Performance Evaluation of 802.11 MAC Protocol with QoS Differentiation for Real-Time Control

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Abstract- **IEEE 802.11 provides several medium access control (MAC) schemes to regulate the control and sharing of the medium access. These MAC schemes provide good real-time quality of service (QoS) under light traffic; they have severe problems when applied to real-time control systems with periodic traffic, particularly under congested network conditions. They either introduce a long delay or assign all periodic traffic flows to the same traffic class without any deadline differentiation. The simulation was carried out using NS 2 network simulator the performance parameter compare with existing protocol.**

Keywords: **MAC protocol, WLAB, BEB, EDCA.**

I. Introduction

Wireless LAN technologies offer a wide range of capabilities and operate in different ways and environments. The common denominator among all of thes technologies is that they do not require a fixed wire connection, but instead transmit signals to one or more wireless receivers over a wireless channel. This chapter describes the portion of the electromagnetic spectrum used to send information and techniques that are used to utilize radio frequencies as a communications medium. The chapter further focuses on the MAC portion of IEEE 802.11, including CSMA/CA, the backoff mechanism and packet collisions.

A. Wireless LAN Model and Slotted Multi-Access Systems

To illustrate the integration of wireless systems into the present wired data network systems the Open Systems Interconnect (OSI) model developed by International Organization for Standards (ISO) is followed. Figure 2.2 depicts the OSI model and the corresponding layers in a wireless system. The physical level is the lowest level. In a wired network information such as cabling types, network interface card (NIC) connections, and voltage levels is addressed by physical layer standards. In a wireless system, information such as frequency levels and modulation techniques is specified

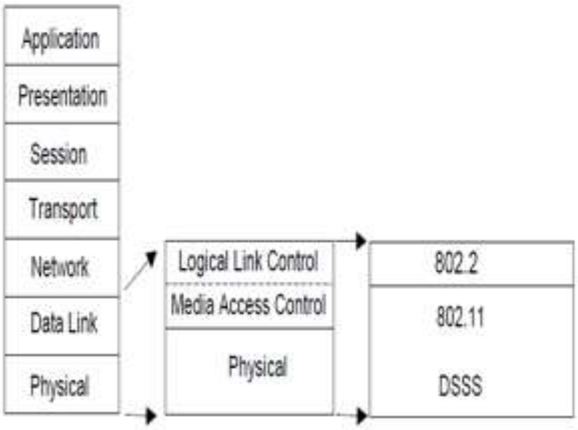

Figure1: Effected Layers of OSI model

The layer above the physical layer is the data link layer. Here, the protocol defines the rules for accessing the network. The data link layer is usually separated into two separate sub-layers. The logical link control (LLC) sub-layer provides a logical link between network nodes. The second sub-layer (beneath the LLC) is the medium access control (MAC) sub-layer, which implements a distributed access control protocol. 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. In these networks nodes with data packets ready for transmission compete for access to the medium. 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. CSMA/CD can only be utilized in logical bus networks. To transmit a frame using CSMA/CD, a node includes a destination address in the frame. The frame is then broadcast over the medium (cable). All nodes connected to the network detect when a frame is transmitted.

As mentioned above, frames are broadcast over the network, thus enabling every node to be aware of frame transmissions. If a carrier signal (CS) is detected, the node defers its transmission until the current transmission over the medium has ended. Once the medium is free, the node will access the medium and commence its transmission. It is highly likely that under heavy load conditions two or more nodes detect the free medium and simultaneously access the medium to transmit their frames. A collision is then said to occur that causes all frames to have corrupted data bits. Since data frames are broadcast over the network, a source also monitors the data frame being sent over the network. In the event of a collision the transmitted signal differs from the monitored signal and a collision is detected. To notify the network of the collision, a jamming signal is sent and the process is repeated to re-transmit the collided frame.

