ENSC 427: COMMUNICATION NETWORKS

(Spring 2011)

Final Report

Video Streaming over the 802.11g WLAN Technologies

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Abstract

The goal of this project is to simulate video streaming over the 802.11g WLAN. In this report, I build and simulate wireless local area networks (WLAN) based on 802.11g to analyze their limited bandwidth usage for video streaming and overload in data traffic. I try to figure out an effective video streaming method as by examine their throughput and pack loss through the WLAN for popular multimedia streaming. I expect to minded-guess the ability for future intensive video streaming.

1. Introduction

1.1 Overview of 802.11g and 802.11n WLAN technology

In general, 802.11g is a third modulation standard of carrying out wireless local area network (WLAN) computer communication in the 2.4 GHz frequency bands, which operates at a maximum physical layer bit rate of 54 Mbit/s.[8] 802.11n is a recent amendment which improves the 802.11g standard by adding multiple-input multiple-output antennas (MIMO), which can operate on both the 2.4GHz and the 5 GHz bands at a maximum physical layer bit rate up to 600 Mbit/s.

1.2 Issues and Situation on Video Streaming over WLAN

Video Streaming over the WLAN is still a wide problem for our high-intensive informational society. Actually, most family plus small offices are use 802.11g and 802.11n WLAN at their personal or tiny area. However, the current common routers that only supporting up to 802.11n are not quite suitable for doing video streaming freely. Especially, uncompressed video format such as High-definition video (HD), which most commonly involves display resolutions of 1,280×720 pixels (720p) or 1,920×1,080 pixels (1080i/1080p), is not fitting with World Wide Web HD but for HDTV. Thus, I only consider the compressed format of video for the 802.11g in this case. According to the table of numerous online services and their HD offering [6], it can be seen that the video bit rate of the most popular compressed HD video provider YouTube is below 6 Mbit/s.

If a physical layer bit rate of router is 108 Mbit/s, it still can afford for 16 clients doing video stream on the 802.11n WLAN theoretically, which is satisfied with small group use. As to 802.11g WLAN, which is with 54 Mbit/s, it can handle with 8 clients doing video streaming concurrently. In practice, we need to consider other factors such as the distance between routers and clients, blocks disturbing the signal of routers, and working performance of routers. Therefore, the practical results of these routers cannot be so well-designed for managing video streaming smoothly. To achieve the better practical-like situation, I reduce some scale factors such as limiting video bit rate at 6Mbps in the simulation.

1.3 Project Goal

In this project, I build 802.11g models for case study. In the practical limited bandwidth, I will analyze 802.11g bandwidth usage which may experience the delay of video streaming or an overload in data traffic when they are implementing concurrently with other applications such as downloading files. For effective video streaming through the WLAN, I use popular video bit rate of compressed multimedia formats such as MPEG-4(H.264 for video) and AAC (for audio). Also, I test Standard-definition video and HD video on both standard of WLAN to figure out their ability for the intensive video streaming. Moreover, I examine specific results such as throughput and pack loss of the 802.11g WLAN on multi-user's video streaming.

2. Technical Design and Implementation Details

2.1 Overall 802.11g WLAN model

The overall model of 802.11g WLAN network topology built by OPNET is shown in Figure 1.

