MAC IEEE802.11 CSMA/CA: A Simulative Performance Analysis

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Abstract- In this paper we introduce an algorithim based analytical model to calculate the performance of the wireless LAN MAC protocol – known as Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) – taking into consideration the random exponential back off algorithm. The effects of changing the load on medium utilization and average waiting time are demonstrated and result concluded for high medium and low load conditions.

Keywords- *Wireless Networks, LAN, Protocol analysis, Performance evaluation, Multiple access*

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I. Introduction

Communication is a process of transforming, interpreting and processing information among persons or machines. This process involves transmission medium over which the information flows, a sender, receiver[15]. Lan denotes the small group of computing devises when connected together for data communication services. Physical level interconnection is done by copper medium in wired communication network. copper wired network is in expensive, readily available and east to install. due to need of more bandwidth fible optic communication begun to play vital role in Lan connections. Networks are divide into two broad categories 1. Point to point 2. Broadcast channels [1]. Our basis of research is broadcast channel where it is necessary to determine who gets the use of channel when there is a completion for it. Interconnecting terminals without control of transmission leads to chaos like in a conference call. Such a chaos is eliminated or avoided in face to face talk by using hand raise mechanism. It is hard to determine who should goes next in single channel. The protocol used to determine who should goes next on a multi level channel belong to a sub layer of data link layer called MAC(medium access control) layer [12]. All Lan network basically used Mac layer as their basis of communication except WAN which use point to pint link. Broadcast channel are sometimes referred to as multi-access channel or random access channel.

In the Open Systems Interconnection (OSI) model of communication, the Media Access Control layer is one of two sub layers of the Data Link Control layer and is concerned with sharing the physical connection to the network among several computers [14]. As depicted in figure 1.1 Mac sub layer represents the bottom part of the data link layer. Protocol is defines as set of rules for accessing the network. In slotted multi-access protocols, such as Ethernet (IEEE 802.3) data packets or frames are sent during time slots that are defined by the protocol [10].

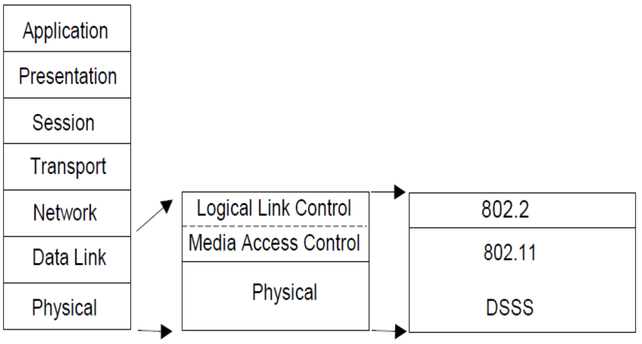

Figure 1.1 Affected Layers of the OSI Model

The most widely used MAC protocol, used in Ethernet is based on a discipline called carrier sense multiple access with collision detection (CSMA/CD) to access the medium [13]. A transmitting CSMA/CD frame contains destination address which can broad cast over the medium. Every node connected to network detect when a frame is transmitted. Correct address contains in the frame header opens the data packet and receives the data. For accessing medium a node a node with data frame to send command to the medium to detect whether frame is presently being transmitted over the medium or not. The node defers its transmission when a carrier signal detected and stop until the current transmission over the medium has ended. Once medium is free the node will access the medium and start its transmission. Under heavy load condition two or more nodes detect free medium and simultaneously access the medium for transmission. A collision is then said to occur that causes all frames to have set of corrupted bit data. As transmission is done at broad cast network , source also monitor the data frame being sent over the network. If collision is determined a jamming signal is sent and process is repeated to re transmit the collided frames.

II. IEEE 802.11 CSMA/CA

Wireless LAN can be categorized by its MAC protocol.One of the major protocols used for wireless LAN is the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) [13], which is a variation of CSMA/CD used for Ethernet. The problem with CSMA/CD is that efficient collision detection in radio channels is difficult to achieve. This inefficiency is a result ofthe high dynamic attenuation of radio signals. This high attenuation makes it practically very difficult for a radio transceiver to listen to other signals while transmitting, which is essential for the collision detection part of CSMA/CD. To be able to overcome this problem and still achieve an acceptable performance, the collision detection is replaced by collision avoidance [16]. CSMA/CA is used for IEEE 802.11 distributed access and has been adopted in many products existing in the market, such as the WaveLAN RF Wireless LAN of AT&T [2]. Due to its importance, this protocol is reviewed in some details in this paper. The protocol differs from the CSMA/CD in two ways, the first is that it doesn't contain a collision detection algorithm, and the second is that it defers the transmission for a random exponential backoff in case of medium busy. Hence, models for CSMA/CD cannot be directly applied to this protocol and a model to be established from scratch.

