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Performance Analysis of Communication in WLAN using 802.11 MAC Protocol with CSMA/CA

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Abstract—*MAC protocols with CSMA/CA have obtained considerable attention in wireless networking research because of its various advantages over CSMA/CD method. The following paper is an attempt to explain how the communication takes place in the wireless LAN network using IEEE 802.11 MAC protocol with CSMA/CA. We have strained to explain how the packet transfer takes place in a WLAN from the source to the receiver and the effect of various parameters like No. of stations,stations are in motion or stationary, Transmission range etc. on it. This is followed by results using a referenced code which has been modified to produce desired results.We have found that the inclusion of RTS/CTS handshaking greatly improves theperformance of our simulated WLAN. We collected data on the number of successful transmissions and the number of collisions, while varying the number of users on the wireless network using our simulation. The performance analysis clearly shows an improvementusing CSMA/CA as the protocol. The results have been shown in various graphs all along and have also been explained.*

Keywords: *WLAN, IEEE 802.11 MAC protocol, CSMA/CA, Carrier Sensing*

1. INTRODUCTION

Wireless LAN is one in which a mobile user can connect to a local area network (LAN) through a wireless (radio) connection. WLANs do not use traditional cable or wired systems for communication purpose. Instead, they use Radio Frequency and Infrared (IR) to connect computers and peripherals over a network.

With the rapid development in mobile computing, much concern has been involved in high speed wireless local area networks (LAN) [1, 2]. A new international standard IEEE 802.11 on wireless LAN has been established [3].The IEEE 802.11 groups of standards specify the technologies for wireless LANs. 802.11 standards use the Ethernet protocol and CSMA/CA (carrier sense multiple access with collision avoidance) for path sharing and include an encryption method, the Wired Equivalent Privacy algorithm.CSMA/CA is a protocol for carrier transmission in 802.11 networks. Unlike CSMA/CD (Carrier Sense Multiple Access/Collision Detect) which deals with transmissions after a collision has occurred, CSMA/CA acts to prevent collisions before they happen. The CSMA/CA specifies that in order for a node to transmit, it first senses medium around it to determine whether another node is transmitting or not. The node will begin transmission only if it finds that the medium is free. The CSMA/CA algorithm also commands a delay between any two consecutive frame sequences. A transmitting node will make sure that the medium is idle for this duration of time. Nodes select a random back-offinterval to initialize a counter, and will decrement this counter while the medium remains idle. Random back off has been implemented in our simulation. The time interval between frames is known as the Inter Frame Space (IFS). Once a node has determined that the medium is idle, two IFSs (Distributed IFS and Short IFS) are defined in order to provide delays between sending and receiving RTS, CTS, DATA and ACK packets. IFS are explained in detail further.

Distributed coordination function (DCF) is the important mechanism in the 802.11 protocol to access the medium. This is a random access scheme which is based on carrier sense multiple access with collision avoidance (CSMA/CA) protocol [4]. There is also an optional point coordination function (PCF) defined by this standard, which is centralized MAC protocol that helps to avoid collision and supports time bound services. In our research we just work on the DCF scheme and ignore PCF. Two different techniques are described by DCF in order to employ for packet transmission. The first and default scheme is called basic medium access, which is a two- way handshaking technique.

In addition to the basic access, the second scheme is an optional four way handshaking technique which is also known as request-to-send/clear-to-send(RTS/CTS) mechanism, which has been standardized. In our test we have used the second scheme.

Some of the important and necessary key terms that are used throughout the paper, are explained below:

1. **RTS**: If a node has a packet data which it wants to transmit, then it first broadcasts a small packet that is called a Request-To-Send (RTS) packet.
2. **CTS**: When on WLAN an intended recipient receives an RTS packet, it then broadcasts a smallCLEAR-TO-SEND (CTS) packet.
3. **ACK**: ACK is an acknowledgement packet that is sent upon successful transmission of data by the receiver to the sender.
4. **CSMA/CA**: Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) is a protocol in which
   a) a carrier sensing scheme is used,
   b) a node or data station that sends a jam signal before transmitting,
   c) the data station start transmitting a frame after waiting a sufficient time in order to jam signal received by all stations, and
   d) if the data station while transmitting detects a jam signal from another station, it stops its transmissions, wait for a random time and tries again.

