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QOS in Wireless Network- Current Trends and Future Directions

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Abstract: *In today's life wireless network is being used everywhere in homes, offices, Universities, Shopping malls and as a hot spot etc. Due to its diversification and development, it is affecting the throughput and hence the quality of service. .The aim of this paper is to provide the survey of QOS mechanism used by the previous researchers and also the open challenges are discussed based on their Research Articles. Finally, we also discuss future trends and the scenarios for the wireless network, and also highlighted the key issues that must still be addressed, like contention aware transmission, power requirements etc , for the performance of the wireless network and to improve the Quality of service.*

Keywords - *MAC, QOS, Throughput, Power Saving Requirements, Wireless Network.*

I. Introduction

The IEEE 802.11 standard for Wireless Networks (WLANs), commonly known as Wi-Fi, is developing technology for the last decade. The Earliest version of the IEEE 802.11 standard was realized in 1997 as a wire- less alternative for wired LANs using Ethernet technology. However, since its evolution, the IEEE 802.11 specifications are continuously developed to include functionalities and several amendments to the basic IEEE 802.11 standards. They have expanded across a wide variety of markets, including consumer, mobile and automobile industry [1]. WLANs are thus widely available everywhere (homes, public, industry and as public hot spots). Many Factors that have contributed to the success of the IEEE 802.11 family are interoperability, ease of use, and flexibility etc. Initially, the IEEE 802.11 standards were designed to be utilized within unlicensed spectrum bands, referred to as Industrial Scientific and Medical (ISM) bands, Exactly, Many IEEE 802.11 standards operates in 2.4 GHz and 5 GHz frequency bands, which are available globally, although some limitations apply to some of the aspects of their use. Thus, a WLAN can be deployed in those bands with a few basic constraints, such as maximum transmission powers are satisfied. On the other side, this also means that most WLANs are deployed in an uncontrolled fashion with restricted interference issues. This has made it challenging to guarantee of performance and hence on Quality of Service. This problem is further exaggerated by network densification, i.e., by deploying a large number of base stations in hotspot areas to cope with the increase in traffic demands [2]. A second Fundamental characteristic of the IEEE 802.11 standards is the adaptability of a media access control (MAC) protocol known as Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The main reason is that IEEE 802.11 is a half-duplex transmission, i.e., a station cannot carrier-sense/receive while it is sending, and it is difficult for them to detect a collision as in the case of transmissions over a medium. A major advantage of the CSMA/CA method is that channel access procedures are simple and inexpensive to implement, as they do not impose timing Constraints on the radio interface. On the other side, CSMA/CA protocols can only provide a best effort service and efforts have been devoted to the design of a mechanism for the provision of better Quality of Service , such as in the IEEE 802.11e amendment [3].

II. IEEE 802.11 Background

2.1 Distributed Coordination Function (DCF)

It is the mandatory MAC mechanism of IEEE 802.11 [1] WLANs Standard. It is based on carrier sense multiple access with collision avoidance (CSMA/CA).

The 802.11 MAC operates with a single first-in-first-out (FIFO) transmission queue. In this mechanism, if the stations want to send the data, it monitors the channel Continuously [5, 6] , If the channel is busy, the MAC waits till the channel becomes idle, then defers for an extra amount time , called the DCF Inter frame Space (DIFS). If the channel is idle during the DIFS deference, the MAC starts the back-off process by selecting a random back-off counter (or BC). For each slot time interval, during which the medium stays idle, the random Back-off counter is decremented. If a particular station does not get access to the medium in the first Phase, it freezes its back-off counter, waits for the channel to be free again for DIFS and starts the counter again. When the counter expires, the station accesses the medium. Hence the deferred stations don't choose a randomized back-off counter again but continue to count backward. Each station maintains a contention window (CW), which is used to select the random back-off counter. The Backward Counter is determined as a random integer drawn from a uniform distribution over the interval [0, CW]. However, under a light load, a small CW ensures shorter access delays .The timing of DCF channel access is illustrated in Fig. 1.

An acknowledgment (ACK) frame is sent by the receiver for the successful reception of every frame. The Contention Window size is initially assigned as CWmin and if a frame is lost i.e. no ACK frame is received for it, the CW size is doubled, with an upper bound of CWmax and another attempt with back-off is performed. After each successful transmission, the CW value is reset to CWmin.

