Modified TDMA-based MAC Protocol to Mitigate Access Collision for Vehicular Ad Hoc Networks

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Abstract

The Medium Access Control (MAC) for Vehicular Ad hoc NETworks (VANETs) provides an efficient and reliable broadcast service of safety application. One of MAC protocol versions named VeMAC is proposed. VeMAC protocol can decrease the rate of transmission collisions and increase the throughput on the control channel. However, VeMAC protocol did not exploit the presence of Road Side Units (RSUs). In this paper, RSUs allocate a particular slot to the vehicles that are moving within its coverage. Simulation result shows that our proposal outperforms VeMAC in term of the average number of access collisions until all nodes successfully acquire a time slot.

Keywords: VANET, MAC, VeMAC, RSU, access collision.

1. Introduction

Intelligent Transport System (ITS) is to support to transport system to make them safe, intelligent and efficient. Vehicular Ad hoc NETwork (VANET) is one of important components in ITS. However, VANETs are dynamic networks because of the high node mobility, the variable node density. Each node vehicle is equipped with a radio interface, called an On-Board Unit (OBU). In addition, to connect to Internet, a set of stationary units is distributed along the road called Road Side Units (RSUs). VANETs provide Vehicle-to-Vehicle (V2V) and Vehicle-to-RSU (V2R) [1] [2] and make them enable to provide a variety of safety applications and non-safety applications. An RSU plays a role of collecting and analyzing traffic data on safety application in VANETs. In other hand, an RSU takes part in controlling traffic low by broadcasting locally analyzed data, forwarding some important message on [3] [4].

Dedicated Short-Range Communications (DSRC) is used by V2V and V2R communications. The DSRC spectrum is divided into seven channels: one Control CHannel (CCH) and six Service CHannels (SCHs), as shown in Fig. 1. A Sync Interval (SI) comprises of a CCH Interval (CCHI) - 50 milliseconds and a SCH Interval (SCHI) - 50 milliseconds. Both CCHI and SCHI have guard interval - 4 milliseconds to switch the CCH and the SCH.

VeMAC protocol [5] shows that it can decrease the rate of transmission collision and provide higher throughput on the control channel than ADHOC MAC. E-VeMAC protocol [6] improves VeMAC protocol in term of the throughput on the service channel by mitigating the exposed terminal problem. However, all of protocol did not consider the special character of RSUs.

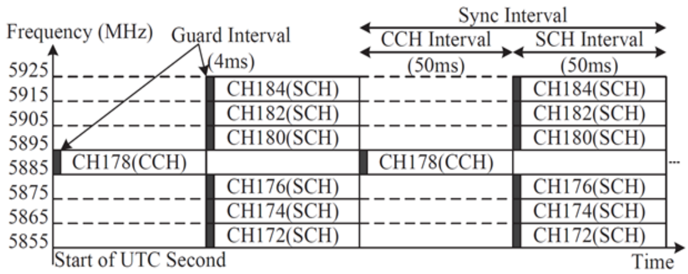

Fig 1: DSRC spectrum allocation.

In this paper, we propose a modified TDMA-based MAC protocol to mitigate access collision for VANETs. In our proposal, RSUs coordinate all nodes in its transmission range. By using RSU's coordination, all nodes can successfully acquire their time slots faster than VeMAC protocol with a few access collisions. Hence, our proposal can improve higher throughput on the control channel than VeMAC protocol.

The rest of paper is organized as follows. Section 2 presents system model. Section 3 is dedicated to present a modified TDMA-based MAC protocol. The simulated result is presented in Section 4 and we conclude this research and suggest some future works in Section 5.

2. System model

In our proposal, RSU's coverage can be divided into 3 sections: RSU's 1-hop neighbors, RSU's 2-hop neighbors and RSU's n-hop neighbors' sections, as shown in Fig. 2. All nodes which can connect directly to an RSU are grouped into RSU's 1-hop neighbors section. Upon an RSU receives packets transmitted by nodes in its coverage, an RSU has acknowledgment of all node among RSU's 2-hop neighbors section. For instance, in Fig 2, nodes *a, b, c, d, e* and *f* are in RSU's coverage.