2. SYSTEM CONFIGURATION

DCF(Distributed Coordination Function) -DCF is the basic and needed MAC mechanism of legacy IEEE 802.11 WLANs that allows for automatic medium sharing between compatible physical layers through the use of CSMA/CA and a random backoff time following a busy medium condition. In addition, all individually addressed traffic uses immediate positive acknowledgment (ACK frame) where retransmission is scheduled by the sender if no ACK is received. The CSMA/CA protocol is designed to lessen the collision chance between multiple stations accessing the medium, at the point where collisions would most possibly occur. Multiple collision occur more frequently after a busy period when there are multiple stations waiting on the medium to transmit their data. This situation demands a random backoff procedure to resolve medium contention conflicts through carrier sense (CS) functions. CS can be performed both through physical and virtual mechanisms. The virtual CS mechanism is attained by distributing reservation information announcing the impending use of the medium. It cuts the probability of two stations colliding that cannot hear each other [5].

IFS (Inter Frame Space) - Besides additional Carrier sense functions the CSMA/CA protocol introduces Collision avoidance functions. One of Carrier Avoidance functions is IFS (Inter Frame Space). The protocol tries to reduce the collision likelihood by using IFS. At the current slot a user finds channel idle, its random back-off is still forbidden to be immediately accomplished until it has assured channel idle for a period of time called Inter Frame Space (IFS). Frames are contention windows (users performing back-off), acknowledgements and data packets. At the commencement of a new transmission an IFS called DIFS (Distributed IFS) is used. A shorter IFS called SIFS (Short IFS) is used to separate transmissions in a single dialogue. SIFS is smaller than DIFS, and because there is always at most one single user to transmit at a given time, the transmitting user has priority over all other users. SIFS is calculated in such a way that the transmitting user will be able to switch back to receive mode and be able to decode the incoming packet.

Fig. 1: 802.11 transmission mechanism.

CS(Carrier Sense) mechanism- Both the physical and virtual CS functions are used to determine whether the medium is busy or idle. When either function indicates a busy medium, the medium will be considered busy otherwise, it shall be considered idle. The virtual CS mechanism is provided by the MAC referred to as the network allocation vector (NAV) which predicts the future traffic on the medium. The CS mechanism combines the NAV state and the station's transmitter status with physical CS to determine the busy/idle state of the medium. The NAV also act as a counter, which counts down to zero at a uniform rate. When the counter is zero, the virtual CS indicates that the medium is idle and when nonzero indicates busy [6].

3. APPROACH

In CSMA/CA, as soon as a node receives a packet that is to be sent, it checks if the channel is free or not. If the channel is clear, then the packet is sent. If the channel is not clear, the node waits for a randomly back-off time, and then checks again to see if the channel is clear. The back-off time is counted down by a back-off counter. If the channel is clear when the back-off counter reaches zero, the node transmits the packet. If the channel is not clear when the back-off counter reaches zero, the back-off factor is reset again, and the process is repeated. As an optional feature, the 802.11 standard includes the RTS/CTS (Request to Send/Clear to Send) function to control station access to the medium. This feature is intended to solve the problem of Hidden Node. When an 802.11 device intends to transmit data, it will first sense whether another station is already transmitting (Carrier Sense). If no other transmissions are sensed, the 802.11 device will send a small request-to-send (RTS) packet to its intended recipient. Since the RTS is very small, it will not waste too much time even the collision happen in the RTS sending time. If the recipient senses that the medium is clear, it sends a clear-to-send (CTS) packet in reply and reserves the channel for the sender. Once the station desiring to transmit receives the CTS packet, it sends the actual data packet to its planned recipient. If the transmitting station does not receive a CTS packet in reply, it begins the RTS procedure over again. If an

IEEE 802.11 user does sense another transmission when it wants to send, the device will apply a back-off time. After the random back off time is finished, it will sense the medium again to see if it can start transmitting. A flow chart of the key features of the IEEE 802.11 MAC layer shows how these features work in figure 2.

