Adaptable Time Slot Acquisition Scheme for Hybrid MAC Protocol in VANETs

VanDung Nguyen and Choong Seon Hong*
Department of Computer Science and Engineering, Kyung Hee University
ngvandung85@khu.ac.kr, cshong@khu.ac.kr

Abstract

In TDMA access channel method, each vehicle must occupy at least one-time slot to broadcast its packet. In addition, one issue in the TDMA-based mechanism is access collision which is defined as more than two vehicles attempt to access the same time slot. The time slot acquisition scheme is designed to reduce the access collision, hence it can improve the packet delivery ratio in hybrid MAC protocol which is used by combining TDMA and CSMA access channel method into the single architecture. In this paper, we propose an adaptable time slot acquisition scheme for hybrid MAC protocol in VANETs. The simulation result shows that our proposal outperforms the existing method in term of access collision rate and packet delivery ratio.

Key word: TDMA access, hybrid MAC protocol, time slot acquisition.

1. Introduction and relative works

Vehicular ad-hoc network (VANET) is designed among the moving vehicle to create the mobile network. To improve the transportation, VANETs can provide three main applications: safety-related applications, traffic management, and user-oriented services as shown in Table 1 [1] [2]. First, safety-related applications, such as the pre-crash sensing, blind spot warning, emergency electronic brake light, and cooperative information broadcast require that each vehicle periodically broadcasts information about its position, speed, heading, acceleration, and so on, to all vehicles within its one-hop neighborhood. Second, traffic management applications form part of a greater intelligent transportation system (ITS) and include toll collection, intersection management, cooperative adaptive cruise control and detour or delay warning. Third, user-oriented services provide information, advertisements, and entertainment for users during their journey. They have two basic applications: Internet connectivity and peer-to-peer applications [1]. However, safety services require fast and guaranteed access and a short transmission delay, while user-oriented services need a broad bandwidth at the same time.

Medium access control (MAC) plays a role to satisfy these requirements. Various MAC protocols are proposed to improve the performances of applications such as throughput, packet delay, packet loss ratio, based either on Time Division Multiple Access (TDMA) or Carrier Sensing multiple access (CSMA). Specially, hybrid MAC protocols, which are designed by combining TDMA and CSMA access channel method into the single architecture, can improve the quality of service and reduce the packet collision. Hybrid MAC protocols consist of two periods: TDMA-based period called reservation period (RP), and CSMA-based period called contention period (CP). Each vehicle must occupy one time slot in RP to broadcast its packet even through it does not have data to transmit.

In hybrid MAC protocols, one issue is known as access collisions which are defined that when more than two vehicles attempt to access the same time slot. In HER-MAC [4], new vehicles attempt to broadcast HELLO packet in CP. If all its one-hop neighbors confirm its ID and the reserving time slot, a new vehicle successfully occupies a time slot. However, the packet loss ratio of HELLO packet increases when the vehicle density is high. On the other hand, in DMMAC [5] and HTC-MAC [6] protocols, new vehicles

TABLE 1: DSRC application requirements [3], [4].

Applications	Packet size / Bandwidth	Latency (ms)	Network Data Type	Application Range (m)	Priority
Intersection Collision Warning/Avoidance	100 bytes	100	Event	300	Safety of life
Cooperation Collision Warning	100 bytes/10 Kbps	100	Periodic	50-300	Safety of life
Work Zone Warning	100 bytes/1 Kbps	1000	Periodic	300	Safety
Transit Vehicle Signal Priority	100 bytes	1000	Event	300-1000	Safety
Toll Collections	100 bytes	50	Event	15	Non-Safety
Service Announcements	100 bytes/2 Kbps	500	Periodic	0-90	Non-Safety
Movie Download (2 hours of MPEG 1)	> 20Mbps	NA	NA	0-90	Non-Safety

randomly choose the available time slot or virtual time slot [5] to broadcast HELLO packet. Nevertheless, if there is no available time slot, the author did not study in HTC-MAC. In DMMAC, there is waste time slots since virtual time slots is included into the length of time slots in CP even through there is no new vehicle entering the topology.

In this paper, we propose an adaptable time slot acquisition scheme for hybrid MAC protocol in VANETs. Our proposal allows a new vehicle can occupy a new time slot in flexible ways.

