***Analysis and Simulation of VOIP***

***LAN vs. WAN***

***WLAN vs. WWAN***

ENSC 427 Communication Networks
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# Analysis and Simulation of VoIP
# LAN vs. WAN
# WLAN vs. WWAN

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**Abstract:**

Voice over Internet Protocol, VoIP, is a multimedia communication methodology that has been favoured over Public Switching Telephone Networks (PSTN) during the past few years. The advantage of this technology is its low cost which allows users to make free audio and video calls with multiple users simultaneously. VoIP is used by many applications on smartphones and personal computers such as Skype. In this project we want to analyze the performance of VoIP on wired connection (LAN, WAN) versus wireless connection s(WLAN,WWAN) using OPNET 16. We will inspect performance issues by analyzing the network latency, jitter and packet loss.

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## Glossaries

**ITU – International Telecommunication Union**

**LAN – Local Area Network**

**MOS – Mean Opinion Score**

**PSTN – Public Switched Telephone Network**

**VoIP – Voice over Internet Protocol**

**WAN – Wide Area Network**

**WLAN – Wireless Local Area Network**

**WWAN – Wireless Wide Area Network**

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**Introduction**

Voice data composes the majority of the telecommunication traffic. The common way to achieve this is by deploying circuit-switched network. However, circuit switching can be highly inefficient and costly especially if long distance communication is an option. Conversely, the Internet's packet-switched networks are much more efficient but need a well thought-out, sensible implementation for voice services. Now, coming together, to achieve the high quality services of the circuit-switched and the efficiency of the packet-switched networks, Voice over Internet Protocol was introduced.

**Background and Related Technology**

There are a few ways to employ VoIP. A PSTN-based telephone can communicate with VoIP application and vice versa. These communications doesn't necessarily need to be exclusively over a dedicated circuit but rather they can be partially over internet. Lastly two VoIP applications can be connected without using PSTN at all.

There are four major groups involved in the VoIP technology namely: signaling, encoding, transport and gateway control[1]. Signaling protocol manages the call connection. Encoding is needed to convert the analog voice signal to digital. The transport layer runs over IP that helps transporting the signal on Internet networks using real-time protocols. The final stage, gateway management, is necessary if the IP system needs to convert to another format (e.g. connecting to PSTN) at a gateway.

There are many protocols to manage VoIP here we shortly discuss couple of these protocols.

Signaling System 7 (or SS7) is a protocol used in PSTN by north America for call set-up and teardown[1]. SS7 is employed as a packet-switched network and usually uses dedicated links. It is a non-associated, common channel out-of-band signaling network allowing switches to communicate during a call. SS7 signals may pass through real or virtual circuits on links that also carry voice traffic[1].

H.323, approved by the International Telecommunication Union-Telecommunication (ITU-T), is a set of protocols for voice, video, and data conferencing over packet-based networks. H.323 is designed so that it can function on top of the transport layer, so it can be used on TCP/IP as an example to provide real-time multimedia communication[1].

**Quality of Service**

Quality of service can be interpreted as the amount of satisfaction of the user from any technology. To access this for VoIP systems there are a few parameters that are considered to show how well the overall performance has been.

**Jitter** the variation of the delay in the voice packages reaching destination is called jitter. This variable time difference may determine interruptions in the voice signal[2].

**Delay or End to End Delay** is the time passed from the moment that the signal is sent to the moment that the signal arrives at the destination.

**MOS – Mean Opinion Score**
This is a subjective assessment of the voice quality. It is an average given by a number of listeners based on the quality of the voice. It cannot be used to compare between 2 different groups. The values are from 1 to 5, 5 being the highest score.
**Packet loss** is the difference between the number of packets sent and number of packets arrived at the destination.

**Project Scenarios**
In this project we assess the VoIP quality for both wired and wireless networks as well as wide area verses the local area. Here is a flowchart of our project flow done in OPNET 16.

