



Slotted Carrier Sense Multiple Access Protocols- A Review

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ABSTRACT

CSMA/CA protocols rely on the random deferment of packet transmissions. Like most other protocols, CSMA/CA was designed with the assumption that the nodes would play by the rules. This is important the nodes themselves control deferment. However, with the higher programmability of the network adapters, the temptation to tamper with the software or firmware is likely to grow; in this way, a user could obtain a much larger share of the available bandwidth at the expense of other users. This paper focuses on slotted CSMA/CA and tries to find out its limitations of the slotted CSMA/CA protocols.

Keywords: Carrier Sense Multiple Access, Collision Avoidance, Request-To-Send (RTS) , Clear-To-Send (CTS) , adaptive time slots



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1. INTRODUCTION

Carrier sense multiple access/collision avoidance (CSMA/CA) [1] protocols rely on the random deferment of packet transmissions for the efficient use of the shared wireless channel among many nodes in a network. In spite of its shortcomings, this class of MAC protocols is one of the most popular for ad hoc networks. A network is a connection between devices that can communicate to each other. Everything from Bluetooth device, to WiFi computer, to cell phone operates on a network. Networks come in all shapes and sizes, and of course, complexities. Implementing the right network for our needs is vital. Wired networks provide stability and security but can be a challenge to setup for the first time. Wireless networks are easy to setup but hard to keep secure. The most challenging implementations involve a secure combination of both a wired and wireless networks. Having a consultant come in to make sure that choose the right network for our needs is vitally important to getting the most from our infrastructure.

The Cost and delay depends upon the time slotted CSMA/CA take to do its decision making. The main attentions of this research work are to understand the working of slotted CSMA/CA and change interval (slot) time in such a way that it becomes adaptive. A suitable simulation will be performed and various parameters regarding wireless networks and CSMA/CA will also be calculated in order to do performance analysis. Suitable comparisons will be drawn among proposed and existing strategies. (CSMA/CA) access method as the name indicates has several characteristics in common with CSMA/CD. The difference is in the last of the three components: Instead of detecting data collisions, the CSMA/CA method attempts to avoid them altogether. Although it sounds good in theory, the method it uses to do this causes some problems of its own, which is one reason CSMA/CA is a far less popular access method than CSMA/CD.

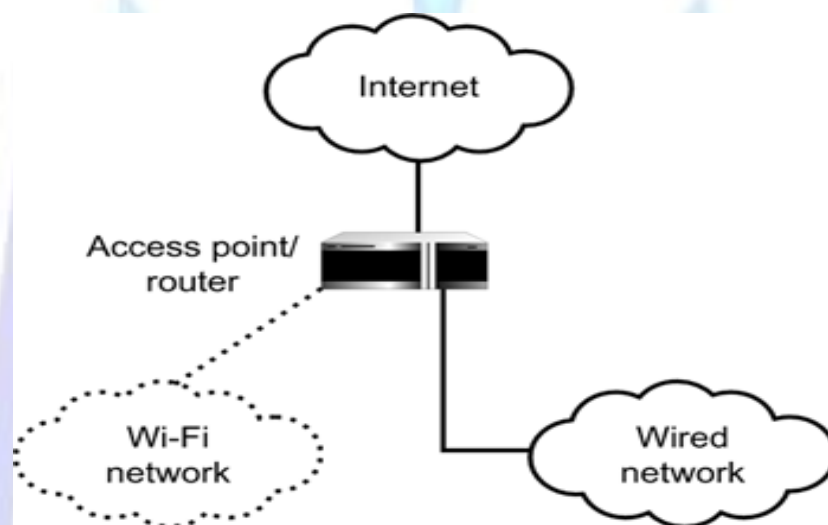
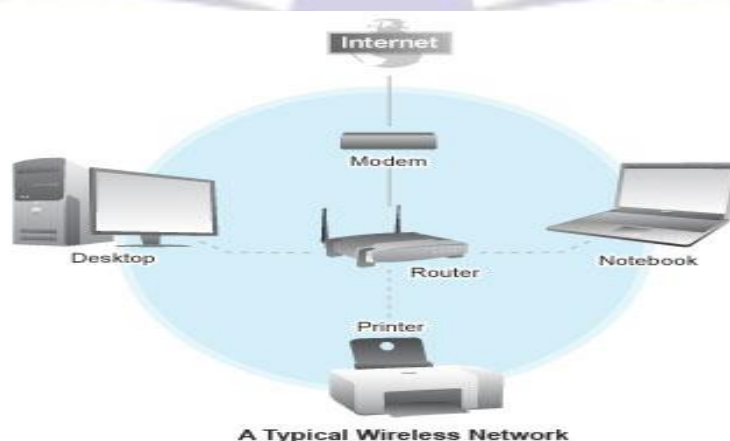


