Prioritization scheme for QoS in IEEE 802.11e WLAN

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ABSTRACT

The exponential growth in demand for multimedia applications in wireless network has resulted in dramatic increased in different devices and connections accessing information. Indeed, this is primarily due to the fact that wireless and multimedia applications have been used quite extensively in business, commercial and communication industry. Supporting multimedia application in wireless environment with different bandwidth and delay requirement is challenging – this can eventually have detrimental impact on the system performance if the necessary quality of service (QoS) requirement has not been provided. This paper presents an approach which prioritizes the application base on its content in order to ultimately support and provide the needed requirements for multimedia application over wireless LAN. Consequently, the throughput of the IEEE 802.11e while maintaining its QoS requirement. The scheme has been simulated using NS2 simulator.

Keywords

IEEE 802.11e, EDCA, HCCA, wireless LAN, Quality of service

1.0 INTRODUCTION

Wireless networking technology has witnessed an unprecedented development over the past couple of years due its significant role in every aspect of life ranging from education to communication. The development trend has moved rapidly from text to multimedia application based. This has posed a serious challenge in order to support multimedia application over unpredictable channel such as wireless medium. It is obvious that most deployed networks does not guarantee quality of service (QoS). Therefore, it is very much necessary to provide more adaptive mechanism to ensure effective delivery of real-time multimedia application over wireless network. Without providing strategy to support such application can seriously affect the video quality as the bandwidth changes. Handling multimedia applications with high bandwidth demand and low latency requirement in a heterogeneous environment require efficient and effective QoS (Nafaa, 2007), (Michaela & Chou, 2007)

The integration of text, graphics, audio and video into handheld devices will provide the capability to ubiquitously access information with relative ease and sophistication. This has been primarily due to standardization and advancement in both multimedia and hardware technology. However, it is very obvious that there is dramatic need to efficiently manage and utilize the limited resources in the wireless environment. Moreover, the dynamic nature of the environment and devices makes it extremely difficult to optimally define the QoS for multimedia application (Chen, Lin, Cheng & Chen, 2008). The trade off between QoS requirement should be taken into consideration since it is very complex to fully achieve the required QoS. In the past, it is very realistic that each layer is considered separately in order to achieve optimum result. Recent research works have shown that prioritization will significantly enhance the system performance especially in error-prone transmission environment where delay and bandwidth have profound impact on the content of the application (Albert, Arturo, Carlos & Ruben, 2005).

The dynamic nature of wireless LAN makes it difficult to manage the resources available within the network more effectively. Hence, there tremendous need for highly efficient scheme to effectively manage the network resources properly due increasing number of wireless station which have detrimental impact on the network performance. It is a known fact that multimedia applications are very much sensitive to delay and hence high priority need to be given to such application in order to be transported over unpredicted channel condition.

As it has been known that video applications are sensitive to delay and bandwidth variation and adequate provision has not been made to provide better QoS support. With the introduction of IEEE 802.11e (IEEE, 2005), more significant improvement have been achieved in terms of QoS provision over WLAN which eventually allow effective video transmission. Integration of IEEE 802.11e into existing MAC for IEEE 802.11 will contribute immensely toward achieving the necessary QoS in wireless environment.

The remainder of this paper is organized as follows. Section II mainly focuses on the overview of IEEE 802.11e MAC protocol and the related work. Section III introduces our proposed scheme. Simulations results are presented in Section IV. Finally, conclusions are enumerated in Section V.

2.0 OVERVIEW OF IEEE 802.11e

It is very realistic that there has been more dramatic development in wireless multimedia technology and subsequently led to different challenges which require more effective solution. The resource management problem needs to be address in order to provide the required QoS. QoS support is required in mobile devices due to limited energy available (Cai, Foh, Zhang, Ni & Ngan, 2007). Both QoS and energy should be considered since providing adequate QoS require high performance which eventually leads to high energy consumption. Tradeoff between energy and QoS need to be considered while designing system or devices. It is very known fact that wireless network provide better mobility and low cost of deployment and high throughput. But for video applications to be supported over WLAN, more necessary steps and capability need to be integrated into the IEEE 802.11 DCF (Bianchi, 2000).

