ENSC 427: Communication Network

Quality of Service Analysis of Video Conferencing over WiFi and Ethernet Networks

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Team 3

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List of Acronyms

ETE	End-to-end
HD	High Definition
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local Area Network
LTE	Long Term Evolution
QoS	Quality of Service
VoIP	Voice over Internet Protocol
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network

Abstract

With the trend to have cameras and microphones on computers, laptops, and even mobile phones, video conferencing has become an essential component in business and everyday life. Many computer applications that support video conferencing, such as Skype and Windows Live Messenger, have popularized this technology by providing free or affordable voice and video calling between users from all around the world The objective of this project is to examine the quality of video conferences between two offices conducted over WiFi and Ethernet connections. The performance of different network types will be examined based on aspects of the Quality of Service (QoS) requirement, which includes end-to-end (ETE) delay, dropped packets, low throughput, and jitter. Performance on selected parameters and settings will be observed using network simulator, OPNET 16.0.

Introduction

Video Conferencing

Video conferencing has become a convenient communication tool for people to communicate at any time and any location. Many companies use this technology to conduct their virtual face-to-face meetings across cities, provinces, and even countries. This technology reduces the time and cost for people travelling to the meeting place. Many universities and companies use the advantages of video conferencing for educating and training purposes. The general public adopts it as a way to stay connected with family and friends.

The connection setup for video conferencing between two computers requires an Internet connection and local area networks (LANs). The general public is introduced with the variety of free video conferencing applications and programs. Other paid programs are usually for company meetings, as they require more reliable and secure service.

The traditional video conferencing requires a minimum bandwidth of 128 kbps (bits per second) for a decent quality. High definition (HD) video conferencing requires a larger transport bandwidth at the maximum of 4 Mbps [8]. However, since HD video conferencing has not been used popularly, the project will focus on the low resolution of video conferencing.

WiFi and Ethernet Networks

Over the past years, WiFi has increased its popularity due to its easy installation and quick connection between electronic devices. Many devices and applications support WiFi, such as mobile phones, video game consoles, tablets, and computers. WiFi, standardized in IEEE 802.11, uses radio waves to provide wireless high speed Internet connection for data exchange. It can transmit at frequencies of 2.4, 3.6, and 5 GHz. This project selects IEEE 802.11g for building wireless network since 802.11g has been used popularly for years. It can transfer data at the minimum speed of 6 Mbps and maximum speed of 45 Mbps [10].

Wireless network enables two or more computers to communicate through a proper network protocol, but with physical connection between them. There are two types of wireless networks: network with an access point and peer-to-peer network [2]. The wireless network with access point is implemented in the project. The access point can be either software or hardware, acting as a hub to provide connectivity for wireless devices (Figure 1). It can connect to an Internet router to gain the access to the Internet.

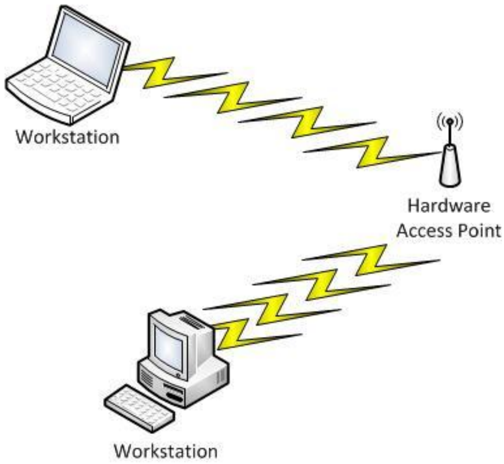

Figure 1 Wireless Network with Access Point

Ethernet, developed by Xerox and standardized in IEEE 802.3, is the popular local networking technology. The most commonly installed Ethernet forms are 10BASE-T, 100BASE-T, and 1000BASE-T. The transmission speed for each form is at 10 Mbps, 100 Mbps, and 1 Gbps, respectively [11]. With the increase in modern advancements, Ethernet network has the ability to provide wider range of networking connection. The project uses 10Base-T for building Ethernet network.

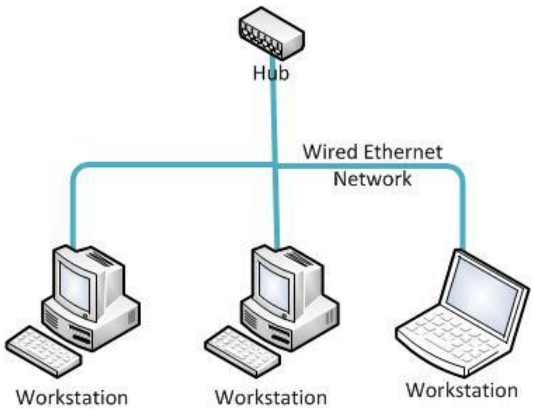

Figure 2 Wired Ethernet Network

Quality of Service

The QoS offers consistent data delivery service to meet the special requirements. Various factors affect QoS, such as delay, jitter, and the error probability. Jitter is related to delay which is defined as the variations in travel time when data has been transmitted between two locations. ETE Delay is defined as how long the data takes to travel between two locations or two nodes. For both delay and jitter, the faster the transfer rate, the better the performance. Dropped packets are the number of the packets being dropped due to the node overflowing. Small value of dropped packets is the best result. Throughput is the amount of the information which can be transferred between two locations in specific time periods. The higher the throughput, the faster the data transfer [1]. The project will evaluate the video conference's QoS parameters over Ethernet, WiFi network or combined networks.

OPNET Implementation

General Configuration

Office Configuration

The central office is set in Vancouver. Two other offices are set up in Calgary and Toronto. Video conferencing will be performed between Vancouver and one of the two offices. The Profile and Application configuration are placed in the highest topology because the general configurations of each subnet are the same. The two cities are connected using a LAN_Mod_PPP_DSO link. The end of the link is connected to the router of each office.

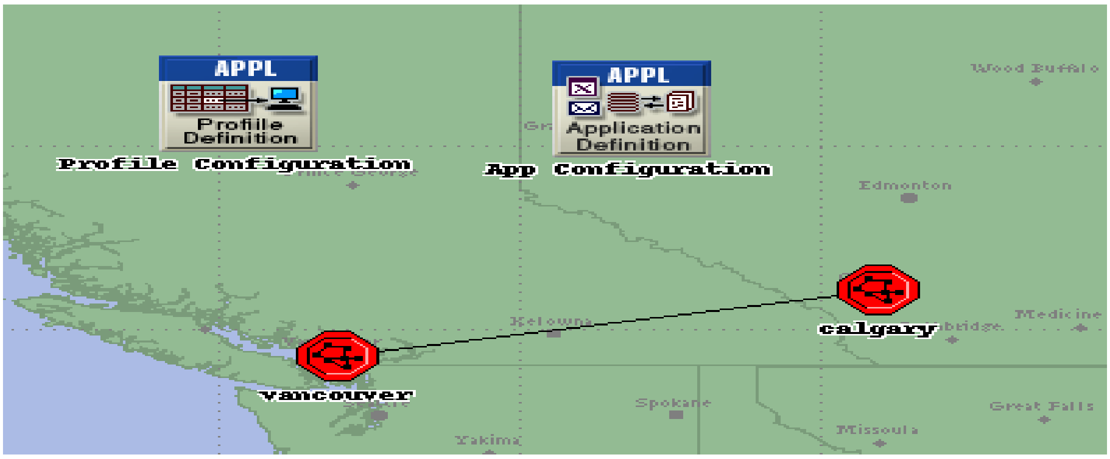

Figure 3 Video Conferencing between Vancouver and Calgary

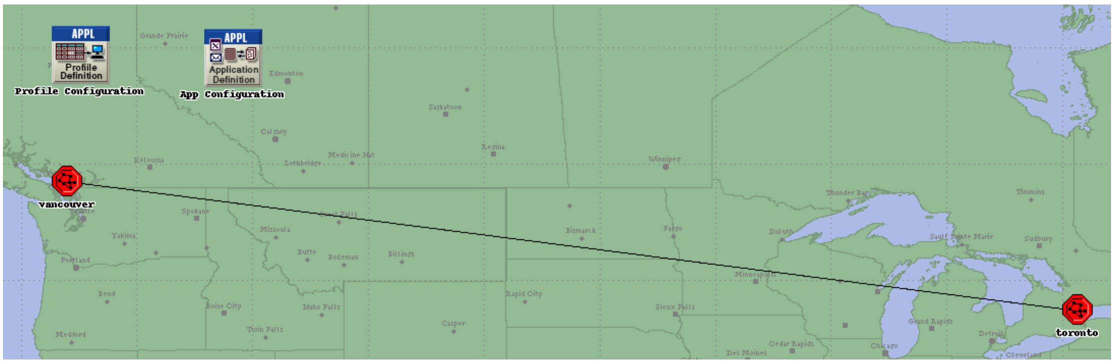

Figure 4 Video Conferencing between Vancouver and Toronto

WiFi Model

The figure below is a screen capture of the Vancouver subnet. Wireless work stations are placed around the access point. To change the number of wireless users, the stations are either duplicated or removed from around the access point. The access point model is then connected to the router with a 10BaseT link. This Cisco 4000 router also connects the server to the rest of the network. The Calgary and Toronto subnets are set up the same way except no server is set up.

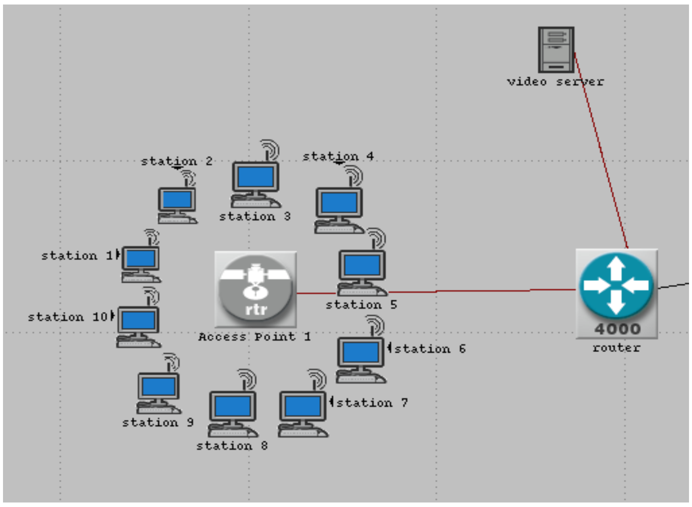

Figure 5 OPNET WiFi Network

Ethernet Model

With Ethernet implementation, the each office contains a 10BaseT Ethernet Network. This object will simulate an office with as many work stations as required. Simply modify the configuration of the model to change the number of Ethernet users. This network is connected again with a 10base line to a Cisco 4000 router. The figure shown below is the main Vancouver office which contains also contains a server.

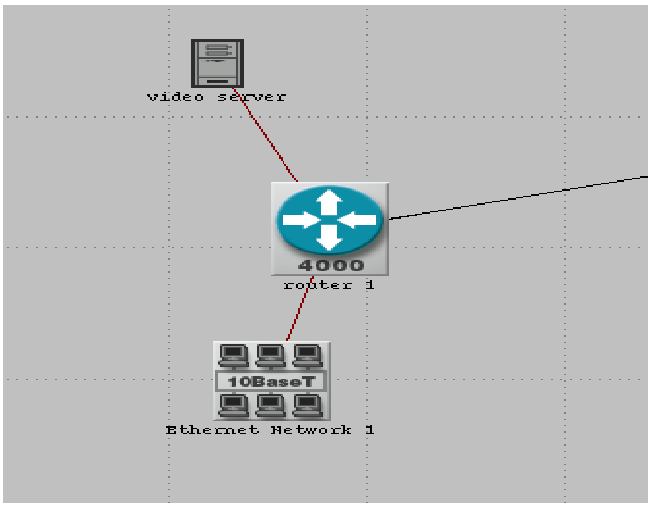

Figure 6 OPNET Ethernet Network

Mixed Network Model

To simulate a more realistic model where offices will contain both Ethernet and WiFi users, the following configuration is set up. The model contains the access point and its wireless work stations as well as the Ethernet Network all connected to the Cisco 4000 router.