Fig.1.1 Network with wired and wireless

1.1) Wireless Networking

Wireless networks are becoming ever more popular and easy to set up. Although setting up a wireless network is becoming easier, doing it correctly is still as challenging. Wireless networks are now faster, have broader ranges, and are more reliable than they used to be. They are also easy to hack, suffer from various forms of interference, and can drop devices from the network if they are not setup properly. It's beneficial to have the help of an experienced network expert when implementing a wireless network. If we have not had a network checked by an expert, it's important for security and stability for the network to be checked.



A Typical Wireless Network

Fig.1.2 wireless network

1.2). Wired Networking

Wired networks are the fastest and most reliable networks that can be implemented. They are not, however, easy to implement. Various wiring standards, the need for additional hardware, and complicated computer configurations require an expert approach. Frequently enough homes and small offices are turning to wireless networks to provide blanket coverage with minimal costs and infrastructure, but wireless networks are frequently not properly secured, can lack speed, and can frequently fail from poor implementation or from interference. When we require the reliability, speed, and security of a wired network it's absolutely vital that consult a professional that can help plan and implement the network properly.

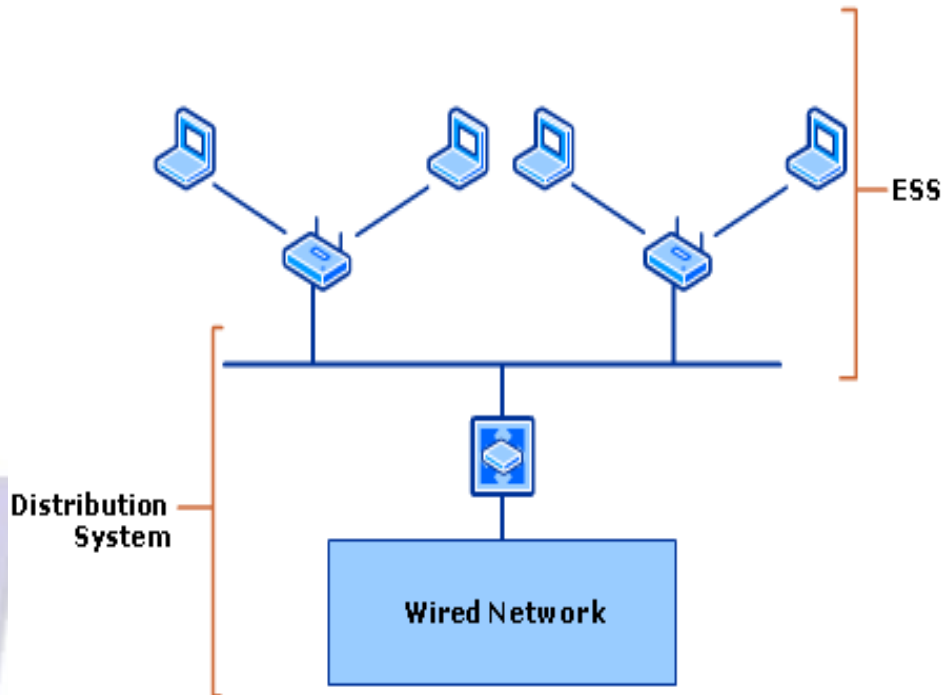


Fig1.3 wired network

1.3) Ad hoc network

An ad hoc network, or MANET (Mobile Ad hoc NETWORK), is a network composed only of nodes, with no Access Point. Messages are exchanged and relayed between nodes. In fact, an ad hoc network has the capability of making communications possible even between two nodes that are not in direct range with each other: packets to be exchanged between these two nodes are forwarded by intermediate nodes, using a routing algorithm. Hence, a MANET may spread over a larger distance, provided that its ends are interconnected by a chain of links between nodes (also called routers in this architecture). In the ad hoc network shown in Figure 1.4, node A can communicate with node D via nodes B and C, and vice versa.

