ENSC 427: COMMUNICATION NETWORKS

Comparison of the Quality of Service (QoS) on the IEEE 802.11e and the 802.11g Wireless LANs

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Final Report

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1. Abstract

For this project, we propose to compare the 802.11g and the 802.11e Wireless Local Area Networks (WLANs). The 802.11g WLAN standards are good for data applications. However, the 802.11g standard is not well-equipped to deal with the intended delay and bandwidth requirements of multimedia applications, such as video and voice over wireless IP. For this reason, an approved amendment (802.11e) was added to the IEEE 802.11 standard. The 802.11e implements Quality of Service (QoS), which enables features through changes in the Medium Access Control (MAC) layer. The performance of 802.11e will be evaluated using OPNET simulation and compared with the 802.11g WLAN standard.

2. Introduction

The demand for streaming multimedia over wireless networks has been steadily increasing over the years. This includes access to various services, “including those that distribute rich media content anywhere, anytime, and from any device [1].” The focus of this report will be streaming multimedia over wireless networks using the IEEE 802.11 protocols, and the Quality of Service (QoS) the protocol offers is our main topic of research. QoS is a method of providing better service for different types of network traffic over various types of packet-switched networks. It basically provides an algorithm for controlling what type of traffic should be given priority to access the network channel. The network medium used could be of any type ranging from Ethernet to WiFi (Wireless Fidelity) [2].

The main difficulty of streaming multimedia in WLANs occurs because of the “bursty nature [3]” of media streams. Hence, the capacity of the network varies with the offered load. Some other difficulties arise from different QoS requirements for WLANs based on different applications. For example, “video conferencing requires low delay and high bandwidth; IP telephony doesn`t need much bandwidth, but is very stringent on packet delay [4].”

Additionally, for real time multimedia applications, the main factors affecting QoS is packet loss and packets dropped due to excessive delay. In particular, the Frame Transmission Delay (FTD -time taken by the entire video frame to go from the sender to the client) is very important for video streaming. Due to a strict bounded FTD, “every multimedia packet must arrive at the client before its playout time with enough time to decode and display the contents of the packet [1]. ” In addition to the FTD, there is also another delay called the Interpacket delay (IPD). The IPD refers to the delay between individual packets in a burst of the video frame. IPD is included in the FTD because the FTD is a sum of the IDP for each frame.

There is usually a packet loss ratio, associated with the FTD, which has to be below a certain threshold to ensure acceptable visual quality. If the packet loss ratio is above the threshold, the packet is lost. Lost packets are retransmitted until the packet is successfully received or that the transmission limit for the packet is reached. A packet which has reached its transmission limit becomes expired, for an expired packet all the data becomes useless thus it no longer has to reach the client.

In this report we will demonstrate the challenge of providing QoS for video streaming applications with IEEE 802.11g and show how these requirements can be met with 802.11e.

2.1 - Overview of IEEE 802.11g and 802.11e

The 802.11 standards define the Medium Access Control (MAC) sub layer, MAC management protocols and services, and physical (PHY) layers. Some of the responsibilities of the MAC layer include reliable data delivery, fairly controlling access to the wireless medium, the protection of data, basic access mechanisms, and Distributed Coordination Function (DCF) and Point Coordination Function (PCF) operation.

In 802.11g networks, the MAC layer uses DCF to access the medium. The DCF is a "random access scheme, based on the carrier sense multiple access with collision avoidance (CSMA/CA) protocol [5]." The CSMA/CA protocol allows for asynchronous data transfer based on a best-effort service, which means that all stations must compete with each other to access the medium in order to transmit data. Hence, DCF forces stations to wait for random lengths of time, called the backoff interval, to try and prevent to transmitters from accessing the medium simultaneously. However, all the stations have equal priority when it comes to gaining access of the medium. Any station that wants to transmit must first determine whether the medium is busy or idle. In the case that the medium is busy, the station waits until the medium has been idle for a certain period of time, defined by the Distributed Inter-Frame Space (DIFS) [1]. Figure 1 shows the basic access method for DCF.