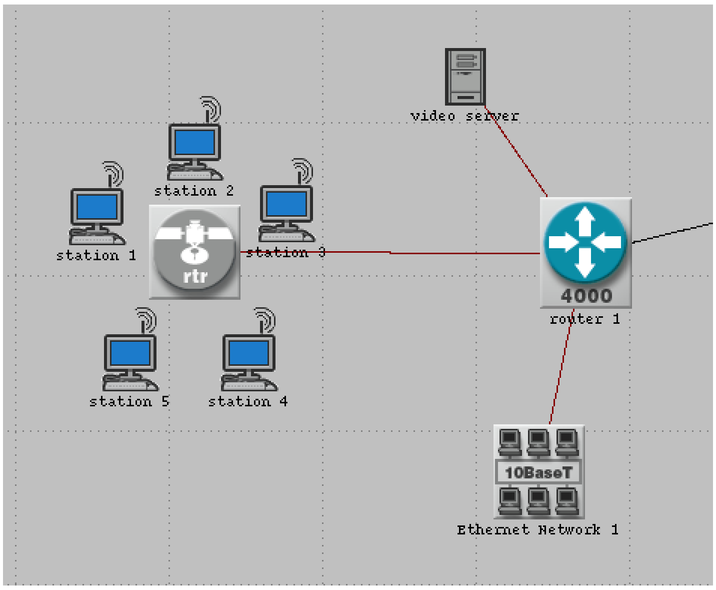

Figure 7 OPNET Mixed Network of WiFi and Ethernet

Network Topology

The following 6 cases are simulated to compare the QoS of Ethernet and WiFi in different circumstances. Some of the cases were designed purely to compare the difference of Ethernet and WiFi while other cases are an attempt to simulate real life situations.

Case 1: Equal User Number, Calgary to Vancouver

The first case is a simple test to see the difference between Ethernet and WiFi between Vancouver and Calgary. In both cases, 10 users in Vancouver and 10 in Calgary are setup for low quality video conferencing. The entire simulated time was 15 minutes

Case 2: Equal User Number, Toronto to Vancouver

Case 2 is set up exactly like case 1 except the office subnet is now placed in Toronto. The total user remained at 10 per office and the simulated time at 15 minutes.

Case 3: Unequal User Number, Calgary to Vancouver

The third case was done between Vancouver and Calgary. The total number of users remained at 20 but the users in each office varied. The first simulation repeated case 1 to be used as reference. Simulation two was with 5 Vancouver video conferencing users and 15 Calgary users. The last simulation had 15 users in Vancouver and 5 in Calgary. This case is the only case where the simulation time was shortened due to the computer system's limited memory.

Case 4: Mixed Network, Equal User Number

After assessing the basic qualities of simple Ethernet and WiFi networks, case 4 will evaluate the QoS of mixed networks. The simulation combines Ethernet with WiFi by adding a 10BaseT Ethernet

Network to the router that is already connected to a WiFi access point. The referenced 10 user per office in the previous cases is split into 5 Ethernet users and 5 WiFi users in each office. The comparison in this case is made between the Vancouver-Calgary network and the Vancouver-Toronto setup. The simulation is set to 15 minutes.

Case 5: Mixed Network, Unequal User Number

Due to the large amount of combinations that can be created by changing the number of total users, the number of Ethernet/WiFi users at a particular location and the distance, case 5 will specifically analyze a mixed network between Calgary and Vancouver with varying user number. The first simulation is again the reference one with 5 WiFi and 5 Ethernet users in both subnets. In the next simulation, the number of Ethernet users is increased to 9 in both subnets while the WiFi users were limited down to 1 user. The third simulation is similar except with 9 WiFi users and 1 Ethernet user.

Case 6: Extra Applications Added

OPNET 16.0 contains many common applications that can be added into the network traffic to simulate a more realistic model. The first simulation is again the reference result with 10 users in Vancouver and 10 in Calgary using only low quality video conferencing. Next, the search engine (medium load) and email (medium load) applications were added to the applications profile. The last simulation included the previous three applications and the addition of medium web browsing and medium FTP loads. The Ethernet, WiFi and combined networks are simulated separately. The three networks are later simulated together with only three applications added.

Discussion

Case 1: Equal User Number, Calgary to Vancouver

The result of packet ETE delay is shown below. From the graph, Ethernet and WiFi networks have almost the same result for the ETE delay. After about 6 minutes, the ETE delay of Ethernet network starts increasing. At the end of the simulation, the Ethernet network has longer delay than WiFi network, by the difference of 40.

During the simulation, the packet delay variation of both networks increased exponentially. At the end of the simulation, the variations of WiFi and Ethernet networks are 20,500 and 16,500, respectively. The difference of two networks is 4,000.

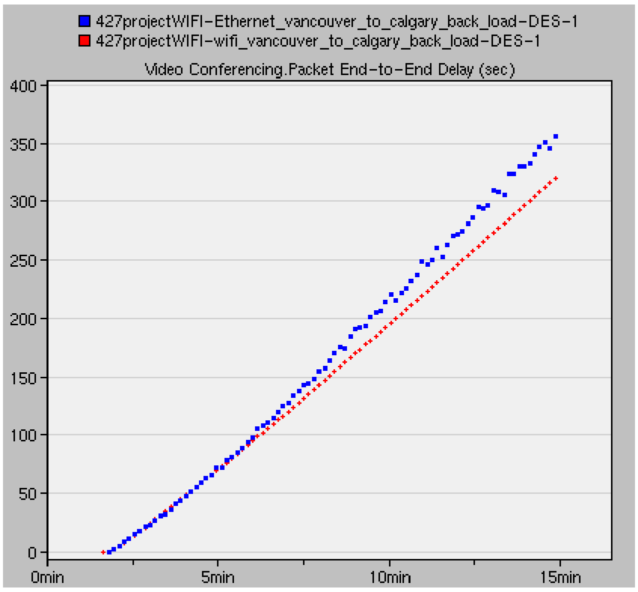

Figure 8 Case 1 Packet ETE Delay

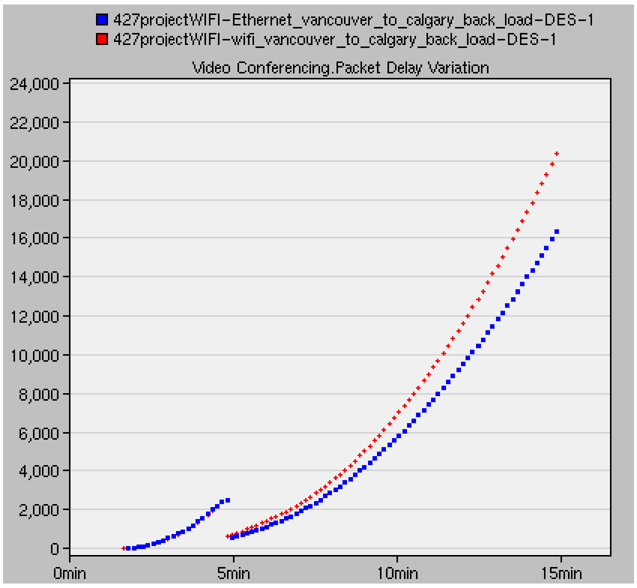

Figure 9 Case 1 Packet Delay Variation

WiFi network sent more traffic and received more traffic than Ethernet network did. The number of dropped packets is the difference between the numbers of traffic sent and received in the unit of packets/second. The number of dropped packets in WiFi network is about 204 packets/second. The number of dropped packets in Ethernet network is around 200 packets/second as well. Hence, there is not much difference between the number of dropped packets from Ethernet and WiFi.

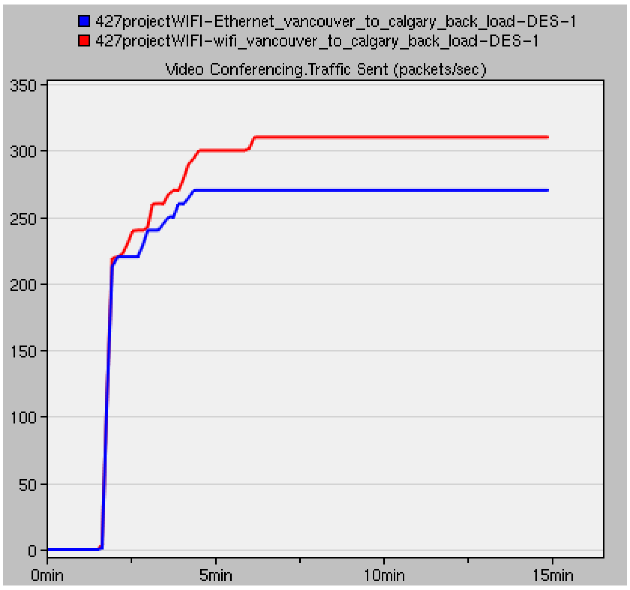

Figure 10 Case 1 Traffic Sent

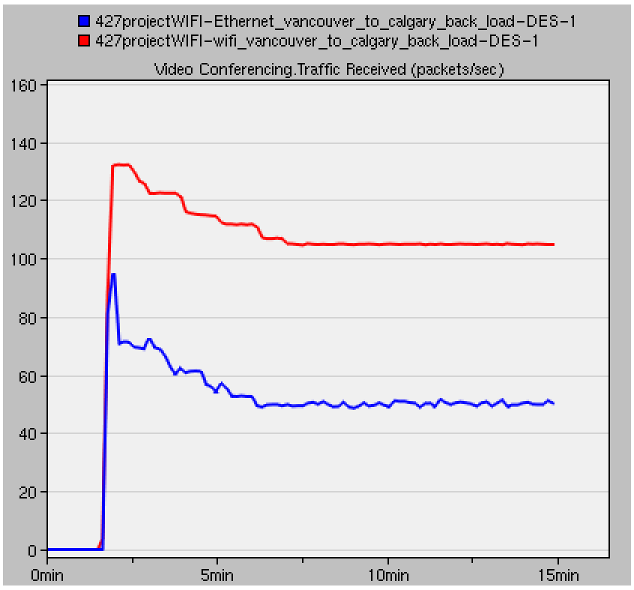

Figure 11 Case 1 Traffic Received

Both networks have almost the same throughput, which stayed between 7 and 8 packets/second.

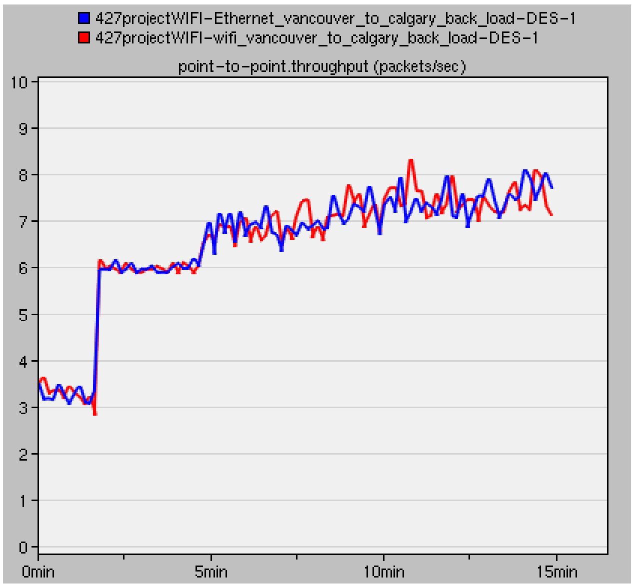

Figure 12 Case 1 Throughput

Case 2: Equal User Number, Toronto to Vancouver

This case tracks the QoS for video conferencing from Vancouver to Toronto. From the figure below, the ETE delay is almost the same between WiFi and Ethernet. WiFi seems to have a slightly longer delay than Ethernet.

The packet delay variation of both networks increased exponentially during the simulation. Around 10 minutes, the variation between the WiFi and the Ethernet has 120 packet differences. However, at the end of the simulation, the variation of WiFi is 20,500 and the variation of Ethernet is 16500.