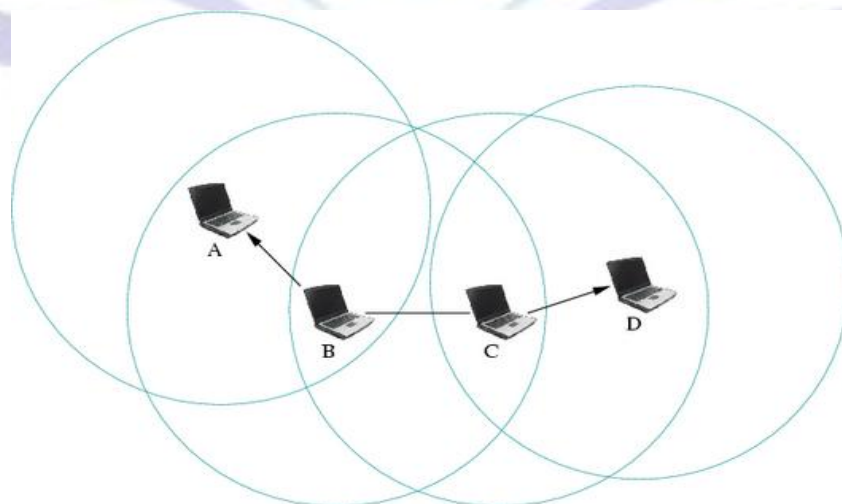


Fig 1.4: An ad hoc network.



A sensor network is a special class of ad hoc network, composed of devices equipped with sensors to monitor temperature, sound, or any other environmental condition. These devices are usually deployed in large number and have limited resources in terms of battery energy, bandwidth, memory, and computational power.

1.4) CSMA/CA

Carrier sense multiple access with collision avoidance (CSMA/CA) has been adopted by the IEEE 802.11 standards for wireless local area networks (WLANs). Using a distributed coordination function (DCF), the slotted CSMA/CA protocol reduces collisions and improves the overall throughput. To mitigate fairness issues arising with slotted CSMA/CA in wireless networks, a modified version of slotted CSMA/CA is proposed that term CSMA with copying collision avoidance (CSMA/CA).

1.5) How CSMA/CA works

On a network that uses the CSMA/CA access method, when a computer has data to transmit, its NIC first checks the cable to determine if there is already data on the wire. So far, the process is identical to CSMA/CD. However, if the NIC senses that the cable is not in use, it still does not send its data packet. Instead, it sends a signal of intent--indicating that it is about to transmit data out onto the cable. CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) is the channel access mechanism used by most wireless LANs in the ISM bands. A channel access mechanism is the part of the protocol which specifies how the node uses the medium .

1.6) CSMA/CA and wireless LAN

Wireless LAN cannot implement CSMA/CD for three reasons

- Station must be able to send and receive data at the same time.
- Collision may not be detected because of the hidden terminal problem.
- Distance between stations in wireless LANs can be great. Signal fading could prevent a station at one end from hearing a collision at other end.