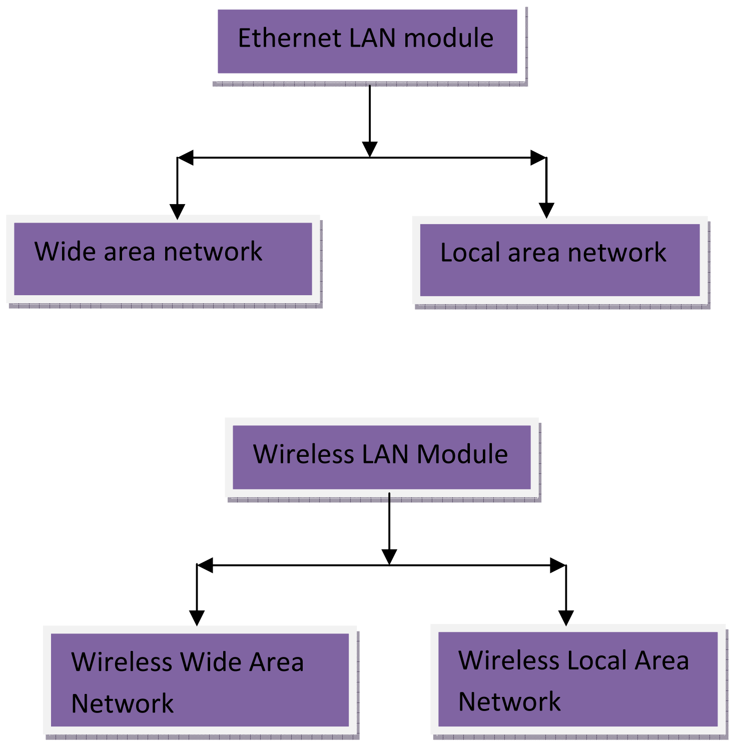


Figure 1 Project Scenario Flowchart

**Parameter Standards:**

As we mentioned earlier good quality of service is measured by various parameters and we have chosen the 4 parameters discussed above to analyze the quality of voice in each of our scenarios. There are confirmed standard values for each of this parameter that ensures good quality of service if actual data values follow the standard values closely. There are different standards for different protocols.

According to the International Telecommunication Union (ITU) standards, the required average value for wireless VoIP using IEEE 802.11g protocol standards is:

| | Average Quality | Ideal Quality |
|---|---|---|
| Jitter | <60ms | <20 |
| End-to-end delay | <150ms | <50 |
| Packet loss | <5% | <1% |

Table 1 ITU Standards for VoIP on IEEE 802.11g Protocol[3][4]

| Quality Scale | Mean Opinion Score (MOS) |
|---|---|
| Excellent | 5 |
| Good | 4 |
| Fair | 3 |
| Poor | 2 |
| Bad | 1 |

Table 2 MOS Scale

**Design Implementation**

We have simulated the discussed scenarios in OPNET 16. For the wired scenario we used the OPNET LAN modules and for wireless scenarios we chose Wireless-LAN Modules from OPNET existing modules.

**LAN Setup**

In the LAN module scenarios we decided to have a small area network of 10 clients in an office setting. Figure below shows the diagram. We used 10BaseT Ethernet connections between all nodes. We used the LAN model provided by OPNET (used in tutorials).