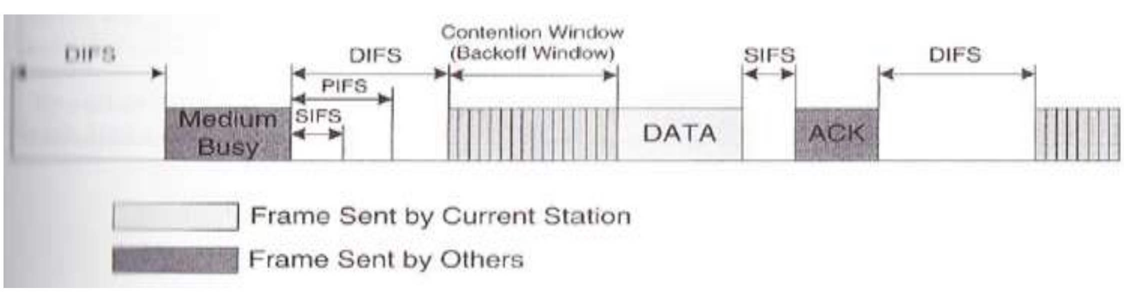

Figure 1: Basic Access Method [6]

The 802.11 standard also defines an optional mode called the PCF. The PCF is a MAC protocol, which is a "centralized, polling based access method, where the AP is responsible for controlling which stations are permitted to transmit, and polling all stations using special control packets to determine if they need to send data [7]." Even though, there is some priority access in PCF, it cannot differentiate between traffic sources with time sensitive data [1].

Overhead to throughput and delay in DCF stems from the losses due to collision and backoff, whereas this overhead in PCF stems from the wasted polls. PCF is preferred over DCF, since the overhead incurred from wasted polls is usually smaller than that of collision and backoff.

In IEEE 802.11e networks, on the other hand, the MAC layer uses Enhanced Distributed Channel Access (EDCA) to access the medium. The EDCA differs from the DCF and PCF in the sense that a probabilistic scheme is used to prioritize stations [7]. In this situation, higher priority stations have a lower delay and lower priority stations have to wait longer amounts of time to access the medium in order to transfer data. Traffic such as voice and video have higher priority than data traffic, which results in a higher QoS for multimedia since there is higher bandwidth available for such applications. EDCA, however, is not a separate coordination function. Instead, it is a combination of the DCF and the PCF, which is called the Hybrid Controller (HC). This standard defines four access control queues rather than just a best effort queue. Traffic is directed in streams of voice (VO), video (VI), best effort (BE), and background (BK) [5]. Table 1 shows the traffic prioritization in the IEEE 802.11e network.

Traffic Category	**Type**	**Priority**
TC1	Background traffics	1 (Lowest)
TC2	Spare traffics	2
TC0	Best Effort data traffics	3
TC3	Excellent data traffics	4
TC4	Controlled load data traffics	5
TC5	Multimedia traffics with delay less than 100 ms	6
TC6	Multimedia traffics with delay less than 10 ms	7
TC7	Network Control traffics	8 (Highest)

Table 1: 802.11e Prioritization of Traffic [6]

3. OPNET Simulation

The OPNET simulation scenario will consist of an access point streaming video and data, a client receiving video, and another one receiving data. One scenario will use the 802.11g standard and the other will use the 802.11e standard. The OPNET simulation network topology is shown in Figure 2. As seen from Figure 1, the network topology contains one application definition, one profile definition, one access point, one server, one workstation and an IP backbone. There are two different Application Definitions configured – a video application (low resolution video conferencing) and a data application (high load FTP). We included the data application to compare how the bandwidth given to the data transfer differs in the two networks.

The user profiles – both data and video -are set to run simultaneously and start using a Poisson distribution (Figure 3). The only difference between scenario IEEE 802.11e and IEEE 802.11g is that for the IEEE 802.11e scenario, the HCF parameters are supported. This enables the EDCA function, which enables the QoS-provisioning for the network. Figure 4, shows where the HCF capabilities can be enabled in the workstation. In the Application Definition, we changed the Type of Service (ToS) for the video application to Interactive Video, and the data application to Best Effort for the 802.11e scenario, whereas for the 802.11g scenario, both applications had the same ToS, namely, Best Effort. The ToS Configuration box in shown in Figure 5.