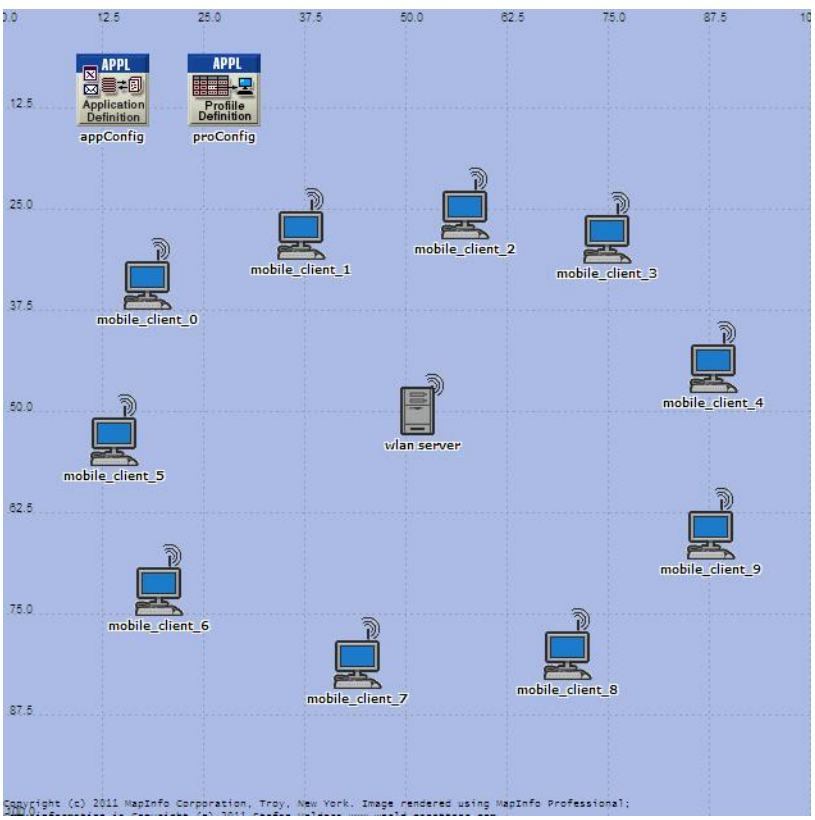


Figure 1: 802.11g WLAN network topology

To simplify simulation, the scale in OPNET model is setting as a small office by 100 meters X 100 meters and the model type is determined as a standard WLAN advanced model. In the model, there are 1 WLAN server providing video streaming and 10 mobile workstation clients with a circle around it for receiving video streaming concurrently. Also, there are an application configuration (appConfig) and a profile application (proConfig) in the topology for setting video application parameters. In the project, for the video server and all clients, I set wireless WLAN parameters: physical characteristics: 802.11g with data rates at 54Mbps.

The progress of construct 802.11g network:
The main steps to build 802.11g network model are followed by:

1. Create the topology
2. Configure nodes and attributes
3. Add video traffic for the model
4. Configure wireless LAN parameters , application and profile

2.1.1 Case 1: general 802.11g WLAN model at different video bit rates

In this part, I build 3 same scenarios as shown in Figure 1 at 2Mbps, 3Mbps and 6Mbps respectively by setting their frame size. At 2Mbps, the frame size should be 8333.3 bytes in Figure 3 according to the formula: frame size = video bit rate / (30 frames/seconds X 8bits). Similarly for 3Mbps and 6Mbps, their frame size is 12500 and 25000 respectively.

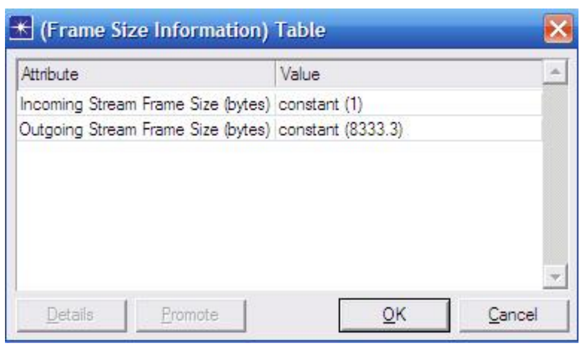


Figure 2: Frame size at 2Mbps video bit rates

Also, from Figure 2, I only set outgoing stream frame size at a large amount because OPENT does not provide attributes for video streaming so that I use the attribute of video conferencing which is set one side with much more video traffic than another side to simulate the operation of video streaming. Moreover, I set the frame size as constant to simply the model and expect to get some reliable results. One point needs to mention is that the type of service of the application of video server is streaming multimedia shown in Figure 3. One the other hand, I assume that the distance from each client to the server is almost the same, and there is no block on the route of video data transferring.

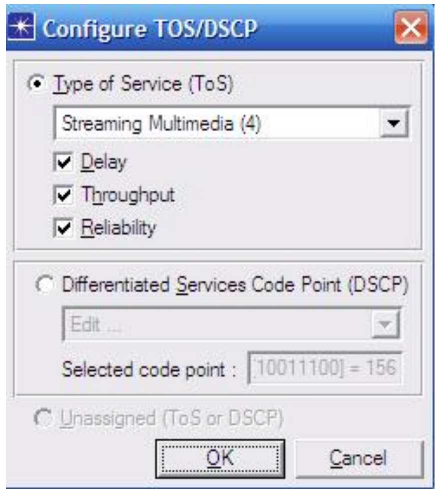


Figure 3: Type of Service for 802.11g model

To achieve video streaming, I set the video server's application > supported services as video streaming, and set all clients to have application > destination preferences: video application and supported profile as video profile.

2.1.2 Case 2: upgraded server at 3Mbps

In order to find out whether hardware parameters of the video server influence the performance of 802.11g WLAN, I change the advanced server configuration of wlan server from the default values: Sun Ultra10 333MHz (1 CPU, 1Core) into Dell PowerEdge 1950 3000MHz (1CPU, 2 Cores).

