A Performance Evaluation of the Quality of Service (Wireless LAN) Standard IEEE 802.11e

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Abstract

At present, the IEEE 802.11 standard is the most successful WLAN technology in the world, due to its cheap cost and easy deployment. But it does not support QoS. The QoS is referred as the quality of the data traffic over a network. Multimedia applications demand consistent QoS support in terms of bandwidth and delay. Unfortunately, 802.11 is incapable to fulfill these requirements due to deficiency in providing QoS support. An enhanced version 802.11e was released to introduce QoS support by differentiating applications based on their QoS requirements. This master thesis presents an overview of 802.11 and its limitations in providing QoS support. It explains the enhanced version 802.11e and how these limitations are overcome in it. This master thesis also discusses the performance evaluation of 802.11 and 802.11e with the help of simulation scenarios in GloMoSim. The scenario results show the QoS support of 802.11e for different types of data traffic due to its service differentiation technique.

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Contents

1 Background of the Problem **1**

1.1 Background . . . 1

1.2 Goal of Thesis . . . 1

1.3 Thesis Outline . . . 2

2 An Overview of IEEE 802.11 **3**

2.1 Introduction . . . 3

2.1.1 Distributed Coordination Function (DCF) . . . 4

2.1.2 Point Coordination Function(PCF) . . . 5

2.1.3 How DCF Works: An Example . . . 5

3 Limitations of IEEE 802.11 regarding to Quality of Service **7**

3.1 Introduction . . . 7

4 An Overview of IEEE 802.11e **9**

4.1 Introduction . . . 9

4.2 Hybrid Coordination Function (HCF) . . . 9

4.3 EDCA(Enhanced Distributed Channel Access) . . . 10

4.3.1 ACs (Access Categories) . . . 10

4.3.2 Enhanced Distributed Channel Access Function (EDCAF) . . . 10

4.3.3 Example of EDCA Access Mechanism . . . 11

5 Evaluation **13**

5.1 Introduction . . . 13

5.2 GloMoSim . . . 13

5.3 DCF vs. EDCA Performance Comparison . . . 14

5.3.1 Scenario 1 . . . 14

5.3.2 Scenario 2 . . . 16

6 Summary **19**

6.1 Summary . . . 19

A List of Abbreviation **21**

List of Figures

2.1 IEEE 802.11 System Architecture 3
2.2 DCF Access Mechanism 4
2.3 Example of DCF Mechanism 5

4.1 EDCA Access Mechanism 11

5.1 Throughput Comparison IEEE 802.11 and IEEE 802.11e, Scenario 1. . . 14
5.2 Aggregated Throughput Comparison IEEE 802.11 and IEEE 802.11e, Scenario 1. 15
5.3 Delay Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 1 . . 15
5.4 Throughput Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 2. 16
5.5 Aggregated Throughput Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 2. 17
5.6 Delay Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 2. . . 17

List of Tables

4.1 UP to AC Mapping 10
4.2 EDCA Parameter Values 11

5.1 Data traffic properties 13

Chapter 1

Background of the Problem

1.1 Background

The IEEE 802.11 wireless local area network (WLAN)nowadays is the most popular wireless technology of the world. It supports a data rate of 11 to 54 Mbps. The medium access control (MAC) protocol of IEEE 802.11, called Distributed Coordination Function (DCF), is based on the carrier sense multiple access algorithm. The IEEE 802.11 is becoming more and more popular due to its low cost and easy installation, but unfortunately it does not support Quality of Service (QoS). The Quality of Service refers to the capability of a network to provide data transfer with good quality. The QoS is often measured in terms of the available bandwidth, delay in data transfer and data loss. Basically the MAC protocol of 802.11 treats all types of data traffic in the same way, on first come first served basis, regardless of the QoS requirements of the data traffic. The QoS requirements of the data traffic vary from application to application. Modern multimedia applications are very sensitive to the available bandwidth, and delay in data transfer. Some examples are, video and audio streaming, Internet telephony and on line network games. This inability of 802.11 in providing QoS support is therefore a big hurdle in the success of multimedia applications over these networks. For this reason, a large amount of research work has been conducted in recent years to provide QoS support in IEEE 802.11 networks. An enhanced version of 802.11, called IEEE 802.11e has been designed to provide QoS support.

1.2 Goal of Thesis

The master thesis presents a performance evaluation of the IEEE 802.11e and IEEE 802.11 in order to support multimedia applications. The final draft of the IEEE 802.11e has been released. The main task is to study what kind of enhancements made in IEEE 802.11e and understand the performance of IEEE 802.11e EDCA by comparing it with the IEEE 802.11 DCF in order to support multimedia traffic. The IEEE 802.11e MAC utilizes a channel access function, called Hybrid Coordination Function, which includes both a contention-based channel access and a centrally-controlled channel access mechanisms. The contention-based channel access is also called Enhanced Distributed Coordination Access (EDCA) and is a priority scheme. The goal of this thesis is to evaluate the performance of high priority traffic over these networks. Simulations will be used to compare EDCA and DCF mechanisms in GloMoSim [6].

1.3 Thesis Outline

Thesis report discusses the IEEE 802.11, its weaknesses in providing QoS support and how QoS is introduced in the IEEE 802.11e. Thesis report is arranged as follows: Chapter 2 provides an overview of the IEEE 802.11 and its basic access mechanism. Chapter 3 discusses QoS limitations of IEEE 802.11. Section 4 presents an overview of the IEEE 802.11e, its access mechanism and how QoS is supported by introducing service differentiation. Chapter 5 discusses about GloMoSim and the performance evaluation of IEEE 802.11 and IEEE 802.11e, by comparing them with the help of real time simulation scenarios. Finally, the summary of the thesis report is discussed.