The other optional function "fragmentation" enables an 802.11 station to divide data packets into smaller frames. This is done to avoid retransmitting large frames in the presence of RF interference or in a severe fading wireless environment. The bits errors resulting from RF interference or fading are likely to affect a single frame, and it requires less overhead to retransmit a smaller frame rather than a larger one. In the flowchart if at any step any of the packets is not received in the set interval of time then the cycle is started again after the random back off interval is completed and counter is updated.

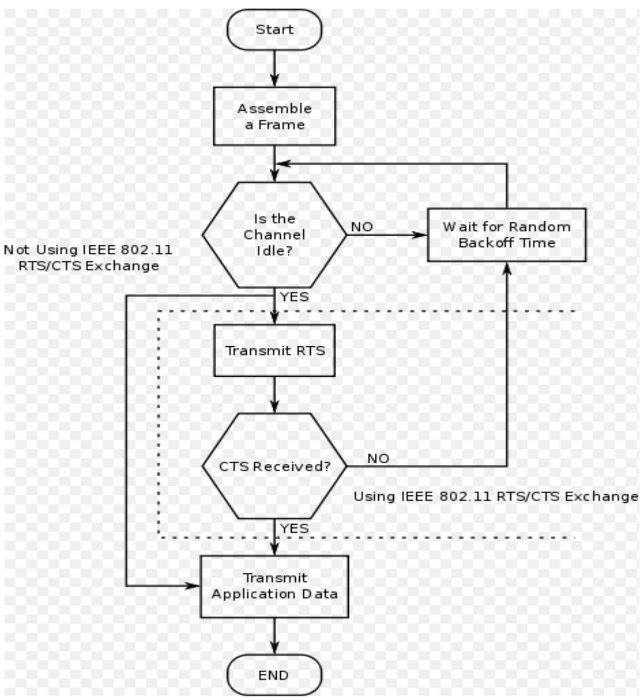

Fig. 2: Simplified flowchart of 802.11 transmission mechanism

4. SIMULATION MODEL OF IEEE 802.11 MAC

There are two ways to authenticate any research. Either the conclusion of research is based on any analytical model through which certain equations are derived or by simulating the whole environment by any simulation tool and deriving the results from that simulation. We have chosen second option and that is the simulation of IEEE 802.11 through which we have derived the results for our project. We have simulated an operation of the IEEE 802.11 MAC layer according to the standard specifications defined by IEEE. The IEEE 802.11 standard specifications are illustrated in [temp]. The simulation is based on the algorithm used in [7].

IEEE 802.11 MAC implies two contention-based methods for medium access i.e. Distributed coordination function (DCF) and Request to Send/Clear to Send (RTS/CTS). We have simulated the DCF function of the MAC layer that uses Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) and the simulation is done in Matlab. In this simulation some assumptions that have been made are listed below

- Perfect channel conditions have been assumed.
- The packet propagation delays between the communicating stations are assumed to be zero.
- As described, only DCF function is simulated.
- Only basic access is employed, no RTS/CTS messages are exchanged.

5. RESULT AND ANALYSIS

In order to check the performance, the coding was done in MATLAB and the simulations are performed in order to get the results. Using the simulation we have determined the performance of the WLAN 802.11 under the different load conditions and for different transmission ranges of mobile stations. Also we have determined the collisions and unreachable packet situations under different loads. Our simulation calculates the following parameters

- Total Transmissions.
- Successful Transmissions.
- Total Collisions.
- Unreachable Packets.
- Total Acknowledgments.
- Successful Acknowledgments.
- Acknowledgment Collisions.
- Unreachable Acknowledgments.

When the simulation is run, the code asks for the certain parameter values which we have to enter according to our requirement. The value which code requires is mentioned below:

- Number of Stations
- Simulation Time
- Frame size
- Time scale of random motion
- Range of Station

Based on the above parameters we have calculated the efficiency of the system subjecting it to different conditions. The results are shown below.