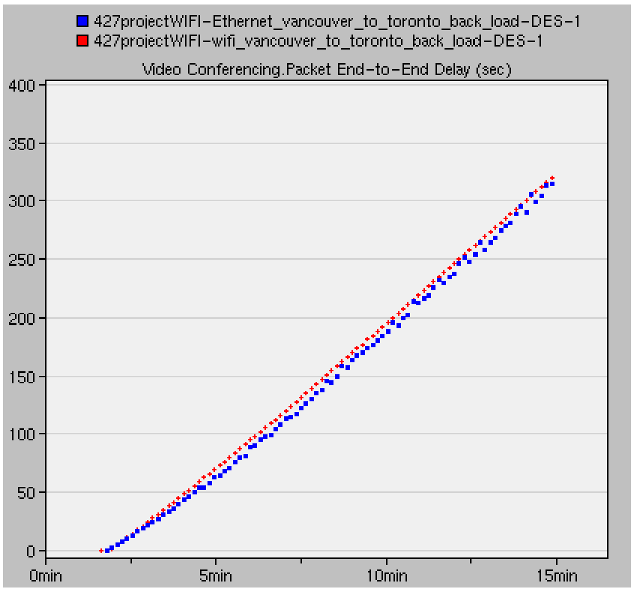

Figure 13 Case 2 Packet ETE Delay

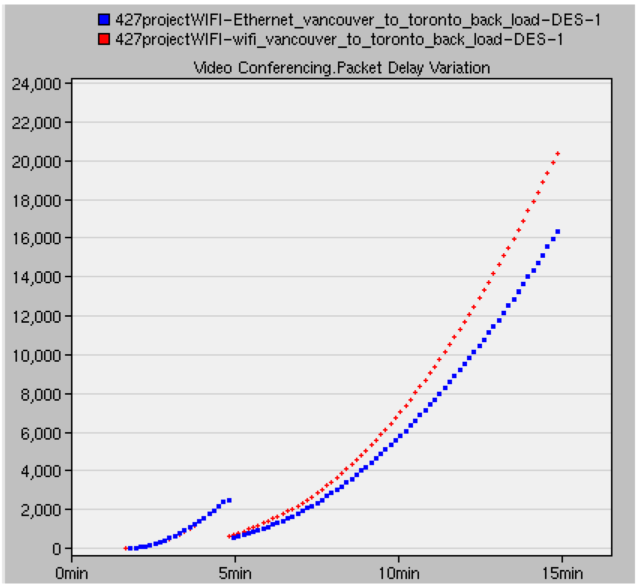

Figure 14 Case 2 Packet Delay Variation

Figure 15 shows the amount of traffic sent during the video conference. After about 5 minutes of the simulation, WiFi's traffic rate stabilized at around 310 packets/second while Ethernet has around 260 packets/second. In the traffic received case, towards the second half of the simulation, WiFi has 105 packets/second traffic while Ethernet has around 60 packets per second traffic received. This shows that WiFi was able to receive almost twice as much as Ethernet. The numbers of dropped packets in WiFi and Ethernet networks are 205 and 200 packets/second, which shows the same result as Case 1.

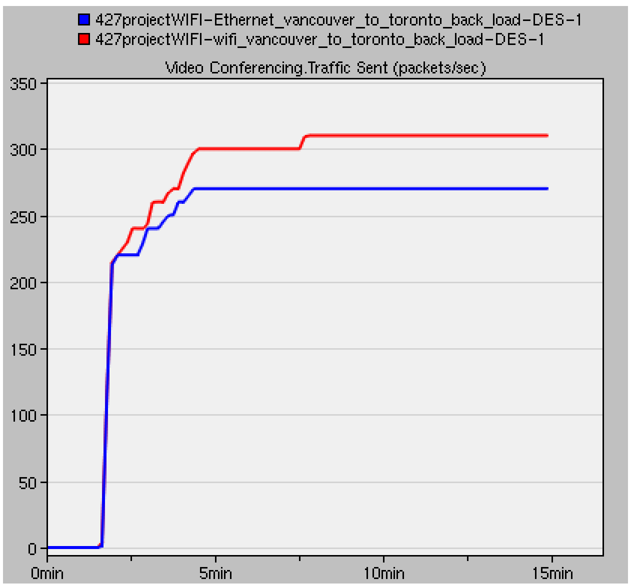

Figure 15 Case 2 Traffic Sent

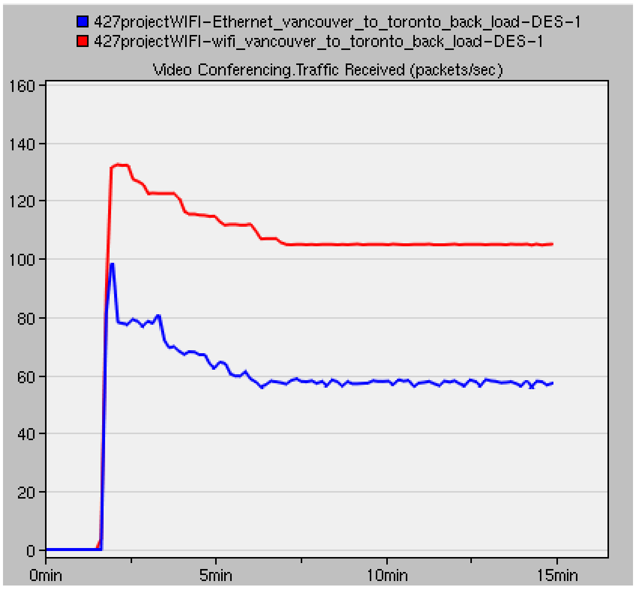

Figure 16 Case 2 Traffic Received

The following figure shows the throughput of the Ethernet and WiFi network. The throughput of the two networks is very similar.

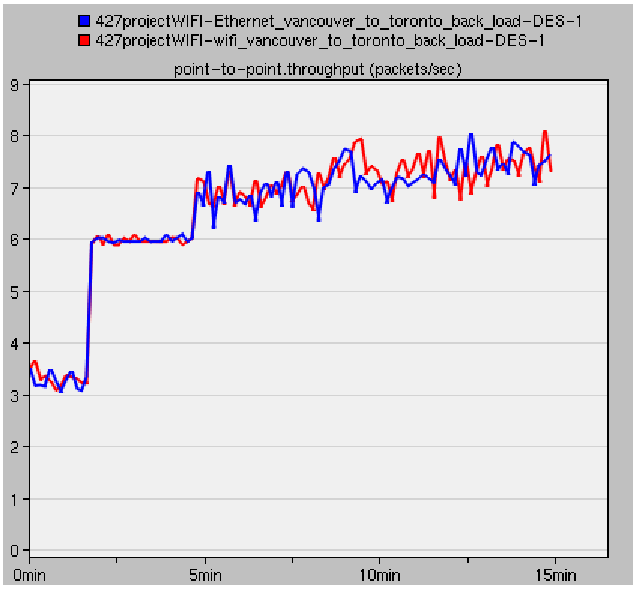

Figure 17 Case 2 Throughput

Case 3: Unequal User Number, Calgary to Vancouver

When user numbers in the two offices have been changed, the results are shown as follows.

ETE delay is the shortest when Vancouver user is 5 and Calgary use is 15. The longest delay for both WiFi and Ethernet was reached at 10 minutes with 60 to 70 seconds delay. The next longest delay time are the reference simulations with 10 users in Vancouver and 10 users in Calgary. The WiFi result reached its highest with 190 seconds of delay while Ethernet data showed a maximum delay of almost 250 seconds. The simulations that had the longest delay is when Vancouver users increased to 15 people and Calgary decreased to 5. The WiFi delay reached a maximum of 275 seconds and Ethernet was the slowest with more than 300 seconds of delay. Based on these results, we can conclude that WiFi in general always have a shorter delay time under the same circumstances. When users increased in Vancouver, the delay increased. The only difference between the Vancouver and the Calgary subnet is the fact that the server for the offices is located in Vancouver. The video conferencing data packets are sent from the server in Vancouver. Therefore, as the number of users in Vancouver increases, the traffic load applied on the server also increased causing a longer delay time.

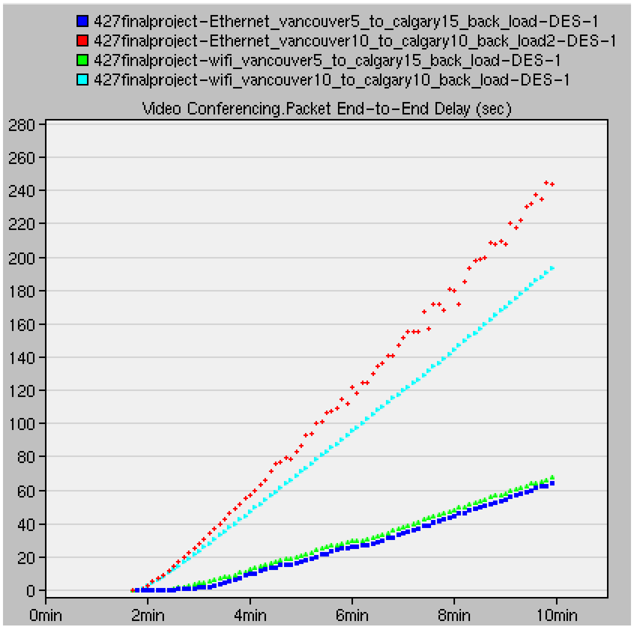

Figure 18 Case 3 Packet ETE Delay 1 (Van 5-10)

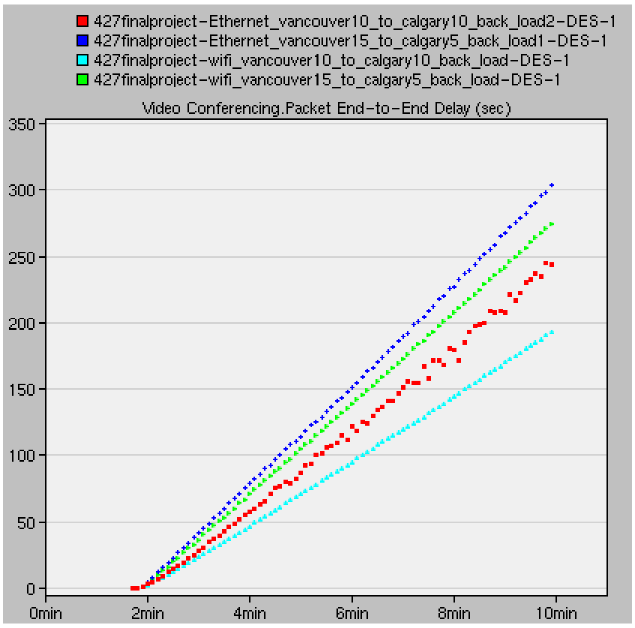

Figure 19 Case 3 Packet ETE Delay 2 (Van 10-15)

Delay variation corresponds to the ETE delay in the previous section. With less Vancouver users, the variation decreased. Again, the Vancouver-5 users set had the lowest delay variation with Ethernet's quality a little better than WiFi's. Vancouver-10 users is second best with the WiFi setup with slightly lower variation than the Ethernet version. The simulation with Vancouver having 15 users resulted in the highest delay variation. In the last set of simulations, the WiFi had the worst quality. From the graphs shown below, the 3 pairs of results are relatively close to one another. The difference between WiFi and Ethernet is very small. In Case 1 and 2, the results showed that WiFi would cause higher delay variations and this is reflected in case 3 when user numbers changed.