2.1.3 Case 3: video server with modified transmit power at 3Mbps

In this case, I try increasing the video server's transmit power from 50mW to 100mW based in Case 1.

2.2 Another 802.11g model with clients at different distance.

In this model, there are 1 video server and 3 workstation clients at different distance shown in Figure 3. As shown, the x and y position for these 3 clients are: (25, 25), (50, 50), (90, 90) respectively. The video server is located at (5, 5). In this model, I build 2 scenarios to simulate video streaming at 2Mbps and 3Mbps, and all the settings of parameters are based on case 1 in 2.1.

Figure 4: 802.11g model with clients at different distance

3. Collected Results and Discussion

For doing simulation, my collected results include:

1. Global statics: Packet End-to-End Delay, Packet Delay Variation, load, throughput
2. 802.11g WLAN node statistics: data dropped, delay, load, throughput

3.1 Analysis on 2.1.1 Case 1:

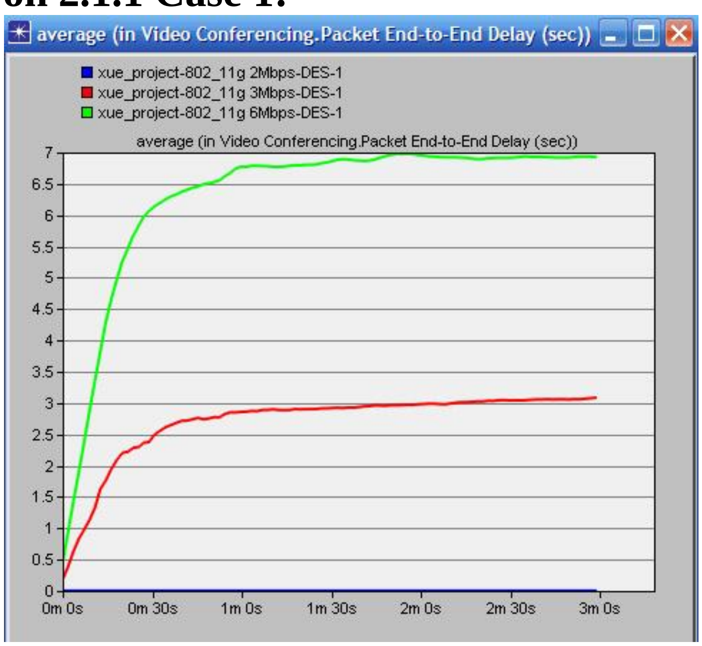


Figure 5: The average of Packet End-to-End Delay at 2Mbps, 3Mbps and 6Mbps

It can be seen that the average of the Packet End-to-End Delay at 2Mbps is tiny and close to zero second, which is the blue line in Figure 5 [delay time (seconds) vs. simulated time (totally 3minutes)], whereas the delay in red line comes up to 3 seconds at 3Mbps video bit rates in only 3 minutes simulated time. Moreover, at 6Mbps, the green line approaches the expected value, which is the largest delay with 7 seconds. In practice, it may be a hard time for customers to wait buffering time up to 7 seconds in every watching a 3 minutes movie clip. Therefore, it will be the only suitable result on doing video streaming application at 2Mbps for 802.11g WLAN when it loads 10 clients synchronized watching movies. For 3Mbps and 6Mbps, 802.11g cannot handle with them, and has to reduce its number of clients to ensure every client in the WLAN could enjoy the movies smoothly.

