QoS in Wireless LANs Final Report

HuFan

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Abstract

Here is the final report for my research on Qos in wireless LANs. The report is mainly about the introduction of Qos in WLANs and my experiment results.

1 Introduction of QoS in WLANs

1.1 Why QoS?

Wireless local area networks (WLAN) are gaining popularity at an unprecedented rate, at home, at work, and in public hot spot locations. As these networks become ubiquitous and an integral part of the infrastructure, they will be increasingly used for multi-media applications. There is limited Quality of Service(QoS) support in WLANs and this will become an impediment in deploying multi-media applications.

1.2 Introduction

Wireless Local Area Networks (WLANs) have increasingly become the edge network of choice. Concurrent with the expansion of WLANs is a high demand for Quality of Service (QoS)-sensitive, i.e. delay-constrained or throughput-specific applications for a variety of professional and personal uses. For example, WLANs are being used in residential networks to support a wide range of applications such as remote controls, video from a security camera, delivery of video on demand, voice telephony, streaming audio and Internet access. WLANs are also being used in community networks and as a low-cost replacement for 3G broadband services by service providers. However, as is the case with all wireless networks, lack of bandwidth and interference constraints make WLANs a potential bottleneck. In order to support a variety of applications and to provide differentiated service quality, QoS mechanisms are required at the link or MAC layer of WLANs.

1.3 How to improve

There are mainly two kind of mechanisms for providing QoS support, the distributed mechanism and the centralized mechanism.Centralized protocols, such as reservation TDMA or polling and scheduling schemes have received much attention from the research community, since they promise precise QoS guarantees. With centralized protocols, each mobile station (MS) requests the right to access the channel from a single point of coordination. The coordination point (called base station or access point) can perform admission control, bandwidth assignment, and channel access control. The major advantage of centralized protocols is that they can guarantee bandwidth resources (or deny admission). Examples of centralized protocols are the Point Coordination Function (PCF) of IEEE 802.11 that employs polling, HIPERLAN/2 of ETSI, and numerous wireless ATM proposals. However, the adoption of these mechanisms has been limited due to high overhead, high cost/complexity and issues in scalability, practicality and flexibility. In contrast, distributed protocols are simple to implement and require smaller overhead. Although, these protocols are currently not equipped with QoS support, they are being widely adopted. Therefore, the focus of this paper is on distributed QoS mechanisms. There are several proposals for incorporating QoS mechanisms with distributed protocols. Ongoing work on a draft standard (IEEE 802.11e) is intended to provide QoS differentiation in WLANs in a distributed manner. So we focus our attention in this report on the widely deployed IEEE 802.11 WLANs and describe several proposed distributed mechanisms at the MAC layer for providing QoS support.

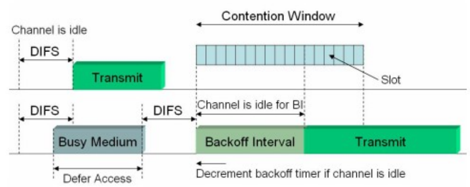

Figure 1: DCF mechanism

2 Distributed MAC Protocols

2.1 Distributed Coordination Function(DCF)of IEEE 802.11

The Distributed Coordination Function (DCF) of IEEE 802.11 is designed for data applications and it is based on CSMA/CA. The channel contention procedure begins when an MS senses the channel to determine whether or not another MS is transmitting. The collision avoidance mechanism employs two techniques C the inter frame space insertion and the backoff algorithm. The inter-frame space (IFS) is the period of time an MS is required to wait after it senses an idle channel and it enters the transmission process.

If the channel is idle for a period of time equal to the DCF Inter-frame Space (DIFS), the MS can begin transmission. However, if the channel is busy, the transmission is deferred as shown in Figure 1. A backoff interval (BI) is randomly selected between a minimum period (CW min) and a maximum period (CW max). The difference between CW max and CW min is called the contention window (CW). A collision occurs if two or more MSs select the same backoff interval which can happen when a large number of MSs contend for the channel. To reduce the probability of collision, the CW is doubled every time a collision occurs until the maximum value of CW is reached. This procedure is called exponential backoff. The length of the backoff interval is calculated as shown in the following equation, where BI is the length of the backoff interval and SlotTime is the length of a timeslot.