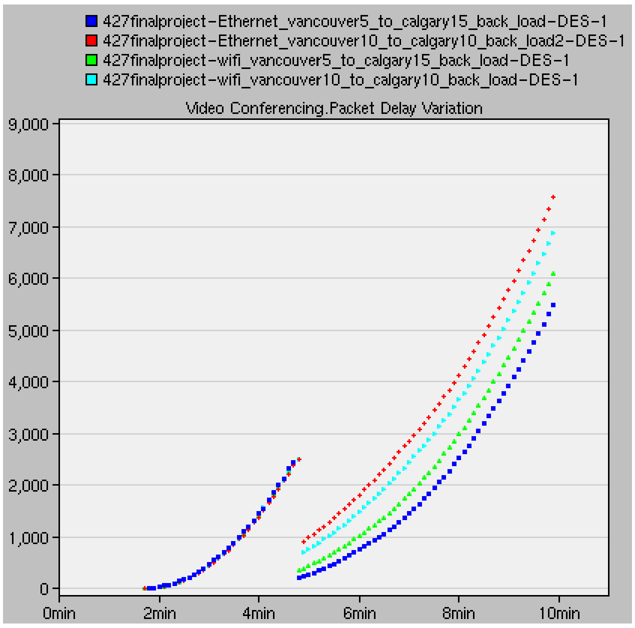

Figure 20 Case 3 Packet Delay Variation 1 (Van 5-10)

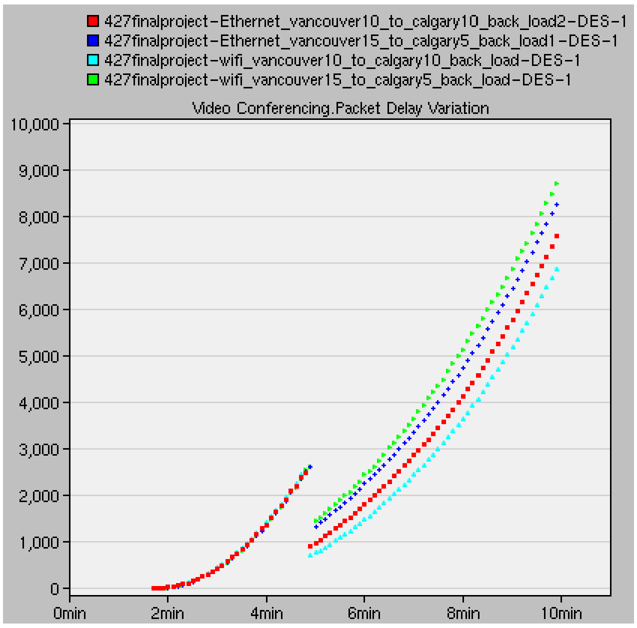

Figure 21 Case 3 Packet Delay Variation 2 (Van 10-15)

The traffic sent results are completely dependent on the number of Vancouver users. When the simulation is set to 5 Vancouver users, the traffic sent stabilized around the 240 packets/second mark. The WiFi network was slightly higher than the Ethernet network during the 2-5 minute section. With 10 users, the Ethernet network sent as high as 330 packets/second and the WiFi version showed a slightly lower rate of 310-320 packets/second. The 15 Vancouver users' traffic sent was around 375 packets/second for both WiFi and Ethernet. The WiFi and Ethernet networks did not differ too much from one another. The traffic sent rate increased with the number of Vancouver users because the Video conferencing server is placed in the Vancouver subnet.

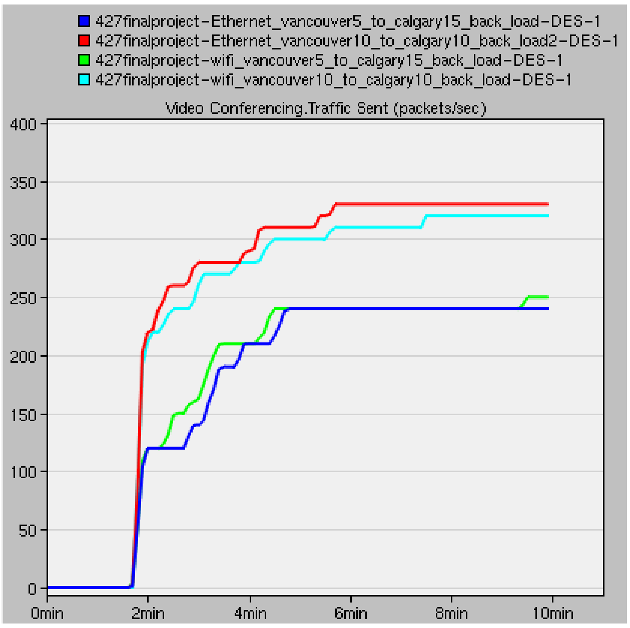

Figure 22 Case 3 Traffic Sent 1 (Van 5-10)

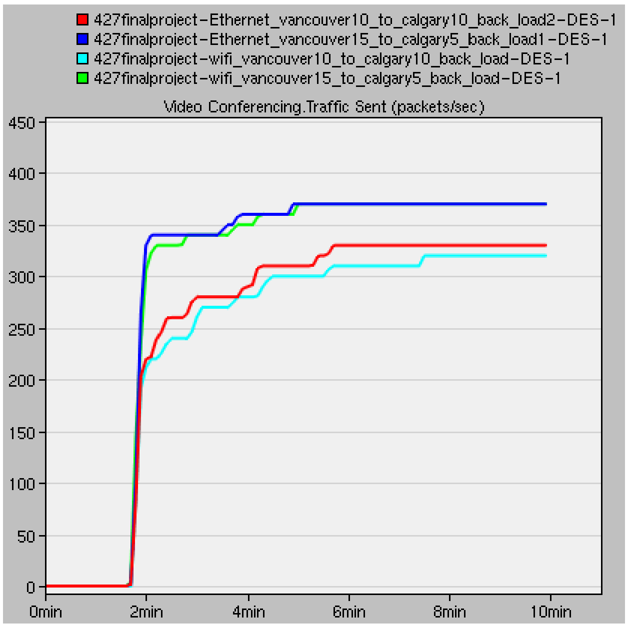

Figure 23 Case 3 Traffic Sent 2 (Van 10-15)

The results for the traffic received simulations shows that WiFi networks are capable of receiving up to twice the number of packets compared to the Ethernet network. The highest receiving rates are found in Figure 24, where the WiFi network with 10 Vancouver users received at a rate between 130-100 packets/second. The WiFi network with 15 Vancouver users received around 100-110 packets/second. The 5 user WiFi network and 5 user Ethernet network were a close third at approximately 70-100 packets/second. The lowest traffic received is the Ethernet network with 10 and 15 Vancouver users. The 15 Vancouver users received between 50-60 packets/second while the 10 Vancouver users simulation only had traffic received at 40-50 packets/second.

The numbers of dropped packets for 5, 10, 15 Vancouver WiFi users are 170, 215, and 260 packets/second, respectively. The number of dropped packets for 5, 10 ,15 Vancouver Ethernet users are 170, 290, 320 packets/second, respectively. The calculation of dropped packets are shown in Table 1.

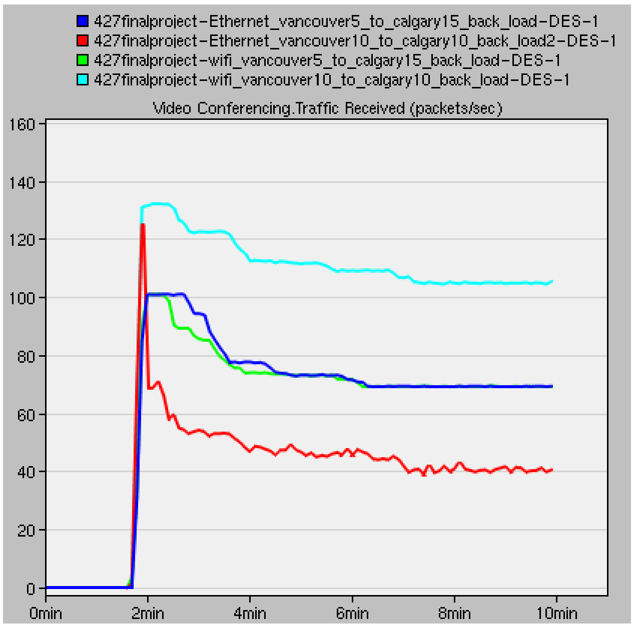

Figure 24 Case 3 Traffic Received 1 (Van 5-10)

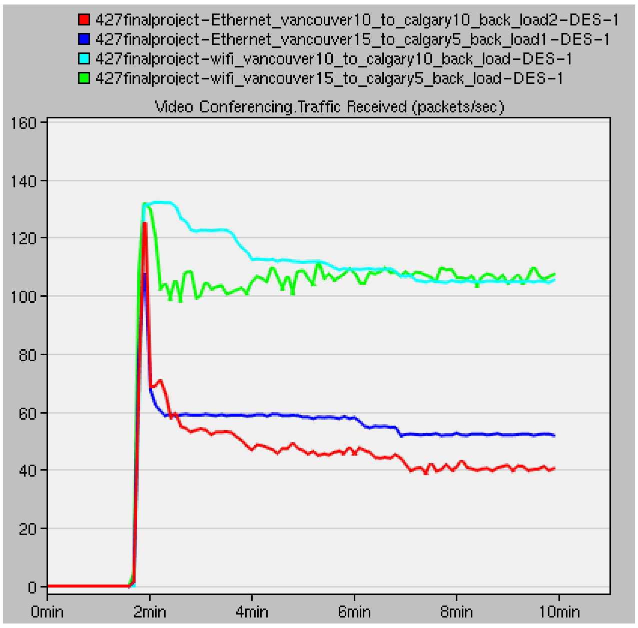

Figure 25 Case 3 Traffic Received 2 (Van 10-15)

Table 1 Case 3 Comparison of Number of Dropped Packets

Network Type	Number of Users	Traffic Sent (packets/second)	Traffic Received (packets/second)	Number of Dropped Packets
WiFi	5	240	70	170
	10	320	105	215
	15	375	115	260
Ethernet	5	240	70	170
	10	330	40	290
	15	375	55	320

Throughput for all three sets of simulations showed no difference, which can be concluded that the number of users does not have any effect on the network throughput.

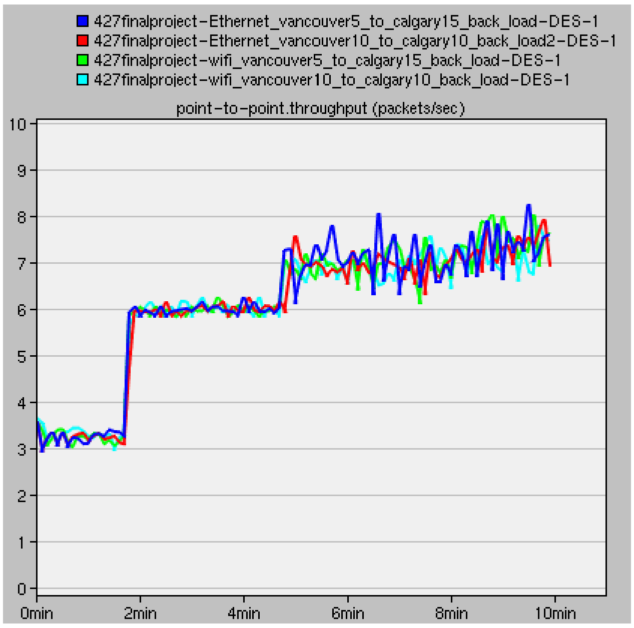

Figure 26 Case 3 Throughput 1 (Van 5-10)

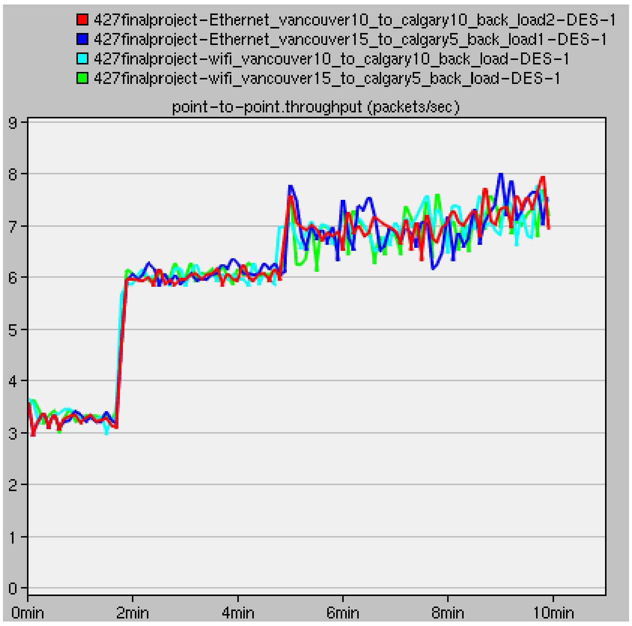

Figure 27 Case 3 Throughput 2 (Van 10-15)

Case 4: Mixed Network, Equal User Number

After simulating the mixed network with a constant user number for both Ethernet and WiFi, the following results were obtained. In case 4, the comparison is made between Vancouver-Calgary and Vancouver-Toronto.