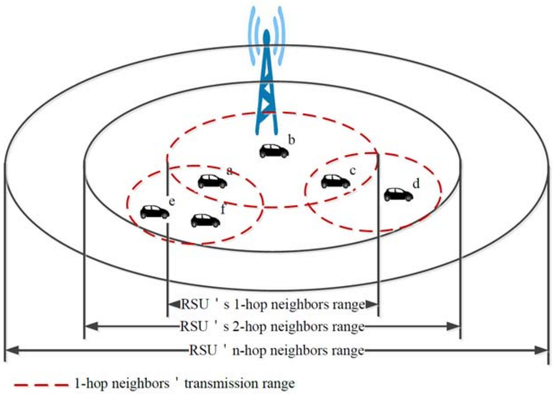

Fig 2: Sections in coverage of an RSU.

Like VeMAC protocol [5], our proposal considers that the VANET consists of vehicles and RSUs in opposite on two-way road. Each node is equipped with global positioning system (GPS). GPS can provide accurately its position and moving direction. A frame partitions to a constant number of time slot. Each frame consists of 3 sets of time slot: *R, L* and *RSU*, as shown in Fig. 3. Each node maintains one-hop neighbors list (ONL). One-hop neighbors list is defined as follows with x is a considering node.

- $N(x)$: The set of IDs of the one-hop neighbor of node on the control channel.
- $T_m(x)$: The set of time slots that considering node must not use on the channel m, $m = 0, 1, 2, \dots 6$ where control channel is defined by $m = 0$ and service channels are defined by $m = 1, 2, \dots 6$.

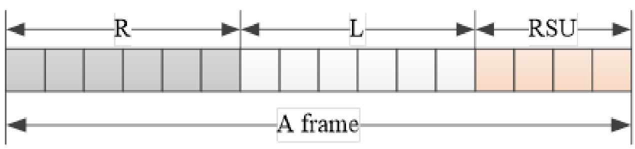

Fig 3: Each frame on the CCH partitions *R, L.* and *RSU.*

3. A modified TDMA-based MAC protocol

Each node in our proposal must successfully acquire one time slot in a frame on the control channel. Each node keeps accessing the same time slot on all subsequent frames on the control channel if it does not collide with another nodes in its transmission range. Each node must transmit its packet in its time lot on the control channel. In both VeMAC and our proposal, a packet transmitted on the control channel is divided into four field: header, announcement of services (AnS), acceptance of service (AcS), and high-priority short applications, as shown in Fig. 4. Unlike to VeMAC protocol, in the header field, each node arranges its neighbor node to two sets: ahead and behind neighbors sets, as shown in Fig. 4. One byte is defined by A, and one byte is defined by B. The A and B are included into packet to divide disjoint sets of neighbor nodes to node moving ahead and behind of a considering node.

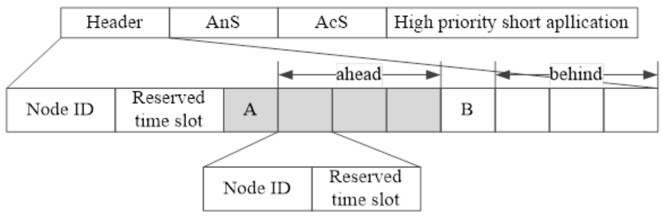

Fig 4: Format of each packet transmitted on the CCH.

Operation of our proposal is as follow:

- Node chooses random time slot based on its ONL and $T_0(.)$.
- Each node transmits a packet in its reserved time slot on the control channel.
- Once nodes and RSU receive packets transmitted on the control channel, they update their ONLs.
- Based on ONL, an RSU will broadcast its packet on the control channel. All nodes in its coverage receive this packet. They will update their ONL to follow packet transmitted by an RSU.
- Because all nodes receive packet transmitted by an RSU, all nodes know that they successfully or unsuccessfully acquire their time slot. If node did not is included in packet transmitted by an RSU, it knows that it unsuccessfully acquire its time slot.
- If nodes successfully acquire their time slot, they keep accessing the same time slots in all subsequent frame on the control channel. If nodes unsuccessfully acquired their time slot, they will choose new time slots. A new time slot is an RSU's available time slot, $T_0(RSU)$. If there is no available time slot in $T_0(RSU)$, it will choose an available time slot associated with $T_0(x)$ where x is a contending node. For instance, we consider in Fig. 5.