Chapter 2

An Overview of IEEE 802.11

2.1 Introduction

The IEEE 802.11 WLAN standard was released in 1997[1] by The IEEE (Institute of Electrical and Electronics Engineers). It gained tremendous popularity after its release. It describes the specifications for the MAC and physical layer. It also describes different types of physical layer specifications which are FHSS (Frequency Hopping Spread Spectrum), DSSS (Direct sequence spread spectrum) and IR (Infrared). FHSS and DSSS physical layers operate in the license free 2.4GHz ISM(Industrial, Scientific and Medical) frequency band. These three layers support data transmission rates up to 2Mbps. In 1999, the IEEE introduced two new versions IEEE 802.11a[2] and IEEE 802.11b[3]. The IEEE 802.11a operates on Orthogonal Frequency Division Multiplexing (OFDM) and provides a data rate from 11 to 54 Mbps in the 5GHz frequency band. The IEEE 802.11b is based on DSSS. It operates in the 2.4 GHz frequency band and supports 54 Mbps data transmission rate. The IEEE 802.11g[4] was launched by improving the physical layer specifications of IEEE 802.11b in the 2.4 GHZ frequency band. The IEEE 802.11g standard provides data rate of 54Mbps. Today, the IEEE 802.11 has become an enormously popular wireless technology and has been deployed in offices, hotels and airports. It is incapable in providing QoS support to different application because of no priority mechanism. The IEEE 802.11 standard comprises of two different basic structures. Figure 2.1 illustrates the architecture of IEEE 802.11.

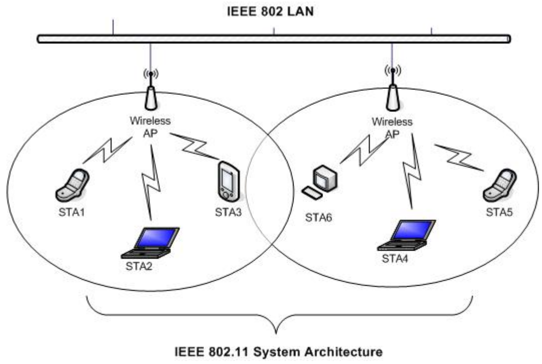

Figure 2.1: IEEE 802.11 System Architecture

These structures are the Basic Service Set (BSS) and the Independent Basic Service Set (IBSS)[9]. A number of wireless stations are connected with an Access Point which is responsible for communication between these stations. In an IBSS, wireless stations are able to communicate with each other, within a provided transmission range. The fundamental access methods are called the Distributed Coordination Function (DCF) and the Point Coordination Function (PCF) and are explained in the next section. In this section, a short overview of the DCF is described.

2.1.1 Distributed Coordination Function (DCF)

The DCF is the basic access mechanism of the IEEE 802.11 WLAN standard which is based on the Carrier Sense Multiple Access (CSMA) algorithm and works as a listen-before-talk scheme. Listen before talk scheme means when a station senses the medium before transmission. Figure 2.2 describes the DCF basic access mechanism. When a station senses and finds the medium idle for the DCF Inter frame Space (DIFS) time period, the station will start the packet transmission. On the other hand, if the medium is sensed busy during the DIFS time period by a station, it postpones its access to the medium and selects a random backoff value.

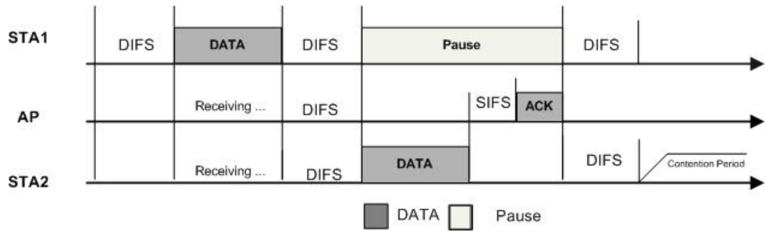

Figure 2.2: DCF Access Mechanism

The random backoff value is specified as the extra time, a station has to wait before trying to access the medium idle again after DIFS time period. If the station finds the medium idle again, it will start decreasing the backoff time. During the backoff procedure, if the medium becomes busy, the station will pause its backoff timer until the medium becomes idle again. When the backoff value becomes zero, the station can transmit the frame. The random backoff time is used to prevent collisions. If two or more stations find the medium idle and transmit their frames at the same time then a collision will occur. To prevent this situation, stations have to wait and choose a random backoff time.

This technique is called Collision Avoidance (CA) and hence the whole mechanism is called CSMA/CA. When a receiver station receives a packet from the sender side, an ACK frame is sent back to acknowledge the sender after the Short Inter Frame Space (SIFS) time period. The IEEE defined three IFS (Inter frame Space) time periods which are SIFS, DIFS in DCF and Point Inter Frame Space (PIFS) in PCF to control the medium access. The DIFS is the largest IFS and SIFS is the shortest IFS. Relying on the priority of the frame exchange sequence, continuous frame transmissions can be divided by these inter frame spaces. Greater the priority of a frame exchange sequence the shorter the inter frame space used between frames. The random backoff value is selected uniformly from the range (0, CW) where CW is called Contention Window. The contention Window (CW) is set to minimum CWmin and becomes doubled every time a transmission fails, until it reaches its maximum size CWmax.