2. Adaptable time slot acquisition scheme

In hybrid MAC protocol, each vehicle has to tune to control channel interval (CCHI) to collect one-hop neighbor's information. Specially, each node must acquire exactly one time slot in RP. Once a node acquires a time slot, it keeps accessing the same slot in all subsequent. Each vehicle broadcasts a HELLO packet during its reserved time slot. HELLO packet is formatted into seven field according to EFAB [7] protocol: (i) Identifier (ID), (ii) a reserved time slot, (iii) Length of map of one-hop neighbors, (iv) OHNM: The bit map of time slots used by one-hop neighbor, (v) THNM: The bit map of time slots used by two-hop neighbors, (vi) Suggestion Field (SF), and (vii) high priority safety application.

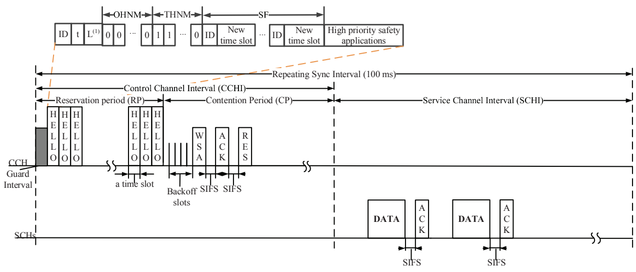

Fig. 1: Broadcast HELLO packet during the reserving time slot.

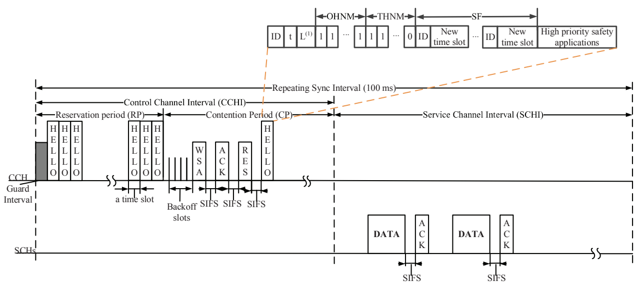

Fig. 2: Broadcast HELLO packet in CP.

When new vehicle, x, is entering to network, it must listen one duration of RP to collect x's one-hop neighbors information. If there are available time slots, vehicle x will randomly choose one available time slot to broadcast its HELLO packet, as shown in Figure 1. Otherwise, if there is no available time slot, vehicle x will attempt to broadcast HELLO packet during in CP, as shown in Figure 2. After all one-hop neighbors confirm its ID and reserving time slot, it

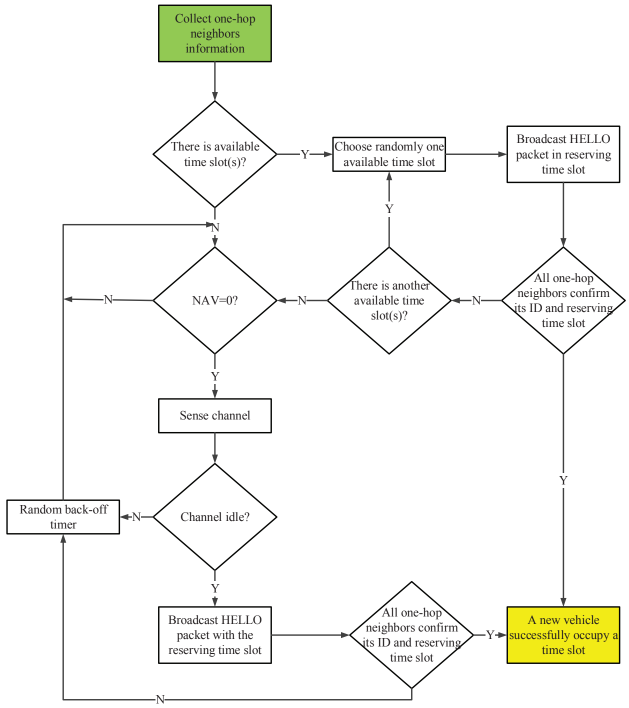

Fig. 3: Flowchart of adaptable time slot acquisition scheme.

successfully occupy a time slot in RP. Our proposal can be shown in Figure 3.

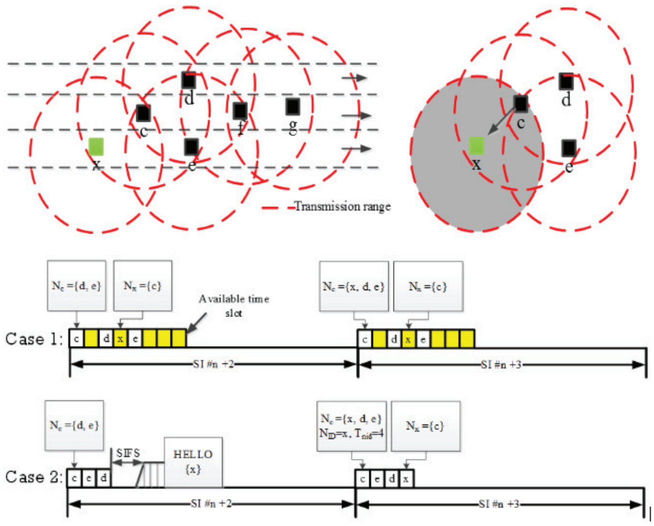

Fig. 4: Example scenario of adaptable time slot acquisition scheme.