ETE delay between Vancouver and Toronto is noticeably and consistently higher than the Vancouver-Calgary network as seen in the image below. The setting between the two networks is identical. Based on this simulation, the packet delay can be affected by the distance packets travel. Compared with Case 1 and 2 where the network was either WiFi or Ethernet, the mixed network's delay is considerably shorter. For example, the end to end delay between Vancouver and Calgary is between 300 to 350 seconds while the mixed network is only around 70 seconds.

The packet variation graph emphasizes the effect of distance on the quality of the video conference. This was not noticeable in the case 1 and 2 where the packet variance of WiFi and Ethernet for both Calgary and Toronto were around 16,000 to 20,000. In the case of a mixed network, the delay variance decreased down to 4,500 for Vancouver to Toronto and to only 2,500 for Vancouver to Calgary.

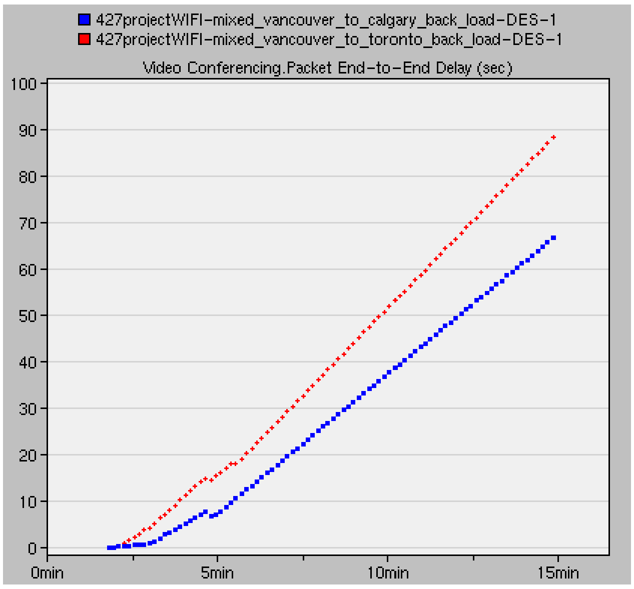

Figure 28 Case 4 Packet ETE Delay

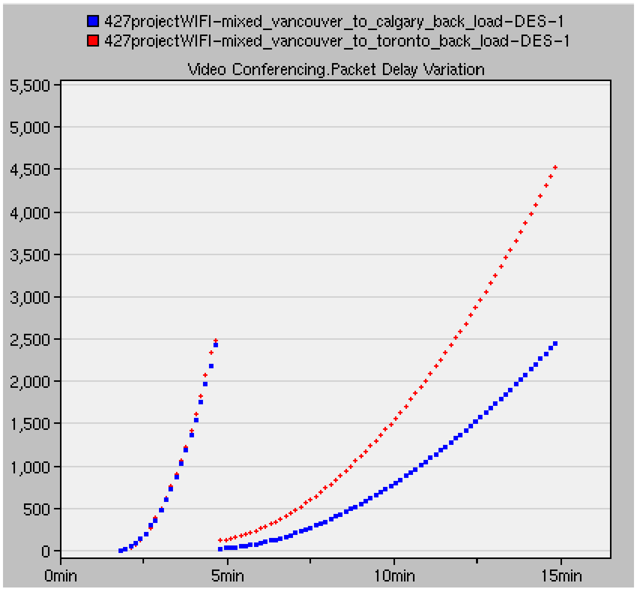

Figure 29 Case4 Packet Delay Variation

In the traffic sent graph shown below, the packets sent from Vancouver to Toronto at 170 packets/second is slightly more than Vancouver to Calgary which is at 150 packets/second. The difference between Calgary and Toronto for the traffic received case is very low as seen below. Calgary received about 90 packets/second while Toronto is slightly lower at 85 packets/second. The numbers of dropped packets for Vancouver-Calgary and Vancouver-Toronto are 60 and 85 packets/second, respectively.

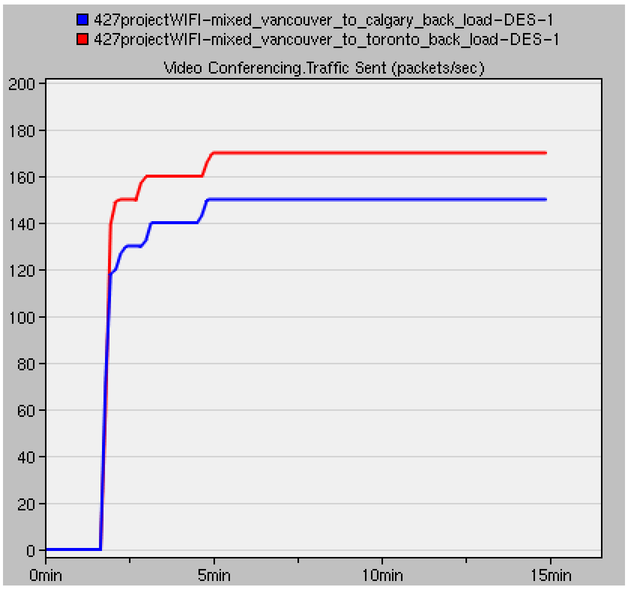

Figure 30 Case 4 Traffic Sent

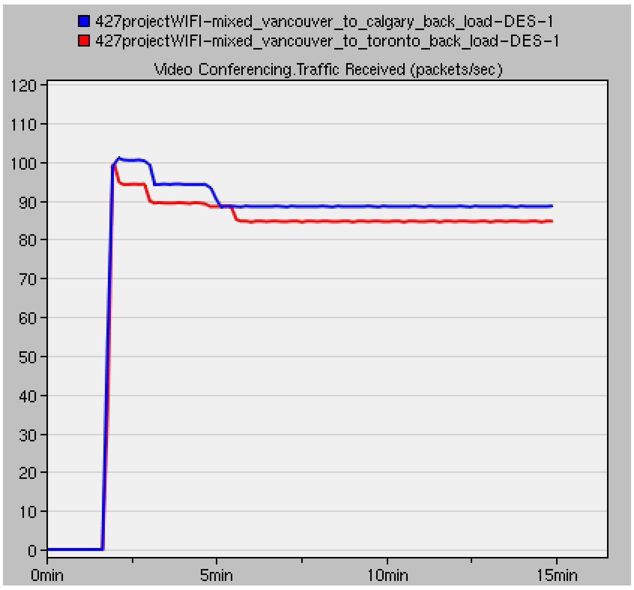

Figure 31 Case 4 Traffic Received

The throughput of the network stayed between 7 to 8 packets/second for all cases. When the results of Vancouver-Calgary are overlaid on top of Vancouver-Toronto's, the graphs' variation during the 15 minute simulation is similar enough to conclude that the distance did not have an effect on the throughput

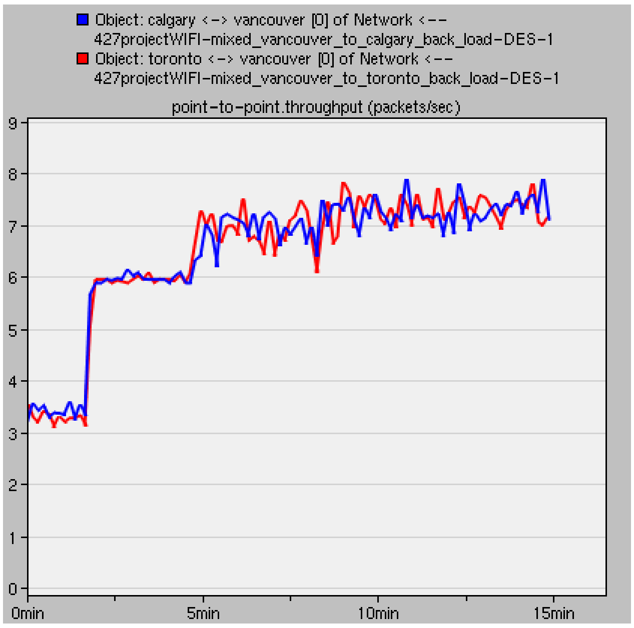

Figure 32 Case 4 Throughput

Case 5: Mixed Network, Unequal User Number

The network with 9 Ethernet users and 1 WiFi user has ETE delay at around 210 seconds. The network with 1 Ethernet users and 9 WiFi user has an almost zero packet delay. . In the packet ETE delay graph, red is the reference result with a balanced Ethernet and WiFi user. Delay variation increases as the number of Ethernet user increases and the number of WiFi users decreases. The network with 9 Ethernet users has delay variation at 19,000. The QoS in terms of ETE delay and packet variation show that mixed networks with more Ethernet users will have longer delays and higher variance.

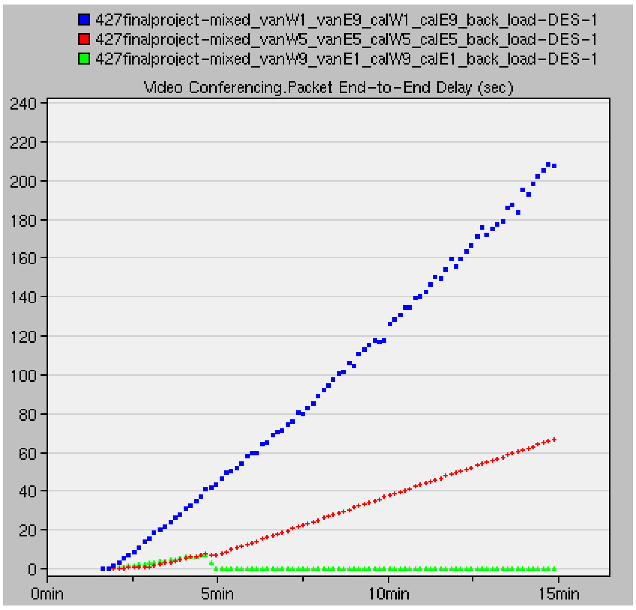

Figure 33 Case 5 Packet ETE Delay

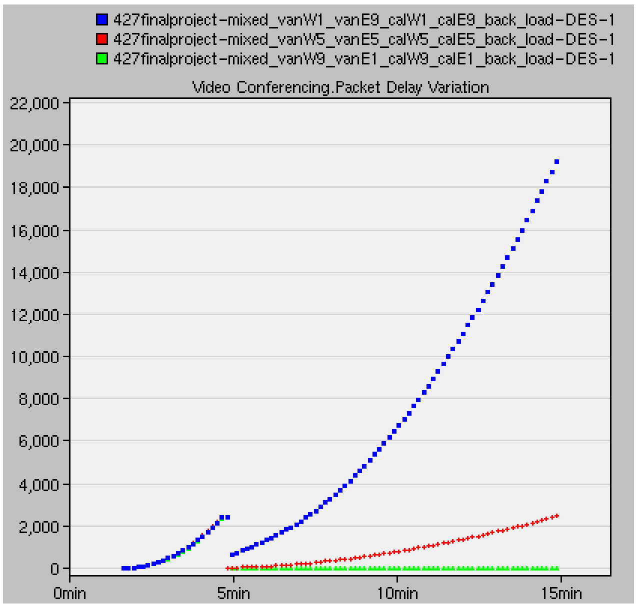

Figure 34 Case 5 Packet Delay Variation

More traffic was sent by the 9 Ethernet users case and less traffic as the Ethernet users decreased. However, more traffic was received with equal number of users for Ethernet and WiFi compared to the other 2 settings. From Figure 36, the traffic received by the 9 Ethernet user case jumped significantly higher than the other 2 cases. For unknown reasons, the graph degraded as the simulation continued. It did not stabilize at a particular traffic rate either. The numbers of dropped packets for blue, red, and green networks (as indicated in the graph below) are 205, 60, and 20 packets/second. The number of Ethernet and WiFi users affects the number of dropped packets significantly.

