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Evaluating The Performance for DCF Protocol and EDCA Protocol

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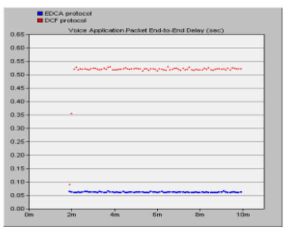
Graphical abstract



Abstract

Nowadays supporting quality of service (QOS) for real time application is the main challenge of the wireless area network. 802.11standards use distributed Coordination Function (DCF) protocol and Enhanced Distributed Channel Access (EDCA) protocol in the MAC layer. DCF protocol has only one queue for different data types, it deals with data depending on the arriving time. There is no priority to serve real time applications faster. However EDCA protocol has four queues and each queue works with specific data type. Voice, video, best effort and background are the different queues in the EDCA protocol. Different parameters and priorities are defined for each queue. The voice queue reserves the highest priority and serves its data first. In this paper QOS parameters are measured for both DCF and EDCA protocol by using OPNET simulation. The QOS parameters must reach the requirements to support QOS. The results show how QOS parameters do not reach the requirements when using DCF protocol. The values of the end to end delay and the packet loss percentage are 0.514second, 19.04% respectively. But, when using EDCA protocol the end to end delay becomes 0.0624 second and the percentage of the packet loss decreases until reach 0.00617%. So the QOS parameters achieve requirements with EDCA protocol and support QOS.

Keywords: DCF; EDCA; QOS

1.0 INTRODUCTION

In the recent years, the increasing of using smart phones and portable devices became noticeable. These devices contain applications which usually need a network connection to work. The wired network was successful to guarantee good connection and high performance, but without any solution for the mobility. On the other hand mobility, scalability and low cost are the most important advantages of the wireless network [1]. These advantages help to spread the wireless network in the world and make the wireless network more popular. Nowadays the wireless network is used in the public locations, because it is easy to excess the number of users without additional cost like a wired network. Figure 1 describes the typical connection of wireless network.

Applying real time application like voice over internet protocol (VOIP) or video conference considers the main challenge of wireless networking. Real time applications are very sensitive to the delay time and packet loss, so it needs to serve its data faster to reduce delay and packet loss [3]. For example VOIP applications will success when delay time is less than 150ms and the percentage of the packet loss is not more than 1%. Delay and packet loss are quality of service (QoS) parameters, so these parameters must achieve the requirements to support an acceptable level of QOS.

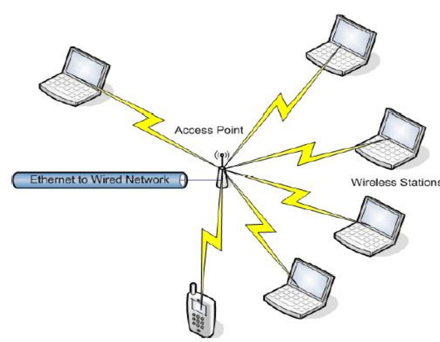


Figure 1 The typical wireless connection[2]

Institute of electrical and electronic engineering IEEE released IEEE802.11 standards to support wireless local area network. Easy to insulation, lower cost and simplicity are making IEEE802.11 standards more popular [4]. IEEE 802.11 standards have two protocols, Distributed Coordinate Function (DCF) and Enhance Distributed Channel Access (EDCA) which are used in Medium Access Control (MAC) layer. In DCF protocol the data are served without any advantage for real time data to send its data firstly. But with EDCA protocol the data of real time applications have higher priority than other types, so it will be served faster.

This paper proposed the difference between DCF protocol and EDCA protocol when using a real time application; also it evaluated the performance for both protocols.