II. IEEE 802.11 MAC

The IEEE 802.11 wireless LAN standard supports operation in two separate modes, a distributed coordination (DCF) and a centralized point-coordination mode (PCF). The IEEE 802.11 MAC is called Distributed Foundation Wireless MAC (DFWMAC) and the access mechanism is based on a modified version of the CSMA/CD access protocol (discussed in the previous section) called carrier sense multiple access with collision avoidance (CSMA/CA). Lower bandwidths in Wireless networks and the fact that collision detection cannot be implemented in a wireless radio frequency network, make collisions a highly taxing proposition, thus the CSMA/CA scheme has a built-in mechanism to avoid collisions and provide fair access to the medium. Figure1.6 shows the structure of the DFWMAC used in this study. One of the issues that arises in a wireless network is that there is no guarantee that the destination is within range of the source at the beginning of the transmission or perhaps it moves out of range during transmission. The DFWMAC handles a four-way handshake procedure shown in Figure 1.6 insure connection integrity. For contention-free service, the Point Coordination Function (PCF) portion of the DFWMAC is used. Whenever a node intends to transmit data using PCF, it first sends a short request-to-send (RTS) message over the network. The message includes the source and destination addresses. If the destination is ready to receive a frame, a clear-to-send (CTS) message is broadcast over the network. If the destination is busy, it broadcasts a receiver busy (RxBUSY) message. If a CTS signal is detected by the source then the source sends the data. If the data frame is successfully received by the destination, it returns an ACK to the source. However, if the data frame is corrupted a NAK is sent to the source. In the case of a station being out of range, it is built into the protocol to repeat the above sequence for a pre-determined number of times. If the destination repeatedly does not send an ACK or a NAK, it is assumed that the node is out of range.

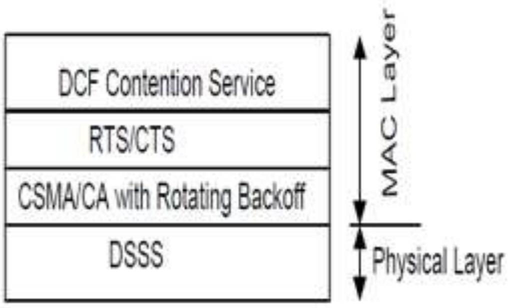

Figure 2:Structure of WLAN layers

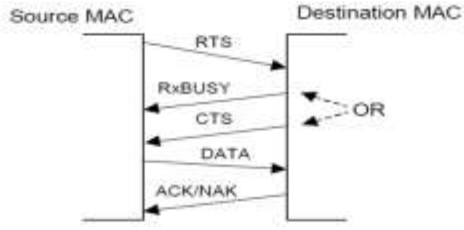

Figure 3: Four –way handshake

Under the CSMA/CA technique, all stations listen to the medium as in CSMA/CD. A station that is ready to transmit a frame will sense the medium and, if the medium is busy, it will wait until the end of the current transmission. It will then wait for an additional predetermined time period, denoted as DIFS (DCF Inter-frame Space), and then pick a random time slot within a contention window to transmit its frame. If there are no other transmissions before this time slot arrives, it will start transmitting its frame. If there are transmissions by other stations during this time period known as the back off time, the station will freeze its counter and will resume the count where it left off after the other station has completed its frame transmission and after DIFS . The collisions can now occur only when two or more stations select the same time slot in which to transmit their data frames. In the event of a collision an explicit NAK is sent to the source by the destination notifying it of the collision. The source will then backoff within a larger contention window to lessen the possibility of a subsequent collision.