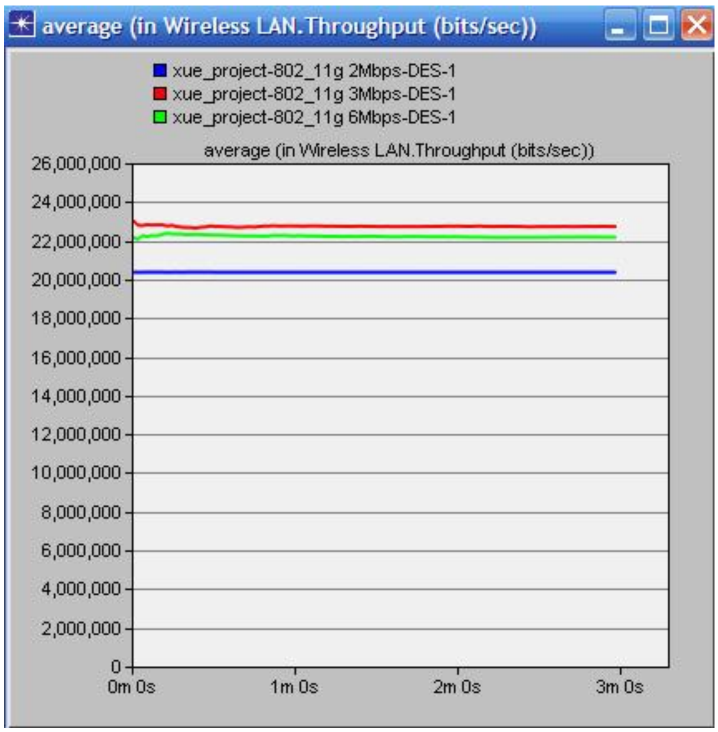


Figure 6: Average of WLAN throughput

One interesting thing is that all the throughput of 802.11g at 2Mbps, 3Mbps and 6Mbps does not pass 24M bit/s as shown in Figure 6, which is much lower the theoretical value at 54Mbit/s for 802.11g standard. In the other words, the channel utilization (bandwidth utilization efficiency) is below 50%, which equals real throughput/ theoretical throughput.

3.2 Analysis on 2.1.2 Case 2:

At 3Mbps, from Figure 7, the average curve of Packet End-to-End Delay and WLAN data dropped are all still quite similar although the scenario in blue line has been already selected a super fast processor for video server. It implies that to provide higher hardware such as processor for the video server does not improve the performance of wireless noticeably, so we can ignore that the processor’s impact on wireless network in practice.

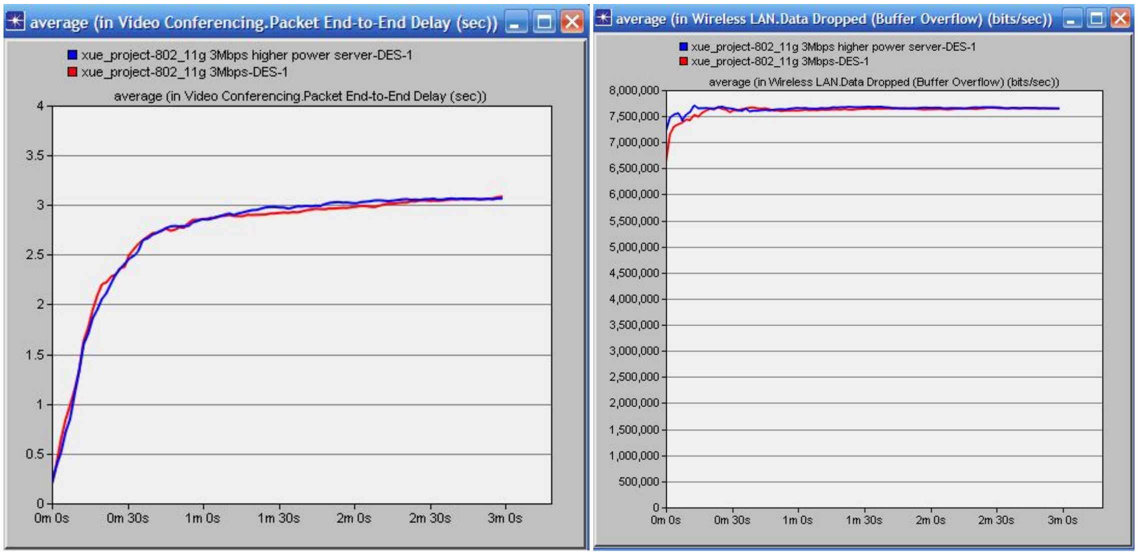


Figure 7: The average of Packet End-to-End Delay and WLAN data dropped

3.3 Analysis on 2.1.3 Case 3:

In this case, I modified the video server's transmit power from 50mW to 100mW to expect better results for video streaming. However, from the comparison between the server in 50mW transmit power and the server in 100mW transmit power in Figure 8, increasing the transmit power does not improve video lag time. To be surprised, on the graph of the packet delay variation in Figure 8, the packet delay variation tends to fall down to below 3 seconds in blue line with 100 mW transmit power compared with the 50mW one in red line which is close to 3.5 seconds. It demonstrates that to rise the transit power can improve the reliability of 802.11g wireless network by reducing the delay variation but not decrease the total delay time obviously. Therefore, in general case, we still can neglect the small fluctuation when we do the analysis on the performance of 802.11g WLAN.