2.0 DCF PROTOCOL

Carrier sense multiple access/collision avoidance (CSMA/CA) mechanism is used with DCF protocol. By applying this mechanism the station that wants to send data looks at the wireless medium if it is reserved or not. In the case the medium is free the station sends its data and reserves the medium, otherwise the station must wait Distributed Interframe Space (DIFS) time and backoff time to avoid the collision. The backoff time is calculated by selecting integer number randomly enclosed between 0 and contention window (CW). The integer number is considered the number of slots time. The station must wait these slots time before checking the medium again. If the medium still busy, the CW value will increase according to the Equation (1). After that the new backoff time will be calculated with new value of the CW.

$$CW = 2\times(\text{old } CW+1) - 1 \quad (1)$$

When the medium is busy, the backoff counter will be frozen until the sender receives the Acknowledge (ACK) from destination. The ACK reaches the sender after waiting Short Interframe Space (SIFS) time [5]. This mechanism is called Basic Access Mechanism of DCF protocol because it is used two way handshaking (data and ACK) as shown in Figure 2.

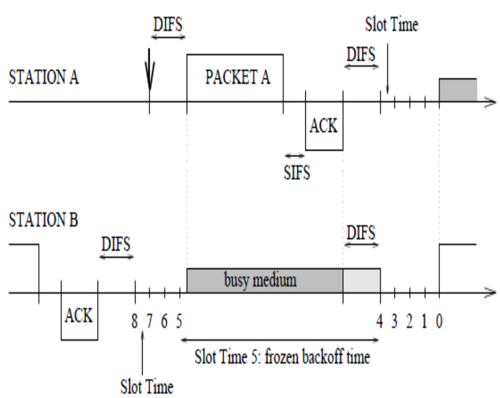


Figure 2 Basic access mechanism of DCF protocol[6]

The disadvantage of the basic access mechanism is hidden node problem [7]. This problem happens when the network has more than one access point. Figure 3 describes the hidden node problem when it has two access points. According to the Figure 3 the nodes in the zone x cannot hear the nodes in zone y. For example, if station A sends data to the station C and station B want to send data to station C. In this case the hidden node problem happens because station B thinks station C is free. This happens because of the channel in zone y not reserved. But actually station C not free and it is receiving data from station A. Thus DCF protocol was developed by using request to send and clear to send (RTS/CTS) mechanism to solve hidden node problem.

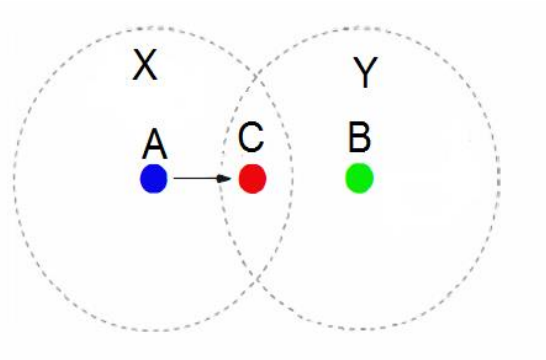


Figure 3 Hidden node problem

With RTS/CTS mechanism the station that wants to send frame checks the medium if it is free or not. If the medium is free the sender sends special frame call RTS to the destination. The destination will send CTS frame if it is free. At this moment the network allocation vector (NAV) will set for all the stations in the network to prevent any station to transmit until the sender received the ACK from destination. This mechanism is called also four way handshaking (RTS, CTS, Data, ACK) as shown in Figure 4.

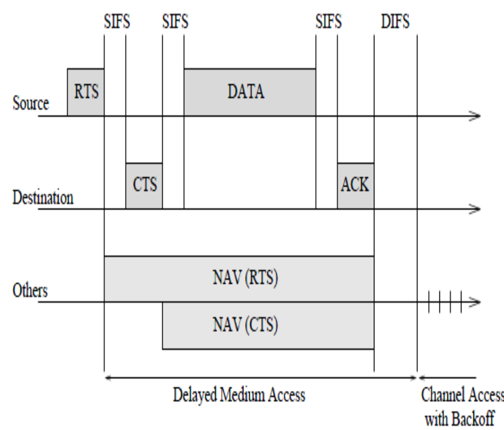


Figure 4 RTS/CTS mechanism[6]

The two mechanisms of the DCF protocol don't give any advantage to real time applications such as voice or video to send its data first. This drawback affects on successful of the real time applications in the wireless network. The voice and video traffic cannot tolerate more delay time or packet loss when comparing it with normal data such as email or browsing traffic. So IEEE802.11e standard, which used EDCA protocol was released to support QOS when using real time application [8].