It will reset again after every successful transmission. Physical Carrier Sensing and Virtual Carrier Sensing are used to investigate the access to the medium. Virtual Carrier Sensing is used at the MAC layer. When a station receives a frame at MAC layer which is not addressed to itself, it will observe the time from the frame header where the frame header explains the time require for the transmission of the frame. Then it defers the medium access for that particular time period. On the other hand, with Physical Carrier Sensing, the station senses itself at physical layer[10, 8].

2.1.2 Point Coordination Function(PCF)

Point Coordination Function (PCF) is also an access mechanism of the IEEE 802.11 which is based on centrally controlled medium access. The AP works as a coordinator called the PC (Point Coordinator) and provides contention free channel access to the medium for individual stations by polling them for transmissions.

2.1.3 How DCF Works: An Example

In this Figure 2.3, the DCF mechanism is illustrated with the backoff procedure. STA1, STA2 and STA3 stations are contending for the medium. As shown in the figure, STA1 senses the channel and the medium is found idle. STA1 starts the packet transmission, in the meantime STA2 and STA3 try to sense the medium for transmission but find the medium busy. Both stations defer their access and waits for a complete exchange of transmission (DATA +SIFS +ACK).

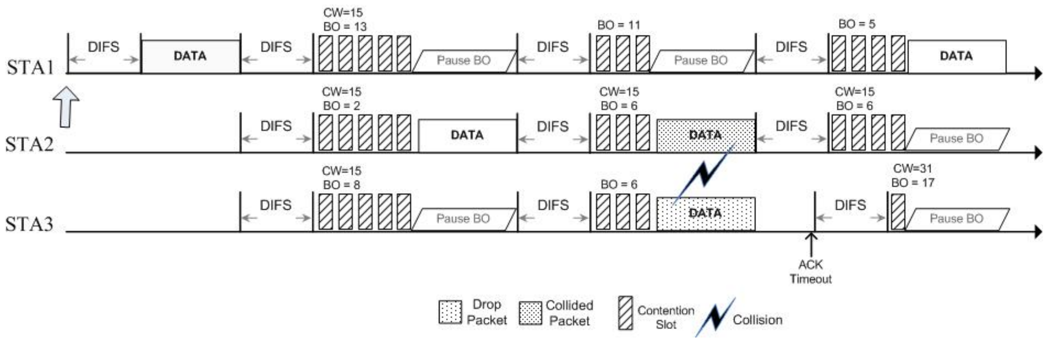

Figure 2.3: Example of DCF Mechanism

After the transmission is finished, the medium becomes idle. All stations wait for a DIFS time period and then they select the random backoff value. The figure depicts that the values selected by STA1, STA2 and STA3 are 13, 2, and 8 respectively. Now, the backoff procedure starts to decrementing the backoff value. The STA2 reaches zero and wins the channel access for transmission.

STA1 and STA3 pause their access and waits for an idle medium. When medium becomes idle again, the stations choose the backoff values after a DIFS time period. The selected backoff values of STA1, STA2 and STA3 are 11, 6, and 6 for this time. Here, STA2 and STA3 try to transmit the packet at the same time after the backoff values reache to zero, which leads to a collision as shown in the figure 2.3.

STA2 and STA3 do not know about the collision, and wait for an ACK. Since no ACK is received before the ACK time out, both stations assume that a collision has happened and double their CW values. The chances of STA1 of winning the medium access increases because of not doubling its CW value. It proceeds counting from its paused state and so on.

Chapter 3

Limitations of IEEE 802.11 regarding to Quality of Service

3.1 Introduction

The QoS is a networking term which describes a set of properties like bandwidth use, jitter, delay, packet loss, and throughput. The QoS is stated as quality of the data traffic over a network. Since, QoS requirements differ from application to application and all applications have particular QoS requirements. A network which is capable of fulfilling each application's QoS requirements is called QoS supported network. The QoS requirements are organized in three types such as bandwidth, delay and data loss [7, 11, 10].

1. Bandwidth: Bandwidth is an important parameter. The amount of data that can be transfered during a given time period is referred to the Bandwidth. On receiving high bandwidth, applications are able to deliver data in large amount. Bandwidth sensitive applications are those application which require consistent data rate and any change in bandwidth may cause in the form of data loss and unnecessary delays. Some examples of Bandwidth Sensitive applications are Internet telephony and video conferencing.

2. Data Loss: Elastic applications such as email, web pages and file transfer are usually classified as loss tolerant applications. These applications are capable to tolerate low bandwidth and undesired delays but demand a constant transfer of data. Multimedia applications are organized as bandwidth and delay sensitive but usually are loss-tolerant. These applications require constant bandwidth and delay assurance. These application can severely be affected due to data or packet losses.

3. Delay: Multimedia applications are considered as delay sensitive applications. Some examples are video conferencing, Internet telephony and VOIP (Voice over IP). These application can be suffer due to an increase in delay. Therefore, strict constraints are applied on these applications in terms of delay and bandwidth.

The IEEE 802.11 standard serves as best effort service model. All kinds of data traffic is treated on first come and first served basis regardless of their QoS requirements. It can not classify applications on the basis of their QoS requirements. The bandwidth sensitive applications have priority over delay sensitive applications regarding to bandwidth. The inability in providing QoS is a big barrier in the success of 802.11. Currently, the IEEE 802.11e standard has been launched which is called QoS supported network.