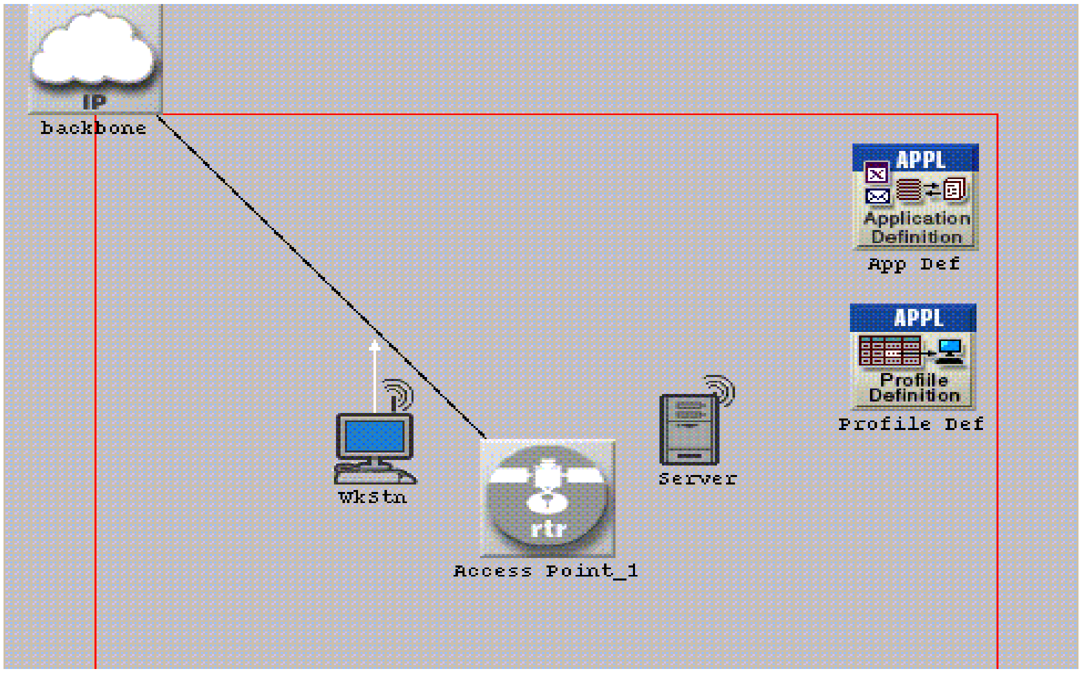

Figure 2: OPNET Network Topology

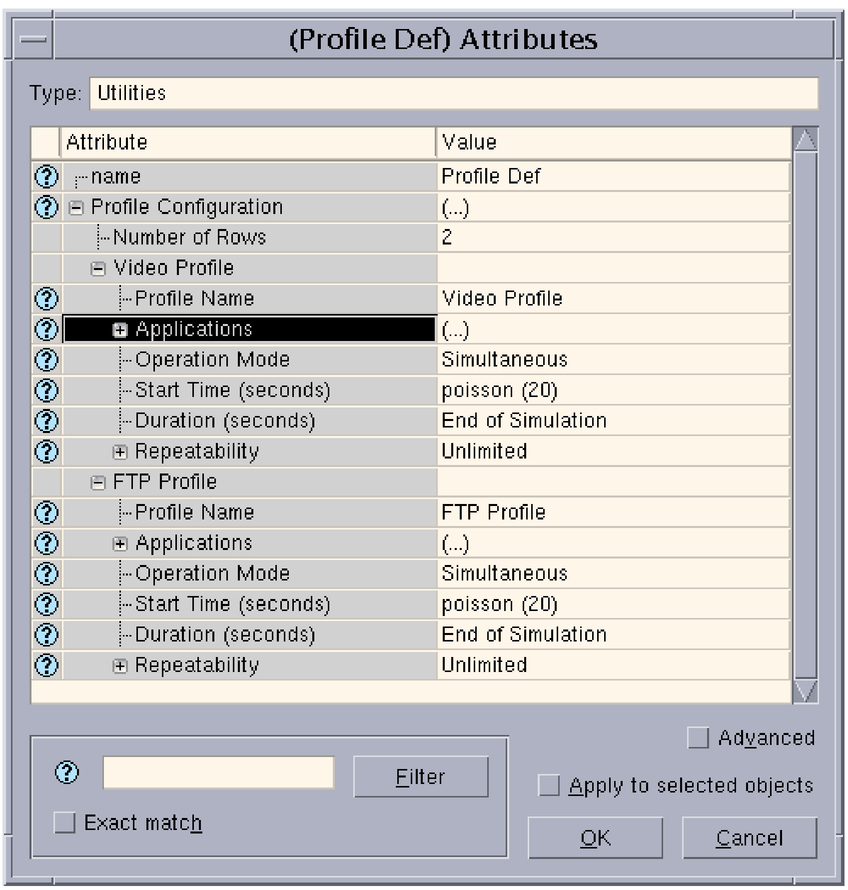

Figure 3: Profile Definition

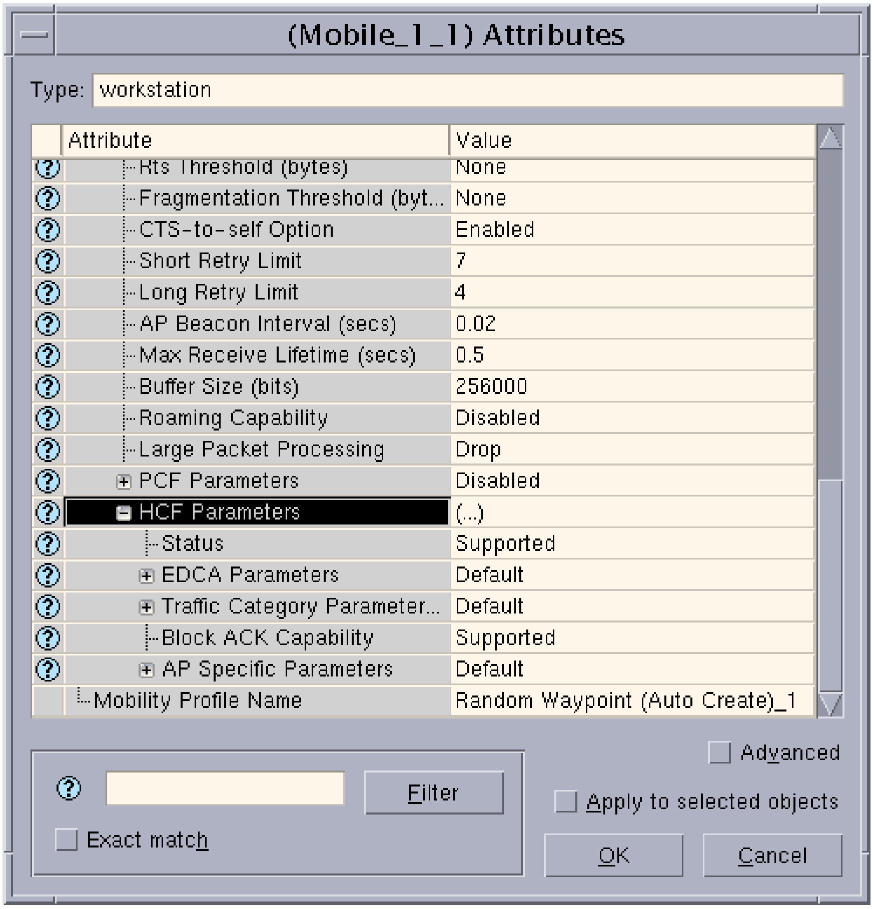

Figure 4: The HCF Parameters for the IEEE 802.11e

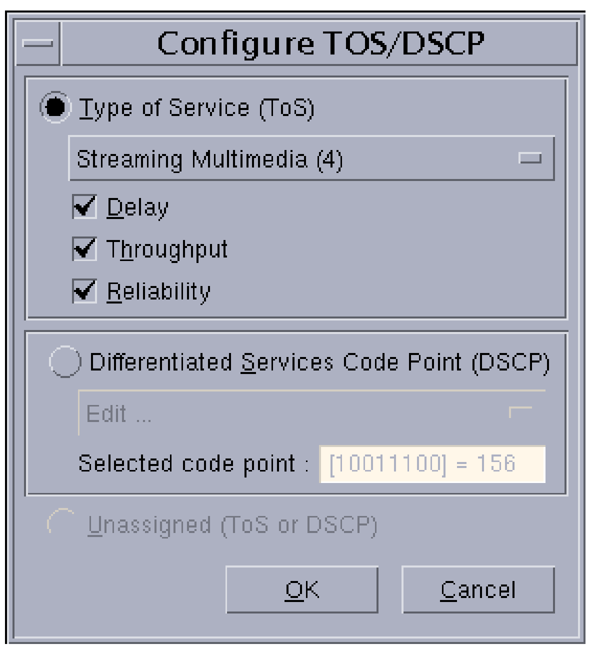

Figure 5: ToS Configuration Box

4. Simulation and Results

Since the main factors affecting video quality are sustained bandwidth, latency, jitter, stream synchronization, and packet loss [7], we will collect the following statistics: packet end-to-end delay, data dropped (bits/sec), media access delay, and packet delay variation. Packet end-to-end delay is the time taken for the source to send a packet to the destination. If this varies greatly over time, synchronization will be lost, thus causing jitter. If the visual quality is low, the data dropped will be high. The media access delay measures the total of the queuing and the contention delays. The packet delay variance measures the variance among the end-to-end delay for data packets from the time created to time received. According to [8], for interactive video streaming, this value should be less than 50ms. The higher the delay variation, the more the application is inconsistent in terms of its responsiveness. This is a very important factor in gaming and interactive video applications.

We chose to simulate the scenario for 1 hour, and the simulation time was about 53 minutes for each scenario. The simulation seed was set to 128. We received no results for the Data Dropped (bits/sec). This is most likely because we only simulated the network with one workstation, which resulted in not enough data being transferred to overflow the buffer.

Figure 6 shows the packet delay variance for both the networks. We can see that the delay variation for the 802.11g scenario stabilizes around 0.0000036s and around 0.0000028s for 802.11e. This shows that the packet delay variation improves in the QoS-enables 802.11e network, where the delay variance meets the requirement for streaming interactive video.

