



## **A Hybrid MAC Mechanism for Multiple Load Intelligent Vehicle Transportation Network**

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*Abstract- The Media Access Control (MAC) mechanism of intelligent vehicle communication network meets a new challenge due to the multiple load data traffic and high speed mobility. This paper proposes a hybrid MAC mechanism which takes the advantages of both TDMA and CSMA mechanism. This hybrid mechanism is based on TDMA, while CSMA mechanism is added in time slots to improve the slot utilization in both high and low load networks. Through the simulation in NS2 we compare the results of the hybrid MAC protocol with those of using CSMA and TDMA individually. It is verified that in terms of flexibility and reliability in channel utilization, packet loss ratio and fairness index, the hybrid MAC protocol is superior. The hybrid mechanism makes the MAC layer self-adaptively switch between TDMA and CSMA according to the data traffic load.*

**Index terms:** hybrid, MAC mechanism, multiple load, intelligent vehicle transportation, CSMA, TDMA.



reference [4] drew a conclusion that CSMA is suitable in the network that the topology changes frequently. However, CSMA cannot deal with the raised delay caused by collision.

TDMA is a MAC mechanism which is widely used in cellular network. The typical practice that TDMA used in traffic system is Automatic identification System (AIS) in the shipping industry. Ships can exchange information, such as position, course and shipping. This system requires complete topology information from GPS or Galileo system to assign slot and synchronize time. TDMA have a good performance in stability and reliability, especially in the high load network. Both [5] and [6] proposed a distributed TDMA MAC protocol is based on the two-hop distance topology information. However, when it comes to a low load network, the management cost is higher than that of CSMA because of the control and management messages. Due to the inflexibility of the assignment, TDMA mechanism has a low flexibility. Reference [8] drew a conclusion that the throughput of TDMA was obviously lower than that of CSMA when the speed of mobile nodes rose up in the NS2 simulation.

According to the above research, the strong and weak points of CSMA and TDMA mechanism are obvious, so is the complementary between CSMA and TDMA. TDMA is suitable in high load but low mobility network, and the performance of CSMA in low load but high mobility network is better. Based this observation, we proposes a hybrid MAC protocol which combines the advantages of TDMA and CSMA mechanism. This hybrid mechanism is based on TDMA and mixed CSMA mechanism in time slot. The hybrid MAC mechanism can switch between TDMA and CSMA according to data traffic by access control rules. It improves the utilization of slot in both high and low load networks, and satisfies the multiple load request of intelligent vehicle transportation system.

## II. HYBRID MAC PROTOCOL

Based on these technologies, the mechanism is designed as followed: firstly, it is important to plan the length and structure of slot, which provide a basic to carry out the design of the theory of hybrid MAC protocol. Then assign the initial slots to the nodes in related area through a certain distribute TDMA algorithm. At last, design a reasonable access control rule that the nodes must follow.



decreases, the protocol tends to be a CSMA protocol. Different  $T_a$  can be used in different communication situation to satisfy different requirements. The planning of slots is shown in Figure 1.