Chapter 4

An Overview of IEEE 802.11e

4.1 Introduction

To provide quality of service (QoS) support, the IEEE carried out a large amount of research work on the IEEE 802.11 MAC. Then a newly improved version IEEE 802.11e was released [5]. A priority mechanism has been introduced in the enhanced version to facilitate the QoS support. It deals with each type of data traffic according to their QoS requirements. Applications can be categorized in four Access Categories (AC) on the basis of their QoS requirements. Every frame with a specific priority of data traffic is then assigned to one of these access categories. For each AC, service differentiation is defined by utilizing a different set of contention parameters to get the medium access. In IEEE 802.11, QoS Access Point (QAP) and QoS station (QSTA) provide QoS and also the Basic Service Set is called QoS Basic Service Set (QBSS).

4.2 Hybrid Coordination Function (HCF)

HCF is the latest centralized coordination function introduced by the IEEE 802.11e. It combines the features of Distributed medium access like DCF and centrally controlled medium access like PCF with improved QoS techniques. HCF defines two types of access mechanisms, The distributed contention-based channel access mechanism is called EDCA (Enhanced Distributed Channel Access) and the centrally controlled contention-free access mechanism is called HCCA (HCF Controlled Channel Access). In this chapter, the focus is on the EDCA.

4.3 EDCA(Enhanced Distributed Channel Access)

The EDCA mechanism is an enhanced version of the DCF mechanism, which provides distributed medium access with the help of access categories (ACs).

4.3.1 ACs (Access Categories)

The EDCA describes four ACs to handle with several types of data traffic. The four access categories AC_BK, AC_BE, AC_VI, and AC_VO are introduced for Voice, Video, Best Effort and Background. Frames are then mapped according to their QoS requirements on their particular AC's where AC_Vo and AC_BK have the highest and the lowest priority respectively.

When a frame reaches the MAC layer, it has a certain priority value which is called User Priority (UP). User Priority of the frame is mapped to its related AC. There are eight different priorities assigned to ACs, which are listed in Table 4.1.

AC	UP	Priority
AC_BK	1	Lowest
AC_BK	2	.
AC_BE	0	.
AC_BE	3	.
AC_VI	4	.
AC_VI	5	.
AC_VO	6	.
AC_VO	7	Highest

Table 4.1: UP to AC Mapping

4.3.2 Enhanced Distributed Channel Access Function (EDCAF)

EDCAF is an improved version of DCF which contends for the medium access on the basis of the specified parameters of an AC. EDCAF parameters which are related to an AC for the medium access are as follows[10]:

1. Arbitration Inter Frame Space (AIFS) AIFS is the minimum time period during which the medium is found idle before transmission of frames. The following equation is used to derive the AIFS.

   AIFS=AIFSN x aSlotTime + aSIFSTime

   Where AIFSN(Arbitration Inter Frame Space Number) refers to length of the AIFS, SlotTime refers to the slot time and SIFSTime is the SIFS time period. Higher priority ACs have to wait for less time before starting transmissions because of their smaller AIFS values. In the case of low priority ACs, they have to wait for longer time and may suffer from long delays because of their higher AIFS values.

2. CWmin and CWmax: The maximum and minimum contention window size varies between ACs. Lower priority ACs have larger CWmin and CWmax values while

higher ACs have smaller CWmin and CWmax values. Therefore, for an AC with a small contention window, the EDCAF related to that particular AC will pick a small random backoff value. In this way, the EDCAF has to wait for a very short AIFS time period when medium becomes idle. The CWmin values for the high priority ACs are half or quarter of the low priority ACs. As high priority ACs select small backoff values, there are very short delays to access the medium. Due to the small CWmin sizes, high priority ACs experience a large number of collisions. Table 4.2 expresses the EDCA parameter values.

ACs	CWmin	CWmax	AIFSN
AC_BK	31	1023	7
AC_BE	31	1023	3
AC_VI	15	31	2
AC_VO	7	15	2

Table 4.2: EDCA Parameter Values

4.3.3 Example of EDCA Access Mechanism

Figure 4.1 illustrates the EDCA access mechanism. The EDCA access mechanism has different sets of parameters for different ACs. When the medium becomes idle for an AIFS time period, the EDCAF selects a random number called backoff (BO) value and begins decreasing the backoff timer. When the backoff timer reaches zero, the transmission is started.

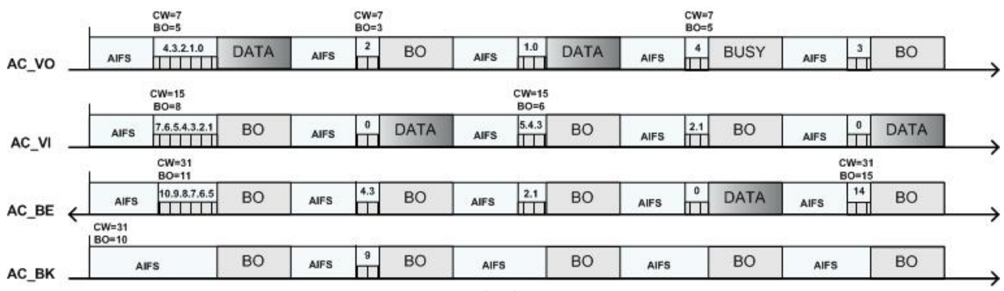

Figure 4.1: EDCA Access Mechanism

Considering figure 4.1, we can see that the high priority ACs, AC_VO and AC_VI have smaller values of AIFS and contend for the medium more quickly compared to the low priority ACs, AC_BE and AC_BK. This is the first benefit the high priority ACs have. Secondly high priority ACs also have smaller CW sizes as compare to low priority ACs. According to the sizes of CWs, a random number is selected (BO). In the context of small values of AIFS and BO, the high priority ACs have more access to the medium as compared to the low priority ACs. This means, that high priority ACs achieve a large bandwidth share.

