use same time slots to parallel transmission. In this paper, we propose the solution of a drawback of the VeMAC protocol in parallel transmission case.

Key word: VeMAC, ADHOC MAC, parallel transmission.

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 and non-safety applications for more driving efficiency, comfort and safety. Dedicated Short Range Communications (DSRC) spectrum 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.

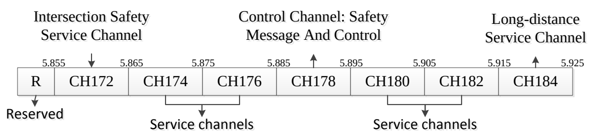

Fig. 1: DSRC spectrum allocation.

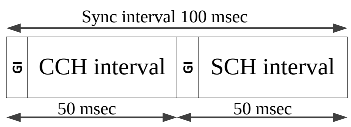

Fig. 2: The CCH interval and SCH interval.

Various MAC protocols [1-5] are proposed to improve the reliable of safety message broadcast. VER-MAC [1] utilizes the SCHI on the CCH and employs retransmission mechanism for safety message broadcast. The proposal in [2] uses the Broadcast Sequence (BS) to allow the vehicle nodes to rebroadcast the safety messages sequentially. 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). Like ADHOC MAC, some TDMA-based MAC protocols [3-5] 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 on the CCH than ADHOC MAC and ADHOC-enhanced protocols.

In this paper, we propose the solution of a drawback of the VeMAC protocol in parallel transmission case. The paper is organized as follows. Section 2 discusses about drawback of the VeMAC protocol in parallel transmission case. Section 3 presents solution of this problem. Section 4 presents the simulation results. Finally, conclusions is presented in Section 5.

2. The VeMAC protocol in parallel transmission case

In the VeMAC protocol, each packet transmitted on the CCH includes four fields: Header, Announcement of Service (AnS), Acceptance of Service (AcS), and high priority short application, as shown in Fig. 3 (refer [5] 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.

Header	AnS	AcS	High priority short applications

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

In the VeMAC protocol, the AnS field consists of 5 parameters: 1) Priority of the service; 2) reliability of the service (i.e, ACKnowledgement (ACK) or not), 3) MAC address of the intended destination, i.e $ID(y)$, 4) The number m of the service channel; 5) the number of time slots, β_m, that a node will access on channel c_m to offer the service, such that $\beta_m \cap T_m = \phi$. T_m is the number of time slots that a node must not to use.

A. The advantage of the VeMAC protocol on parallel transmission.

We consider 3-hop neighbor situation, as shown in Fig. 4. Node x has a reliable service to offer to node d in time slots 1, 2 and 4, $\beta_2(x) = \{1, 2, 4\}$, on the SCH 2, $m = 2$. Node x will send packet on the CCH with full knowledge about its service. Once node d accepts the service, it announces $\beta_2(x)$ in the AcS field of its packet transmitted on the CCH. When node y overhears packet transmitted by node d, it will add $\beta_2(x)$ to $T_2(y)$ to avoid using the same time slots. Nodes v and z do not overhear the packet transmitted by node d and do not update the $T_2(v)$ and $T_2(z)$. Based on information of the time slots, nodes v and z can use same the time slots 1, 2 and 4 on the SCH 2 to exchange data packets without collision.

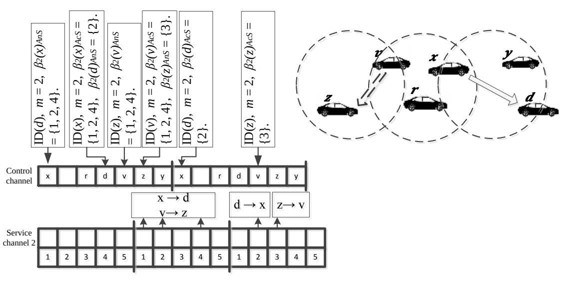

Fig. 4: A parallel transmission in the VeMAC protocol.