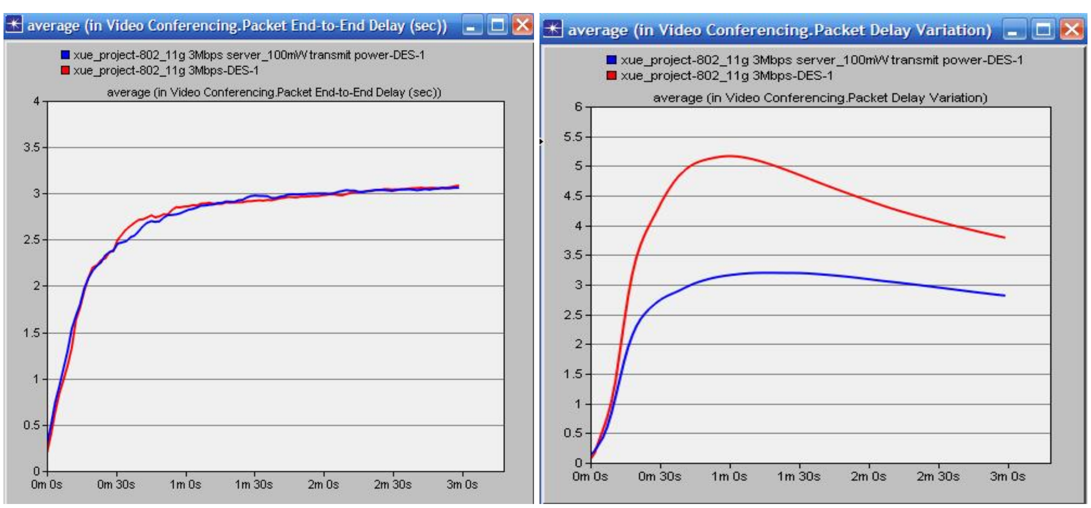


Figure 8: packet end-to- end delay and packet delay variation at different transmit power.

3.4 Analysis on 2.2: the 802.11g model with 3 clients at different distance

In this case, I analyze on the results of 3 workstation clients at different distance, and find that mobile_client_0 in blue line which is the nearest to the video server does not have the lowest end-to-end delay. This result mismatches with my expected result that the closest one should have the strongest wireless signal to perform the least delay. However, for the delay of mobile_client_1 and mobile_client_2, they are followed by the rule that the closer produces the lower delay.

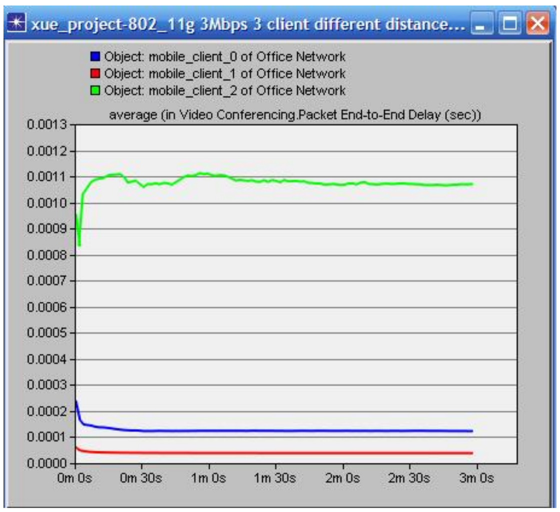


Figure 9: packet end-to- end delay at different distance. **Figure 10: 802.11g model with 6 clients**

To prove the results valid or not, I rebuild this model with 6 clients at different distance as shown in Figure 10. Then, from the results in Figure 11, the closest one - mobile_client_0 in blue line still does not have the lowest end-to-end delay. Moreover, mobile_client_4 in yellow line has less delay than mobile_client_1 in red line. However, the whole trend on the graph for all lines toward to the rule that the further has the more delay. Therefore, in the 802.11g wireless network, we just can say that the whole delay trend when it depends on distance.