In figure 4.1, the high priority ACs choose small BO values and reach zero first and start the transmission where low priority ACs pause their backoff timers. Every time EDCAF of AC_VO and EDCAF of AC_VI choose small BO from the fixed CW sizes, '7' and '15', respectively. High priority ACs EDCAF win the medium access and low priority ACs suffer from their large AIFS time periods.

The selection of different BOs from different CW sizes reduce the probability of collisions among stations. But still there is a possibility that the EDCAF of low priority AC and EDCAF of high priority AC choose the same BO values, which causes a collision.

Chapter 5

Evaluation

5.1 Introduction

This chapter presents a short overview of the GloMoSim [6]. It also describes the performance comparison of IEEE 802.11 and IEEE 802.11e in order to support QoS requirements of different applications. The data traffic types and their properties are shown in the Table 5.1. The evaluation of the EDCA and DCF performance is observed by considering some real time scenarios. The performance metrics used are stated below.

- Throughput: The amount of data delivered over a network in a specific time. It is directly proportional to the available bandwidth/capacity and is shown in bits per second.
- Delay: It is measured from the time at which a sender sends a packet to the time at which a receiver receives the packet.
- Aggregated Throughput: It is the throughput of the whole network.It is measured by addition of throughputs of different traffic streams.

ACs	pkt Size (Bytes)	Rate (Kbps)	Interval (ms)
AC_BK	1024	76	107.8
AC_BE	1024	112	73.1
AC_VI	1460	96	122
AC_VO	80	28	22

Table 5.1: Data traffic properties

5.2 GloMoSim

Global Mobile Information System Simulator (GloMoSim) is a scalable network simulation environment developed at the UCLA Parallel Computing laboratory. By using parallel execution, GloMoSim achieves scalability to reduce simulation time. The GloMoSim is written in PARSEC, a C based language and is an event discrete simulator.

It is built by using a layered architecture approach similar to the OSI (Open Systems Interconnection) layered architecture. It works as a powerful simulator, that can simulate a wide range of protocols and models at different layers. Parallel and sequential executions of event discrete simulations are supported as well.

The simulation depends on handling discrete events. Execution contains a set of events and an event causes a change in the state of the system. A particular event or combination of events may activate other events and so on, this is how the simulation proceeds. A node movement, a packet reception can be an event. It is free for educational purposes but supports only the sequential simulations.

5.3 DCF vs. EDCA Performance Comparison

5.3.1 Scenario 1

A simple scenario is considered in order to provide a comparison of the IEEE 802.11 DCF and the IEEE 802.11e EDCA. The aim is to observe the performance of individual ACs and how data traffic related to a specific AC is treated and also to evaluate the performance of the IEEE 802.11e EDCA and 802.11 DCF. Just for revision, in the IEEE 802.11e EDCA, all traffic streams are served related to their ACs. There is no priority mechanism in the IEEE 802.11 DCF, all traffic streams are treated with the same way. The number of stations are used from 1 to 30 which are transmitting all four type of data traffic. In this scenario, there are three station for the high priority traffic streams (Voice and Video). The rest of the stations are for the Low priority traffic (Best Effort and Background), and are increased gradually from 4 to 30. The performance metrices are considered aggregated Throughput, throughput and delay.

Results

It is obvious from the results in figure 5.1 that the 802.11e EDCA defines service differentiation successfully through different ACs while the IEEE 802.11 DCF serves all kinds of traffic streams in the same way.

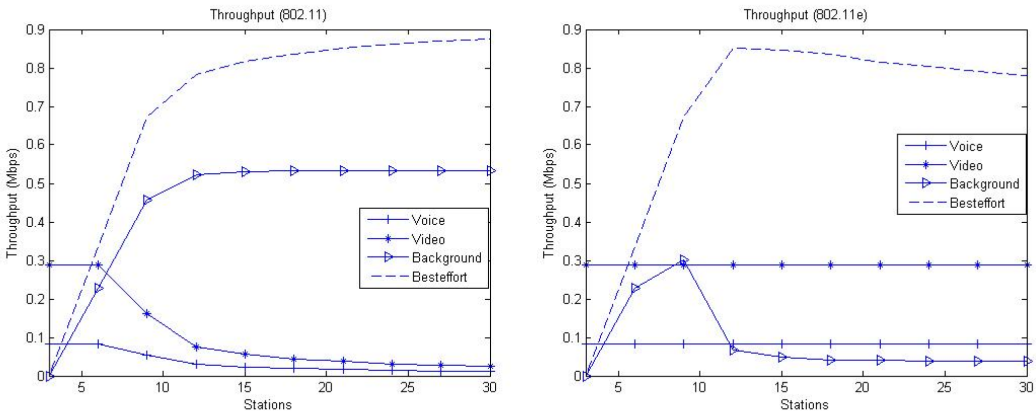

Figure 5.1: Throughput Comparison IEEE 802.11 and IEEE 802.11e, Scenario 1.