B. Criticality of the VeMAC protocol on parallel transmission.

In this section, we mention multi-parallel transmission. Consider the 3-hop neighbor configuration shown in Fig. 5, node x announces to offer to node d in the time slots 1, 3 and 4, $\beta_2(x) = \{1, 3, 4\}$, on the SCH 2, $m = 2$. When node d accepts this service, it includes $\beta_2(x)$ in the AcS field of its packet transmitted on the CCH. Node z overhears packet transmitted by node d and update $\beta_2(x)$ to $T_2(z)$ to avoid using the same time slots 1, 3 and 4 on the SCH 2. In this case, node v announces to offer to node z in the time slots 2, 3 and 5, $\beta_2(v) = \{2, 3, 5\}$, on the SCH 2, $m = 2$. When node z receives packet transmitted by node v, it compares $\beta_2(v)$ with $T_2(z)$. Because of $\beta_2(v) \cap T_2(z) \neq \phi$, the node z will include the new time slots, i.e $\beta_2(v) = \{1, 2, 5\}$ in the AnS field of its packet transmitted on the CCH. When node v receives packet transmitted by node z, it compares $\beta_2(v)$ with $T_2(v)$. Because of $\beta_2(v) \cap T_2(v) = \phi$, the node v will include $\beta_2(v)$ in the AnS field of its packet transmitted on the CCH. Using the VeMAC protocol, multi-parallel transmission is limited at nodes z although it can receive packets from source node v.

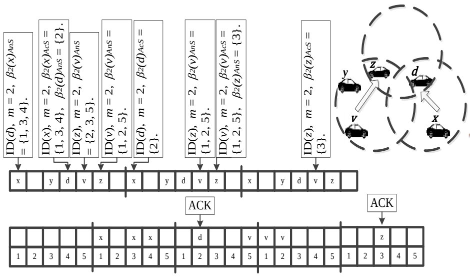

TABLE I: ONL of the node **z** in Fig. 5

$N(z)$	m	$Tm(z)$	S/R	B/I
v	2	1, 2, 5	1	1
d	2	1, 3, 4	0	1
y			0	0

Fig. 5: A drawback of the VeMAC protocol on multi-parallel transmission.

3. An improvement in the VeMAC protocol.

Based on packet transmitted on the CCH, each node is provided with full knowledge of the time slots and the SCH of its one neighbors. We define One-hop Neighbor List (ONL) for a certain node to store full knowledge of the one-hop neighbor node. Each node consists of 4 parameters: One-hop neighbor of node z ($N(z)$), the number m of the service channel, the number of time slot that a node must not to use, denoted T_m, one bit defined a status of node (1: Sender or 0: Receiver, S/R), 1 bit defined a status of the SCH (1: Busy or 0: Idle, B/I), as shown in Tab. 1.

Following ONL, we propose algorithm to communicate to pair source-destination, as shown in Fig. 6. By using this algorithm, we can transmit simultaneously two or more pair source-destination without collision. In criticality presented in section 2(B), node z has full knowledge of one-hop neighbor. Node z receives a packet transmitted by node v on the CCH. In node z's ONL, node d is receiver and no node is source which is reserving one of time slots on AnS field transmitted by node v. When node z accepts this service, it includes $\beta_2(v)$ to AcS field of its packet transmitted on the CCH. In this case, we can use multi-parallel transmission without collision.

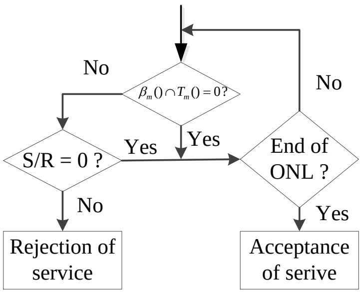

Fig. 6: Algorithm used for checking on ONL.

4. Simulations

To compare our proposal with VeMAC, we use Matlab simulation with parameters as shown in Tab. 2. In the same scenario, we simulate two protocols within 200 frames (200 frames * 10 ms/frames = 2 seconds) to evaluate the performance of our proposal and VeMAC protocol.