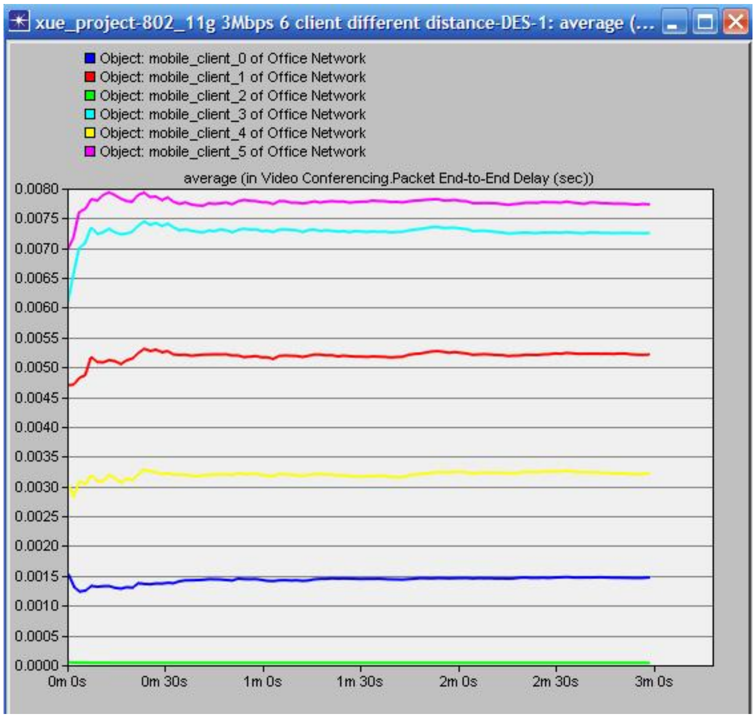


Figure 11: 802.11g model with 6 clients at different distance at 3Mbps

4. Conclusion

Summary on 802.11g:

Through the analysis on 802.11g WLAN, we can see that 802.11g wireless has good performance in controlling end-to-end delay at low video bit rates, and it can do good job in standard definition video streaming with 10 clients. However, to achieve HD video streaming, we have to reduce the number of clients for keeping smooth video streaming.

Also, there is no helpful to improve the wireless performance by upgrading the CPU of server. To increase the transmit power of wireless server can only help reduce packet delay variation but no influence in total delay time.

From the throughput analysis, it seems that 802.11g cannot work at its maximum theoretical throughput at 54Mbit/s in practice, which causes some waste of bandwidth.

In all, 802.11g WLAN still performs well in light video traffic.

Difficulties and Future work for improvement

In this project, I tried building the model for 802.11n in OPNET initially, but I had got no lucky because OPNET only supports for 802.11a, b, e, g. I also tried support for 802.11n from OPNET website through OPNET Contributed Model Library, but I still can't include this model into OPNET Model Library with only compiling errors.

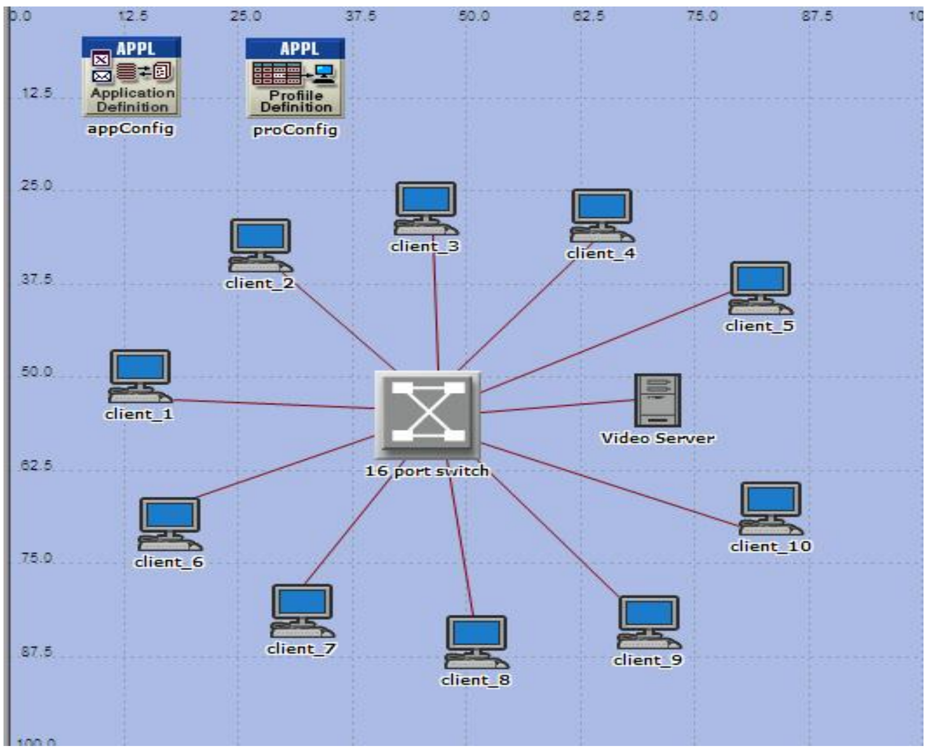
Actually, if I can fix 802.11n into OPNET standard model library, I should compare the different performance between 802.11g and 802.11n. Then, the results I get will be more reasonable for analysis on benefits of 802.11n instead of 802.11g. Now I just can expect that 802.11n should be suitable for HD video streaming with 10 clients as its throughput is over 108Mbit/s up to 600Mbit/s.

