Efficient Access Time Slot for MAC Protocol Using TDMA and CSMA in VANET

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Abstract

Vehicular Ah Hoc Network (VANET) is one special type of the Intelligent Transportation Systems (ITSs). VANET is characterized by particular features such as huge number of mobility nodes, high speed of nodes, time-varying network topology and fast network portioning. To provide timely and effective safety application in VANET, the Medium Access Control (MAC) needs an efficient broadcast service of safety application. One of MAC protocols uses combination between TDMA and CSMA to adapt itself to different traffic conditions. One of the well-known problems of MAC using TDMA and CSMA is access collision when two or more nodes within the same two-hop neighborhood set attempt to access the same available time slot. In this paper, we propose a new protocol to solve this problem. The simulation result shows that the MAC protocol using the new protocol can support more efficient packet delivery ratio than MAC using current TDMA and CSMA.

Key word: MAC, TDMA and CSMA schemes, access problem.

1. Introduction and relative works

Vehicular Ad-hoc NETwork (VANET) consists of moving vehicles to create dynamical networks. VANET as one of special types of Mobile Ad-hoc NETworks (MANET) is characterized by particular features such as huge number of mobility nodes, high speed of nodes, time-varying network topology and fast network portioning. The VANET classifies of a set of vehicles equipped with communication device and a Global Positioning System (GPS) receiver, called On-Board Unit (OBU) and a set of stationary units along roads, called Road Side Units (RSUs). Based on OBU and RSU, VANET has two essential communications: Vehicle-to-Vehicle (V2V) and Vehicle-to-RSU (V2R). To support V2V and V2R communications, the United States Federal Communication Commission (FCC) dedicated 75MHz radio spectrum in the 5.9GHz band for Dedicated Short Range Communications (DSRC) spectrum. The DSRC spectrum is divided into seven 10MHz channels: six Service CHannels (SCHs) and one Control CHannel (CCH). A Sync Interval (SI) comprises of a CCH Interval (CCHI) - 50 milliseconds and SCH Interval (SCHI) - 50 milliseconds. Both CCHI and SCHI have guard interval - 4 milliseconds to switch between the CCH and the SCH.

The multi-channel MAC protocol supports not only reliable transmission packets with low latency but also provides the maximum throughput for non-safety application. Many multi-channel MAC protocols are proposed for efficiency and reliability, such as in [1]-[3]. The IEEE 1609.4 [1] is considered to be a default multi-channel MAC standard in the family of IEEE 1609 standards for VANETs. In [1], the standard is developed to efficiently coordinate channel access on

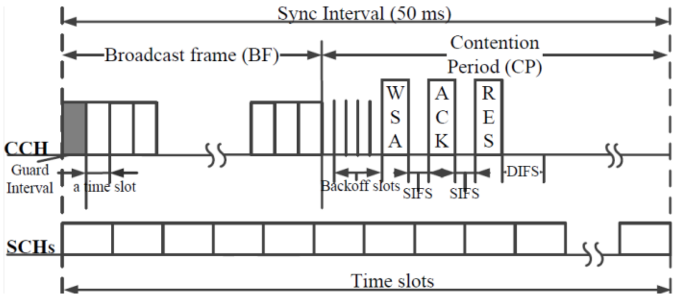

Fig. 1: The considered multichannel MAC protoco

the CCH and SCHs, called globally synchronized channel coordination scheme based on the Coordinated Universal Time (UTC). The channel time is divided into synchronization intervals with a fixed length of 100ms. It consists of a CCH Interval (CCHI) and SCH Interval (SCHI) with a length of 50ms, as shown in Fig. 1. This scheme allows the safety and non-safety application packets to be transmitted on different channels without missing important packets on the CCH. However, the IEEE 1609.4 cannot utilize all SCH resources during the CCH interval.