Table 1: Result obtained after simulation

No. of stations (Load)	Efficiency		
	Frame Size=5	Frame Size=10	Frame Size=15
0	0	0	0
3	0.76	0.79	0.80
5	0.70	0.61	0.51
10	0.48	0.34	0.37
15	0.35	0.28	0.31
20	0.30	0.23	0.19

Based on the simulation results as obtained in table 1 it is clear that increasing the load (No. of stations) in a WLAN system drastically reduces the efficiency of the network. However it is seen in Fig. that when frame size is 5 there is less decrease in efficiency as compared to another frame sizes. So with small frame size we can have more efficiency in our communication network.

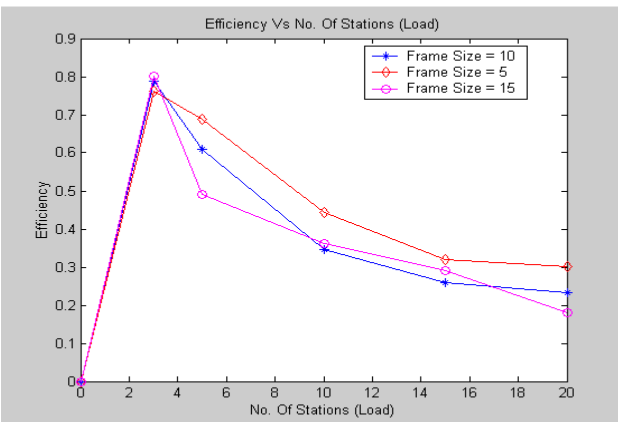

Fig. 1: Efficiency vs. No. of stations

After scrutinizing the results, we propose to increase the transmission range for stations. We found that by increasing the transmission range the value of efficiency is increased for increased no. of stations as shown in table 2.

Table 2: Efficiency of algorithm w.r.t transmission range

Transmission Range(0-10)	Efficiency		
	No. of stations=3	No. of stations =5	No. of stations =10
0	0	0	0
1	0.04	0.15	0.08
3	0.60	0.55	0.48
6	0.97	0.82	0.59
8	0.91	0.80	0.62
10	0.8	0.80	0.58

From Fig. 3 shown below we concluded that for increased no. of loads the collisions also increased. But we found that as frame size increases, for the same no. of loads the collisions decreased to some extent as shown by red line in Fig. 3.

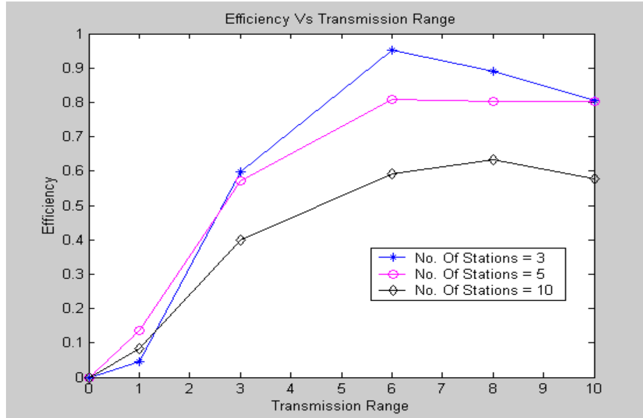

Fig. 2: Efficiency vs. Transmission Range

Table 3: No. of collisions w.r.t No. of stations

No. of stations (Load)	Collisions		
	Frame Size=5	Frame Size=10	Frame Size=15
0	0	0	0
3	3	3	3
5	9	7	6
10	20	16	15
15	30	20	17
20	37	30	26

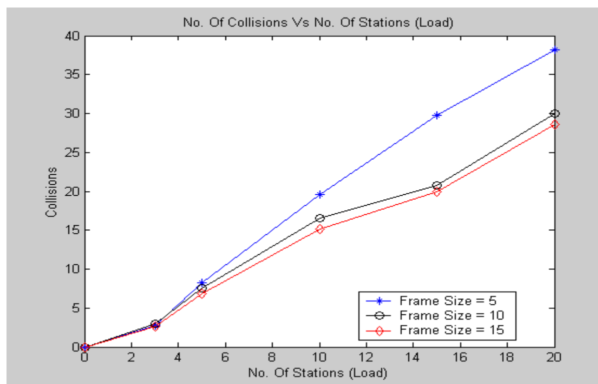

Fig. 3: Collisions vs. No. of stations

From the last graph 4 it is clear the like collisions the no. of unreachable packets also increases with the increasing no. of loads. But if we increase the transmission range of loads the unreachable packets decreases considerably as shown by black line in Fig. 4.