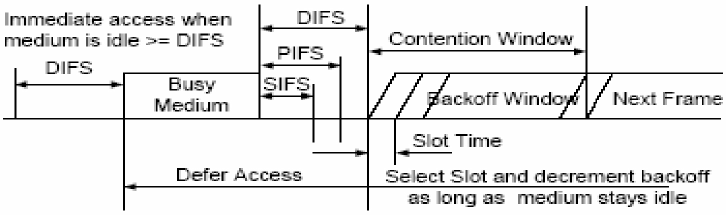

Figure 1: The timing relationship for DCF

2.2 Enhanced Distributed Channel Access (EDCA)

It is designed to provide QoS-prioritized by enhancing the contention-based DCF. It provides differentiated access to the medium for QoS stations using eight different user priorities classes [6,7]. Before entering the MAC layer, each data packet received from the higher layer is assigned a specific user priority Class. The EDCA mechanism defines four different queues, called access categories (ACs) that provide support for the delivery of traffic. Each data packet from the higher layer along with a specific user priority value should be mapped to a corresponding AC according to Table I.

Fig. 2 shows the implementation model with four transmission queues, where each AC behaves like a virtual station, it contends for access to the medium and independently starts its back-off after sensing the medium idle for at least AIFS. In EDCA a new type of IFS is introduced, the arbitrary IFS (AIFS), in place of DIFS in DCF. Each AIFS is an IFS interval with arbitrary length as follows:

$$AIFS\ [AC] = SIFS + AIFSN\ [AC] \times slot\ time$$

Where AIFSN [AC] is called the arbitration IFS number and determined by the Access Category, and the slot time is the duration of a time slot. The timing relationship of EDCA is shown in Fig 3. The AC with the smallest AIFS has the highest priority. The values of AIFS[AC], CWmin[AC], and CWmax[AC], which are referred as the EDCA parameters, are defined by the Access Points through beacon frames. The purpose of using different contention parameters for different queues is to give a low-priority class a longer waiting time than a high-priority class, so the high-priority class is likely to access the medium earlier than the low-priority class. An internal collision occurs when more than one AC finishes the back-off at the same time. In such a case, a virtual collision handler in every Station allows only the highest-priority AC to transmit frames, and the others perform a back-off with increased CW values.

TXOP-Transmission opportunity is defined in IEEE 802.11e as the interval of time when a particular Station has the right to start the transmissions, where a station transmits one data frame per TXOP transmission round.

Table I: Priority of access category mapping

Priority	Access Category	Traffic Class
0	0	Best Effort
1	0	Best Effort
2	0	Best Effort
3	1	Video probe
4	2	Video
5	2	Video
6	3	Voice
7	3	Voice

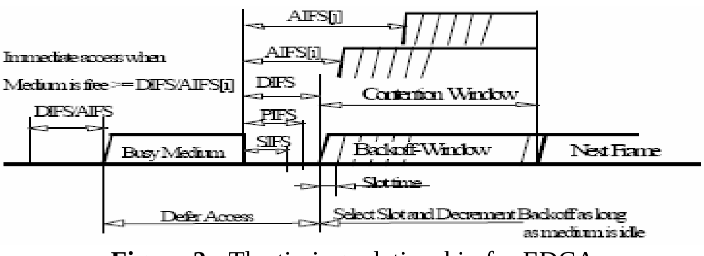

Figure 2: The timing relationship for EDCA

2.3 HCF Controlled Channel Access

It is a coordination function proposed by IEEE 802.11e to enhance both Distributed Coordination Function (DCF) and Point Coordination function (PCF). HCF uses two methods, the first method is contention-based and it is known as enhanced distributed channel access (EDCA), and the second method is contention-free access and it is known as HCF-controlled channel access (HCCA).

HCF uses the Access Point (AP) works as a traffic Controller which is termed as the hybrid coordinator (HC) which is a centralized coordinator. The HC negotiates the exchange of frames and the frame handling rules given in HCF. The HC is placed within the range of AP and works both in the contention-based and contention-free periods. The traffic is composed of wireless station "streams" or pipes, with each Station stream associated with a set of QOS parameters [8] negotiated with the AP. The AP uses a polling method to control the traffic. It sends polling packets to the stations. When a station is polled, it answers to the poll in a frame that contains the response and the frame to be transmitted. In this method, the polling is based upon the priority on which QOS has to be ensured [9,10] .