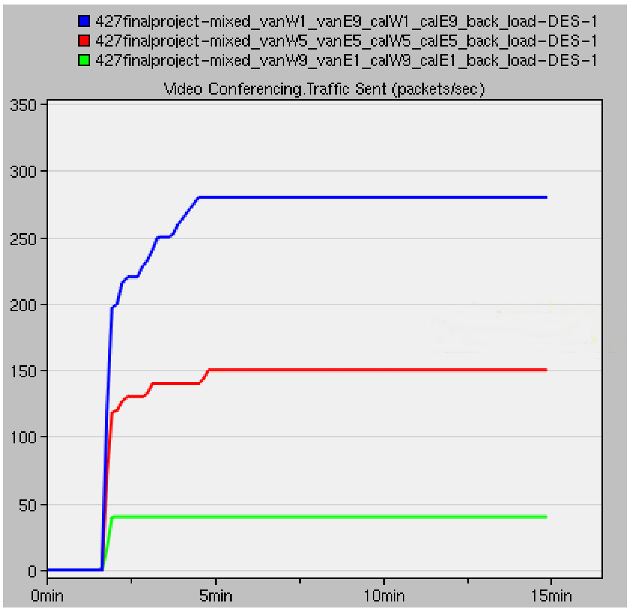

Figure 35 Case 5 Traffic Sent

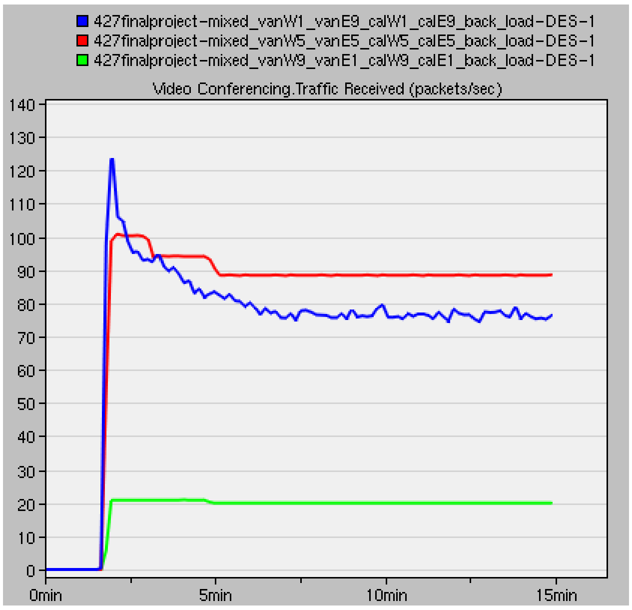

Figure 36 Case 5 Traffic Received

The throughput shows no huge difference with different number of users.

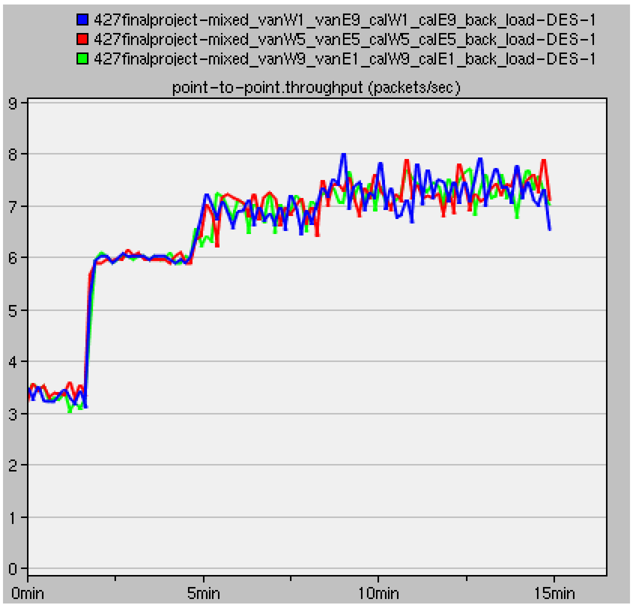

Figure 37 Case 5 Throughput

Case 6: Extra Applications Added

There are 4 sub-sections for Case 6. The results are shown as follow:

Comparison 1: Ethernet Network with more Applications

ETE delay is shortest with three applications and longest with video conferencing only. The difference between the shortest and longest ETE delay is about 40 seconds. The result is surprisingly beyond the theoretical expectation: ETE delay should be longer with more applications added.

Packet delay variation increases with video conferencing only and decreases with five applications. The difference between the highest and lowest delay variations is about 1500. There is no huge difference between the delay variations of five and three applications.

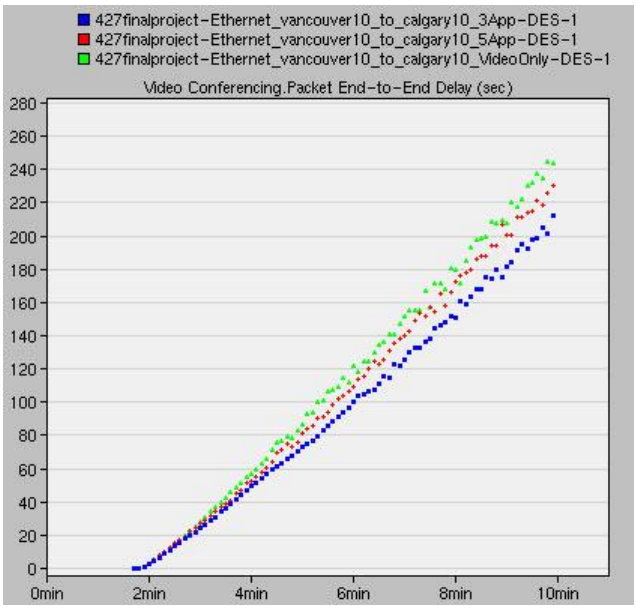

Figure 38 Case 6 Comparison 1 Packet ETE Delay

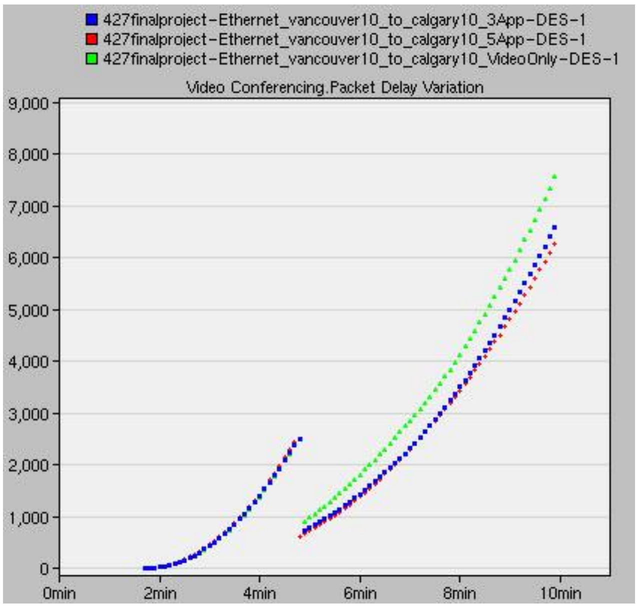

Figure 39 Case 6 Comparison 1 Packet Delay Variation

From the graphs of packet ETE delay and delay variation, it is hard to understand the interesting result that OPNET simulated. The reason could be that not every workstation is video conferencing during the simulation.

Traffic was sent more with the video conferencing only case and less with the five applications case. The network with video conferencing stabilized around 340 packets/second. The networks with more applications did not stabilize to a particular traffic rate throughout the simulation period. Traffic received was less with video conferencing only and more with three applications. According to Table 2 found at the end of this section, the network with five applications has less packets dropped and the network with video conferencing only has more packets dropped.

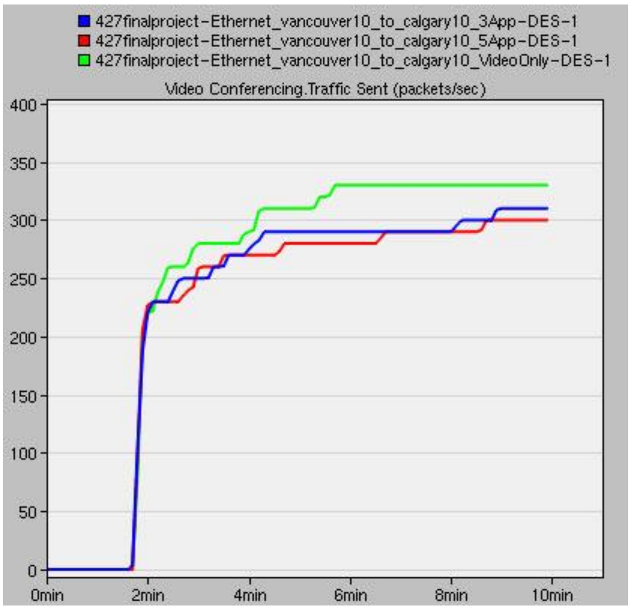

Figure 40 Case 6 Comparison 1 Traffic Sent

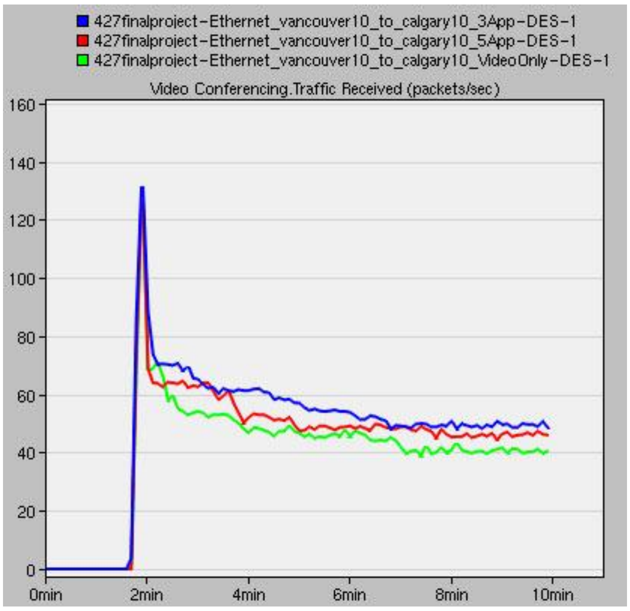

Figure 41 Case 6 Comparison 1 Traffic Received

The throughput of the network stayed between 6.5 and 8 packets/sec. The graph below showed no difference; hence, the number of applications does not affect throughput in Ethernet network.

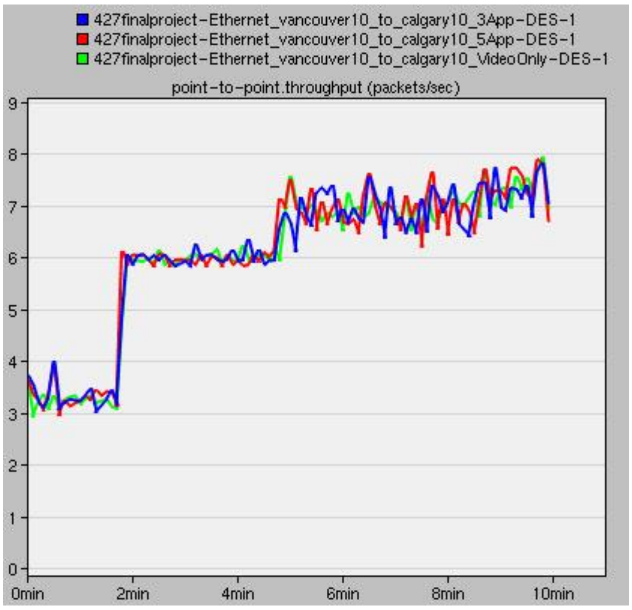

Figure 42 Case 6 Comparison 1 Throughput

Comparison 2: WiFi Network with more Applications

Unlike the Ethernet network, the result of ETE delay for the WiFi network is almost the same, despite the number of applications being used during the simulation. The packet variance showed results similar to Comparison 1.

