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Optimization of Wireless Network MAC Layer Parameters

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Abstract- Abstract—Wireless communication systems either ad hoc or infrastructure mode the key challenges that must be overcome to realize the practical benefits of Quality of Service (QoS). Generally the QoS is the ability for network element to provide some level of assurance for consistent network data delivery. The ability of Wireless Local Area Network (WLAN) to support real-time services is possible with QoS. IEEE802.11 is a standardized protocol for Wireless LAN (WLAN). The access mechanism of 802.11e, referred to as Enhanced Distributed Channel Access (EDCA), assigns different types of data traffic with different priorities based on the QoS requirements of the traffic, and for each priority, uses a different set of medium access parameters to introduce QoS support. In This paper optimized network parameter of IEEE 802.11e simulation model using Qualnet 5.02 Simulator, which is popular simulation software for wireless networks

Key words: MAC, QoS, wireless LAN, EDCA.

I. INTRODUCTION

There are various versions of IEEE802.11 WLAN in the market, and each applies different modulation technique and operates in different frequency bands. 802.11 WLAN can be considered as a wireless version of Ethernet supporting best effort service (e.g., mail, browsing …, etc). However, the need of wireless networks that support Quality of Service (QoS) has recently grown. In addition, the increasing needs of transmitting voice, video, and other multimedia applications with high-speed Internet access over WLANS made it necessary to have such networks. Relatively, the idea of enhancing the 802.11 MAC protocols and upcoming with the 802.11e (QoS enabled version of IEEE 802.11) was initiated. 802.11e adds QoS features and multimedia applications support to the existing 802.11b and 802.11a wireless standards, while maintaining full backward compatibility with these standards [1, 2].

. As the raw data rate at the PHYsical (PHY) layer of IEEE 802.11 standard is now up to 54 Mbps, applications such as VoIP over WLAN and video streaming become feasible. However, the MAC protocol in the original 802.11 standard was designed with best-effort applications in mind and thus cannot meet the basic quality of service QoS requirements for these emerging applications. To address this issue, the IEEE 802.11e working group was established to strengthen QoS support at the MAC layer. Although the IEEE 802.11e has not been finally ratified, it has already received much attention from the research community.

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IEEE 802.11e provides a channel access function, called Enhanced Distributed Channel Access (EDCA). It also provides a controlled medium access function, referred to as Hybrid Coordination function controlled Channel Access (HCCA), support applications with QoS requirements [3, 12].

II. IEEE 802.11 MAC LAYER

The original 802.11 MAC layer is built around two coordination functions that control medium access by the use of distributed coordination and centralized coordination. In the Distributed Coordination Function (DCF), the access control mechanisms are located at the station as opposed to the Point Coordination Function (PCF) in which control is centralized to the Access Point (AP). In 802.11 networks, DCF is always used, although PCF may be used optionally along-side DCF. Both DCF and PCF are network management techniques based on collision avoidance. In Figure 1, it is clear that components that are controlled by smaller time delay intervals will have a distinct advantage over those that use longer time intervals.

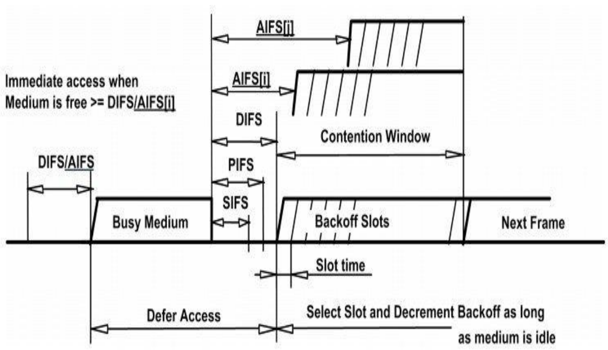

Figure 1 – 802.11e transmission intervals.

2.1 DCF

DCF allows stations to transmit without a central coordinator. When a station wishes to transmit, and has sensed that the medium is free; it waits for a DIFS and transmits. If during the DIFS, the medium becomes busy, it begins decrementing a back-off counter that is defined by the Contention Window (CW). The CW begins equal to CW_{min} and ends equal to CW_{max}. After each consecutive collision, the counter is set to a random value between 0 and CW. Each time a collision occurs the CW is increased until it equals CW_{max}.