$$BI = Random(CW_{min}, CW_{max}) * SlotTime)$$

Once it enters backoff, the MS monitors the channel as before. As long as the channel is idle, the backoff timer decreases until it reaches zero. The backoff timer is frozen when a transmission is detected and it is reactivated when the channel becomes idle again. The receiving MS (or access point) waits for a Short Inter-frame Space (SIFS) and responds with an acknowledgement (ACK) to confirm a successful transmission. This is necessary as transmissions could be corrupted by the wireless channel or by collisions. The SIFS is smaller than DIFS to allow acknowledgements to be transmitted immediately without entering the backoff process. The PCF mode in 802.11 uses a PCF Inter-Frame Space (PIFS) to announce a contention free period and provide priority access for PCF aware MSs. The PIFS value is larger than SIFS but smaller than DIFS. The hidden node problem occurs when a MS can hear only some but not every MSs transmission. To overcome this problem, an optional mechanism employing Request-To-Send (RTS) and Clear-To-Send (CTS) messages is used. In this operation, the MS first transmits an RTS message and wait for a CTS message from the recipient before beginning data transmission. This method significantly alleviates the hidden node problem and reduces average access delay [1]. Many researchers report that the performance of DCF depends primarily on CW min and the number of active MSs and it is only marginally dependent on these parameters when RTS/CTS mechanism is used. [2] In summary, the DCF in IEEE 802.11 has advantages of simplicity, ease of implementation and suitability for most data

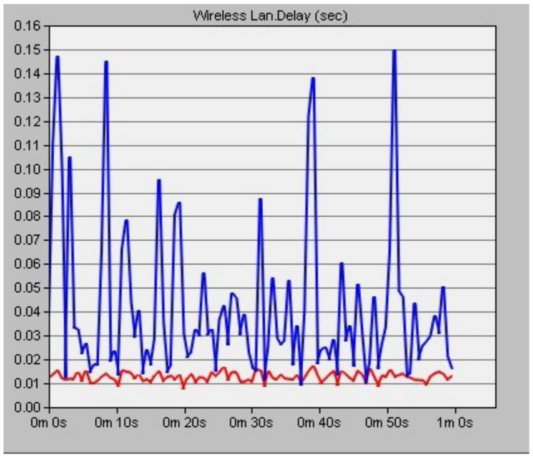

Figure 2: Delay of two different priority nodes

applications. However, DCF does not support QoS requirements or guarantee delay/throughput. Several studies report relatively poor performance for voice transmission and the inability to provide a low delay variation . Because of this, there is a need for QoS support mechanisms in DCF. [3]

2.2 Simulation results

The simulation environment is Windows XP and OPNET 14.5. First, I simulated two nodes applied DCF mechanism with different priority.

From pic2, we could clearly see that the delays are different from each other. The one with higher priority has a lower delay.

From pic3, we see that through they have different priority, but the throughput are almost the same. And the overall throughput is not high. And we'll see later that in EDCF mechanism it is much higher. That is a vital shortcoming in DCF.

Pic4 also shows a shortcoming in DCF, that is the delay is variable. We can use some algorithm to relieve it, such as the DDRR(Distributed Deficit Round Robin) algorithm.