With the introduction of IEEE 802.11e (IEEE, 2005), it has ultimately lead to better MAC mechanism to provide the necessary QoS requirement in order to effectively support different multimedia applications over WLAN. Also, it has provided the capability to set priority to different application base on their significance. This will eventually allow packets to be assigned to different priorities and quality of service as well. Also, stations can have many packets in queue at the MAC layer. It is very obvious that packets are transmitted using different contention parameters. Basically, the packets are prioritized base on the services provided – it primarily included background, best effort, video and voice applications. More importantly, the priority increase from the background to voice. In order to efficiently handle prioritization, enhanced distributed coordination function (EDCA) and HCF controlled channel access (HCCA) have been included as it can be seen in figure 1.

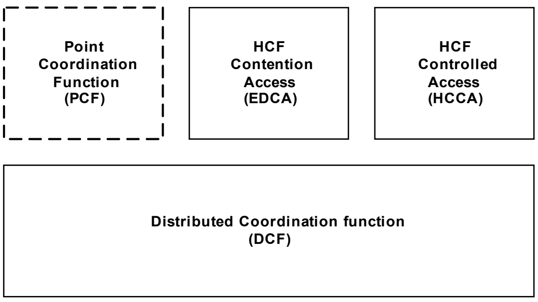

Figure 1: IEEE 802.11e MAC

The parameters set on EDCA significantly assist in establishing policies and changing the policies when accepting new stations. The aforementioned traffics can be categorically divided into categories shown in the table I below.

Table 1: *EDCA access category and description*

Priority	***Access category***	***Access Category***	***Description***
Lower	AC0	AC_BK	Background
	AC1	AC_BE	Best effort
	AC2	AC_VI	video
Highest	AC3	AC_VO	voice

In order for station to access the medium, two way handshake is normally established. Initially when channel is idle, the terminal is allowed to transmit. When the channel is busy, the terminal will defer transmission and enter into collision avoidance mode. A random back off interval is set and terminal waits for the period of time set on the back off timer until the time expires and figure 2 elaborates more on the how wireless medium is accessed by stations. The random back off tremendously reduce the probability of collision as the station access the medium.

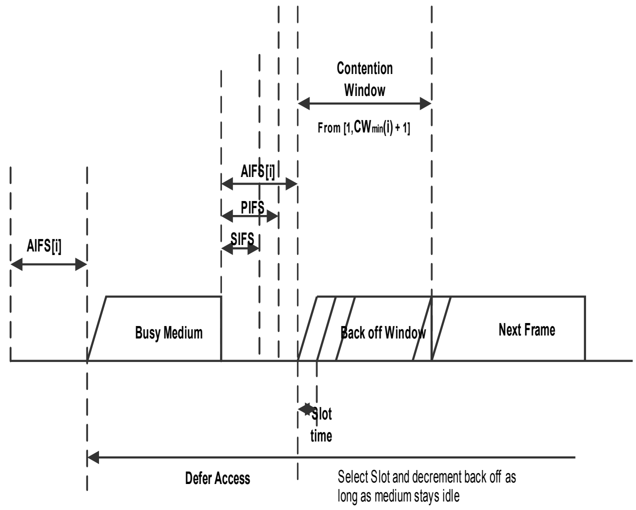

Figure 2: IEEE 802.11e EDCA mechanism

Hence, the throughput of IEEE 802.11 DCF can be determine mathematically by

$$throughput = \frac{E[l]}{T_s - T_c + \dfrac{T_c + \sigma(1 - P_{tr})}{P_s}} \qquad (1)$$

Where σ is the duration for an empty slot. L is the time length of packet and P_{tr} is the probability of terminal transmitting in the slot time. E[L] represents the average length of the longest packet. T_s defines the time of a busy slot with successful transmission and T_c the average time of a busy slot with collision Also, the throughput of the network depend greatly on the network topology, traffic profile and MAC protocol parameters.

The provision of QoS can be achieved by using traffic category. It is very important to note that using this mechanism, different traffic category can used arbitration inter frame space (AIFS[TC]) periods in order to determine the idle condition for the medium. The table below shows the details about AC0, AC1, AC2 and AC3.

Table 2: *Traffic class for EDCA*

Access category	CW_{min}	CW_{max}	$AIFS_n$
AC0	31	1023	7
AC1	31	1023	3
AC2	15	31	2
AC3	7	15	2

The four access categories have been provided in EDCA and priorities of eight different traffics can be assigned. Each traffic class has it own settings for AIFS, CW_{min}, and CW_{max}. It is very important to note that IEEE 802.11e has the capability to map the traffic classes. It can be clearly seen from figure 2 that priority increases from left to right and hence the buffer for higher priority traffic is relatively small when compared to low priority traffic (Choumas, Korakis & Tassaiulas, 2008). This is important such that the waiting time will be significantly reduced in high priority queue. AIFS assists greatly toward achieving the aforementioned goal by setting the waiting time. As it can be seen in fig 2, the packets are normally transmitted when the medium is free. But when the medium is busy, it waits until the medium is free and backup timer is set.