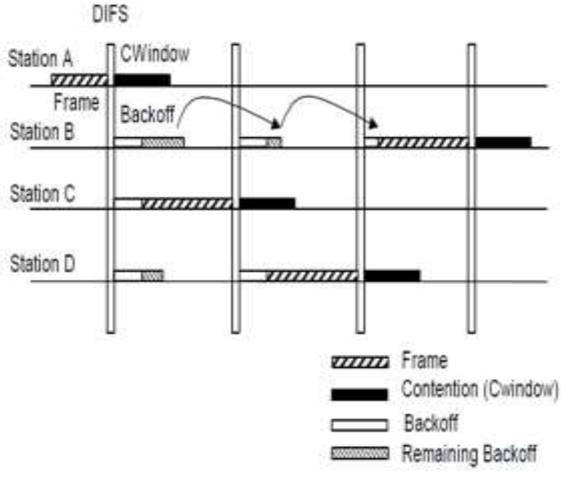

Figure 4: Transmission and Backoff Procedure

A. Random Backoff Time

As noted above, if the medium is busy, the protocol dictates that stations follow the random backoff procedure. The backoff procedure selects a random slot from the slots that are available in the contention window according to the following equation. *BackoffTime* = INT(CW * Random()) * Slot-Time) (2.1) *CW* is an integer between *CWmin* and *CWmax*. *Random()* is a random number between 0 and 1. *Slot-Time* is the constant value of time for each slot and is fixed for a given physical transmission scheme. The backoff timer will decrement by amount *Slot-Time* after every slot, while the medium is free. The timer freezes while the medium is busy. The counter will resume counting when the medium becomes free. Transmission occurs when the counter reaches zero. A station that has just transmitted a frame and has another frame to transmit will enter the contention competition and follows the backoff procedure for a new time slot .

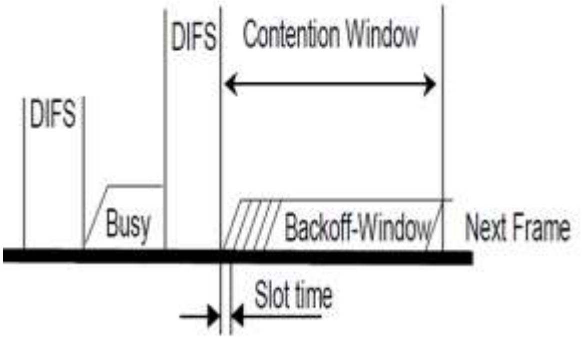

Figure 5: Basic access and backoff procedure

The contention window (*CW*) in the above equation controls the time slot competition among the stations. Let us assume that station A is ready to transmit a frame at time X1, station B is ready to transmit a frame at time *X2* (*X2 > X1*) and that *CW* is constant at 31. Each station will then calculate a backoff time using Equation 2.1. Station A selects a time slot from the first contention window and starts its counter. This shrinks the portion of the contention window that overlaps the contention window for station B. By time *X2,* when station B enters the competition, station A has shrunk its window by *X2-X1*, thus giving station A higher probability for transmission than station B with its newly selected time slot.

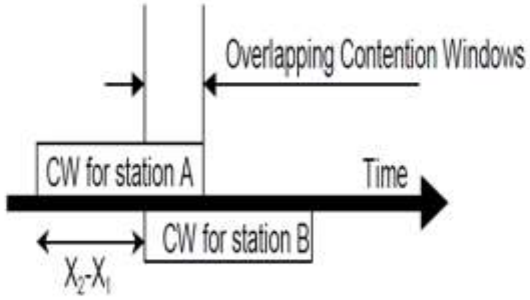

Figure 6: Contention Window

B. Collisions

As mentioned in the previous sections, collisions can and do occur with DFWMAC when two or more stations select the same time slot from overlapping contention windows. Unlike IEEE 802.3 a collision cannot be detected and transmission stopped. The corrupted frames are transmitted in full, resulting in a reduction in throughput. After each collision, stations must reenter the competition with exponentially increasing *CW* values. Initial transmissions occur with 31 time slots per contention window. The first retransmission occurs with 63 time slots per contention window, the second occurs with 127 time slots and finally the third and subsequent occur with 255 time slots per contention window. As the contention window becomes larger the probability of selecting a unique time slot increases, thus enabling a particular collided frame to be successfully transmitted without further delay