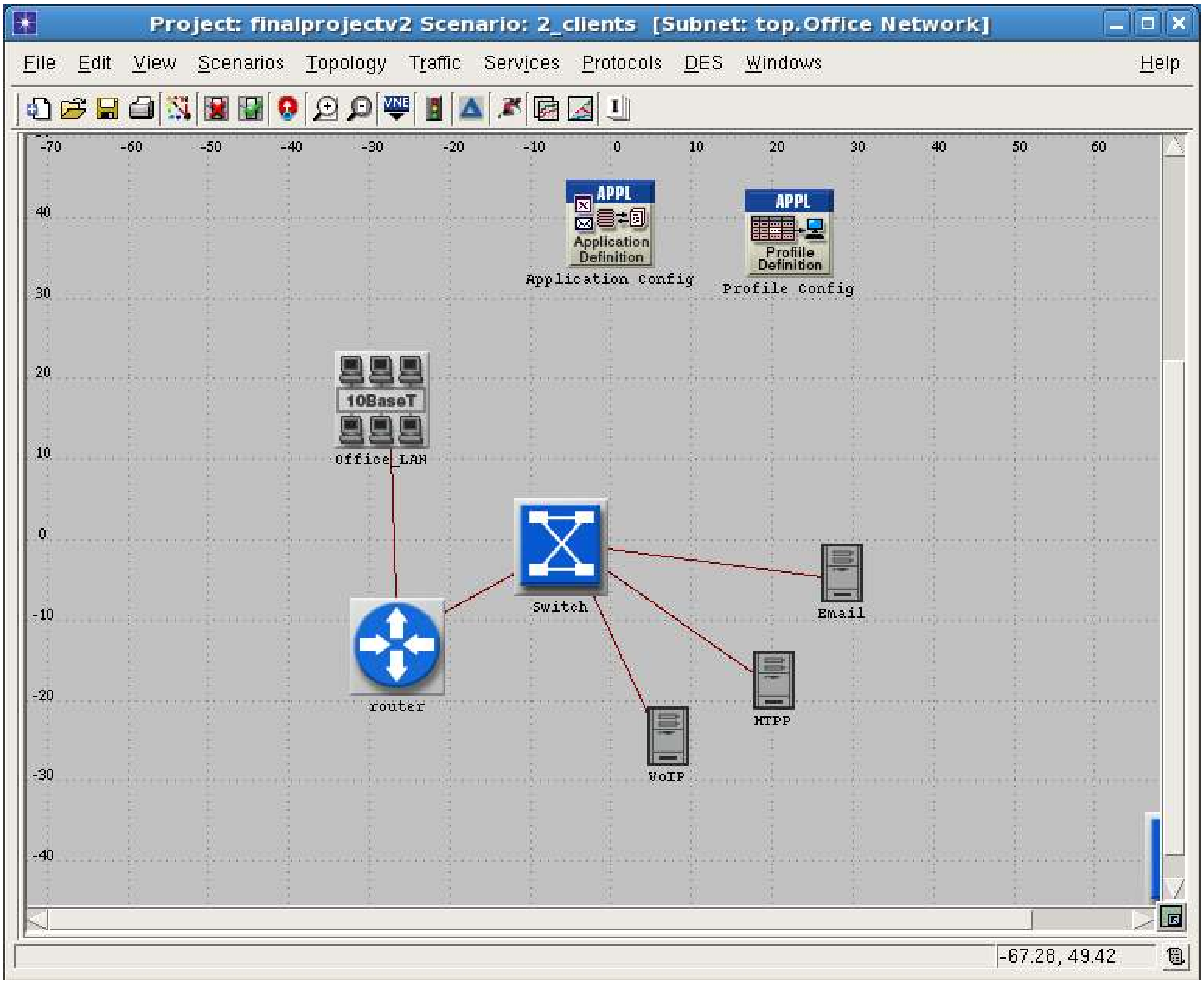


Figure 2 LAN Office set up

In this set up we have 2 other applications supported: light Email and light HTTP access.

**WAN Setup**

In the second scenario we wanted to compare the office setting verses the wide area networks. One of the subnets in this topology is at Toronto and the other is in Vancouver. Figure below shows such configuration.