One of proposed MAC protocols is used combination between TDMA and CSMA. In this protocol, each Sync Interval (SI) is divide into Broadcast frame (BF - using TDMA) and Contention Period (CP - using CSMA). This MAC protocol allows every vehicle to send collision-free and delay-bounded transmission for safety applications. One of the special advantages in this MAC protocol, such as [2] [3], is that the length of BF is not uniform over the entire network. Each vehicle dynamically adjusts the BF length according to its neighbors. Each node will broadcast control packet or WSA/ACK/RES packet

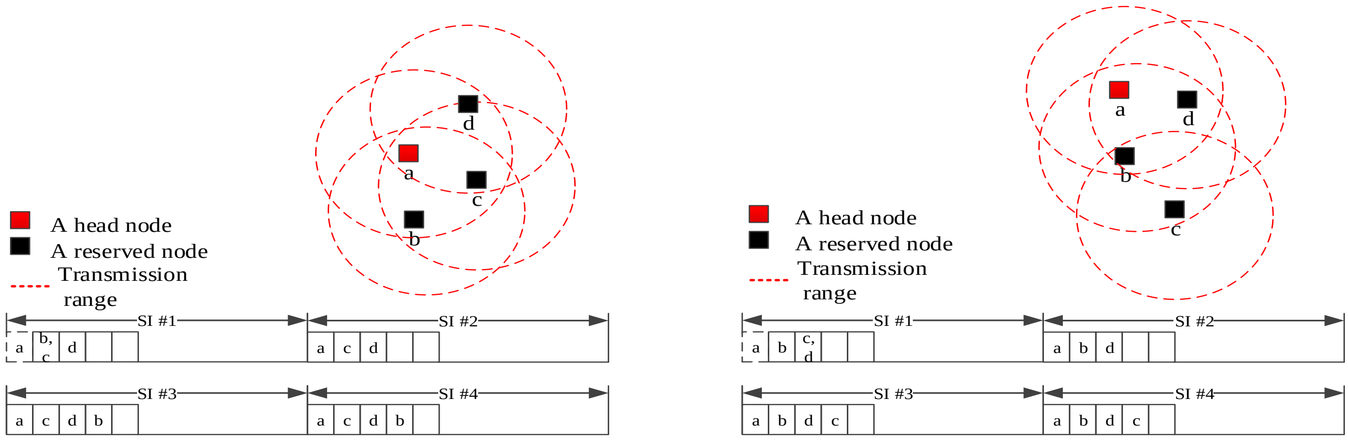

Fig 3: Solution of access collision in one-hop (a) and two-hop neighborhood set (b).

after one-hop neighbor length from the beginning of the broadcast frame. Hence, the Packet Delivery Ratio (PDR) of safety packets during the sync interval will be increased.

One of the well-known problems of MAC using TDMA and CSMA is access collision when two or more nodes within the same two-hop neighborhood set attempt to access the same available time slot. In this paper, we propose a new protocol to solve this problem.

2. Solution of access collision for MAC protocol

a. Access collision for MAC protocol

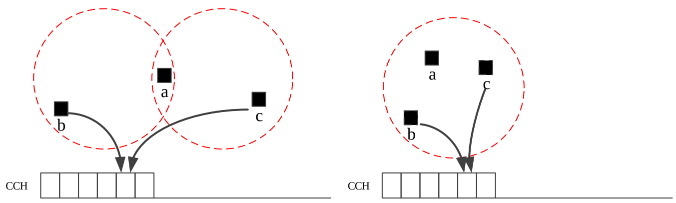

Fig 2: Access collision occurred in two-hop and one-hop neighborhood set.

An access collision happens when two or more nodes within one- or two-hop neighbor attempt to acquire the same available time slot, as shown in Fig. 2. Nodes **b** and **c** attempt the same time slot and then, the collision is happen at node **a**. Because node **a** does not confirm any information about this time slot in next SI, nodes **b** and **c** did not successfully acquire time slot.

b. New MAC protocol to solve access collision

Rule 1: Considering one-hop neighbor, if node x is the first node transmitting packet in the BF, it becomes a head node.