If the CW reaches zero, and the medium is still free, then the station begins transmitting. If during the countdown, the medium is seized by another station, the station stops the counter and resumes after the transmission period.

If the station senses the medium to be free, reaches a counter value of zero, and begins a transmission that results in a collision (no ACK received), the station will pick a new CW value [3,10, 11, 13].

DCF also includes an optional Request to Send/Clear to Send (RTS/CTS) mechanism to eliminate the hidden station problem. The hidden station problem occurs when two stations can sense transmissions of the AP, but not of each other. Due to their inability to receive each other's signals, the two stations can claim the medium simultaneously, and will cause a collision at a central destination. To prevent this, before sending a frame, a station transmits a RTS and then receives CTS from the central station. Both of these frames include information regarding the time it will take to send the frames, which allows other stations to set a timer called the Network Allocation Vector (NAV) since the medium will be busy at least for that length of time. After that time, stations begin normal time interval waiting, and back-off counter decrementing. Since RTS/CTS frames are allowed to be transmitted after a SIFS, they have priority over normal DCF transmissions [6, 5, 7].

2.2 PCF

In PCF, medium access is controlled by a Point Coordinator (PC). The PC controls access by looking for stations wishing to transmit during a Contention Period (CP), and polling stations during a Contention Free Period (CFP). Together the CP and the CFP form a super frame which repeats for each time period. During the CFP, PCF is used to control access, and then during the CP, DCF is used.

The CFP portion of the super frame begins with a beacon frame that contains management information such as protocol parameters and time synchronization. After the beacon frame has been transmitted, the CP polls stations, and upon successful response, allows the station to transmit either an ACK indicating it has nothing to send, or a DATA+ACK frame. Having received no response from a station the CP moves on, and the station is not allowed to transmit until the CP, or during the next CFP. The CFP ends when the time period specified by the beacon frame expires, or a CFP-End Frame is sent. After the CFP has ended, a normal DCF period proceeds.

PCF was intended to provide QoS to 802.11 networks, it is generally agreed that it fails to provide this service adequately. Although PCF gets priority over DCF since the PIFS is always less than the DIFS, it suffers from the fact that individual network flows cannot be singled out for prioritization since the PC polls in a round-robin fashion. High priority can be given to individual stations, but affecting service on a more granular level is impossible with PCF. Also, polling can result in excessive overhead and large end-to-end delay when the number of stations is large [6, 9,10].

III. QOS IN 802.11E

In an effort to give 802.11 networks true QoS, 802.11e was standardized. 802.11e introduced enhancements to the existing DCF and PCF, placed them under the heading of the Hybrid Coordination Function (HCF). The HCF is comprised of Enhanced Distribution Coordinate Access (EDCA), which is an enhanced DCF, and HCF Controlled Channel Access (HCCA), which has many traits in common with PCF. These two access methods work separately or together, just as in 802.11, where DCF is mandatory and PCF is optional. While the fundamentals of the original functions were not changed, augmented information allows HCF to provide QoS to specific flows and/or stations.

Hybrid Coordination Function Controlled Channel Access

The controlled medium access of the HCF, referred to as HCF HCCA extends the EDCA access rules by allowing the highest priority medium access to the Hybrid Coordinator (HC) during the CFP and the CP. The details about the controlled medium access are summarized in this section. A TXOP can be obtained by the HC via the controlled medium access. The HC may allocate TXOPs to itself to initiate MSDU Deliveries whenever it requires, after detecting the medium as being idle for PIFS, and without backoff. To give the HC higher priority over legacy DCF and EDCA access, Arbitration Inter Frame Space Number (AIFSN) must be selected such that the earliest medium access for EDCA stations is DIFS for any AC. During CP, each TXOP of an 802.11e station begins either when the medium is determined to be available under the EDCA rules, that is, after AIFS plus the random backoff time, or when a backoff entity receives a polling frame, the QoS CF-Poll, from the HC. The QoS CF-Poll from the HC can be transmitted after a PIFS idle period, without any backoff, by the HC. During CFP, the starting time and maximum duration of each TXOP is also specified by the HC, again using the QoS CF-Poll frames. During CFP, 802.11e backoff entities will not attempt to access the medium without being explicitly polled, hence, only the HC can allocate TXOPs by transmitting QoS CF-Poll frames, or by immediately transmitting downlink data. During a polled TXOP, a polled station can transmit multiple frames that the station selects to transmit according to its scheduling algorithm, with a SIFS time gap between two consecutive frames as long as the entire frame exchange duration is not over the allocated maximum TXOP limit [2]. The HCCA mechanism is designed for the parameterized QoS support, which combines the advantages of PCF and DCF.