The minimum size of the contention window depend greatly on AC. Normally, the initial value for the backup counter is selected randomly from the intervals by the CW. The contention windows CW0, CW1, CW2 & CW3 are assigned to their respective AC's as it can be seen in Figure 3.

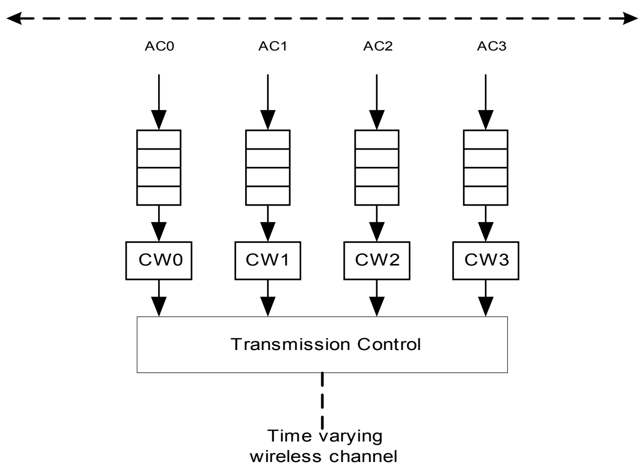

Figure 3: EDCA Access mechanism

3.0 SYSTEM MODEL

In the previous section, the basic of IEEE 802.11e has already been discussed in more details in order to pave away toward this section. Nevertheless, it is very important to note that the protocol provides fairness for all the access categories. It eventually allows more efficient queuing management of the packets and subsequently enhances the system performance.

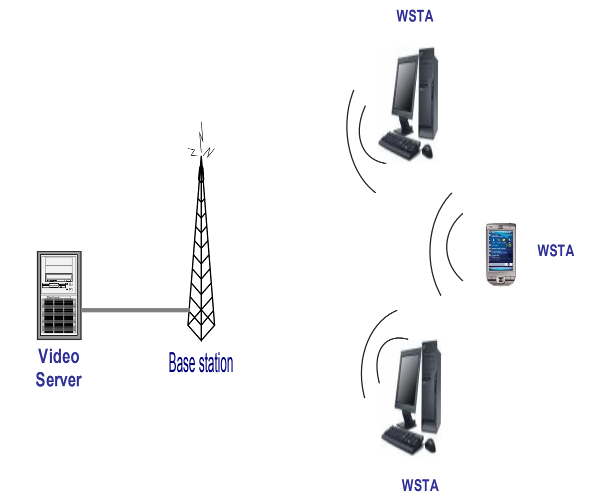

Figure 4: System model diagram

As it can be seen from figure 4, the system model comprised of an access point (AP) and streaming server. Several wireless STA's were included onto the network to measure the throughput and delay with different parameter settings. It has been assumed that all the WSTA's streamed the video data through the AP. The IEEE 802.11e capability was integrated onto the AP through which the client access information. The bandwidth is shared by the client base on the priority of the content to be accessed. Interestingly the number of WSTA's was varied to measure the throughput and delay.

In the first scenario, high priority is assigned to packets and hence more packets queued toward AC3. Since the buffer size for AC3 is small when compared to AC0, the tendency for delay increases dramatically and necessary required QoS has not been provided. Secondly, assigning low priority to packet channeled toward AC0 and subsequently leads to low performance due to limited bandwidth.

In order to fully explore the IEEE 802.11e, packets have been assigned to the same priority in each of the access categories. It eventually leads to even distribution of all traffic across the queues in the AP. Additionally, this have provided equal opportunity to all the WSTA's so that to access the medium since all the traffic have the same priority. Next section clearly shows the dramatic impact of assigning the same priority on throughput and delay.

4.0 SIMULATION & DISCUSSION

The experimentation has been conducted using NS-2 Simulator and it is base on the system model shown in figure 4. In order to critically analyze the performance, the throughput and delay have been considered to juxtapose the proposed system performance with the existing schemes. The traffic classes have been tested under different conditions to evaluate the performance and the system model of the network has been set as shown in Figure 4. Different scenarios were considered in the experimentation, the AC was adjusted to mimic different traffic scenarios in order to determine the throughput and delay under different AIFs and number stations.