TABLE II: Simulation parameters.

Parameter	*highway*
# lane/direction	4/2
# highway length	$1km$
Speed mean value	$100km/h$
Speed standard deviation	$20km/h$
Transmision range	$150m$
# slots of left directions	50
# slots of right directions	50
# slots of RSUs	0
# slots of a frame on the SCH	100
Slot duration	$1ms$
# vehicles	180
Accessing the CCH	VeMAC protocol

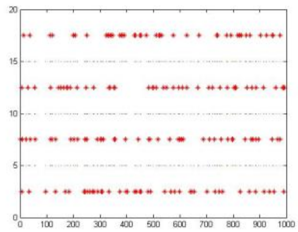

Fig. 7: A highway scenario in our simulation.

Each vehicle moves with constant speed in one of the 4 lanes. The vehicle are divided uniform into 2 directions (left or right). The number of vehicles on the highway segment remains constant during the simulation time, as shown in Fig. 7.

Each node has to broadcast packet on the CCH even if it does not have data to exchange. We assume that the arrival process of the event-driven safety messages can be modeled by Poisson process with rate λ_m messages/slot. In our simulation, we choose λ_m = 10. We set up rate with 1 pair source-destination nodes within a frame (λ = 1 pair/frame) on the first simulation. With λ = 2 pairs/frame, the second simulation is shown in Fig. 8. Under same condition, both first and second run show that the number of nodes resent packet on the CCH in our proposal is lower than VeMAC protocol. Our proposal has 1 node and the VeMAC protocol has 3 (λ = 1) or 4 (λ = 2) nodes. Notification, at the time the node resent packet happened in our proposal also is happened in the VeMAC protocol because the source node will update information of other destination node behind (in the same one-hop neighbor). The first node resent packet on the CCH (at thirst frame (λ = 1), at second frame (λ = 2)) is happened in both our proposal and VeMAC protocol, as shown in Fig. 8.

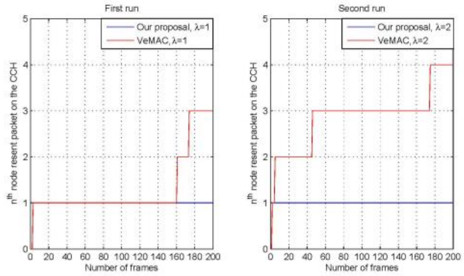

Fig. 8: The number of nodes resent a reliable service on the CCH.

5. Conclusions

We propose an improved VeMAC protocol for parallel transmission without collision. Simulation results in highway scenario show that our proposal provides not only a lower rate of collision but also higher throughput on SCH than the VeMAC protocol.

6. Acknowledgement

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References

[1] D. N. M. Dang, C. S. Hong, S. Lee and E. Huh, "An Efficient and Reliable MAC in VANETs," *IEEE Communications Letters*, Vol. 18, no. 4, pp. 616-619, March 2014

[2] D.N.M Dang, H.N Dang, C.T. Do and Choong Seon Hong, "An Efficient and Reliable MAC for Vehicular Ad Hoc Networks", *APNOMS-2013*, pp. 1-5, 2013.

[3] F. Borgonovo, A. Capone, M. Cesana, and L. Fratta, "ADHOC MAC: New MAC architecture for ad hoc networks providing efficient and reliable point-to-point and broadcast service." *Wireless Network*, 2004, pp. 359–366 Vol. 10.

[4] N. Lu; Y. Ji; F. Liu; X. Wang, "A Dedicated Multi-Channel MAC Protocol Design for VANET with Adaptive Broadcasting," *WCNC-2010*, pp.1-6, 18-21 April 2010.

[5] H. Omar, W. Zhuang, and L. Li, "VeMAC: A TDMA-based MAC protocol for reliable broadcast in VANETs," *IEEE Transactions on Mobile Computing*, vol. 12, no. 9, pp.1724–1736, 2013.