IV. SIMULATION SETUP

The Qualnet 5.0.2 simulator is used for the analysis. The animated simulation is shown in fig. 2. The EEE 802.11e for wireless LANs is used as the MAC layer protocol. In the scenario UDP (User Datagram Protocol) connection is used and over it data traffic of Constant bit rate (CBR) is applied between source and destination. The basic network topology consists of 10 nodes/stations. The number of nodes is increased from 10 to 50. Over the region of 1000m x1000m. The frame rate depicts the number of frames/data items to be sent, keeping the frame size constant. Initially the 100 frames are sent, and then it is gradually increased to 500 frames. Frame size depicts the number of bytes per frame. The simulation was done by changing the frame size from 512 bytes to 2560 bytes, keeping the frame/data rate constant for CBR.

The basic network topology consists of an AP and varying number of stations depending on the simulation scenario. All communications take place between the stations and the AP, i.e., there is no direct communication between stations.

All stations are stationary, and transmission powers are set such that all stations are within each other's transmission ranges. The various parameters are set as in figure:

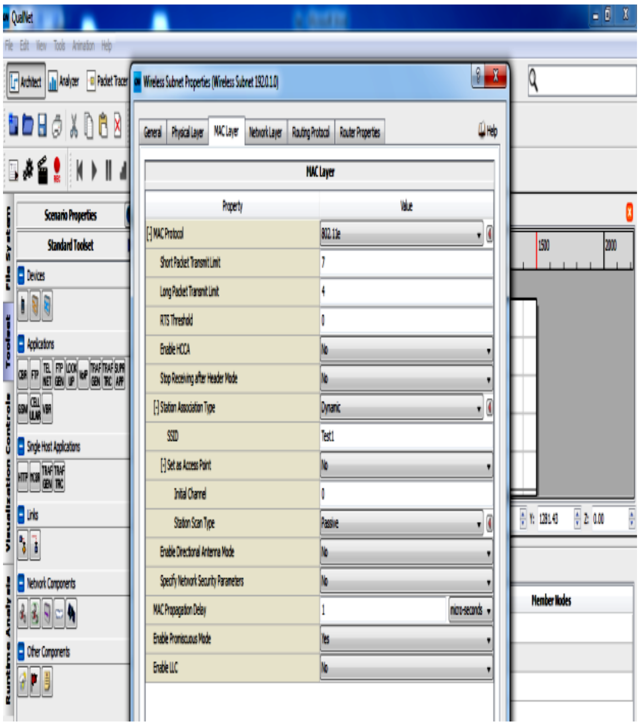

Figure2: MAC layer Parameter

V. RESULTS & DISCUSSION

➢ **Frame rate**

The frame rate depicts the number of frames/data items to be sent, keeping the frame size constant. Initially the 100 frames are sent, and then it is gradually increased to 500 frames.

The Figure3 shows consistent throughput of 4345bps, delay (30.6373ms) and jitter (12.8591ms) irrespective of the change in frame rate. This happened because the data is transmitted at constant bit rate flow between the nodes.