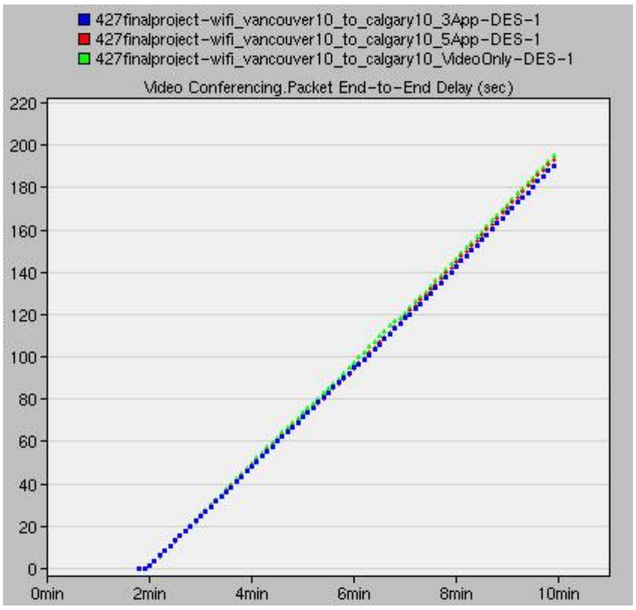

Figure 43 Case 6 Comparison 2 Packet ETE Delay

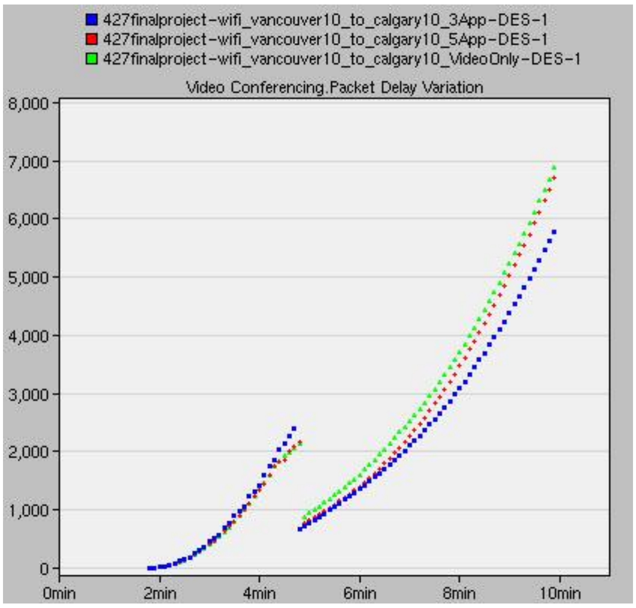

Figure 44 Case 6 Comparison 2 Packet Delay Variation

The traffic sent was stabilized for the network with three applications and video conferencing only after 5 minutes of simulation time, which are around 290 and 320 packets/second, respectively. The traffic sent with five applications was stabilized around 310 packets/second for a while and went up after 9 minutes of simulation time. The traffic received was more with three applications and less with five applications and video conferencing. The network with three applications has fewer packets dropped. The network with video conferencing has more packets dropped.

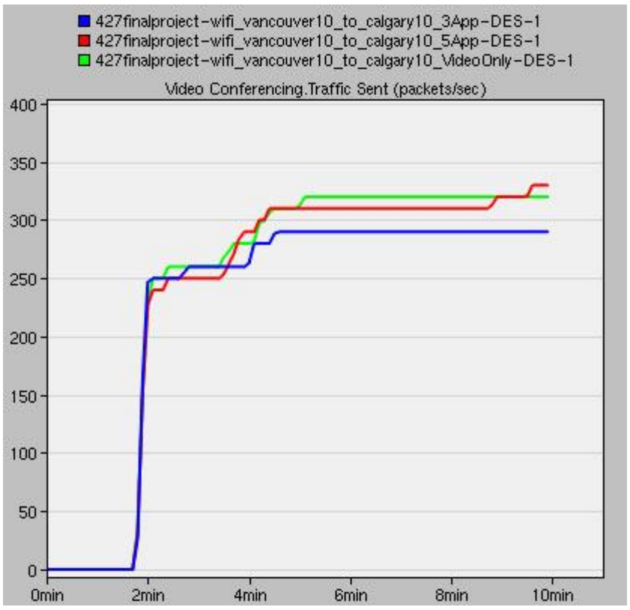

Figure 45 Case 6 Comparison 2 Traffic Sent

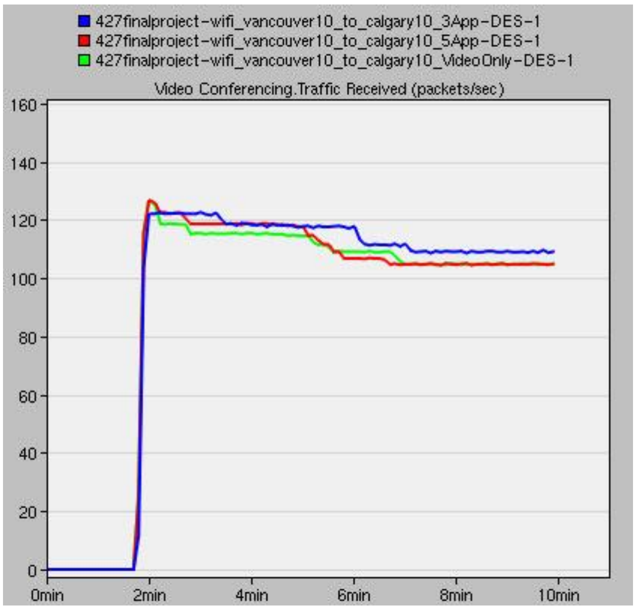

Figure 46 Case 6 Comparison 2 Traffic Received

The throughput graph showed no difference as before and stayed between 6 and 8 packets/second after 5 minutes of simulation time. The number of applications does not affect throughput in WiFi network.

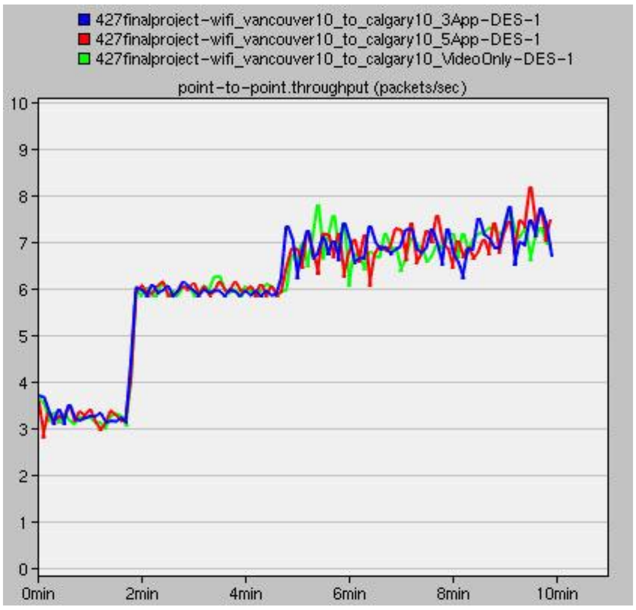

Figure 47 Case 6 Comparison 2 Throughput

Comparison 3: Mixed Network with more Applications

For the combination network, ETE delay is longest with five applications and shortest with video conferencing. The difference between the longest and shortest delay is around 7 seconds. Delay variation increases with more applications and decreases with fewer applications. Hence, there is more delay when increasing the number of applications in the combination network.

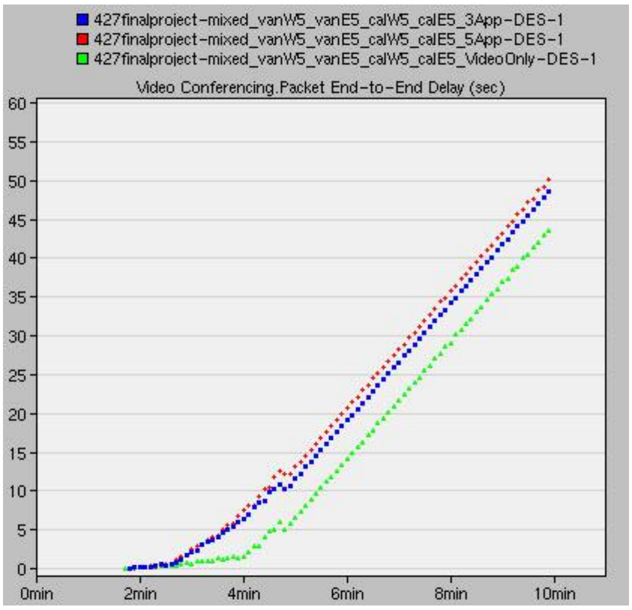

Figure 48 Case 6 Comparison 3 Packet ETE Delay

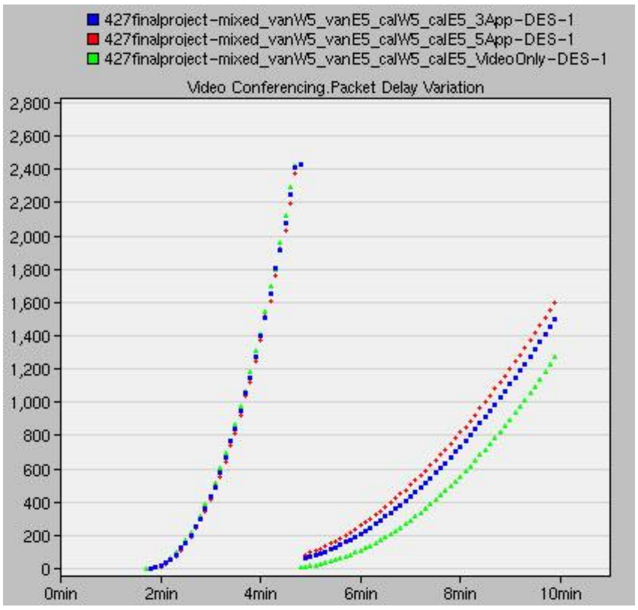

Figure 49 Case 6 Comparison 3 Packet Delay Variation

The network with five applications sent more traffic, while the network with three applications sent less traffic. The network with video conferencing has unstable performance during the simulation. It sent more traffic as much as the network with five applications after 8 minutes of simulation time. Traffic received was the same for all, which is around 85 packets/second. The network with three applications has fewer packets dropped.

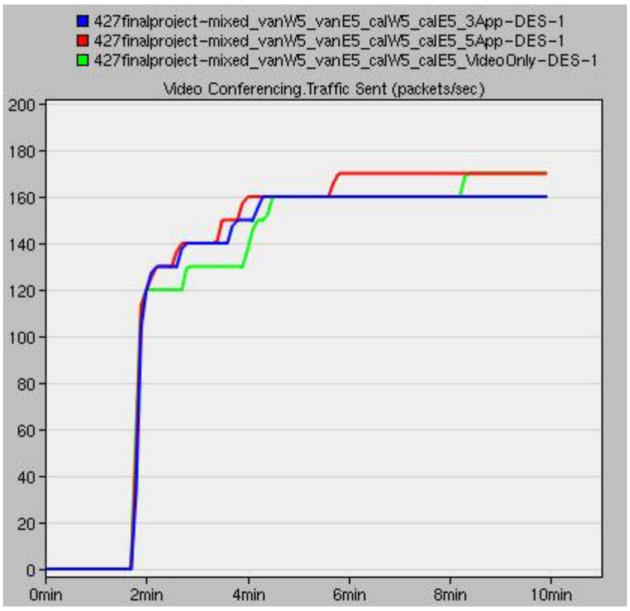

Figure 50 Case 6 Comparison 3 Traffic Sent

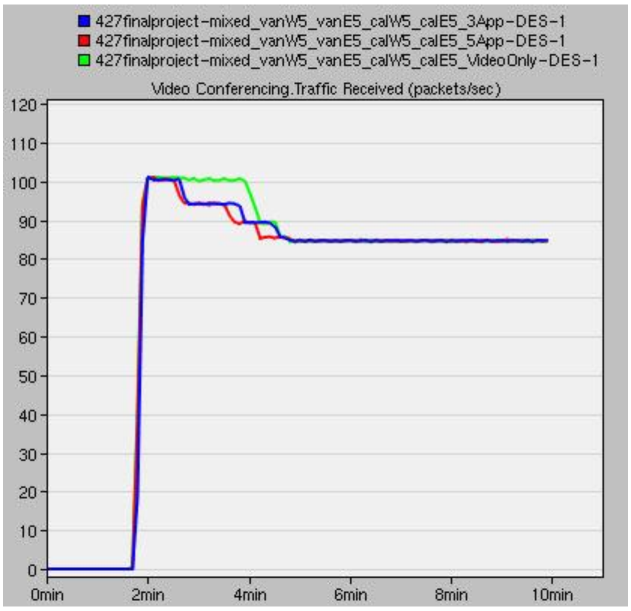

Figure 51 Case 6 Comparison 3 Traffic Received

The throughput graph showed no huge difference, except the throughput of three applications increased suddenly at the end of the simulation. The graph stayed around 7 packets/second.