4. Simulation result

In this section, we evaluate the performance of our proposal in MATLAB and compare it with VeMAC and ADHOC-MAC protocols.

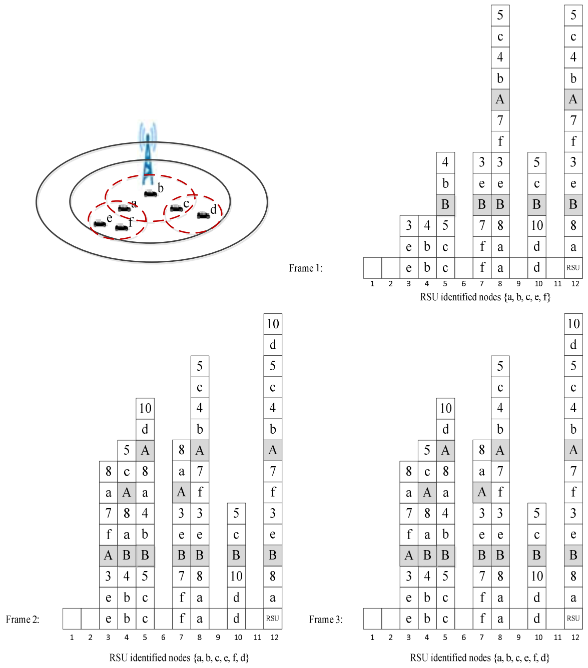

Fig 5: Example of our proposal.

The simulated scenario is considered a segment of a two-way traffic highway, *20m x 300m*. Each node moves with constant speed and the number of nodes on the highway remains constant during the simulated time. The transmission range of each node is *150m*. The transmission rang of RSU is *300m*. Each node can communicate with all nodes in its transmission range. We vary the node density in the highway scenario. The simulation runs *100* times to compute an average of number of access collisions until all nodes successfully acquire a time slot.

An access collision is defined as an event when two or more nodes within 2-hop of each other access the same available time slot. As the number of nodes in simulated highway scenario increases, an access collision also increases. Our proposal and VeMAC protocols divide a frame into 3 sets: *R*, *L* and *RSU*. Hence, the number of access collisions is lower than ADHOC-MAC protocol. In our proposal, an RSU coordinate all nodes within its coverage. Compared to VeMAC protocol, our proposal can decrease the rate of access collisions, as shown in Fig. 6.

5. Conclusion

In this paper, we propose a modified TDMA-based MAC protocol to mitigate access collision for VANETs. In our proposal, RSUs coordinate all nodes in its transmission range. By using RSU's coordination, simulation result shows that all nodes can successfully acquire their time slots faster than VeMAC protocol with a few access collisions. Hence, our proposal can improve higher throughput on the control channel than VeMAC protocol.

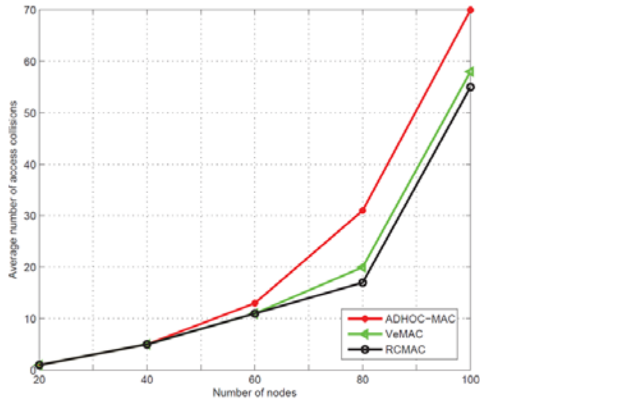

Fig 6: Average number of access collisions .

6. Acknowledgements

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