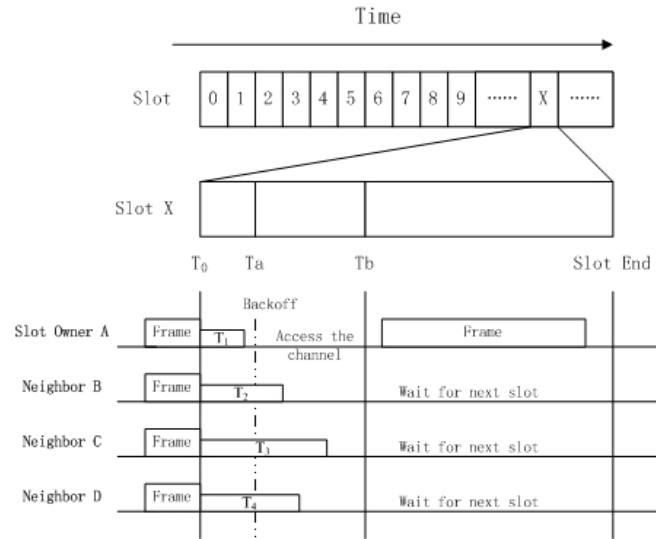


Figure 1. Slot Planning

#### b. Proposed Access Control Rule

First of all, nodes access a channel according to the slots assigned to them. When the slot owner has no data to transmit, its one hop neighbors would take the free status of the channel by carrier sensing. The neighbors that have data to transmit can access the channel by competition through CSMA mechanism. Furthermore, these nodes have higher priority in their own slot. The neighbors start competition only when the slot owner has no data to transmit. The priority is determined by the length of backoff time, the MAC mechanism can adaptively switch between TDMA and CSMA based on the different priorities of the slot owner and neighbors. According to this design of access control rule, when the network traffic is heavy, the nodes have data to transmit in their own slot, the CSMA competition mechanism shall not be started, so it is TDMA essentially. In contrast, when the network load is low, some nodes may have no data to transmit, its one hop neighbors can access the channel through CSMA competition.

Suppose node A have data traffic, it firstly checks the time and determines whether the slot belongs to it. If yes, the node chooses a random backoff time  $T_1$  in  $[0, T_a]$ , and transmits data immediately after the backoff time. Otherwise, it keeps listening to the channel for  $T_a$ . If the



is used to simulate road-side beside the road. While the rest 18 moving nodes divided into two groups equally are used to simulate the process of the motion of vehicles by letting the two groups move to each other face to face. During the motion, the distance between two nodes is 50 meters while the velocity of the motion is a custom value. In this paper, we will contrast two typical speeds: a speed of 45km/h of normal driving 90km/h of high-speed driving.

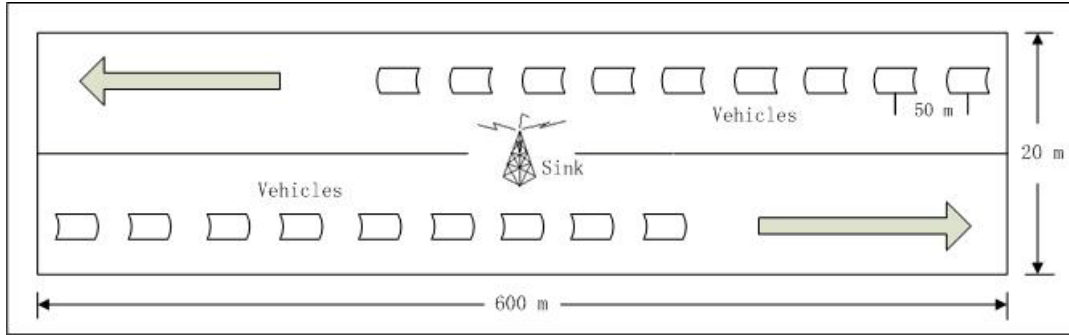


Figure 3: A graphical guide of the simulating scene

Different parameters must be set in the simulating program first of all, especially the parameters of physical layer and the generator of Constants Bit Rate (CBR) data stream. Since the result of proposed hybrid MAC mechanism is required to compare with that of 802.11 protocols, parameters of the physical layer are almost taken from those of 802.11 protocols. The generator of CBR data stream used in this paper is setup independently. The routing protocol adopted here is Destination-Sequenced Distance-Vector Routing (DSDV) which can not only establish routines and send data for nodes rapidly but also avoid generating routing loop. Parameters of the simulation are listed in the following Table 1.