Figure 5.1 depicts that, in the IEEE 802.11, throughput of high priority traffic streams are consistently decreased and the throughput of low priority traffic streams are increased continuously with the addition of low priority stations. In IEEE 802.11e, due to its service differentiation mechanism, throughput of high priority traffic streams remains constant, as there is no effect of change throughput with the addition of low priority stations. Concerning to low priority traffic streams, the throughput of AC_BE is sharply increased up to station 12 and after that it is decreased slowly. The throughput of AC_BK is also increased to the 10th station but severely dropped at the 12th station. After the 12th station, the throughput has started decreasing.

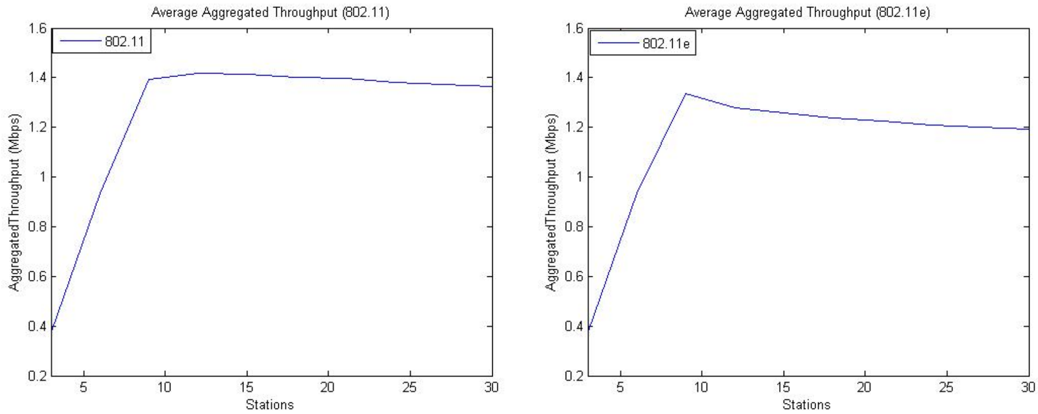

Figure 5.2: Aggregated Throughput Comparison IEEE 802.11 and IEEE 802.11e, Scenario 1.

The aggregated throughput results in figure 5.2 shows that 802.11e provides improved throughput as compared to IEEE 802.11. Considering the scenario, the IEEE 802.11 shows stable aggregated throughput but IEEE 802.11e throughput starts decreasing.

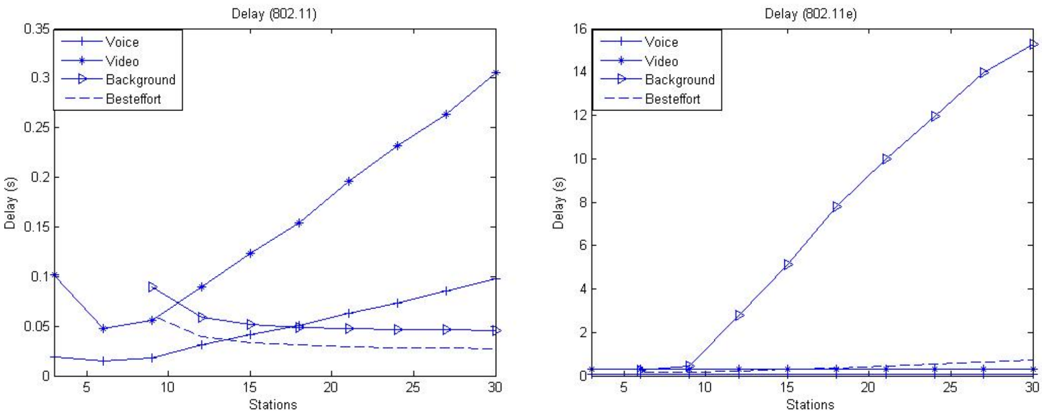

Figure 5.3: Delay Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 1

Delay results are presented in figure 5.3, which describe that the high priority traffic suffer more delays compared to low priority traffic in the 802.11 due to the lackness of the QoS support mechanism. AC_VI experiences delay which starts increasing subsequently and AC_VO also suffers delay which increases afterward, but low priority traffic do not suffer as high priority traffic do. In the IEEE 802.11e, AC_VO and AC_VI (High Priority Traffic) do not suffer longer delays because of their CWmin and CWmax values as compared to AC_BE and AC_BK (Low Priority Traffic). The delay for AC_BK begins increasing, but at the same time, AC_BE experiences a very mall delay.

5.3.2 Scenario 2

Scenario 2 is similar to Scenario 1, except that initially there are first 6 station for Voice and Video traffic. The number of stations in this scenario are increased from 7 to 60 and reserved for best effort and background traffic. First six stations only transmit Video and voice traffic, but rest of the stations transmit best effort and background streams. the main aim is to observe the performance of high priority traffic with increasing number of stations of low priority traffic. The performance metrices studied are throughput, aggregated throughput and delay.