A)Algorithm

```
A:  sense channel;  if idle
    then
        {

         transmit frame and monitor the channel;
          if detect another transmission
    then
        {
          abort and send jam signal;
          update # collisions;
          delay as required by exponential back off algorithm;
          go to A
          }
     Else
         {
         done with the frame; set collisions to zero
          }
          }
      else
         {
         wait until ongoing transmission is over and go to A
          }
```

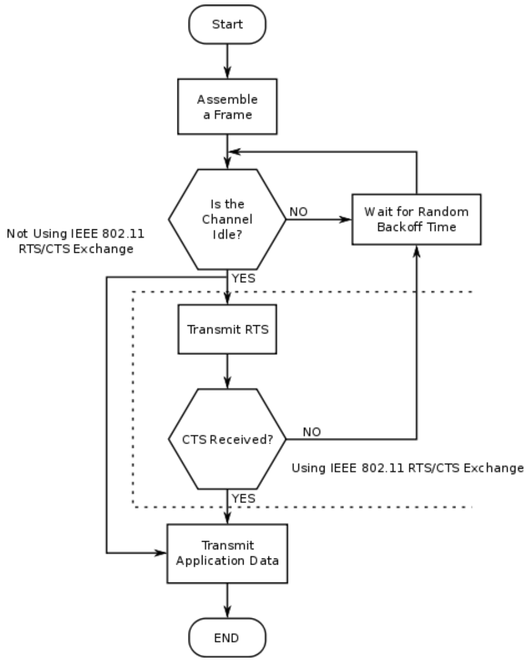

Figure2.1 Flow Chart CSMA/CA

III. SIMULATION MODEL: IEEE802.11 (CSMA/CA)

This topic focuses on the development of the simulation model for carrier sense multiple access with collision avoidance i.e. CSMA/CA.. The fixed parameters are:

- Packet lengths are set to 18704 bits, the maximum length permitted by the protocol.
- The simulations are done for the maximum achievable rate of 2 Mbps. It implies that one
- packet will take 9.35 ms for transmission.
- The slot-time is defined as the fixed unit of time which comprises a contention window. The value is set at 50 ms. In a slotted multi-access system events are processed in terms of slot-times.
- DIFS is the waiting period before and after packet transmissions. Positive and negative acknowledgements are sent during this time interval which is set at 150 µsec.

The duration for the simulation runs in this chapter is 300 seconds. The accuracy gained as a result of runs that are beyond 300 seconds is insignificant. Moreover, simulation runs of greater than 300 seconds under high loads are extremely time consuming, and are difficult to achieve using a microcomputer. All the coding is done in C language and the programs are run on both Windows and Linux platforms.

A) Parameters for the Simulation Model [3]

As discussed earlier, there are two sets of parameters that are utilized by the simulation model. The first group includes constants that are coded directly into the program. The second set consists of a single parameter, namely load, that can be specified for each simulation run. These parameters have been

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defined through pilot studies. For example, three Levels of load are considered, high, medium and low. Based on pilot studies, network utilization values of 60, 40 and 20 percent constitute high, medium and low load factors.

Tables 1 and 2 summarize the parameters.

Slot time	50	µ sec
DIFS	150	µ sec
DSSS capacity	2	Mbps
Packet sixe	18704	Bits
Simulation duration	300	Seconds

Table 1 Constant Parameters

High Load	1200 and above	Kbps
Medium Load	800-1200	Kbps
Low Load	0-800	Kbps

Table 2 Variable Parameters

B) Simulation Model [3]

This is an event-driven simulation model. This means that rather than being based on pre-determined units of time such as "ticks" of a clock, the flow through the program is controlled by events, specifically by the next event, whatever that event may be.

Now, let us look at a slightly more complicated sequence of events where two stations receive packets for transmission. Figure 3.1 shows the event diagram for such a system. The events for station A are represented by solid arrows, the events for station B are represented by dashed arrows, and the numbers in the parentheses represent the order of event occurrences.