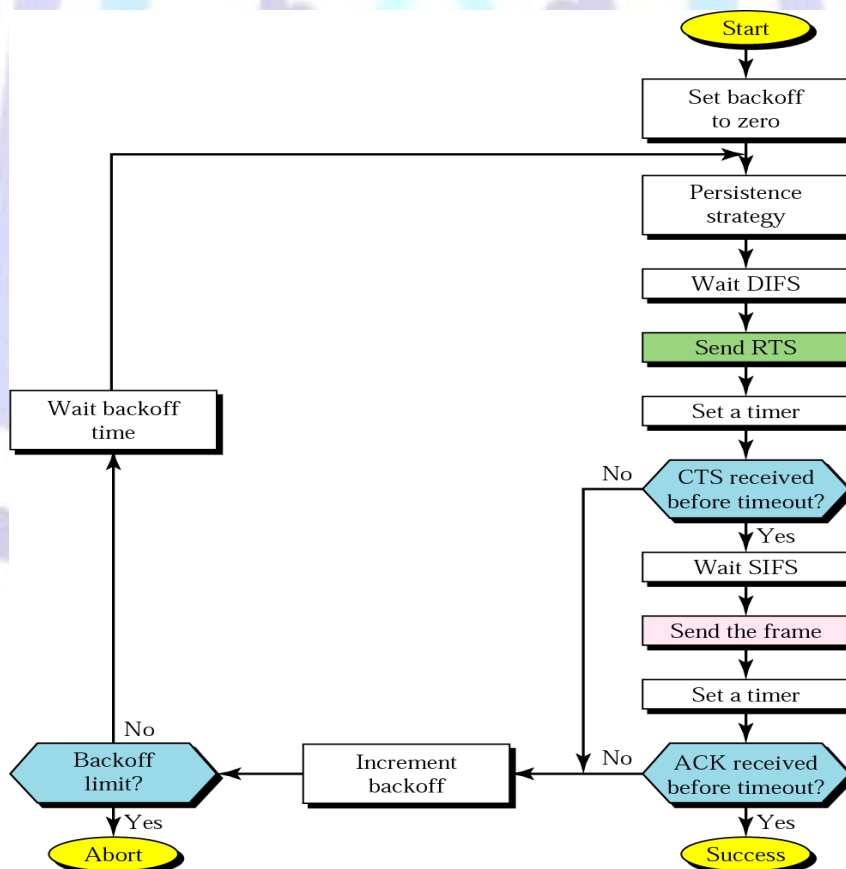


Fig 1.5.Flow diagram of Slotted CSMA/CA.

Before sending a frame, source senses the medium by checking the energy level at the carrier frequency.

- Backoff until the channel is idle.



- After the channel is found idle, the station waits for a period of time called the Distributed interframe space (DIFS); then the station sends a control frame called request to send (RTS).

After receiving RTS, the destination waits for a period called Short interframe space (SIFS), the destination station sends a control frame, called Clear to Send (CTS) to source.

This control frame indicates that the destination station is ready to receive data.

- Source sends data after waiting for SIFS
- Destination sends ACK after waiting for SIFS.

1.7) CSMA/CA Mechanisms

Collision avoidance is used to improve the performance of the CSMA method by attempting to divide the channel somewhat equally among all transmitting nodes within the collision domain. Although CSMA/CA has been used in a variety of wired communication systems, it is particularly beneficial in a wireless LAN due to a common problem of multiple stations being able to see the Access Point, but not each other. This is due to differences in transmit power, and receive sensitivity, as well as distance, and location with respect to the AP. This will cause a station to not be able to 'hear' another station's broadcast. This is the so called 'hidden node', or 'hidden station' problem. Devices utilizing 802.11 based standards can enjoy the benefits of collision avoidance (RTS / CTS handshake, also Point coordination function), although they do not do so by default. By default they use a Carrier sensing mechanism called 'exponential backoff', or (Distributed coordination function) that relies upon a station attempting to 'listen' for another station's broadcast before sending. CA, or PCF relies upon the AP (or the 'receiver' for Ad hoc networks) granting a station the exclusive right to transmit for a given period of time after requesting it (Request to Send / Clear to Send).

1.9) CSMA/CA in Wireless LAN and MAC

The most important differences between the wireless LAN and the MAC protocol of most wired networking applications is the impossibility to detect collisions. With the receiving and sending antennas immediately next to each other, a station is unable to see any signal but its own. As a result, the complete packet will be sent before the incorrect checksum reveals that a collision has happened. It is therefore of utmost importance that the number of collisions be limited to the absolute minimum. This is achieved by a protocol called Carrier Sense Multiple Access with Collision Avoidance. The idea is to prevent collisions at the moment they are most likely to occur, i.e. when the bus is released. All clients are forced to wait for a random number of timeslots and then sense the medium again, before starting a transmission. If the medium is sensed to be busy, the client freezes its timer until it becomes free again. Thus, the chance of two clients starting to send simultaneously is reduced. In the case of a collision, the delay is doubled progressively: 15, 31, 63,...1023, until a successful transmission occurs and the delay is reset to the minimal value. The 802.11 standard does not fix the minimum and maximum values of the contention window. However, it does advise a minimum of 15 or 31 and a maximum of 1023