III. Current Trends and Future Directions

In recent years several MAC enhancements have been analysed to improve QoS guarantees for real-time multimedia applications in IEEE 802.11 networks [11]and the IEEE 802.11aa.In [12], standard, which was finalized 2012 , included several of this proposed enhancement. Research efforts have focused o*n* improving the transmission reliability of multicasting by integrating ARQ Approaches in IEEE 802.11 based multicast transmissions. Modifications to the MAC protocol were proposed in [12] to enable the RTS/CTS option in multicast mode and to select one or more multi- cast receivers (Known as *leaders*) for acknowledging multicast data packets. However, these enhancements need changes to the standard specifications. The main problems of leader-based ARQ schemes are leader election and the trade-off between scalability and reliability. The authors in [13] propose selecting the multicast receiver to operate in the worst channel conditions as the unique leader but this mechanism performs inefficiently in lossy transmission. In the Batch mode multicast MAC (BMMM) [14] every multicast recipient is polled by the multicast originator to send individual ACKs, but this scheme is not suitable for large multicast groups. The Enhanced Leader Based Protocol (ELBP) is proposed in [15] on the basis of multiple ACK leaders and block acknowledgment techniques. Analytical models are then developed to help select optimal ACK-leaders to meet application Quality of service requirements. However, the models apply only to heavy traffic while multimedia streams are typically bursty. Another class of reliable multicast protocols relies on busy tones to reduce packet losses due to collisions [16], but the additional radio interface is needed for the busy tone limits the practicality of such methods. An alternative approach to avoid collisions of multicast packets is the multicast collision prevention (MCP) scheme [17], which is based on the use of a shorter waiting time for transmitting multicast packets. An interesting approach is also proposed in [18], to retransmit lost packets using an online linear XOR coding algorithm. Despite, a modification to the standard MAC protocol is needed to enable simultaneous ACK transmissions. In summary, several different Approaches have been proposed to improve multicast transmission reliability by integrating ARQ schemes into the protocol architecture, but there are no conclusive results on which to get the best solution. The choice of the best and suitable mechanism depends on a variety of dependent factors, such as loss ratios, multi- cast group size, channel congestion and Quality of service requirements for multimedia streams. An analytical framework is needed to optimize the setting of the parameters for every scheme and to dynamically choose the best one. As discussed above one major difference between unicast and multicast services in IEEE 802.11 standard was the missing of acknowledgments. Another difference is that multicast frames should be transmitted using a *fixed* rate in the basic rate set while the transmission rate of unicast frames can be variably adapted to the channel and traffic conditions [19]. Fewer of research the paper has use of the rate adaptation to improve the throughput of multicast services in IEEE 802.11 networks [10, 20-23]. Authors in [20] propose a scheme using RTS frames to allow group members to estimate channel conditions. Each member will then send a dummy CTS frame with a length inversely proportional to channel quality. In this way, the multicast transmitter can use the collision duration to know the lowest data rate that can be used for group transmissions, but the overhead by this mechanism may be quite high, However, the solution mentioned in [21], called ARSM, also relies on feedback messages sent by the multicast receivers, called multicast response frames, to identify the group member exhibiting the poorest channel conditions. Although, in this case, a different back-off timer is associated with each multicast receiver depending on the Signal to Noise Ratio (SNR) of previously received feed- back message in order to prevent the possibility of collision. An approach similar to the one employed in the Auto Rate Fall-back (ARF) protocol also a rate adaptation scheme originally proposed in [23], is used in [22].Generally, the number of successful transmissions and transmission failures are also decided when to increase