From figure 5, it can be clearly seen that the same priority for all the AC's yields negligible delay when compared to high priority as the number of station increases. The delay for both cases remains relatively constant as the number of station increase from 2 to 7 stations. More importantly, it is very obvious that the same priority yields better performance than other options. This clearly indicated that it ensure prioritization and more throughput without affecting the QoS of high priority traffics. Hence, this can be used in supporting real-time multimedia applications due to its brilliant feature which will ultimately support delay sensitive applications such as video.

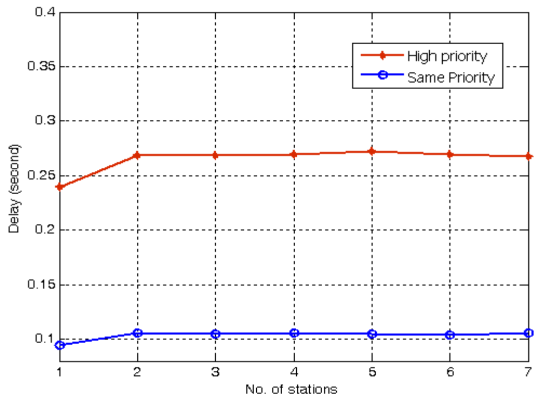

Figure 5: Impact of number stations on delay

It can be seen from figure 6, it clearly show that the relationship between throughput and different AIFs as the number of wireless station increase. As it has been expected, the throughput reduces significantly as the network load increase and vice visa. In a nutshell, effective utilization and setting of the provided parameters such as AIFs, CW, PF and AC can significantly improves the system performance in terms of throughput and delay as it has been shown in the graphs. The challenges anticipated while supporting video application over WLAN is very crucial and require more sophisticated strategies in order to ultimately provide the required QoS for present and future multimedia applications in time varying channel condition.

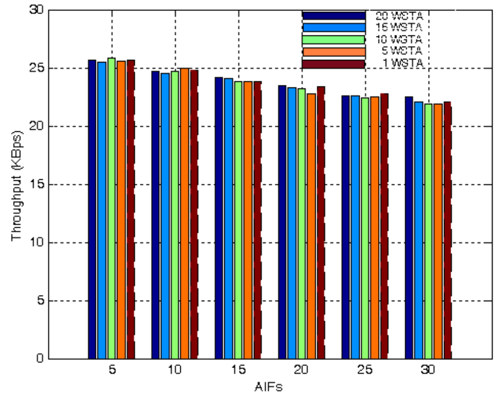

Figure 6: AIFs Vs throughput

In fig 7, it indicated that the throughput for same priority has been maintained reasonably constant as the number of stations increases as well. This is primarily due the fact that the throughput has reach its maximum or in nutshell saturation point such that any further increase in number of clients would not have any impact on the output throughput. The throughput for low and high priority decreases as the number station or clients increases.

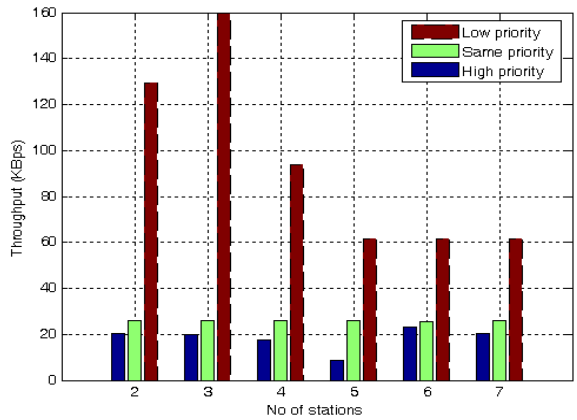

Figure 7: AC2's throughput Vs number of users

5.0 CONCLUSIONS

In this paper, we examined and presented IEEE 802.11e WLAN throughput enhancement which can eventually support multimedia applications over error prone transmission environment such as the wireless environment. In order to ultimately support multimedia applications, it has been established that given different priority with different QoS requirement can significantly enhance the throughput and at the same time maintaining the QoS requirement in an unpredictable channel condition. Our future will mainly focus on enhancing the bandwidth utilization using cross layer design approach. This will eventually provide necessary QoS needed to support video application over wireless network.

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