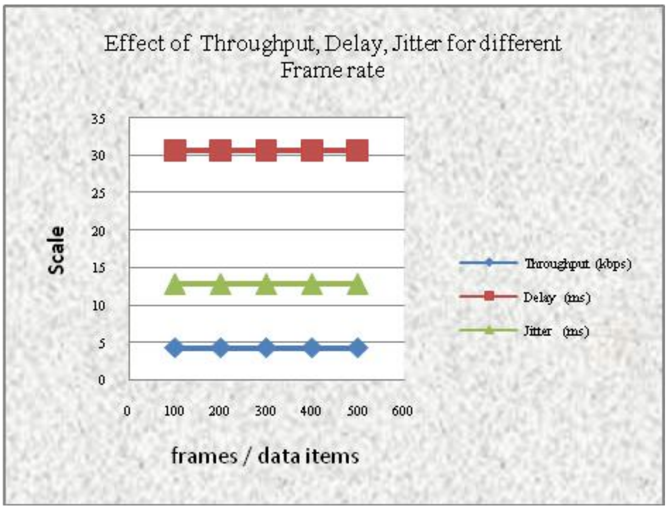

Figure 3 Throughput, delay and jitter vs Frame rate

➢ **Nodes**

The basic network topology consists of 10 nodes/stations. The number of nodes is increased from 10 to 50. At each step, throughput, end-to-end delay and jitter is calculated using the simulator, keeping the data rate constant. Figure.4 shows the decrease in throughput and the rapid increase in delay and jitter.

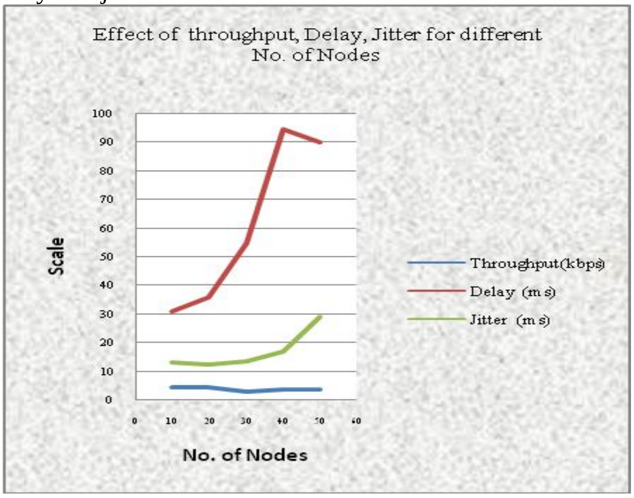

Figure 4 Throughput, delay and jitter vs nodes

➢ **Frame Size**

Frame size depicts the number of bytes per frame. The simulation was done by changing the frame size from 512 bytes to 2560 bytes, keeping the frame/data rate constant for CBR. The Figure5 gives a pictorial view of the parameters when the bytes per frame are increased linearly.

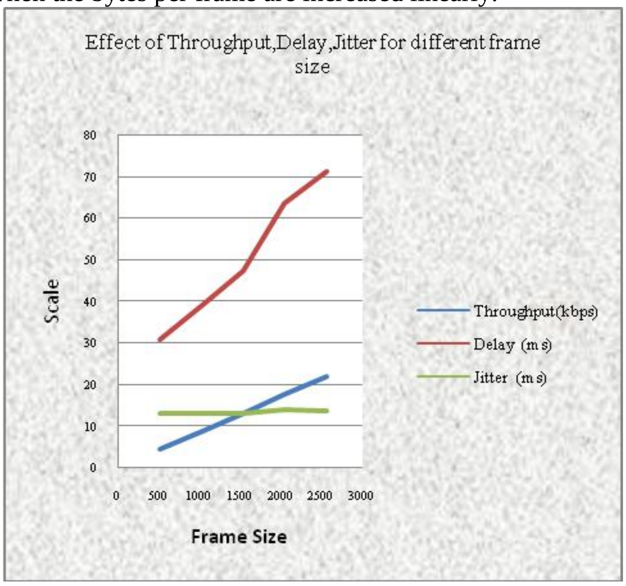

Figure5. Throughput, delay and jitter vs. Frame size

VI. CONCLUSION

The performance of IEEE 802.11e Wireless LANs in terms of optimum MAC Throughput, Delay and Jitter has been discussed in this paper. It examines the effects of variety of variables including MSDU size, Frame rate, Frame Size.

It can be concluded that these parameters are highly influenced by the number of nodes present in the network and the traffic sources for constant bit rate transmission. For the better performance of the network it is required that jitter and delay should be less and throughput should be high. The higher throughput can be achieved by having an optimum number of nodes and higher frame rate. The lower value of delay and jitter can be achieved by frame size of optimum level.

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