or decrease the transmission data rate. A modified ARF scheme is also investigated in [10], which can be applied to videos that are encoded into two layers, namely the base and enhancement layers. However, how to integrate rate adaptation with the different retransmission policies that are defined in IEEE 802.11 is still an open issue. One research area that is expected to be crucial in the successful development of IEEE 802.11 based products is the design of best scheduling algorithms for supporting voice/video traffic. The research work in this field has been improved by the IEEE 802.11e that enhanced the original IEEE 802.11 MAC layer with two new QoS-aware access mechanisms, i.e., EDCA[6] and HCCA [24]. In principle, with a well-designed admission control and scheduling scheme, HCCA is able to give QOS guarantees to traffic flows [25]. But, HCCA is rarely implemented in IEEE 802.11e-based WLANs due to its higher complexity and cost. Instead, EDCA is widely adopted. Most papers have thus Concentrating on improve EDCA performance. Many Research papers have proposed analytical models for various aspects of EDCA functionalities. For Example, a saturation-based performance analysis is conducted in [27] by differentiating the minimum back-off window size, the back-off contention window increasing factor, and the retransmission limit. The researchers of [28, 29] also models AIFS differentiation, while the model in [30] combine the four EDCA parameters for traffic differentiation. More recent research papers have analysed the EDCA performance for non-saturated conditions and for arbitrary buffer sizes [31]. The researchers in [32] have been developed an analytical model to predict the Quality of Service that can be obtained once a new voice/video stream is initiated in the Wireless local area network. A Kalman filter is proposed in [33] to estimates on the number of active transmission queues of each Access Category in EDCA. These analytical models can then be used to derive the optimal configuration of the EDCA parameters to achieve given performance criteria or to design admission control schemes that save the Quality of service constraints. For instance, a scheme that assigns contention window values to achieve pre-defined weighted- a fairness target is proposed in [34]. A control-theoretic scheme is also introduced in [35] with the goal of minimizing the video traffic delay. However, most of these solutions depend on non-realistic assumptions about video traffic dynamics. An alternative class of solutions is to dynamically update the EDCA parameters based on the observed network conditions. In [36], the EDCA parameters are optimized on relying on a WLAN with rigid and elastic traffic simultaneously, analyzing the interactions between both types of traffic. The authors in [37] specify several bandwidth-sharing mechanisms with guaranteed QOS for voice and video traffic. Measurement-based admission control schemes are proposed in [38]. A TXOP adaptation method is introduced in [39] that take into account video frame sizes and send queue lengths. However, the main drawback of these solutions is that they are based on heuristics and hence do not guarantee optimal performance. Finally, the third category of research papers tries to improve video performance by designing cross- layer scheduling approaches. Specifically, these works take benefits of multi-layer video encoding to classify the frames according to their importance and assign them to different access categories [40]. For instance, the authors in [41] define classifiers and waiting for time priority schedulers that dynamically changes the packet priorities according to end-to-end delay measurements. A drawback of this approach, however, is that an additional adaptation layer may be needed to implement the complex interactions that are typically required between the video coding applications and the MAC layer. We conclude this section by pointing out that present studies provide the basic design principles and techniques for improving multimedia streaming performance in IEEE 802.11 networks. Still, the IEEE 802.11aa standard poses new research challenges that have not been sufficiently explored and that will require innovative solutions. For Example, scheduling between primary and alternate queues are a remains an open research area, as the mapping of individual frames and the multiple queues in order to achieve graceful degradation of video/voice quality.