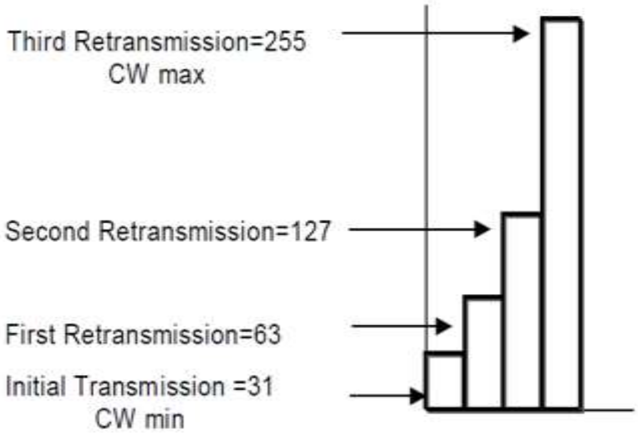

Figure 7: Exponential increase of contention window

III. Deadline-Constrained MAC Scheme with QoS Differentiation (EDCA)

To overcome these problems, introducing two new mechanisms to 802.11 MAC protocol the following algorithms

- Contention – sensitive binary exponential backoff (BEB) mechanism .
- Intra –access control QoS (quality of service) differentiation mechanism

Contention – sensitive binary exponential backoff (BEB) mechanism

Contention – sensitive binary exponential back-off (BEB) mechanism offers bounded back-off delays, which improves the delay performance. A transmitting station uses back-off mechanisms to determine how long to wait following a collision before attempting to retransmit. For each transmitting station, the new BEB chooses a uniformly random back-off-value. Stations wait before trying retransmission until the backoff value counts down to zero

Contention-sensitive BEB

```
W <-Wmin; backoff value <- Random(0,W -1);
retry <-1;
while Contention AND Transmission Incomplete do
Backoff Countdown(backoff_ value);
  if Channel Busy OR Collision then
    if retry< retry limit then
        W <- 2W; retry ,<- retry+1;
        backoff value <- Random(0,W – 1);
    else
        W <- Wmin; retry <-1;
          backoff value <- Random(0,W – 1);
```

Intra –access control QoS differentiation mechanism

Intra –access control QoS (quality of service) differentiation mechanism differentiates QoS levels for periodic traffic in terms of their respective deadline requirements. This mechanism is designed for periodic NCS(Network Controlled System) traffic flows that belong to the same high priority trafffic but have different deadline requirements. To differentiate the periodic traffic with different deadline requirements, a deadline-dependent retry limit is assigned to each of the traffic classes

IV. Simulation Results

The following Simulation parameters used for performance evaluation of the above protocols as shown in table 1

Table 1: Simulation parameters

Parameter	Value
No. of Nodes	50
Area	1250 X 1250 sq.m
MAC	802.11, EDCA MAC
Radio Range	250m
Simulation Time	15 sec
Traffic Source	CBR
Packet Size	200 MB
Mobility Model	Random Way Point
Parameter	Value
No. of Nodes	10,20,30,40

The performance evaluation of MAC protocol and EDCA has been evaluated using NS 2 Network simulator in terms of number of nodes transmission rate versus delay, delivery ratio and loss rate is compared and presented below.