The first event is a packet arrival event, and is calculated by the event-arrival module in the program. The event arrival module considers the load variable specified as program input. The module uses the following relationship to calculate exponentially distributed interracial times for packets.

arrivals=-load*log (r)....................................(3.1)

Variable r is a uniformly distributed random variable between 0 and 1.

Event 1 is a packet arrival at station A. Event 2 is a packet arrival at station B. At event 2, DIFS for station B begins, while DIES for station A had already begun at event 1. Now, let us calculate the time remaining from event 2 to event 3 using Figure 3.1. At event 2, the elapsed time of DIFS for station A is calculated as T2-T1, with T1 representing time at event 1 and T2 representing time at event 2. Therefore, the DIFS counter for station A, which starts at 150 µsec at event 1, is reduced by T2-T1. At event 2 the time that remains to reach event 3 is calculated by:

$$T_3(\mu s)=150-(T_2-T_1) \qquad (3.2)$$

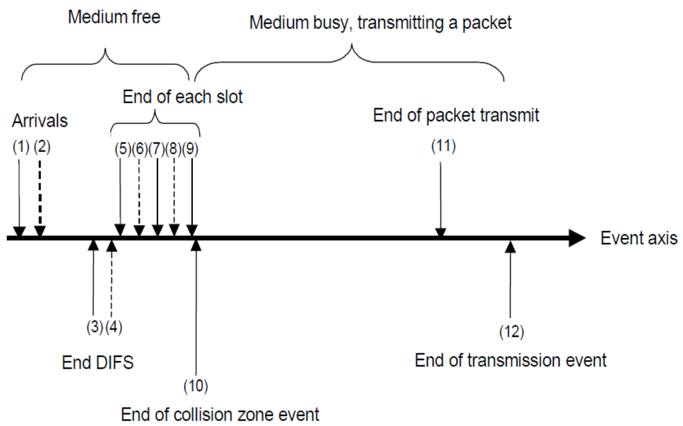

Figure 3.1 Events for Two Stations with Data Packets

Once, event 3 is reached, station A selects a backoff counter, while station B is still within its DIES zone. Let us assume station A selects a backoff value of 3. This means that station A needs to complete 3 slot events before the backoff counter reaches zero. Let us further assume that station B selects a backoff value of 5. At event 4 Equation 4.2 is applied using the slot-time interval constant (50 µsec) to calculate the remaining time to event 5 (the completion of first slot event by station A) as shown below.

$$T_5\ (\mu S) = 50-(T_4 - T_3) \qquad (3.3)$$

Every time an end-of-slot event occurs for any station, the back off value counter for that station is reduced by 1. When the back off counter of station A in Figure 3.1 reaches 0, station A enters a collision zone interval. At the end of the collision zone interval, the statuses of the medium changes from "free" to "busy." Upon occurrence of this event station B freezes its back off counter and the counter reverts back to the previous integer value which would be 3 in our example. Events 11 and 12 are reached by station A while station B remains at event 8. The system status flag changes from "busy" to "free" at event 12, thus the next event (barring any new arrivals for either station) is for station B to complete an end-of-slot event, thus reducing the value of the back off counter by 1. At this point the back off value for station 13 is at 2. Therefore, station B completes 2 more successive end-of-slot events. This allows station B to reach event 9, continue on to event 12 of Figure 3.1, and transmit its packet.

The above example involves only two stations, but the same logic is applicable to any number of stations. The only difference between a multiple station systems versus two-station systems lies in what event for which station is occurring next. Every event for each station needs to be calculated individually and then all the next-events are compared with one another. The next event for the entire system is the smallest next-event value. The value of next-event is then subtracted from every active station's event counters, and the process is repeated.

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For the two-station example above, let us assume that station A has an arrival at time T, and station B has an arrival at T+x, where 0<x<1 µs. Furthermore, stations A and 13 select the same random slot-time to transmit their respective packets. Station A starts its packet transmission and before the end of collision zone event in Figure 3.1 is reached which notifies other stations that the medium is busy, station B starts its transmission. The simulation model will advance to the next two events, although a collision has occurred, and both stations must re-transmit the collided packets.

IV. Performance Results

This section describes the results of performance experiments using the simulation models. Appendix B contains tabular data associated with the figures presented in this chapter.