3.0 EDCA PROTOCOL

As DCF protocol, the EDCA protocol uses CSMA/CA mechanism. But in EDCA protocol CSMA/CA is applied on four queues in one station [9]. Each queue is reserved for the specific kind of data and it is called Access Category (AC). These data types are voice, video, best effort and background as it is described in Figure 5. When using EDCA protocol the data will be separated to four AC's depending on the types of data. The idea of EDCA protocol gives the real time applications (voice and video) higher priorities to send its data first rather than best effort and background data. When using default EDCA protocol the voice AC has the highest priority, followed by video AC as shown in Table 1 [10]. By using this technique the real time data will be served firstly and send its data faster, so the real time data will record low delay time and low percentage of packet loss.

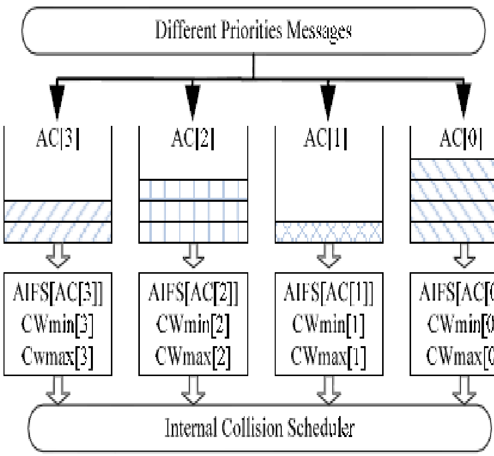


Figure 5 EDCA protocol access categories[11]

Table 1 Default priorities for EDCA protocol

Priority	Access Category	Designation
1	AC_BK	Background
2	AC_BK	Background
0	AC_BE	Best Effort
3	AC_BE	Best Effort
4	AC_VI	Video
5	AC_VI	Video
6	AC_VO	Voice
7	AC_VO	Voice

Each AC in EDCA protocol contains different parameters than other AC's. These parameters determine the priority for each AC[2]. Table 2 describes the EDCA parameters and its default values.

Table 2 Default values of EDCA parameters

AC	CWmin	CWmax	AIFSN	TXOPlimit
AC_VO	7	15	2	3.264ms
AC_VI	15	31	2	6.016ms
AC_BE	31	1023	3	0
AC_BK	31	1023	7	0

Contention Window Minimum (CWmin) is the first value of CW which is used to select the random integer value for backoff time. If the collision happens again the CW will increase while it reaches the Contention Window Maximum (CWmax). The highest AC priority has the lowest values of CWmin and CWmax [12]. When the CWmin has low value, the selecting range of integer random value will decrease. Thus the backoff time value for this AC will have low value and the AC will check the medium faster than other AC's.

Each AC waits amount of time before starts decreasing the value of the backoff time. This time called Arbitration Interframe Space (AIFS). AIFS value affect to the priorities of AC's. The higher AC priority has the lowest value of AIFS time because it helps to sense the medium faster and decreasing its backoff counter earlier[13]. Figure 6 shows the different value of AIFS for different AC's.

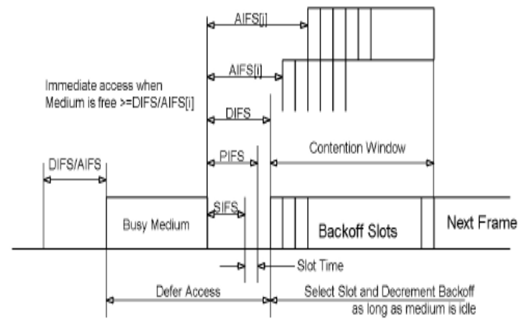


Figure 6 Relationship between AIFS values and priorities[10]

The number of frames which can be sent from specific AC can be controlled by Transmitting Opportunity Length Limitation (TXOPlimt) parameter. The zero value of TXOPlimt means, the AC can send only one frame when it reserves the medium [14]. Other values of TXOPlimit determine the duration time of reserving the medium and the AC can send more than one frame [15].