For instance, we consider to scenario shown in Figure 4. A vehicle, x, is entering the network. After one duration of SI, vehicle x collects its one-hop neighbors information, vehicle {c} including c' one-hop neighbors information, $N_c = \{d, e\}$ and length of the reservation period, $L^{(1)}$. Based on these information, we classify into two case: case 1) there is available time slots, and case 2) there is no available time slot. In case 1, node x will choose one available time slot, #4 and broadcast its packet including its ID and #4 into SF filed during time slot #4. Otherwise, node x will broadcast HELLO packet including its ID and #4 into SF field. If node c confirm x' ID and #4 into SF field in c' HELLO packet, node x successfully occupy time slot #4. Note that, in case 2, in HELLP packet, node c will increase the length of reservation period and broadcast this information to c' one-hop neighbors, as shown in Figure 4.

3. Simulation results

TABLE II:PARAMETER SETTINGS

Parameters	*Value*	*Parameters*	*Value*
Data rate	12Mbps	ACK	14 bytes
WSA	100 bytes	RES	14 bytes
Slot time σ	13 μs	SIFS	32 μs
Propagation time δ	1μs	DIFS	58 μs
λ_s	25 pkts/s	W_0	16

To validate our model, we use NS-2 and SUMO. The values of the parameter are summarized in TABLE. II to obtain the numerical result for the analytical model.

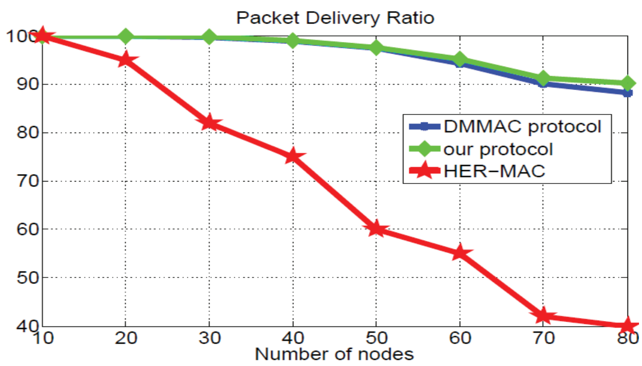

Fig. 5: Packet delivery Ratio.

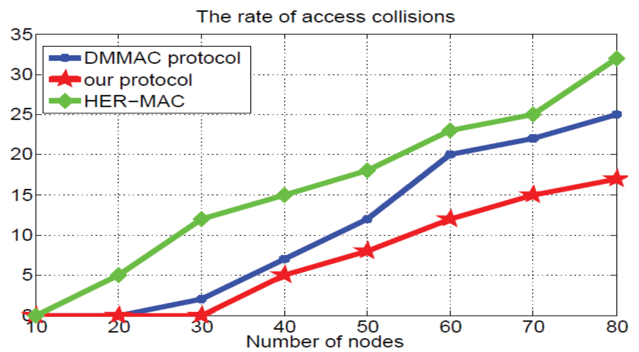

Fig. 6: The rate of access collision.

First, in figure 5, the packet delivery ratio (PDR) of WSA packets in our proposal is higher than HER-MAC and DMMAC. A new vehicles can occupy the time slots in flexible way and hence, the collision of packets in contention period is increased in our proposal. The PDR between our proposal and DMMAC is approximate since the DMMAC has the virtual time slot for new vehicles. But, the length of reservation period is greater than our proposal. In HER-MAC, the collision is high because there is many types of packets transmitted during the contention period.

Second, in figure 6, the access collision is our proposal is lower than HER-MAC and DMMAC. Our proposal not only reduces the length of reservation period but also supports a flexible way for occupying time slots.

4. Conclusion

In this paper, we propose a novel scheme for time slot acquisition in hybrid MAC protocol. This scheme not only allows that a new vehicle randomly available time slot but also a new vehicle broadcasts HELLO packet when there is no available time slot. The simulation results show that our proposal outperforms HER-MAC and DMMAC in terms of packet delivery ratio and the access collision rate.

5. Acknowledgment

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