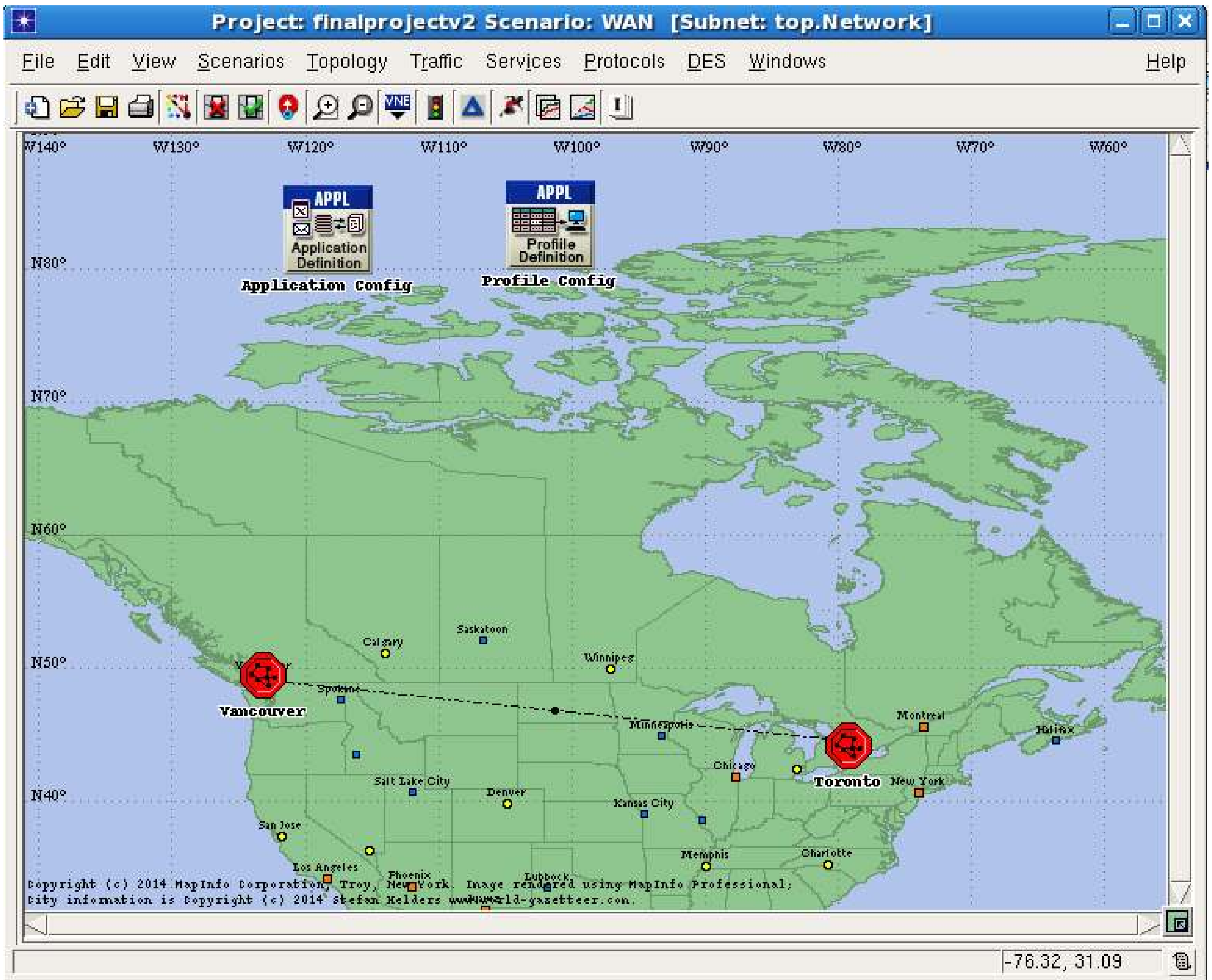


Figure 3 WAN Configuration

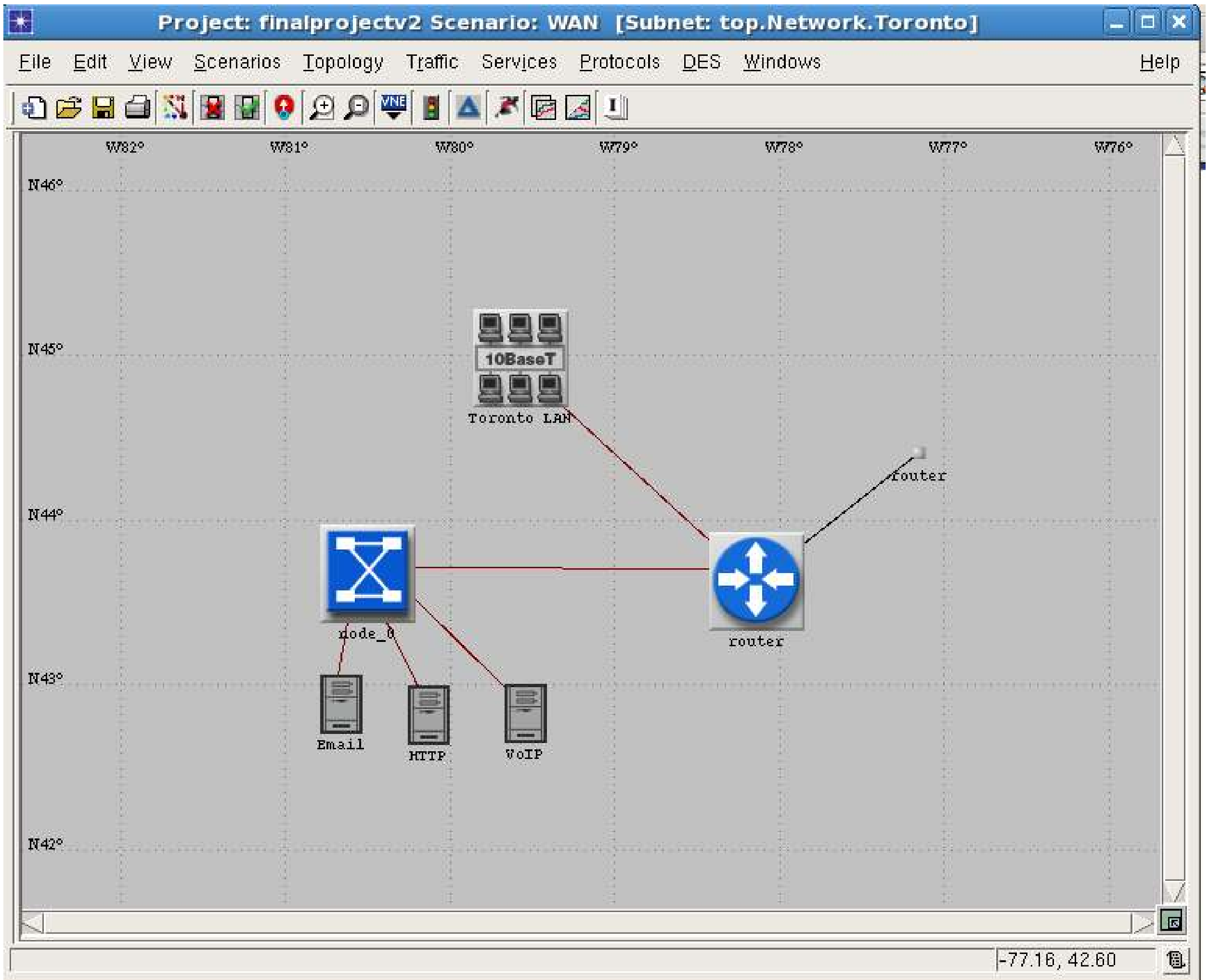


**Figure 4 WAN Configuration: Toronto Subnet**

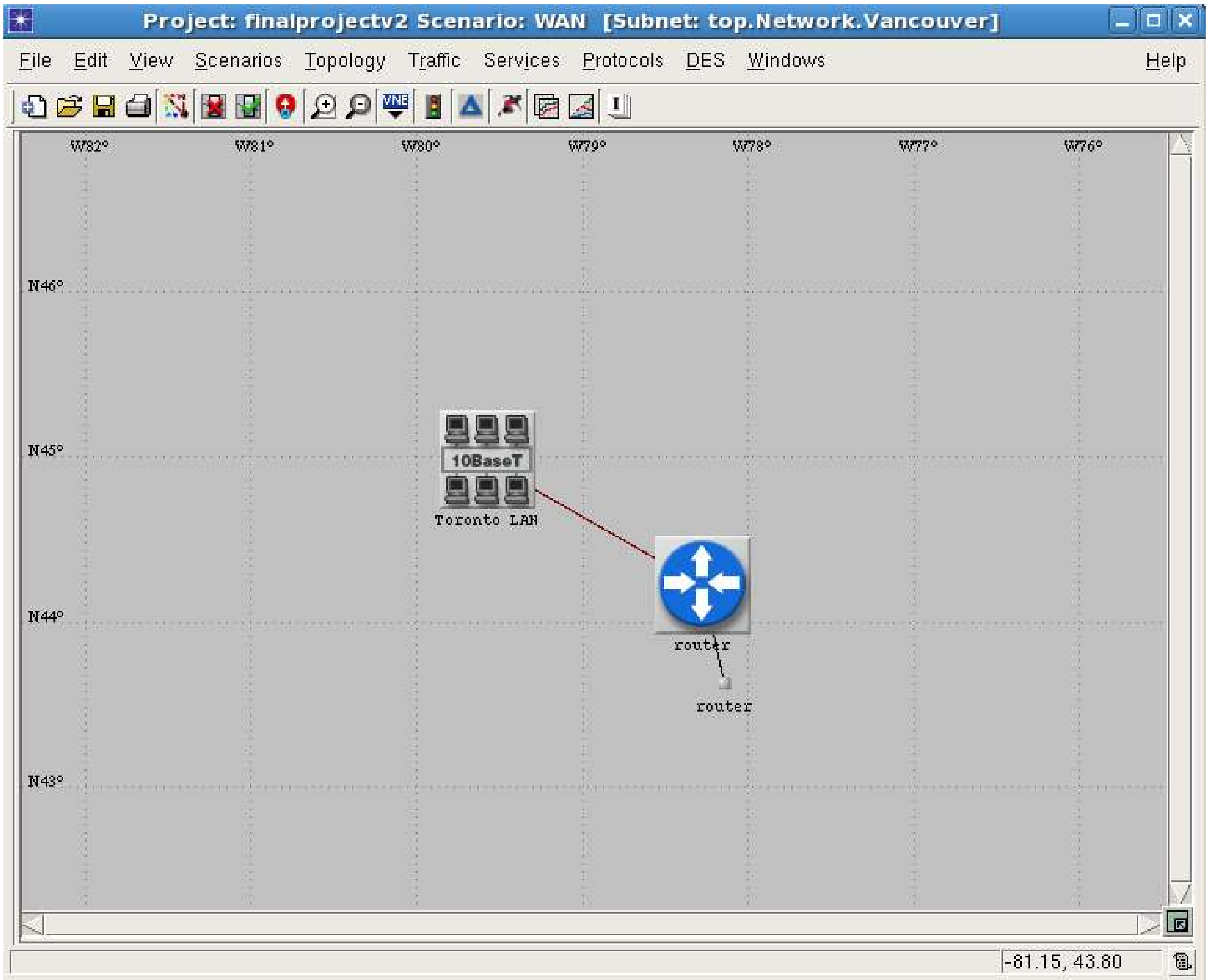


Figure 5 WAN Configuration: Vancouver Subnet

**WLAN Setup**

Wireless scenario is also implemented like the wired section. We have employed the IEEE 802.11g with 54Mbps protocol. The first scenario is based on an office setting with 2 clients that have wireless connection with a local router. In the second scenario we have considered the wireless wide area networks between Toronto and Vancouver. The 2 subnets are connected using a 100baseT Ethernet connection. Figures below show the project set up for wireless configuration.