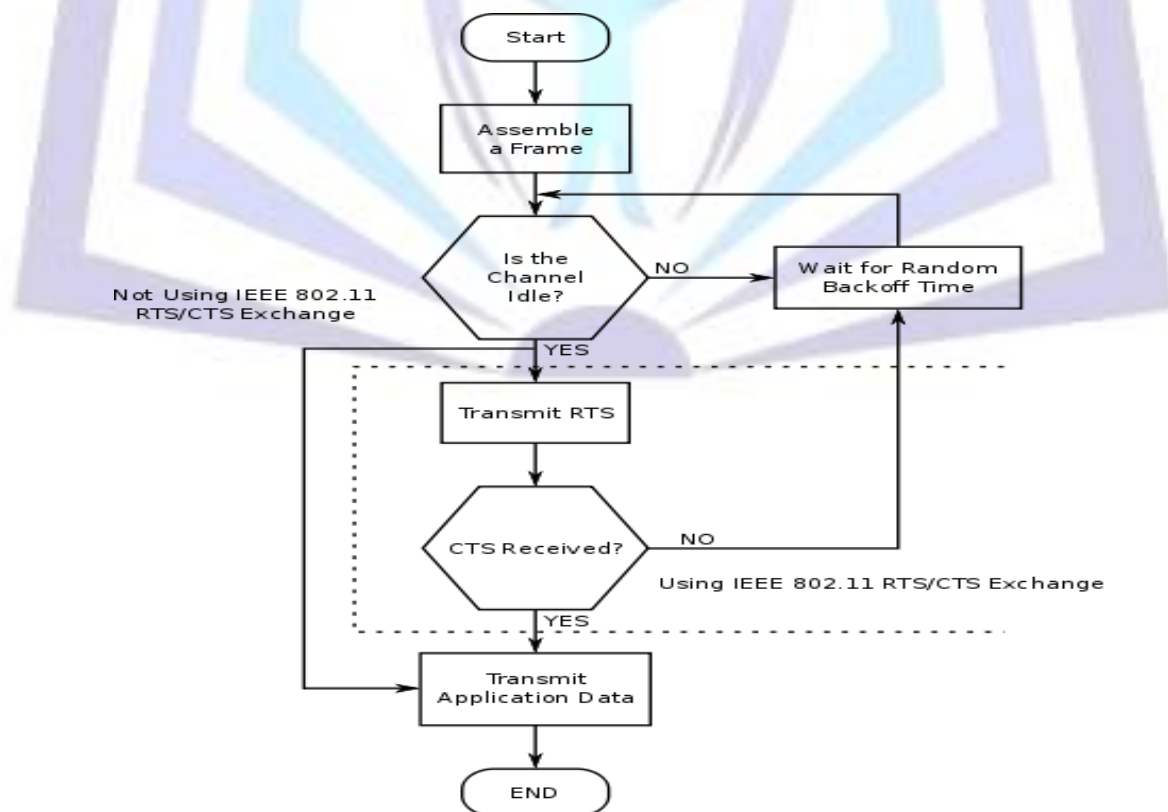


Fig1.6.Simplified Algorithm of CSMA/CA



2. REVIEW OF LITERATURE

Jing, Hui, and Hitoshi Aida (2011) [1] has discussed the most widely implemented standards for wireless networks, IEEE 802.15.4 defines physical and MAC specifications for low data rate wireless personal area networks (WPANs). To accurately analyze the performance of slotted CSMA/CA (SCSMA) algorithms Jing, Hui, and Hitoshi Aida (2011) [1] has optimized the network throughput by considering the number of 802.15.4 devices and the data payload by nonlinear programming (NLP). Comparing with the SCSMA protocol of IEEE standard through the simulation, performed by Jing, Hui, and Hitoshi Aida (2011) [1] has improved network throughput with non-ACK and ACK modes up to 4.8% and 8.1% on average, respectively. The performance analysis also shows that the network scalability is improved, that is the system can accommodate more contending devices in Jing, Hui, and Hitoshi Aida (2011) [1]'s proposal.

Wang, Feng et al. (2009) [2] has analyzed the carrier sense multiple access (CSMA) mechanism, and simulates its application in IEEE 802.15.4. Wang, Feng et al. (2009) [2] has found that the throughputs are relevant to the normalized propagation delay and the basic time period (BTP) of slotted CSMA. The throughputs of slotted and unslotted CSMA are almost equal when the normalized propagation delay is much less than 1 and the BTP is equal to the propagation delay. Moreover, for slotted CSMA, the BTP selection should be cautious because an unsuitable BTP will make the performance of the protocol worse.