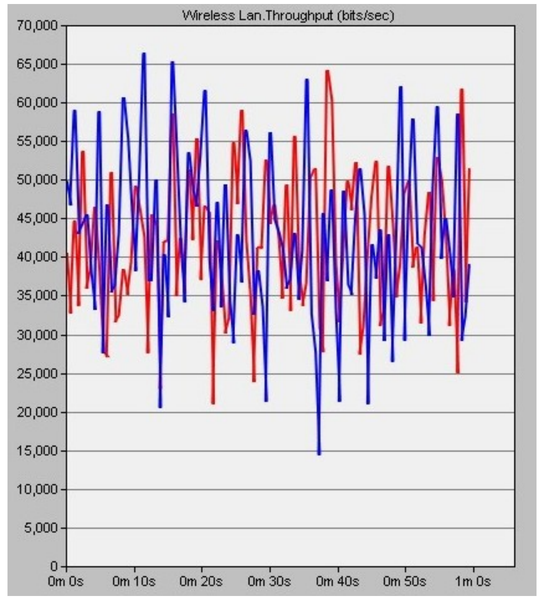

Figure 3: Throughput of two different priority nodes

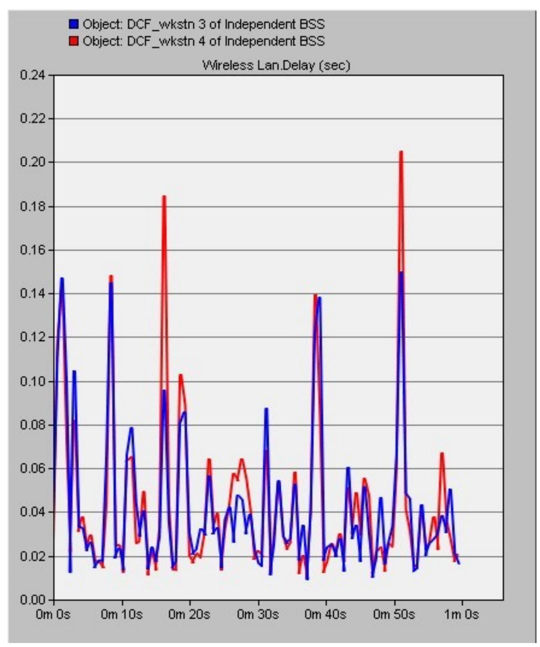

Figure 4: delay is variable

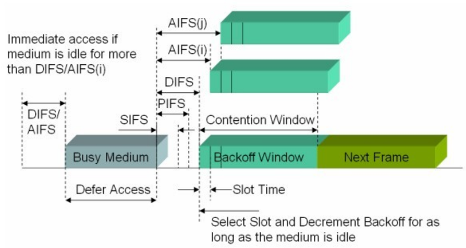

Figure 5: EDCF mechanism

2.3 Discussion and Summary

From the above introduction and the simulation, we know that DCF mechanism is easy to implement, but the shortcoming is obvious. The throughput is low, the delay is variable and also there are only three priorities to choose from, which makes it hard to transmit several queues. So next, we introduce a new kind of mechanism–EDCF(Enhanced DCF).

3 EDCF

3.1 Using new IFS values for priority

In contrast to using only the DIFS and PIFS values, the Enhanced DCF (EDCF) proposals (presented to the IEEE 802.11 working group E) introduce new IFS values . [4]EDCF consists of up to 8 prioritized queues which map onto and coincide with the standard 3-bit priority classes of 802.1p. A new type of IFS named Arbitrary IFS (AIFS) is introduced. AIFS is an IFS value of arbitrary length. The AIFS value depends on the priority class of traffic as shown in the figure 5

Each priority class has its own queue and back-off counter. Also a small random time is added at the end of the IFS period to avoid collisions among frames in the same priority class. A potential problem of this mechanism is that the new AIFS values are longer than the existing DIFS. Therefore, the frame of an MS using the current DCF scheme receives higher priority than that of a QoS-aware MS using the EDCF mechanism. Aad et. al. also proposed using multiple IFSs to differentiate among priority classes.

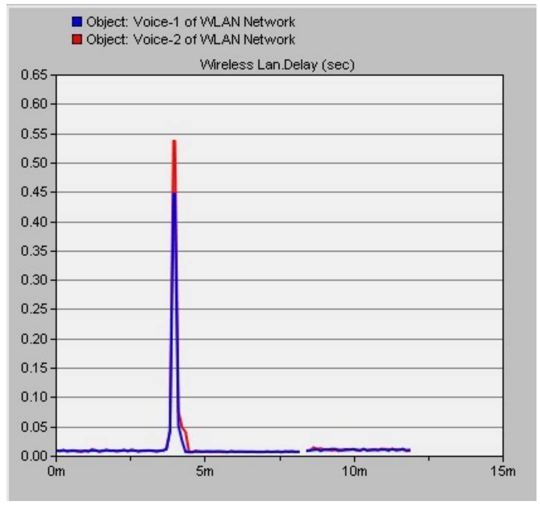

Figure 6: Delay of two different queue

3.2 Simulation

This time I simulated a test scenario in which there two different queue priorities for VoIP traffic.

From figure 6 and 7, we can conclude the same result as that in DCF. In view of the difference between the priority in this simulation is smaller than the one in the DCF, the delay also differs a little. And also the throughput does not differ a lot, but it is higher than that in DCF.

And next I simulated a number of priority queues: background, best effort, video and voice. The highest to the best effort and the lowest to the background.

This time, the delays are all smooth, except several comparatively large delays in some point(I still don't know why). And the throughput is larger than that in DCF. From the two pictures, we can see that the delay of the Background is the largest and that of best effort is the lowest, just as I set in the parameters. And at first, the throughput of best effort is the largest, but when the other three began to travel, they become almost the same again.