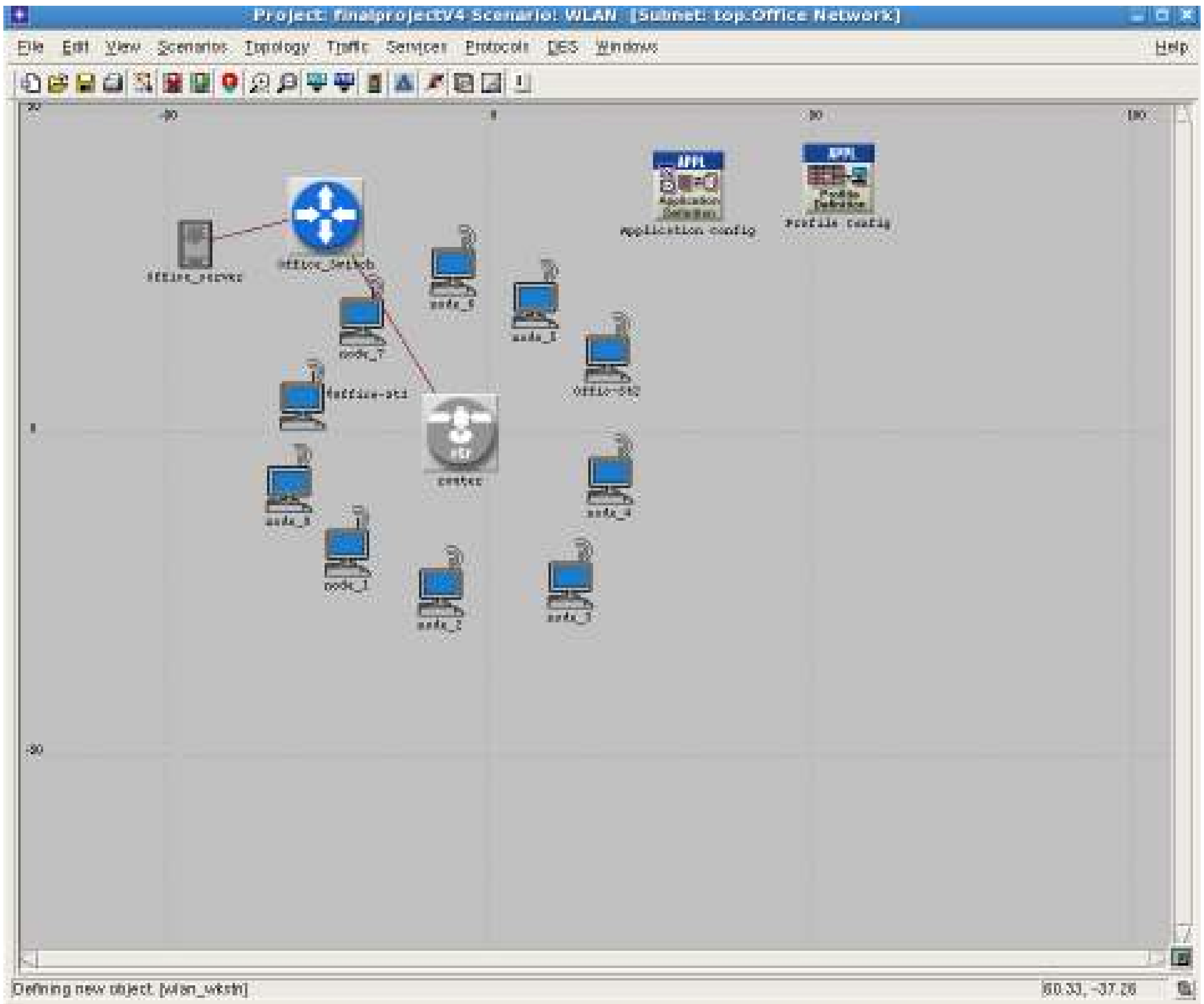


Figure 6 WLAN Office Setup