In addition, following the suggestion from my professor Ljiljana during my demo, I move the analysis on 100Mbit/s Ethernet into the section of Appendix. I use it as reference for comparing with 802.11g. If I could do a little more comparison between 802.11n and 100Mbit/s Ethernet will be more interesting in analyzing why wirelesses technology instead wired technology in development.

Appendix: 100Mbit/s Ethernet

To compare the performance of 802.11g wireless and wired network, I build another 3 scenarios for 100Mbit/s Ethernet in similar method in 2.1 expect adding one 16-port switch and connecting all other devices into it by 100 BaseT wires.

The scenarios have the same number of clients as in 802.11g general model in 2.1; the topology is shown in Figure A1. I also simulate them at 2Mbps, 3Mbps, and 6Mbps respectively.



A1: 100Mbit/s Ethernet network model

From Figure A2, it can be seen that 100Mbits Ethernet has got larger packet end-to-end delay than 802.11g at 2Mbps. This is out of my expectation that the 100Mbits Ethernet should be working better than 802.11g at low video bit rate. However, from the two graphs in Figure A3, 802.11g performs much worse in packet end-to-end delay compared with 100Mbits Ethernet which obtains lower delay for smoothing video streaming. After all, 100Mbits Ethernet which has the maximum throughput at 100Mbits can easily handle with 10 clients doing video streaming at the same time.