Zhang, Yijin et al. (2006) [3] has proposed and validated an analytical model for the capacity throughput of the IEEE 802.15.4 slotted CSMA/CA which can be studied as slotted non-persistent CSMA. Key to the accuracy of our model is a careful study of the idle period after last collision, which has not been considered by all previous 802.15.4 models. Specifically, Zhang, Yijin et al. (2006) [3] has also derived the probability of sensing the channel that maximizes the throughput and provide analytical closed formulas. With results from the OPNET simulator, Zhang, Yijin et al. (2006) [3] has shown that their model can accurately predict the saturation throughput over a wide range of scenarios.

Wang, et al. (2010) [4] has shown that when an IEEE 802.15.4 network has many nodes and is almost saturated, the probability of collision is large, and the throughput is small. The main reasons are the adoption of slotted CSMA/CA and the mechanism that if a data transmission cannot be completed before the end of contention access period (CAP), it has to wait until the start of the CAP in the next superframe. Wang, et al. (2010) [4] has proposed an enhanced collision-avoidance MAC protocol for IEEE 802.15.4, and establishes a simulation model to

analyze and compare the enhanced collision-avoidance MAC and the IEEE 802.15.4 MAC. The proposed protocol, compatible with the IEEE 802.15.4 protocol, has less probability of collision (almost 0), higher probability of successful transmission (close to 1), and larger network throughput (more than two times of that of IEEE 802.15.4).

Pollin, et al. (2008) [5] has studied the advances in low-power and low-cost sensor networks have led to solutions mature enough for use in a broad range of applications varying from health monitoring to building surveillance. The development of those applications has been stimulated by the finalization of the IEEE 802.15.4 standard, which defines the medium access control (MAC) and physical layer for sensor networks. One of the MAC schemes proposed is slotted carrier sense multiple access with collision avoidance (CSMA/CA), and Pollin, et al. (2008) [5] has analyzed whether this scheme meets the design constraints of those low-power and low-cost sensor networks.

Wen et al. (2009) [6] has studied IEEE 802.15.4 protocol is proposed to meet the low latency and energy consumption needs in low-rate wireless applications, however, few analytical models are tractable enough for comprehensive evaluation of the protocol. To evaluate the IEEE 802.15.4 slotted CSMA/CA channel access mechanism Wen et al. (2009) [6] has proposed a practical and accurate discrete Markov chain model, which can dynamically represent different network loads. By computing the steady-state distribution probability of the Markov chain, we obtain an evaluation formula for throughput, energy consumption, and access latency. Then Wen et al. (2009) [6] has further analyzed the parameters that influence performance including packet arrival rate, initial backoff exponent and maximum backoff number. NS2 simulator has been used to evaluate the performance of the 802.15.4 CSMA/CA mechanism under different scenarios and to validate the accuracy of the proposed model.

Alvi (2012) [7] has discussed the IEEE 802.15.4 standard is specifically designed for low Rate Wireless Personal Area Network (LR-WPAN) with low data rate and low power capabilities. Due to very low power consumption with duty cycle even less than 0.1, the standard is being widely applied in Wireless Sensor Networks applications. It operates in Beacon and Non Beacon enabled modes. During Beacon enabled mode, it has Contention Access Period (CAP) and optional Contention Free Period. We have analyzed its performance during CAP where slotted CSMA/CA algorithm is used. The performance analysis includes channel access busy, transmission failure chances along with reliability and throughput against all three frequency bands with load variation.

3. CONCLUSION

Carrier sense multiple access with collision avoidance (CSMA/CA) has been adopted by the IEEE 802.11 standards for wireless local area networks (WLANs). Using a distributed coordination function (DCF), the slotted CSMA/CA protocol reduces collisions and improves the overall throughput. To mitigate fairness issues arising with slotted CSMA/CA in wireless networks, a modified version of slotted CSMA/CA is proposed that term CSMA with copying collision avoidance (CSMA/CA). The main objective of this research work is to find the gaps in existing work. In near future suitable protocol will be proposed which may reduce the limitation of CSMA/CA.



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