Figure 7 shows the result for the packet end-to-end (E2E) delay statistic. We can again see that the E2E delay is lower for the 802.11e scenario than the 802.11g scenario – it is almost halved. The media access delay (Figure 8) is also decreased for the 802.11e scenario.

The client FTP download response time increases for the QoS-enabled scenario (Figure 9). This shows that since the FTP application has a lower priority than the video application, the bandwidth given to the FTP application decreases, thus increasing the download response time. The increase in the download response time, however, is not very significant – it increased by 0.005s in the 802.11e scenario.

The results that we received are as expected. The 802.11e specification of WiFi does provide better quality of service by prioritizing different traffic streams, thus increasing the application responsiveness and presentation quality.

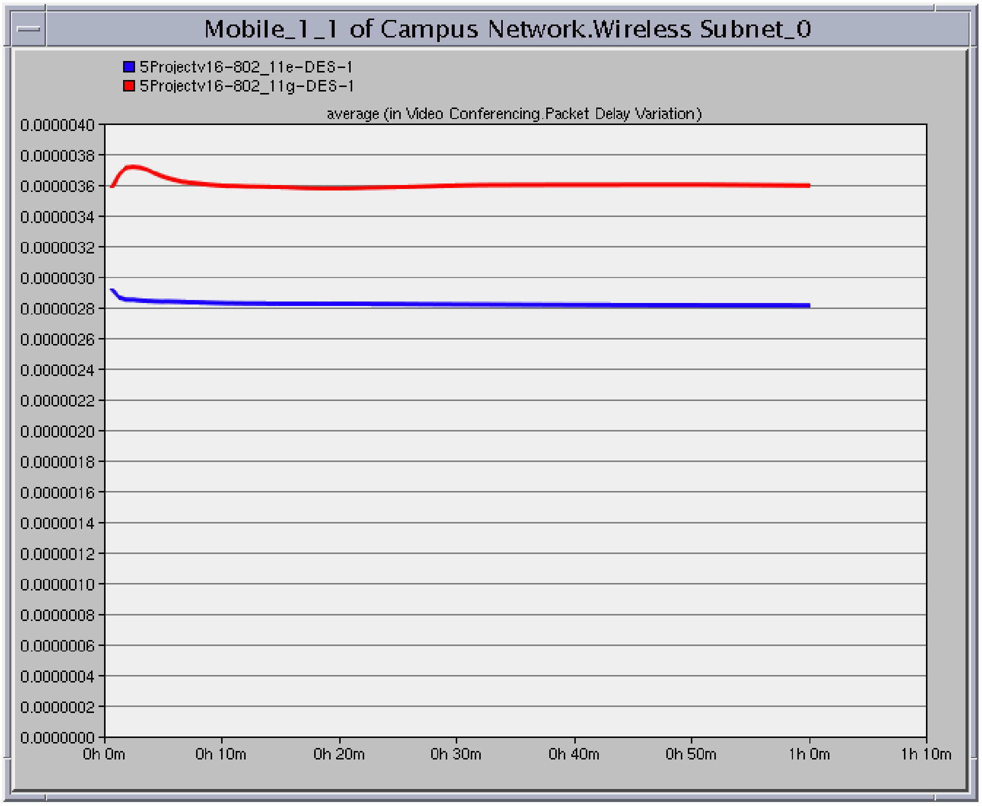

Figure 6: Video Packet Delay Variation

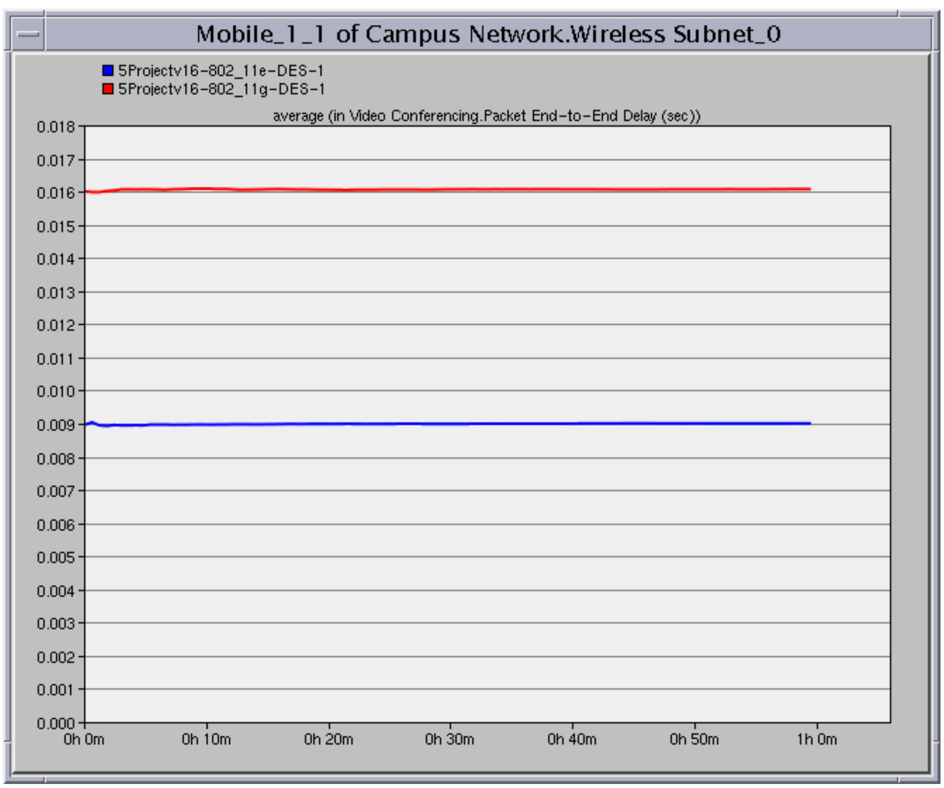

Figure 7: Video Packet End-to-End Delay

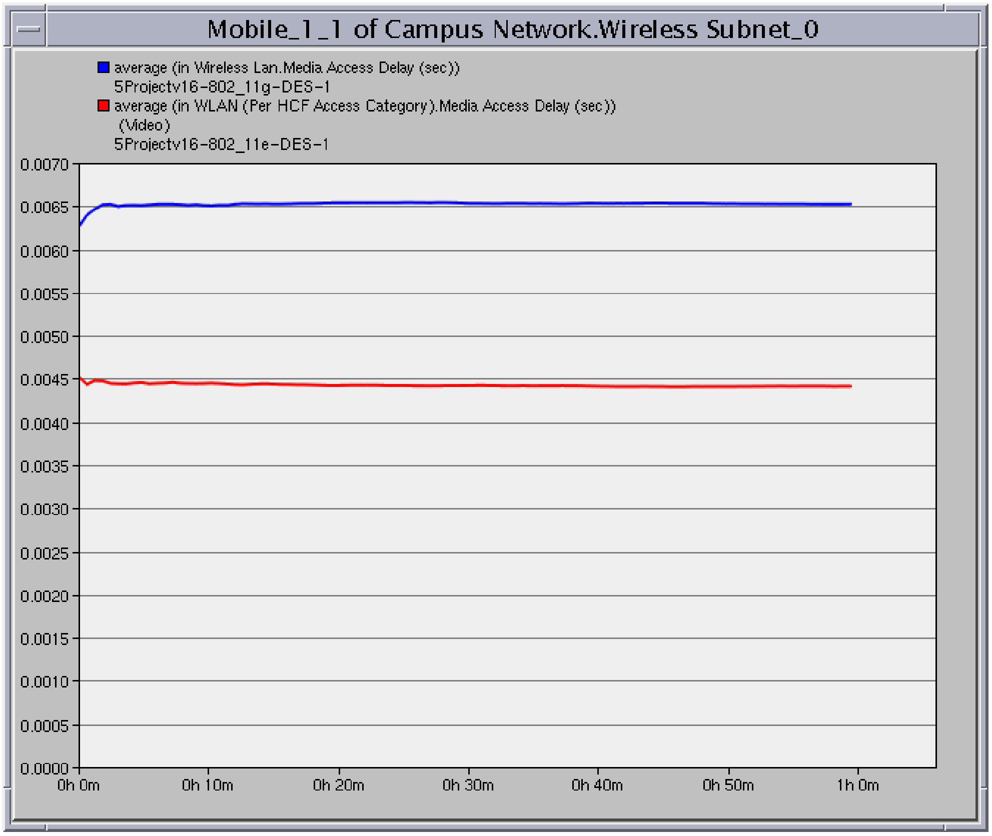

Figure 9: Video Media Access Delay

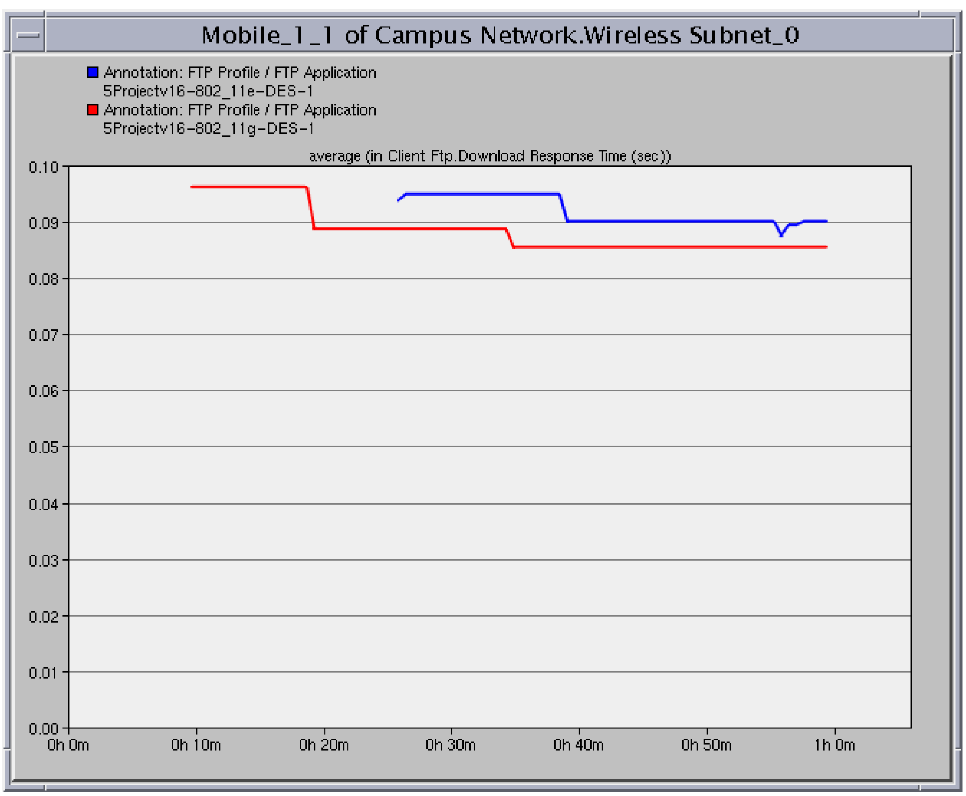

Figure 9: Client FTP Download Response Time

5. Future Work

In the future, we would like to expand our work by adding more workstations to the initial network topology. We have already started working on a network topology that uses ten workstations instead one. This network topology can be seen in Figure 10. However, at the moment we are having some difficulty getting accurate results for this network topology. Thus, for the future we would like to continue to debug this network topology until we get better results. Additionally, we would like to simulate both the scenarios using more data than just FTP and Video streaming. We would like to use more data such as Control load traffic because it is just one level of priority lower than the multimedia traffic. Hence, it will be interesting to see if the HCF still prioritizes the video traffic over the other types of traffic.