Table II: Performance Requirements for different HD streaming applications.

Type	Max data rate	Max latency
Uncompressed raw video	1.49 Gbit/s	100 ms
uncompressed HDTV	150 Mbit/s	150ms
Blue-ray Disc	54 Mbit/s	200ms
MPEG2	19.2 Mbit/s	300ms
HDTV	8-10 Mbit/	500ms

IV. Future Scenarios and Directions

Wireless LANs have become the part of our daily lives, They are almost used in homes, offices, Gardens , shopping malls , airports etc. and able to provide instant and reliable wireless access to the Internet for browsing the web, exchanging information , chatting, e-mails, and for low-quality real- time audio/video streams, are the certain examples ,and the scenario is changing rapidly as the number of persons and the objects are increasing exponentially every day resulting in Internet traffic[11]. Two major Factors change in Internet use are:

(i) The High demand for mobile devices multi-media content, motivated by the use of smartphones, Tablets , and other portable devices;
(ii) The increasing development of internet of things (IOT) Applications using the ubiquitous devices able

to collect data from the environment, ranging from low-power sensors to sophisticated connected cars. Therefore, Wireless networks must evolve to provide better solutions to these new upcoming scenarios, and the challenges they impose to satisfy their requirements.

Some of the key issues in Wireless Networks are discussed below.

4.1 High-quality multimedia content Transmission

Smart and mobile devices are designed to handle rich multimedia contents, including high-definition video and images. Table 2 describes the requirements in terms of maximum data rate and latency for some of the most common real-time video applications [42]. The Major factors, which has to supports the real-time video transmission is to include Internet TV and video streaming, Video conferencing etc. Similarly, scenarios in which multiple end users connect to the same Wireless network to transmit, different multimedia content at the same time are increasing every day. Despite, not all multi-media content are real time, stored video and image files can also be sent to different devices and can have different sizes ranging from a fewer of bits to several Gigabits hence requires a high network capacity in order to provide a good Quality of service to the End users. Although video encoding schemes already exists that offer video compression efficiency, such as H.264/MPEG- 4 AVC [43], wireless network must be able to achieve very high transmission rates and have content-aware approaches that are specifically designed for multimedia applications to ensure satisfactory service multimedia transmission. The mechanisms that are considered by various IEEE 802.11 standards satisfy those requirements are group-cast communication protocols, single and multi-user spatial multiplexing and channel bonding to make the communication very efficiently, and to offer higher QOS [11].

4.2 Power Saving Requirements.

Enormous Wireless protocol standards for M2M communications are Bluetooth, Zig-Bee, and BT-LE [11]. An alternative, created by mobile networks, is to connect devices in M2M systems directly to the Internet by using the cellular network infrastructure, for which the particular protocols are being developed [43]. Wireless Networks are conceptualized as an alternative to both multi-hop Wireless Sensor Network and cellular networks. However, current Wireless networks are not able to provide the minimum requirements for M2M communications [11, 44]. New specific power-saving approaches have to developed support the long periods of inactivity needed by the sensor/actuator devices and to manage the thousands of nodes associated with a single AP.

Also, there is a requirement needed to investigate the trade-off between QOS techniques and energy consumption. Due to limited battery resources, energy consumption is a major challenge in wireless networks and may further increase the problem in 802.11e networks. In EDCA, service differentiation can lead to longer waiting times depending on traffic priority classes, thus affecting energy consumption. However, depending on the scheduling scheme, stations must have to be awake to responds to the Access (AP) polls in the HCCA period. Mechanisms need to be developed that incorporate the battery resources and sleeping schedules of flows in the network.

4.3 Efficient utilization of the Spectrum

The ISM bands are used by Enormous wireless communication technologies, including IEEE 802.11 , IEEE 802.15.4 and Long Term Evolution (LTE) in an Unlicensed network. This resulted for high spectrum occupancy. Moreover, wireless networks working in the same spectrum band may suffer from mutual interference, which might degrade the performance of all the networks. This is further exacerbated by the uncontrolled deployment of WLANS in the ISM band, which is very common in advanced environments. For example, let us imagine a complex with several apartments and a WLAN in each one. There would easily allow many WLANs operate in overlapping medium and suffering mutual interference [45]. To overcome this issue, it is expected that new APs will increasingly incorporate DCA (Dynamic Channel Allocation technique is to select and update their operating channel/Medium at run-time.

An alternative Approach to increase the spectrum occupancy problem is to move to a different part of the spectrum, even if the new portion of the spectrum is occupied by communication systems operating under a license. In that case, Wireless networks will be the secondary users and must avoid causing interference to the primary users.

In today's scenarios, the change from analog to digital TV broadcast transmission has resulted in a reorganization of the spectrum at UHF/VHF bands. This reorganization has shown that there are many empty TV channels, called TV white spaces, which can be used for data communication, especially in underdeveloped areas /rural areas [46]. Furthermore, WLANs operating in those TV white spaces may take the advantage of radio propagation properties in the UHF band to provide large coverage areas. Here the challenge is to use a CSMA/CA protocols in UHF/VHF bands, as well as how to obtain Throughput when the spectrum is fragmented.

V. Conclusions

In conclusion, in this article, we provide an overview of challenges facing the wireless network on Quality of service and provided a survey of techniques associated with these efforts and proposed some solutions depending upon the previously surveyed articles.

Finally, discussed future scenarios and direction which is occurring in the development of the wireless network and the issues which may occur on the performance of the wireless network and hence on the Quality of Service.

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