Simulation Time	200 s
Carrier Sense Distance	90 m
Transmission Distance	60 m
CBR Packet Size	200 byte
Slot Size	50 ms
Communication Bandwidth	2 M

Table 1. Simulation Parameters





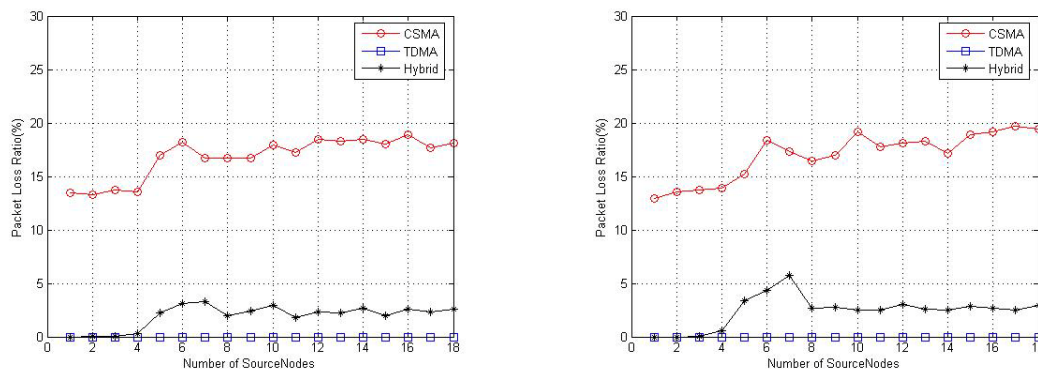
From the above figures, we can see that when CSMA is employed, because of the existence of some inherent drawbacks like out-of order contention and hidden terminal, the rate of channel utilization is low.

As for TDMA, when the network is under low load the rate of channel utilization is also low, which is due to the fixed allocation of channel that causes a waste of resources when the network has a low load. As the number of nodes increases and consequently the load of network increases, TDMA will have a distinct advantage compared to the other two protocols.

The hybrid protocol proposed by this paper maintain a high rate of channel utilization whether it is under high or low load thus showing flexible adaptability to various load conditions. When the velocities of nodes increase, utilization of three protocols all share some declines, but those of TDMA and the hybrid protocol are more distinct while CSMA only has a minor change. This is because when the topology structure of a network changes frequently, reserved protocols have to spend more resources in management. However, protocols based on competition do not need to update information of the typology structure, thus showing a higher flexibility under high speed moving conditions.

### c. Analysis of Packet Loss Ratio

The packet loss ratio can fully reflect the quality of communication. Results of packet loss ratio are shown as Figure 5.



a: Packet loss ratio when speed is 12.5m/s      b: Packet loss ratio when speed is 25m/s

Figure 5. The Packet Loss Ratio with Different Speed



nodes and load of the network, the accessing probability varies, especially when velocities of nodes increase. Contention among nodes becomes more complicated and the fairness will correspondingly become more difficult to be guaranteed. However, the hybrid protocol greatly increases the fairness of the network by planning the contention of nodes orderly and achieves a highly stable performance even under the circumstance that network has many information sources and loads. When the velocities of nodes increase, FI of the hybrid protocol decreases to some extent yet it is acceptable.

#### IV. CONCLUSION

In ITS network, according to the simulation results, single MAC mechanism is hard to meet the challenge of multiple load data traffic caused by more and more vehicle sensors. With the change of source node number, TDMA have a good performance in high load network and show its excellent stability in packet loss ratio and fairness. However, due to the management cost, its utilization is lower than that of CSMA and hybrid MAC mechanism when it comes to a low load network. On the other hand, CSMA is good at flexibility. But the stability of CSMA is unacceptable when the network load changes. In particularly the fairness index reduces significantly when the load becomes higher. Through the scientific and suitable mechanism design, slot planning and access control rule, the hybrid mechanism can meet the requests of both mobile Ad hoc network and wireless sensor network. The hybrid MAC mechanism has a good and stable performance in the channel utilization, packet loss ratio and fairness index according to the result of simulation. Hybrid MAC protocol performs better at different speeds through the comparison with single MAC mechanisms. According to the research in this paper, the improvement only in MAC layer cannot meet the request of wireless communication in the future, so the cross layer research will become an important trend. And the RTS/CTS mechanism can greatly improve the performance of the competition based MAC protocol, so RTS/CTS mechanism will be considered to develop in the CSMA part of the hybrid MAC protocol so as to improve the performance of the hybrid MAC mechanism in the future work.

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