The voice AC in EDCA protocol has the highest priority. It has a lower value of CWmin, CWmax and AIFS, in addition to that it has value more than zero for TXOPlimit to send more than one frame. These advantages for voice packets help data to reach destination faster with less delay time and low percentage of packet loss, achieving QOS requirements. However the DCF protocol does not have any advantages for voice and video traffic so it will take more delay time to reach the destination and does not achieve the requirements of QOS [16].

4.0 SIMULATION RESULTS AND DISCUSSION

In this part we used the OPNET simulation to present the difference between DCF protocol and EDCA protocol. The wireless network is implemented by using 15 wireless nodes in addition to one access point and one server. Different application is defined inside the scenario. VOIP is assigned as voice traffic, browsing and using database are assigned as best effort traffic, loading email is assigned as background traffic. Six wireless workstations in scenario use voice, best effort and back ground traffics simultaneously. Also six of the workstations use browsing, and the last three workstations use database. Figure 7 shows the components of the scenario and how the applications are divided between the stations. Evaluating the performance for DCF and EDCA protocol depend on measuring the QOS parameters such as end to end delay, percentage of packet loss and the jitter.

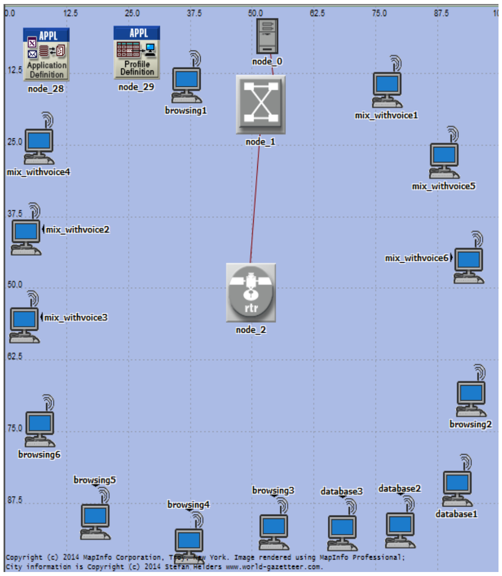


Figure 7 The scenario components

End to end delay parameter is used with multimedia traffic such as voice or video data. It measures the total delay time between sender and destination. It starts counts the time when the sound gets out from the sender while reaching the speakers of the destination. If the end to end delay with voice application elapses less than 150 ms, this means the end to end delay parameter achieves QOS. Figure 8 describes the difference in the end to end delay between DCF and EDCA protocol. When applying DCF protocol the average of end to end delay is about 0.514 second. However, when using EDCA protocol the result changes significantly to become around 0.0624 second. This value of end to end delay with using EDCA protocol achieves QOS requirements.

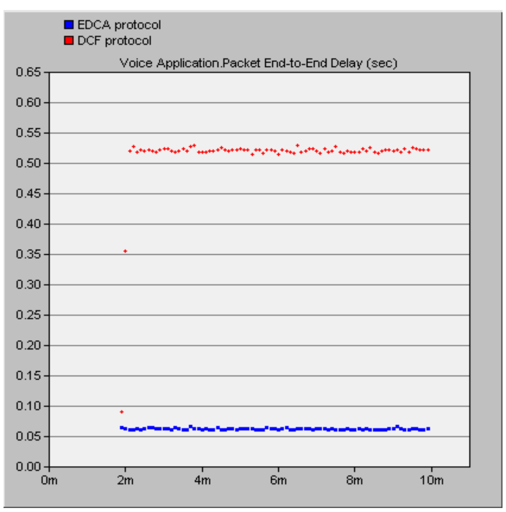


Figure 8 End to end for DCF and EDCA protocol when using voice application

Packet loss percentage is the second parameter of QOS requirements. It happens when some packets do not reach the destination. The collision inside the network is the main reason of the packet loss. The voice application can tolerate packet loss percentage until 1% to success. That means when the percentage of the packet loss grows more than 1%, it will not achieve the QOS requirements. So it is very important to keep this value less than 1% during the transmission. In our experiment the sender of voice application sends 100 packet/second. According to the result that appears in the Figure 9 for the traffic packet receiver, the percentage of the packet loss is 19.04% with DCF protocol. Otherwise, when applying EDCA protocol the percentage of the packet loss decreases to become 0.00617%.