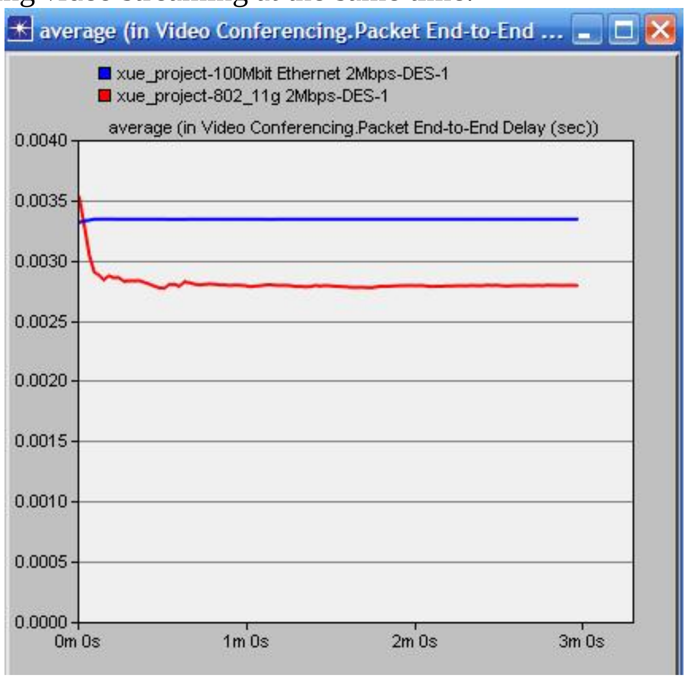


Figure A2: 100Mbits Ethernet at 2Mbps

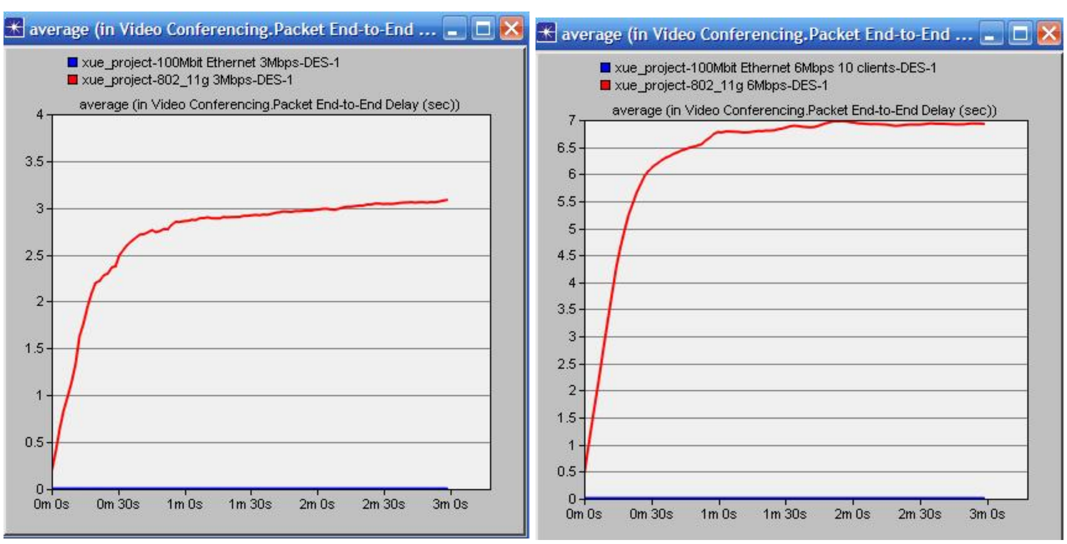
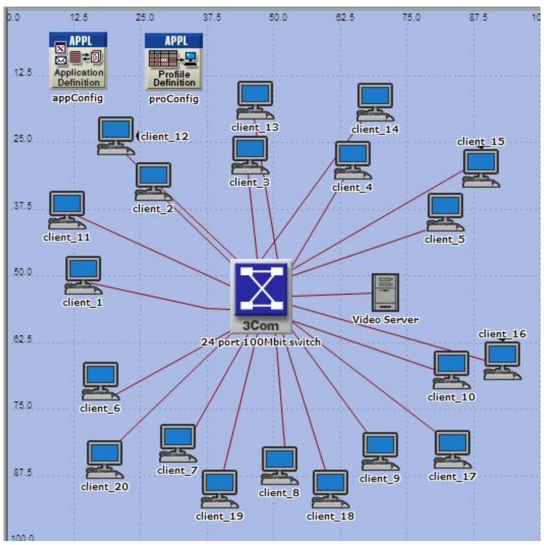


Figure A3: 100Mbits Ethernet at 3Mbps and 6Mbps

To be more interesting, I add 10 more clients for 100Mbits Ethernet in Figure A4 to test its performance in overloaded status. From Figure A5, it shows that the delay of 100Mbit/s Ethernet is not at the lowest level any more, but rising linearly with the increasing of simulated time. One more important thing is that from the graph, I can see that the curve of 802.11g at 6Mbps in green becomes flat when it performs in overloaded status. This means that 802.11g has better control management in delay than 100Mbits Ethernet although it cannot load clients as much as 100Mbits Ethernet due to its 54Mbit/s bandwidth.



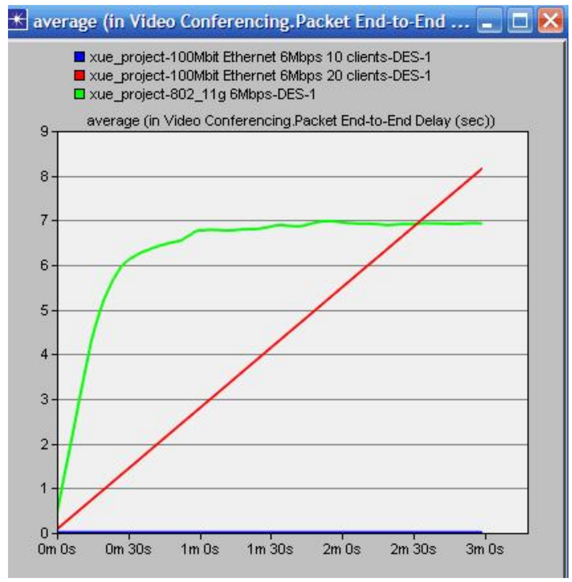


Figure A4: 100Mbit/s Ethernet network model with 20 clients **Figure A5: packet end-to- end delay**

References

[1] M. Fanny,“Testing 802.11n systems” [Online].
Available: http://www.eetimes.com/design/microwave-rf-design/4012912/Testing-802-11n-systems--Part-3--Video-test-results

[2] “Optimizing Enterprise Video Over Wireless LAN” [Online].
Available:
http://www.ciscosystemsverified.biz/en/US/prod/collateral/wireless/ps6302/ps8322/ps10315/ps10325/white_paper_c11-577721.pdf

[3] “Quality of Experience Requirements,” [Online]. Available: http://www.broadband-forum.org/technical/download/TR-126.pdf

[4]W. Hrudey, “Streaming Video Content over IEEE 802.16/WiMAX,” [Online]. Available:
http://www.ensc.sfu.ca/~ljilja/ENSC835/Spring08/Projects/hrudey/whrudey_WiMAX.pdf

[5]http://www.wi-fi.org/discover_and_learn.php

[6]http://en.wikipedia.org/wiki/High-definition_video

[7]http://en.wikipedia.org/wiki/Wi-Fi

[8]http://en.wikipedia.org/wiki/IEEE_802.11