Table 4: No. of Unreachable Packets w.r.t No. of stations

No. of stations (Load)	Unreachable Packets		
	Range=1	Range=2	Range=3
0	0	0	0
3	13	8	6
5	26	15	8
10	50	30	9
15	72	31	11
20	88	42	10

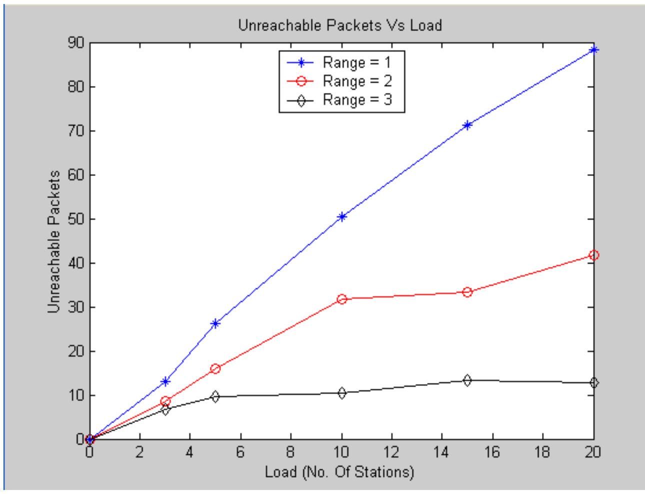

Fig. 4: Unreachable Packets vs. No. of stations

6. CONCLUSION

We have found from our readings that it makes a lot of difference if we apply the CSMA/CA protocol with the IEEE 802.11. It has been proven already that CSMA/CA protocol reduces the number of collisions, but through our study we tried to find how the various factors like the number of nodes, movement of the node and the IFS times effect the number of transmissions and the number of conflicts. When know thatif stations are not in motion then we have greater number of transmissions as compared to when the stations are in random motion. But we have obtained results in case when loads are in motion so that efficiency of system in motion can be obtained. Overall conclusion is that the transmission range affects our network efficiency. For the validation of our conclusion we present the following proof.

For the frame size 5, range 3 and No. of Stations 10, the efficiency of network is 0.4423. If we increase the transmission range from 3 to 10, keeping the frame size 5 and No. of Stations 10, the network efficiency comes close to 0.6. That is 15.77% improvement in efficiency.

But increasing the range for stations will require some kind of power control mechanism. It is not possible to increase the range of stations or in other words power transmitted by stations to a very large value but this tradeoff has much area for optimization as the interference factor in not present

REFERENCES

[1] IEEE Standard for Wireless LAN Medium Access Control and Physical Layer Specification, STD 802.11-2007.

[2] C. E-A Campbell, I. A. Shah, K.K. Loo, Medium Access Control and Transport protocol for Wireless Sensor Networks: An overview, International Journal of Applied Research on Information Technology and Computing (IJARITAC), 2010, pp. 79-92.

[3] E. H. Callaway, Jr., Wireless Sensor Networks Architectures and Protocols, Auberbach publication, 2004.

[4] Performance Analysis of IEEE 802.11 C SM A/C A Medium Access Control Protocol by Tien-Shin Ho, Kwang-Cheng Chen

[5] KavehPahlavan, Prashant Krishnamurthy, Principles of Wireless Networks–A unified Approach, Prentice Hall, 2002

[6] Kin K. Leung, Bruce McNair, Leonard J. Cimini, Jr., and Jack H. Winters"Outdoor IEEE 802.11 Cellular Networks: MAC Protocol Design and Performance," AT&T Labs–Research Middletown, NJ 07748

[7] ChuanHeng Foh and Moshe Zukerman ARC Special Research Center for Ultra–Broadband Information Networks EEE Department, The University of Melbourne "Performance Analysis of the IEEE 802.11 MAC Protocol"