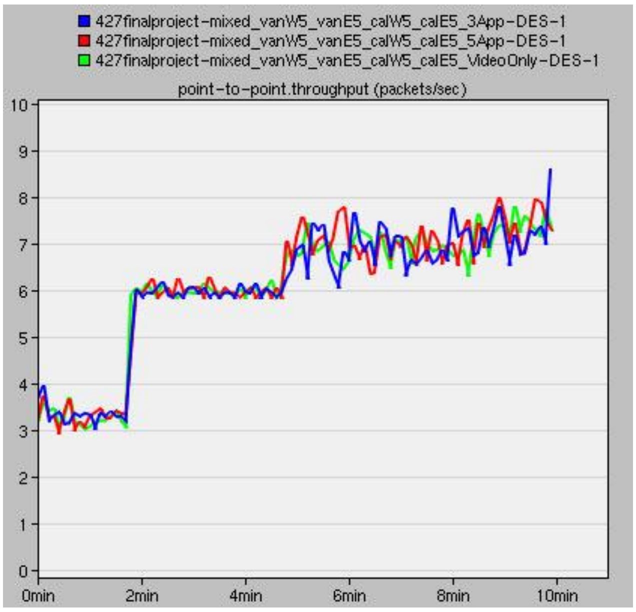

Figure 52 Case 6 Comparison 3 Throughput

Comparison 4: Various Networks with Three Applications

With three applications during the simulation, Ethernet network has the longest ETE delay and the mixed network has shortest delay. The difference between the longest and shortest delay is around 160 seconds. There is not much difference between Ethernet and WiFi networks since WiFi network has almost the same delay as Ethernet does. From the delay variation graph, the performance of combination network is the best since it has less delay variation. Ethernet network has largest delay variation among the three networks. The difference between Ethernet and the combination networks is around 5,000.

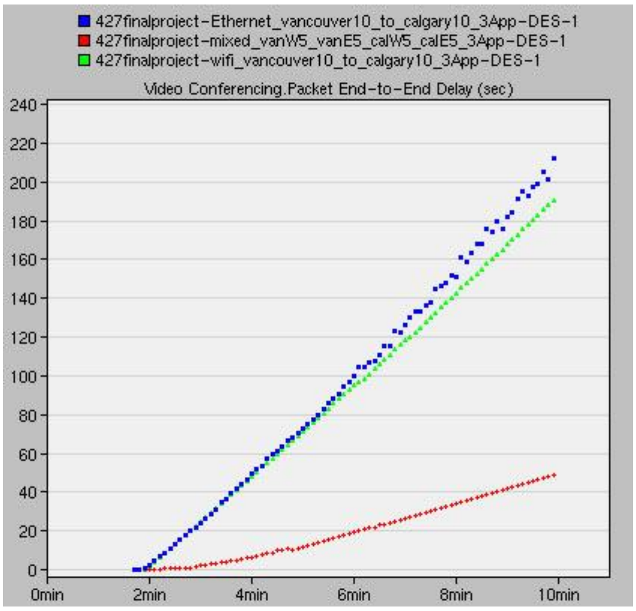

Figure 53 Case 6 Comparison 4 Packet ETE Delay

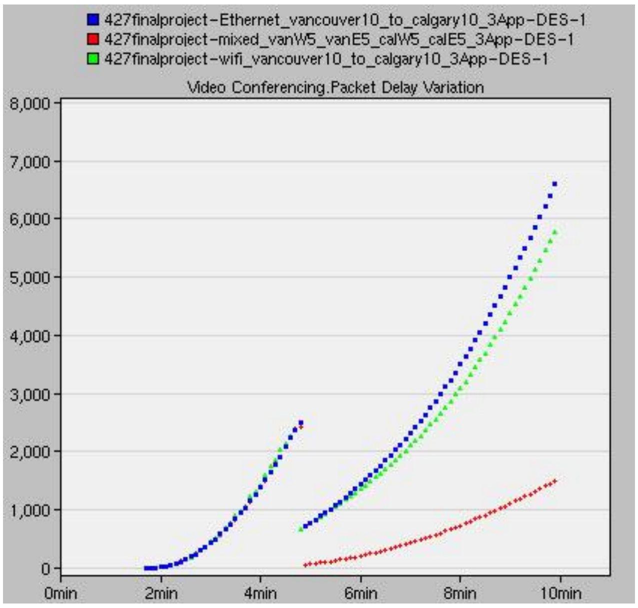

Figure 54 Case 6 Comparison 4 Packet Delay Variation

The combination networks sent the least traffic than the other two networks. Both Ethernet and WiFi sent more traffic, although Ethernet network sent a little bit more than WiFi network after 8 minutes of simulation time. The difference between the traffic sent by Ethernet and the combination networks is around 150 packets/second. From the traffic received graph, WiFi network received more traffic than Ethernet network. The difference between those two networks is around 60 packets/second. The combination network is second best.

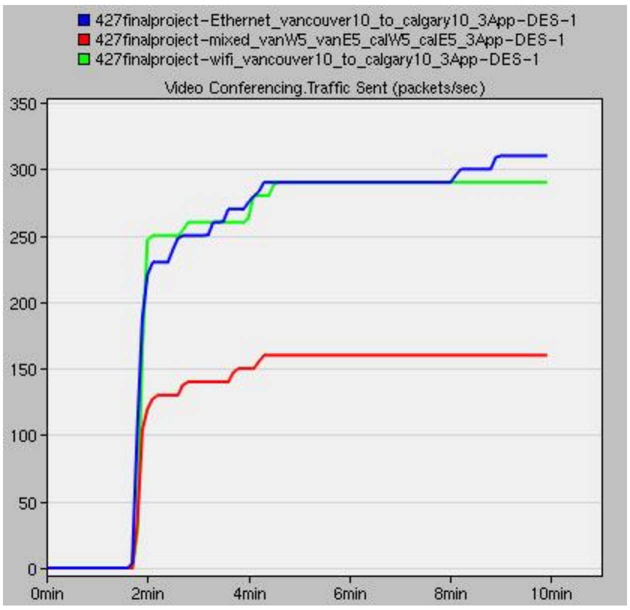

Figure 55 Case 6 Comparison 4 Traffic Sent

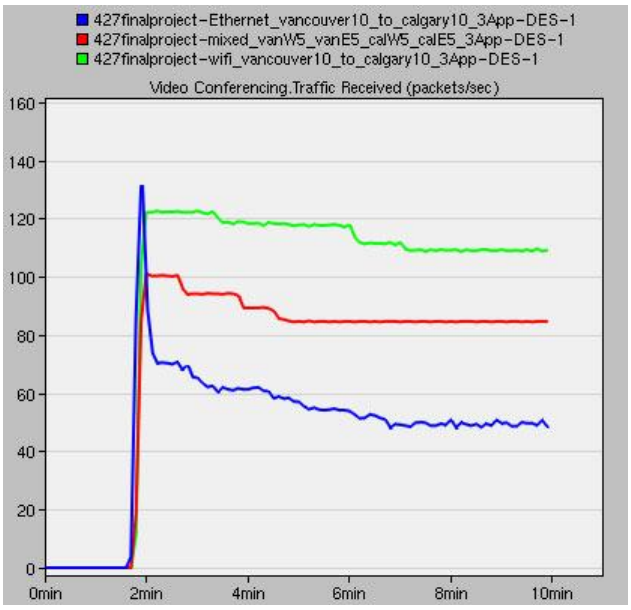

Figure 56 Case 6 Comparison 4 Traffic Received

The throughput result showed no difference between the networks.

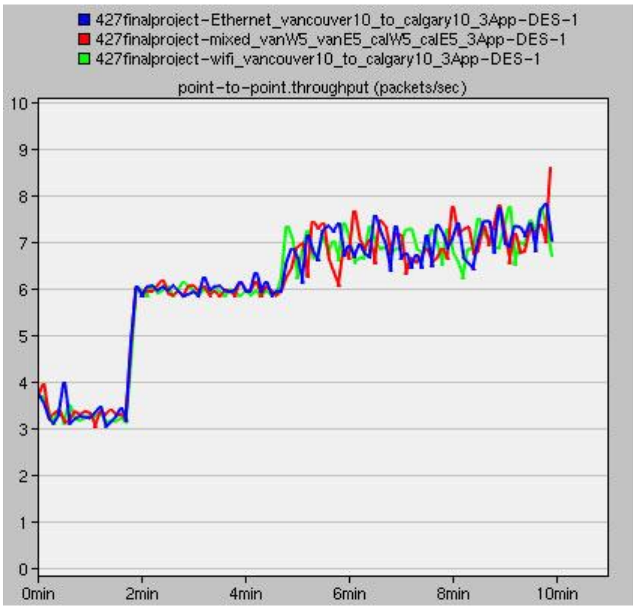

Figure 57 Case 6 Comparison 4 Throughput

The traffic sent and received results for all simulations of case 6 are summarized in Table 2. The difference in Traffic sent and receive is also calculated to find the rate of packets dropped.

Table 2 Case 6 Comparison of Number of Dropped Packets

Network Type	Number of Applications	Traffic Sent (packers/second)	Traffic Received (packets/second)	Number of Dropped Packets
Ethernet	1	340	40	300
	3	310	45	265
	5	300	50	250
WiFi	1	320	105	215
	3	290	110	180
	5	310	105	205
The Combination	1	170	85	85
	3	160	85	75
	5	170	85	85
Ethernet	3	300	50	250
WiFi		290	110	180
The Combination		160	85	75

Conclusion

By the analysis of Case 1 and 2, WiFi showed lower ETE delay and the traffic received and sent are all higher than the Ethernet version. This means that WiFi will have less delay when video conferencing and the network is capable of handling greater amount of traffic. WiFi showed more jitter in both cases; Ethernet would work better for a more smooth video conference.

Case 3 is consistent with case 1 and 2 where WiFi had a shorter delay and is able to receive more traffic. In this case study, the number of users was varied while the distance stayed constant. As the users in Vancouver increased, the end to end delay and the delay variance increased. Vancouver is also where the video conferencing server is located; therefore increasing the number of Vancouver users increased the amount of traffic sent.

In Case 4, a mixed network is simulated between two cities. Each city contained 5 Ethernet users and 5 WiFi users so the comparison is to see whether distance is a factor of a video conference's quality. Packets traveling between Vancouver and Toronto had longer ETE delay and greater delay variance. Traffic sent to Toronto was higher than to Calgary but Calgary's receiving traffic was slightly higher than Toronto. It can be concluded that distance is a deciding factor in the quality of a video conference.

In Case 5 the network has more Ethernet users and fewer WiFi users, the ETE delay was much longer, delay variation was significantly greater and the number of dropped packets was high. As the number of WiFi users increased and Ethernet users decreased, the QoS improved. The number of Ethernet and WiFi users affects the performance on the mixed network.

Case 6 simulated with different number of applications added along with video conferencing. The mixed network performs the best since it has the least number of dropped packets. Ethernet network has the poorest performance since it has highest delay variation, longest ETE delay, and largest number of dropped packets. The comparison 4 shows that the delay increases as the number of applications increases in a mixed network.

Future Work

For a completed simulation for Case 6, each workstation must be checked if it is always video conferencing during the simulation. The inconsistent results should be investigated further. Due to OPNET licensing issue, many details such as the exact model number used and the configuration settings were not included in this report. In order to perform a more realistic video conferencing, the simulation time should be at least an hour. Due to lack of computer memory, the time for video conferencing could only be set to 10-15 minutes. If time allowed, the simulation over different networks, such as Worldwide Interoperability for Microwave Access (WiMAX) and Long Term Evolution (LTE), could be compared with Ethernet and WiFi networks.

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