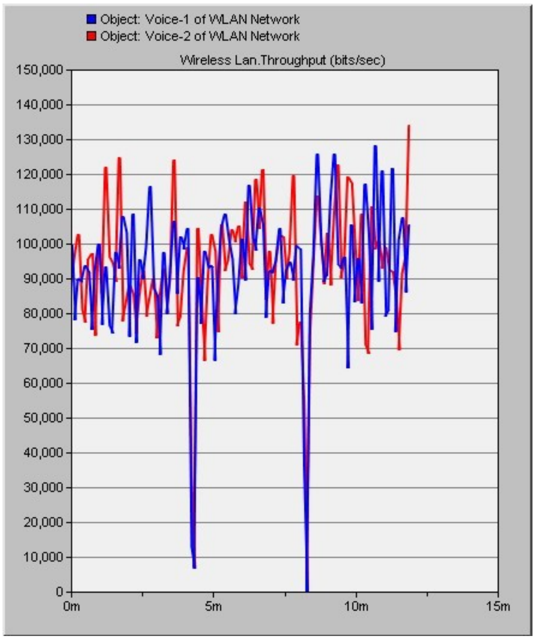

Figure 7: Throughput of two different queue

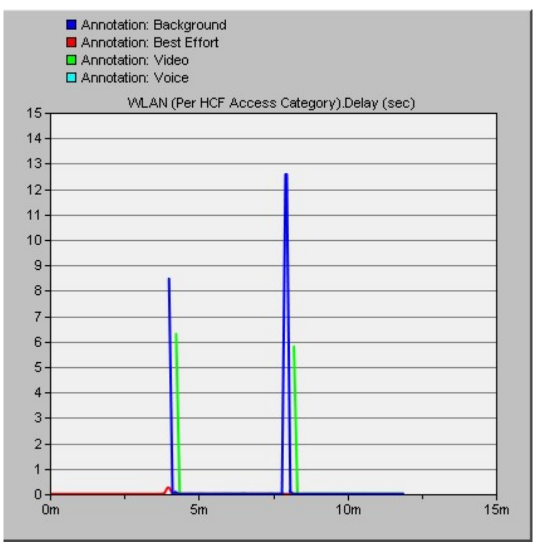

Figure 8: Delay of multimedia traffic queues

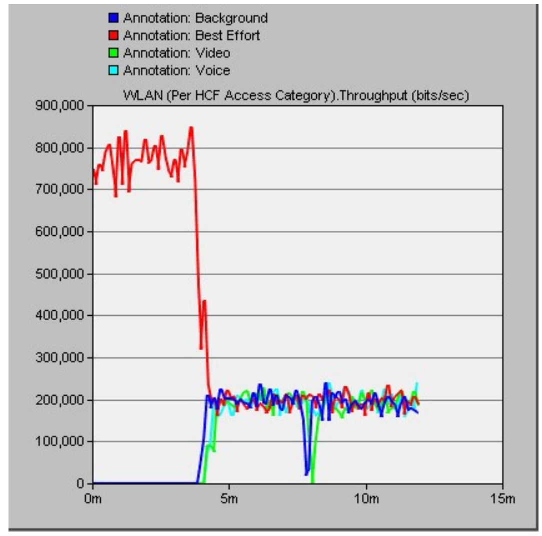

Figure 9: Throughput of multimedia traffic queues

3.3 Discussion and Summary

From the main idea and the simulation results, we know that EDCF can be applied to multimedia traffic, which attributes to the AIFS. And in EDCF, the delay is much more smooth. And also the throughput is higher. These are superior to the DCF mechanism. But also there is another problem to solve, that is the throughput is still variable. So the further work can be devoted to that one.

4 Group Member Introduction

This is group 22. And I'm the only member in this group. This is my picture as shown in figure 10. So I did all the work in the group, browsing material, doing the simulation and compose the report. Maybe the work is tough for a single person, so there might be some fault in the report.

Figure 10: Group Member:Hufan

References

[1] G. Anastasi and L. Lenzini, QoS provided by the IEEE 802.11 wireless LAN to advanced data applications: a simulation analysis, Wireless Networks. vol.6, no.2; 2000; p.99 108, 2000.

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[4] G. Chesson, M. Benvenisite, W. Diepstraten, M. Hoeben, A. Singla, H. Teunissen, and M. Wentink, EDCF proposed draft text, Tech. Rep., IEEE working document 802.11-01/131r1, 2001.