Results

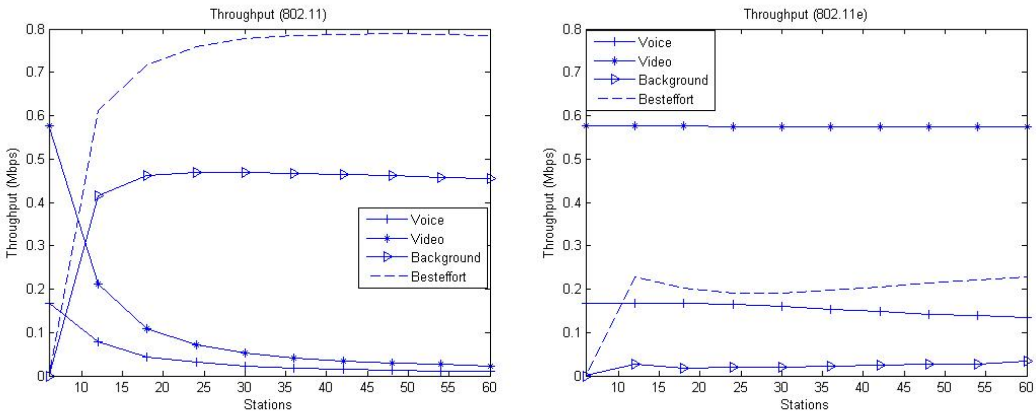

Figure 5.4: Throughput Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 2.

Figure 5.4 shows the throughput results for IEEE 802.11 and IEEE 802.11e to compare the results of traffic streams with different bit rates. The figures 5.4 show the efficiency of the IEEE 802.11e QoS mechanism clearly that Voice and Video traffic streams achieves consistent throughput and there in no effect of addition in best effort and background ACs. While in IEEE 802.11, best effort and background traffic starts to increase and voice and video traffic starts to drop.

Figure 5.5 shows aggregated throughput results of IEEE 802.11 and IEEE 802.11e. In the IEEE 802.11e, aggregated throughput is less than 1 Mbps, but in the IEEE 802.11, it is more than 1 Mbps.

Here we can observe from the Figure 5.6 that in IEEE 802.11, due to increase in low priority stations, voice and video traffic suffer from longer delays but low priority traffic suffer from very small delays. From the results, we can examine that in 802.11e, delays for voice and video traffic stay under satisfactory limits while best effort and background streams experience longer delays.

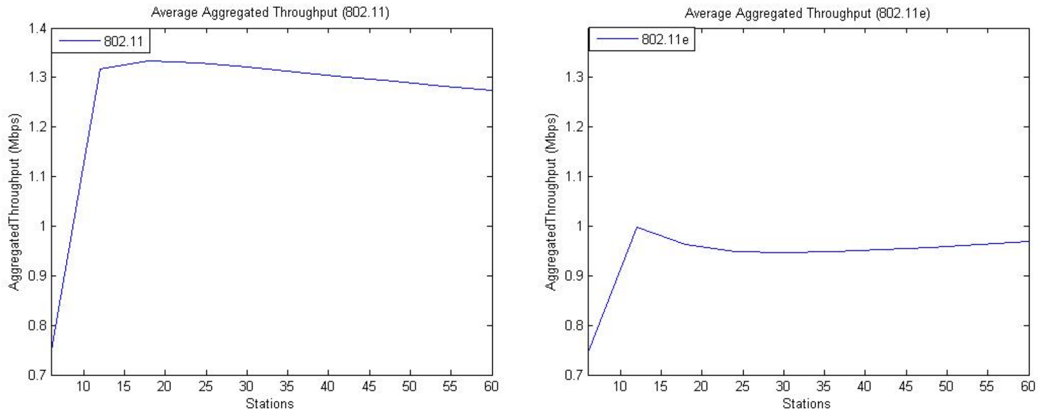

Figure 5.5: Aggregated Throughput Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 2.

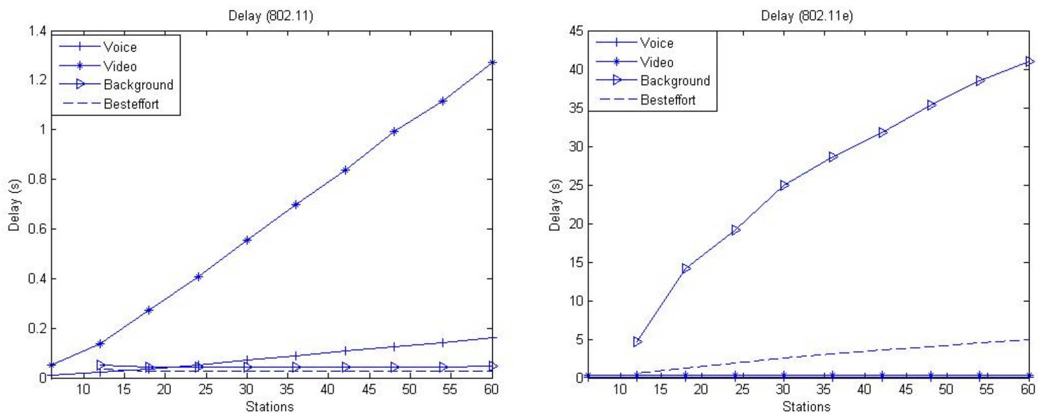

Figure 5.6: Delay Comparison of the IEEE 802.11e and IEEE 802.11, Scenario 2.