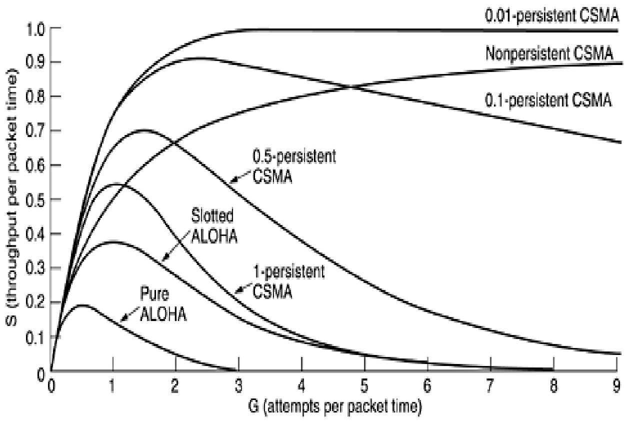

Figure 4.1 Comparison of the Channel Utilization versus Load for Various Random Access Protocols

Figure 4.2 represents the medium utilization under varying load conditions for CSMA/CA protocol. Medium utilization is defines as the total number of the useful iterations i.e. the iterations in which the packets are served successfully divided by the total iterations.

MEDIUM UTILZATION:CSMA/CA

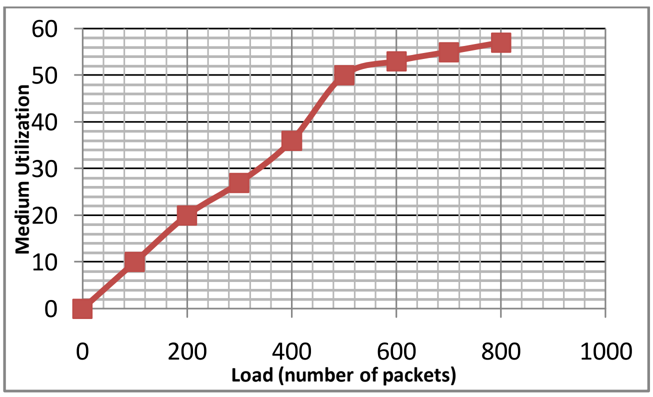

Figure 4.2 : Medium utilization for CSMA/CA

Figure 4.3 represents the average waiting time per packet under the varying load conditions for CSMA/CA protocol. To calculate this output parameter, we add up all the times which the packets are required to wait either because the channel was busy when they arrived or the wait they had to undergo because of collisions. The average waiting time is defined as the total waiting time divided by the total number of packets.

AVERAGE WAITING TIME: CSMA/CA

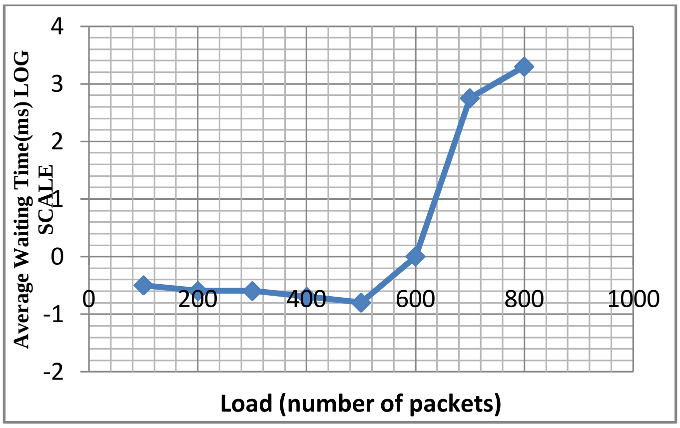

Figure 4.3 : Average Waiting Time for CSMA/CA

V. Conclusions

Based on the above results and the associated comments the following conclusions are deduced:

CSMA/CA protocol results found best at collision avoidance at especially in high contention environment. As the protocol has large delay value at high loads so it makes un suitable for real time and time bounded applications. For time bounded application it is accompanied with standard IEEE 802.11.

As simulation results clear that offered load and number of station do not equally effects the protocol as we increase the number of stations the large burden is presents on network an oppose to an increase in just offered load by fewer stations. As the network character realise from the example that it is rare for two packets of same station to collide. However collision is very possible for two packets of two different stations if there is large number of stations.

Through put efficiency of longer packets are higher. Longer packets are safe for transmission as they contain long data bits so station can transmit more information from them.

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