In one-hop neighborhood set, if two or more nodes attempt the same time slot, based on packet transmitted by other nodes, a head node will arrange time slots for the collided nodes. For instance, in Fig 3(a), nodes **b** and **c** attempted the same time slot and hence, a head node **a** did not receive packets transmitted by them. However, nodes **a**, **d** and **c** are one-hop neighbor, node **a** will know the existing node **c**. In SI #2, node **a** will announce that node **c** will occupy the time slot 2. Once node **b** receives this packet, node **b** will reject its time slot and attempt a new time slot in SI #3. After all nodes confirm time slots information, they will occupy successfully theirs time slots in SI #4.

Similarly, consider that nodes **d** and **c** are not neighbor of each other. However, when nodes **d** and **c** attempt the same time slot, the collision is happened at node **b** as shown in Fig. 3(b). A head node **a** based on the packet transmitted by node **d** will announce that node **d** reserves time slot 2 in SI #3. Once node **c** receives packet transmitted by node **b**, it will reject its current time slot and attempt a new time slot in next SI. After SI#4, all nodes occupied successfully their time slots in BF.

3. Simulation Result

To validate our model, we use an event-driven simulation program written in Matlab. The values of the parameter are summarized in Table I to obtain the numerical result for the analytical model. In our model, we fix the WSA packet arrival rate λ_s at 25 packets/second. We also assume that in the CP there are Nmax = 100 which always have available WSA packets. In our model, time slot allocated operation similar to HTC-MAC [4]. Each node had successfully acquired time slot in TP.

For basic MAC protocol using TDMA and CSMA, when two or more nodes within one- or two-hop neighbor attempt to acquire the same available time slot. They will reject their time slots and attempt a new available time slot in next SI. In our proposal, when a collision is happen between nodes using the same time slot, a head node will arrange the time slot based on the packet transmitted by other node in its one-hop neighbor.

TABLE I: PARAMETER SETTINGS			
Parameter	Value	Parameter	Value
Data Rate	12 Mbps	ACK	14 bytes
WSA	100 bytes	RES	14 bytes
Slot time	13 μs	SIFS	32 μs
Propagation time δ	1 μs	DIFS	58 μs
λ_s	25 pkts/s	W_0	16

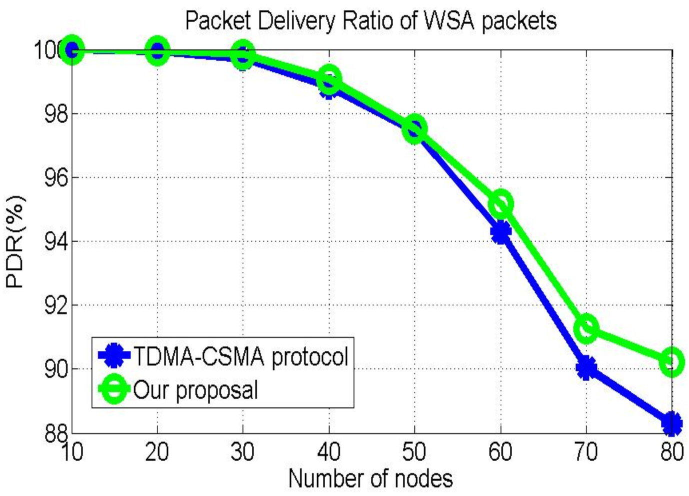

Fig 4: Packet delivery ratio of WSA packets.

Because a head node in one-hop neighborhood set can arrange the time slots for collided nodes, the collision will decrease. Then, the length of CP will increase and WSA packet has more chance to attempt to exchange. In Fig. 4, when a number of nodes is small, the PDR using TDMA and CSMA is similar to using our proposal. However, when a number of nodes is large, the PDR using our proposal is better than using TDMA and CSMA.

4. Conclusion

This paper proposed a new MAC protocol in VANET. A head node can receive all packets transmitted by its one-hop neighborhood set and know that nodes are colliding. A head node will arrange a new time slot and announce reserved time slot for each collided node. The simulation result shows that PDR using our proposal is better than using TDMA and CSMA when a node density is high.

5. Acknowledgement

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