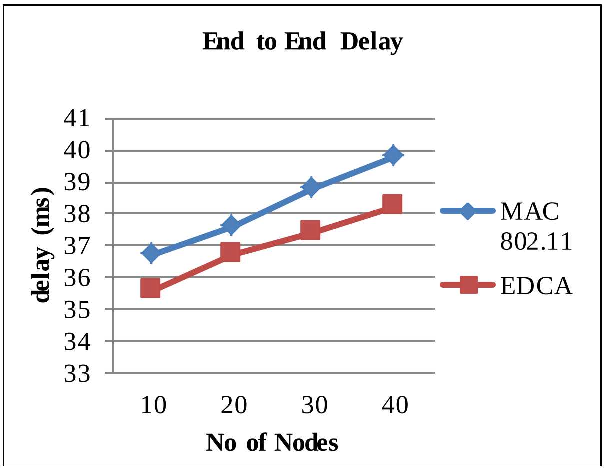

Figure 7: End to End Delay Vs No Nodes

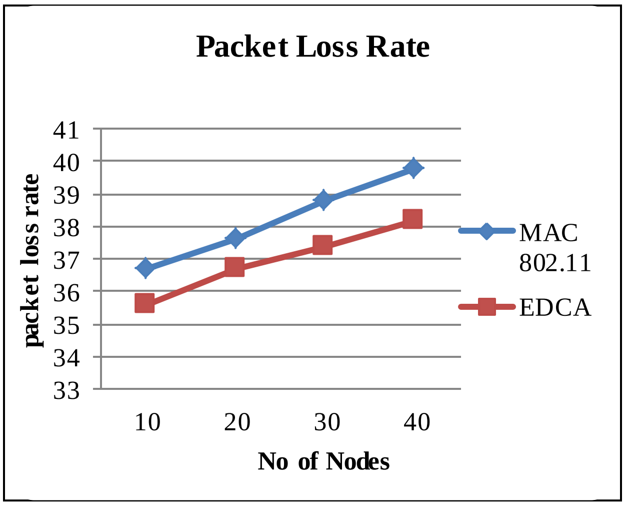

Figure 8: Packet Loss Rate Vs No Nodes

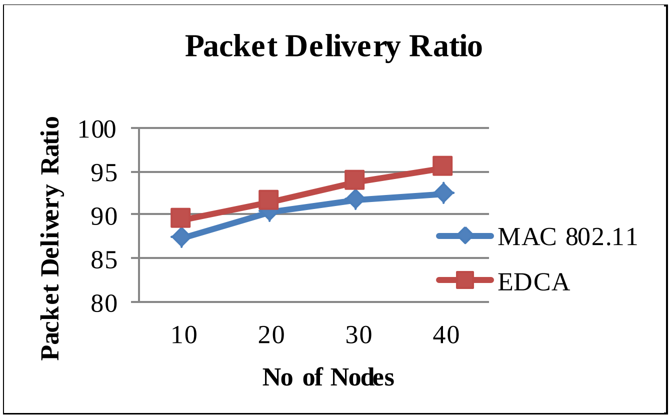

Figure 9: Packet Delivery Ratio Vs No Nodes

V. Conclusion

In this paper MAC protocol for load balancing in mobile ad hoc networks is developed. The congestion is detected using congestion detection technique and routing overhead is reduced using the load balancing technique. The performance of the proposed EDCA MAC Protocol and MAC 802.11 Protocol is evaluated and compared using different metrics such like packet delivery ratio, end – end delay and loss Rate by varying the number of flows nodes using NS2 simulator From simulation results it is observed that there is improvement in PDR and delay in EDCA Protocol.

References

[1] Guosong Tian, Seyit Camtepe, Member, IEEE, and Yu-Chu Tian, Member,"A Deadline –constrained 802.11MAC protocol with QoS Differentiation for soft Real-Time control," IEEE Trans 2015.

[2] G. Tian and Y.-C. Tian, "Modelling and performance evaluation of the IEEE 802.11 DCF for real-time control," Computer Networks, vol. 56, no. 1, pp. 435–447, 2012.

[3] L. Seno, S. Vitturi, and F. Tramarin, "Tuning of IEEE 802.11 MAC for improving real-time in industrial wireless networks," in IEEE Conf. on Emerging Technol. Factory Autom. (ETFA), Sept 2012, pp. 1–8.

[4] Y. Gao, X. Sun, and L. Dai, "Throughput optimization of heterogeneous IEEE 802.11 DCF networks," IEEE Trans. Wireless Commun., vol. 12, no. 1, pp. 398–411, January 2013

[4] L. Feng, J. Li, and X. Lin, "A new delay analysis for IEEE 802.11 PCF," IEEE Trans. Veh. Technol., vol. 62, no. 8, pp. 4064–4069, Oct 2013.