Chapter 6

Summary

6.1 Summary

The IEEE 802.11 standard was released in 1997. It has become most well known WLAN technology due to its simplicity, ease of deployment and low cost. Three versions of 802.11 were also introduced to support maximum data rates of 11 to 54 Mbps. The two fundamental access mechanisms of the IEEE 802.11 are called DCF and PCF. The DCF is a distributed medium access mechanism based on CSMA while in PCF, access to medium is centrally controlled by the AP. In DCF, a station senses the medium and if it is found idles for DIFS time period, it starts the transmission.

When the medium becomes busy, it chooses a random BO value and waits for the medium until it becomes idle again. The random BO value is selected in the range of (0, CW), where CW is called the contention window. The limitation in the IEEE 802.11 DCF is that, it does not provide QoS support. The QoS is the capability of a network to provide data traffic with good quality. The term QoS defines a set of quantitative and qualitative characteristics like bandwidth, delay and data loss.

The QoS requirements vary from application to application. Unfortunately, In DCF, all type of applications are served on a first come and first serve basis. The IEEE 802.11 is unable to differentiate between the applications on the basis of their QoS requirements. A recently released version of the IEEE 802.11 is called the 802.11e, which provides support for QoS by introducing a service differentiation mechanism. Four ACs are defined to serve applications. Data traffic from different applications are mapped to these access categories on the basis of their QoS requirements. The EDCA uses different medium access parameters for different access categories to support the QoS.

This thesis also concludes a performance comparison between the EDCA and the DCF mechanisms in order to support QoS requirements for different type of data traffic. The results show that all types of data traffic are treated equally in the IEEE 802.11 DCF which causes lackness in QoS support. Conversely, the IEEE 802.11e treats all data traffics on the basis of their QoS requirements and priority. Two scenarios are simulated in order to compare EDCA and DCF performance concerning to support the QoS. There are 30 stations and then 60 stations have been taken in scenario 1 and scenario 2 respectively. In the 1st scenario, initially 3 stations are transmitting voice and video traffic and the remaining stations are transmitting low priority traffic of best effort and background traffic.

Similarly, in second scenario, first 6 stations are transmitting high priority traffic and rest of them are transmitting low priority traffic. It is very clear from the results that EDCA performs better and provides service differentiation mechanism for different types of data traffic, while lacking of priority mechanism, DCF serves each application in the same way apart from their QoS requirements. There are three performance metrics are used to evaluate the performance of EDCA and DCF which are throughput, delay and aggregated throughput.

Appendix A

List of Abbreviation

Abbreviation	Designation
AC	Access Category
AC_VO	Access Category Voice
AC_VI	Access Category Video
AC_BE	Access Category BestEffort
AC_BK	Access Category BackGround
AIFS	Arbitration Inter Frame Space
AP	Access Point
BO	Back off
CSMA/CA	Carrier Sense Multiple Access / Collision Avoidance
CW	Contention Window
CWmax	Contention Window Maximum
CWmin	Contention Window Minimum
DCF	Distributed Coordination Function
DIFS	DCF Inter Frame Space
DSSS	Direct Sequence Spread Spectrum
EDCA	Enhanced Distributed Channel Access

EDCAF	Enhanced Distributed Channel Access Function
GloMoSim	Global Mobile Information System Simulator
HCCA	HCF Controlled Channel Access
HCF	Hybrid Coordination Function
IBSS	Independent Basic Service Set
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
MAC	Medium Access Control
Mbps	Mega bit per second
OFDM	Orthogonal frequency-division multiplexing
PCF	Point Coordination Function
QoS	Quality of Service
SIFS	Short Inter Frame Space
STA	Station
UCLA	University of California, Los Angeles
WLAN	Wireless Local Area Network

References

[1] IEEE Std. 802.11, Part 11: *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.* 1997.

[2] IEEE Std. 802.11a, Supplement to Part 11: *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 5 GHz Band.* 1999.

[3] IEEE Std. 802.11b, Supplement to Part 11: *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band.* 1999.

[4] IEEE Std. 802.11g, Supplement to Part 11: *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher-Speed Physical Layer Extension in the 2.4 GHz Band.* 2003.

[5] IEEE 802.11e/D13.0, Draft Supplement to Part 11: *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Medium Access Control (MAC) Quality of Service (QoS) Enhancements.* January 2005.

[6] R. Bagrodia and X. Zeng. Glomosim, A Library for the Parallel Simulation of Large Wireless Networks. *Proceedings of the 12th Workshop on Parallel and Distributed Simulation (PADS 98)*, pages 154–161, 1998.

[7] Albert Banchs, Arturo Azcorra, Carlos Garcia, and Ruben Cuevas. *Applications and Challenges of the 802.11e EDCA Mechanism: An Experimental Study*. In *IEEE Network*, volume 19, July 2005.

[8] Giuseppe Bianchi. *Performance Analysis of the IEEE 802.11 Distributed Coordination Function*. In *IEEE JSAC*, volume 18, pages 535–547, March 2000.

[9] D.J. Deng and R.S. Chang. A priority scheme for IEEE 802.11 DCF access method. *IEICE Trans. Commun*, 82:96–102, 1999.

[10] Jahanzeb Farooq and Bilal Rauf. *Implementation and Evaluation of IEEE 802.11e Wireless LAN in GloMoSim*. Department of Computing Science, Umea University, Umea, Sweden, 2006.

[11] Thomas Nilsson. *Resource Allocation and Service Differentation in Wireless Local Area Networks.* Licentiate Thesis, Dept. of Computing Science, Umeå University, June 2005.