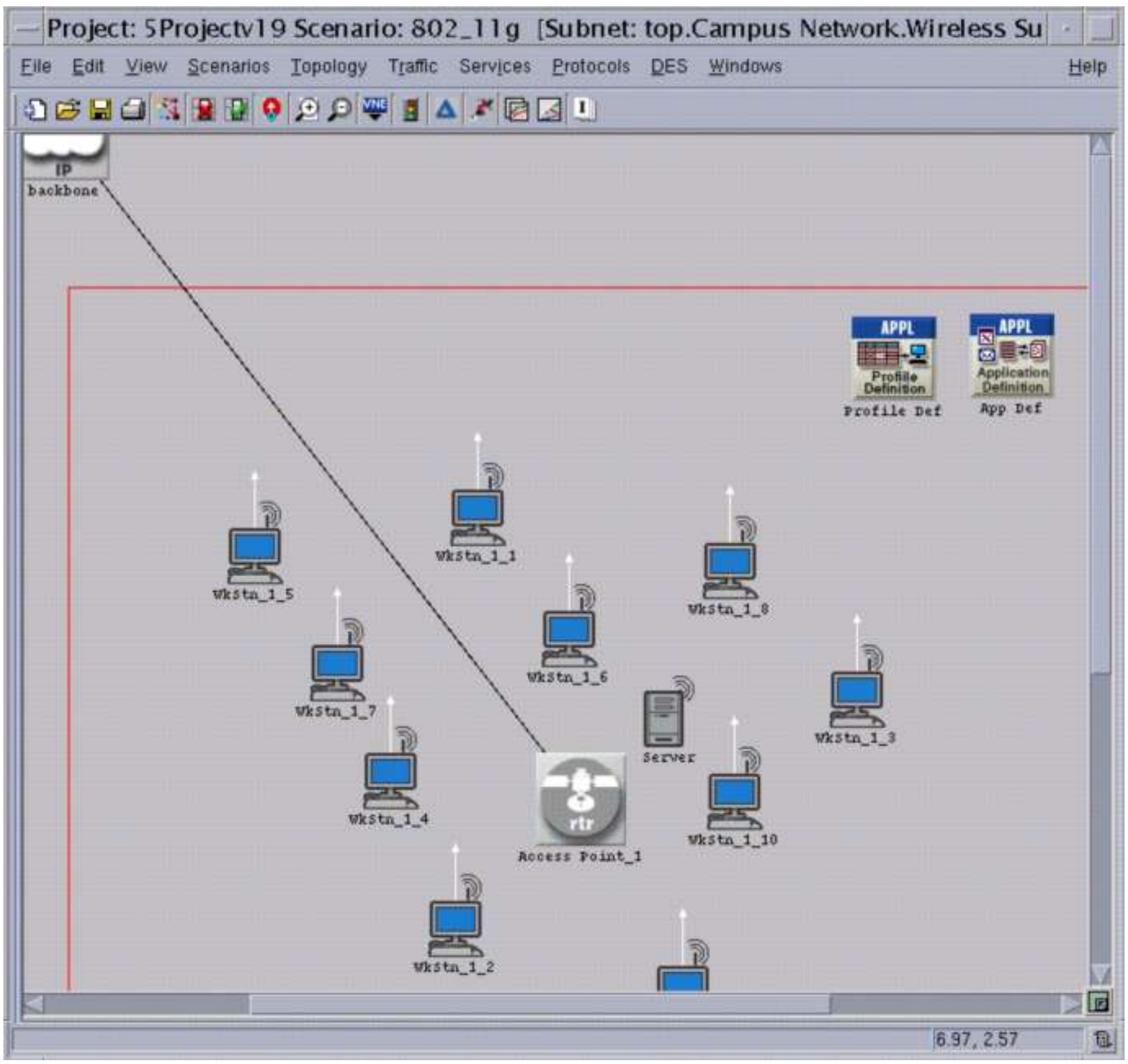

Figure 10: WLAN Network with Multiple Nodes

6. Conclusion

The purpose of this project was to evaluate the quality of service of the IEEE 802.11e and IEEE 802.11g standards. In order to test this, we simulated two different scenarios, one with clients accessing low streaming video and high load FTP, using the IEEE 802.11e standard, and another using the IEEE 802.11g standard. Due to the changes in the MAC layer of the IEEE 802.11e standard to improve quality of service of video, we expect lower packet loss, delay, and jitter in the scenario that uses the IEEE 802.11e standard than the scenario that uses the IEEE 802.11g standard. The QoS for the IEEE 802.11e was better because HCF function has a priority mechanism, which prioritizes video much higher than the FTP data. Our results matched our expectations as the packet loss; the packet delay and the jitter were all lower for the IEEE 802.11e scenario. Thus, for streaming video wirelessly the IEEE 802.11e standard should be preferred than the IEEE 802.11g standard, which at this moment is used more extensively than the IEEE 802.11e.

7. References

[1] N. Cranley and M. Davis, "QoS for multimedia streaming applications over IEEE 802.11b and 802.11e WLANs" in *Wireless Quality of Service: Technique, standards, and applications,* M. Ma, M.K. Denko, Y. Zhang, Ed. Boca Raton, Fla.: Auerbach Publications, 2009, pp. 57-70.

[2] D. Schauland, "What is QoS?" Internet: http://www.wisegeek.com/what-is-qos.htm, [April 11, 2010]

[3] R. MacKenzie, D. Hands, and T. O`Farrell. "Video Quality over 802.11e with a Multi-Rate 802.11e Physical Layer." Internet: ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=05133779, [Marc. 14, 2010]

[4] L. Pan and H. Wu, "QoS-Aware Medium Access Control Protocols" in *Medium Access Control in Wireless Networks*, H. Wu, Y. Pan, New York: Nova Science Publishers, 2008, p. 155

[5] E. Kartsakli, J. Alonso-Zarate, *et al*. "Contention-Based Collision-Resolution Medium Access Control Algorithms" in *Medium Access Control in Wireless Networks*, H. Wu, Y. Pan, New York: Nova Science Publishers, 2008, p. 81

[6] Y-K. R. Kwok and V. K. N. Lau, *Wireless Internet and Mobile Computing: Interoperability and performance*. Hoboken, N.J.: Wiley-Interscience: IEEE Press, 2007, pp. 271, 278-279

[7] T. Alexander, *Optimizing and Testing WLANs: Proven techniques for maximum performance.* Amsterdam, Boston: Elsevier Newnes, 2007, pp. 10, 131, 159.

[8] X. Xiao, *Techinical, Commerical and Regulatory Challenges of QoS: An Internet Service Model Perspective*. Amsterdam, Boston : Elsevier/Morgan Kaufmann, 2008, pp. 13-18, 227-233