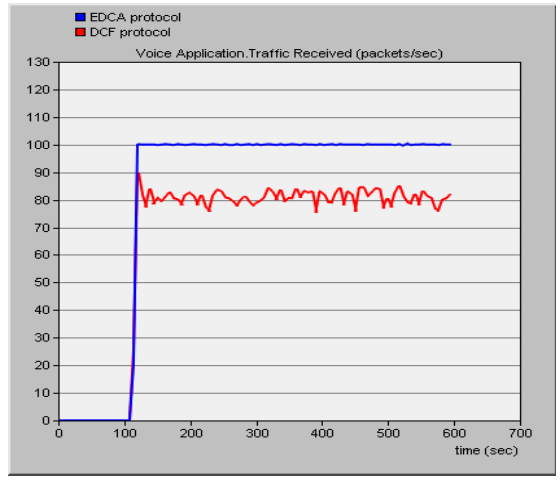


Figure 9 Packet loss for DCF and EDCA protocol when using voice application

Jitter is the third parameter which measures the difference of delay time between the series packets. For example, if the packet takes 62 ms to reach the destination and the next packet takes 64 ms, the difference between these two values is 2 ms. This difference is called jitter. Small value of jitter helps the real time application to achieve the QOS requirements. Figure 10 shows the jitter values of EDCA and DCF protocol. Depending on these results, it is easy to note that when using EDCA protocol the jitter decreases dramatically. The average of jitter goes down from 3.8×10-5 second with DCF protocol until reach 4.2×10-6 second with EDCA protocol.

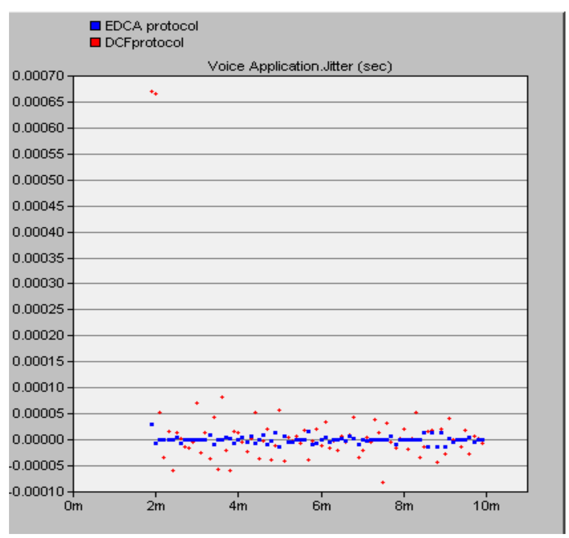


Figure 10 Jitter for DCF and EDCA protocol when using voice application

Each data type in EDCA protocol has different CWmin and CWmax values. The voice packets take the lowest value of CWmin and CWmax. So the backoff time, which is calculated depending on the value of the CW will be small. Small value of backoff time will decrease the end to end delay and jitter for the voice packets. Also the small value of the AIFS for voice packet helps to counter down the backoff time faster and sends data early before other data types. Thus the QOS parameters achieve the requirements to support QOS with EDCA protocol. On the other hand, DCF protocol has one value for CWmin and CWmax to several data types. Therefore, all data types use the same value of CWmin and CWmax without any feature for voice packets to have small backoff time. So the results of QOS parameters when using DCF protocol have higher values and do not reach the QOS requirement.

■5.0 CONCLUSION

In this paper QOS parameters were evaluated for both DCF protocol and EDCA protocol when using voice applications. Depending on the results of QOS parameters, we can see how EDCA protocol supports QOS with voice application compared with DCF protocol. Dividing the data in EDCA protocol to different priorities and giving the voice traffic highest priority lead to enhance the QOS parameters to achieve the QOS requirements. The voice traffic with highest priority ensures fast arrive for the data with less end to end delay and jitter. In contrast the voice traffic or the real time traffic does not have priority to send its data before than other types when using DCF protocol. DCF protocol has one queue only to send the data. It serves the data depending on the arriving time, not on the data types. So the real time application does not have opportunity to send its frame before than normal data. In the conclusion the EDCA protocol supports QOS when using real time application unlike DCF protocol.

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