**WWAN Setup:**

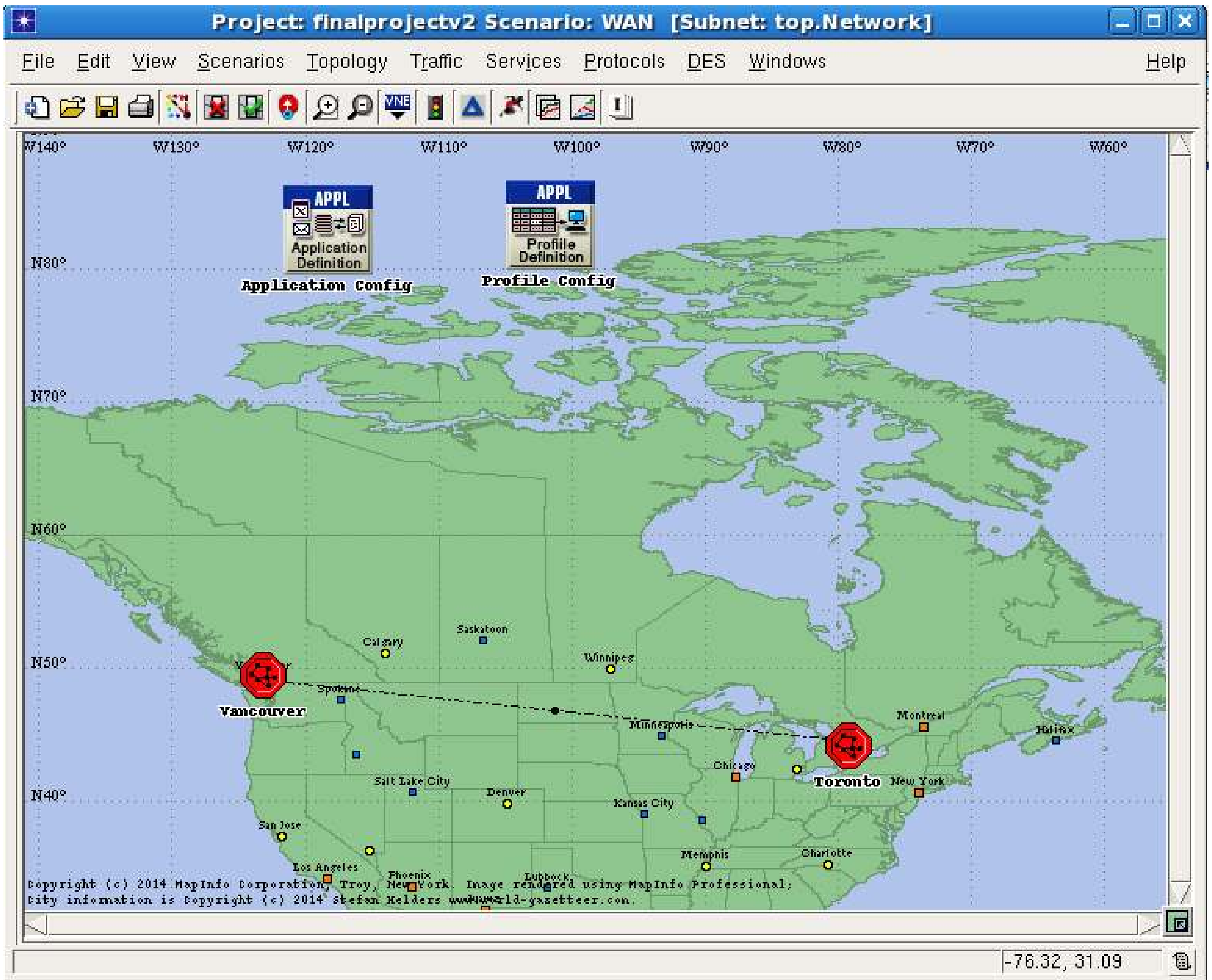


Figure 7 WWAN Configuration

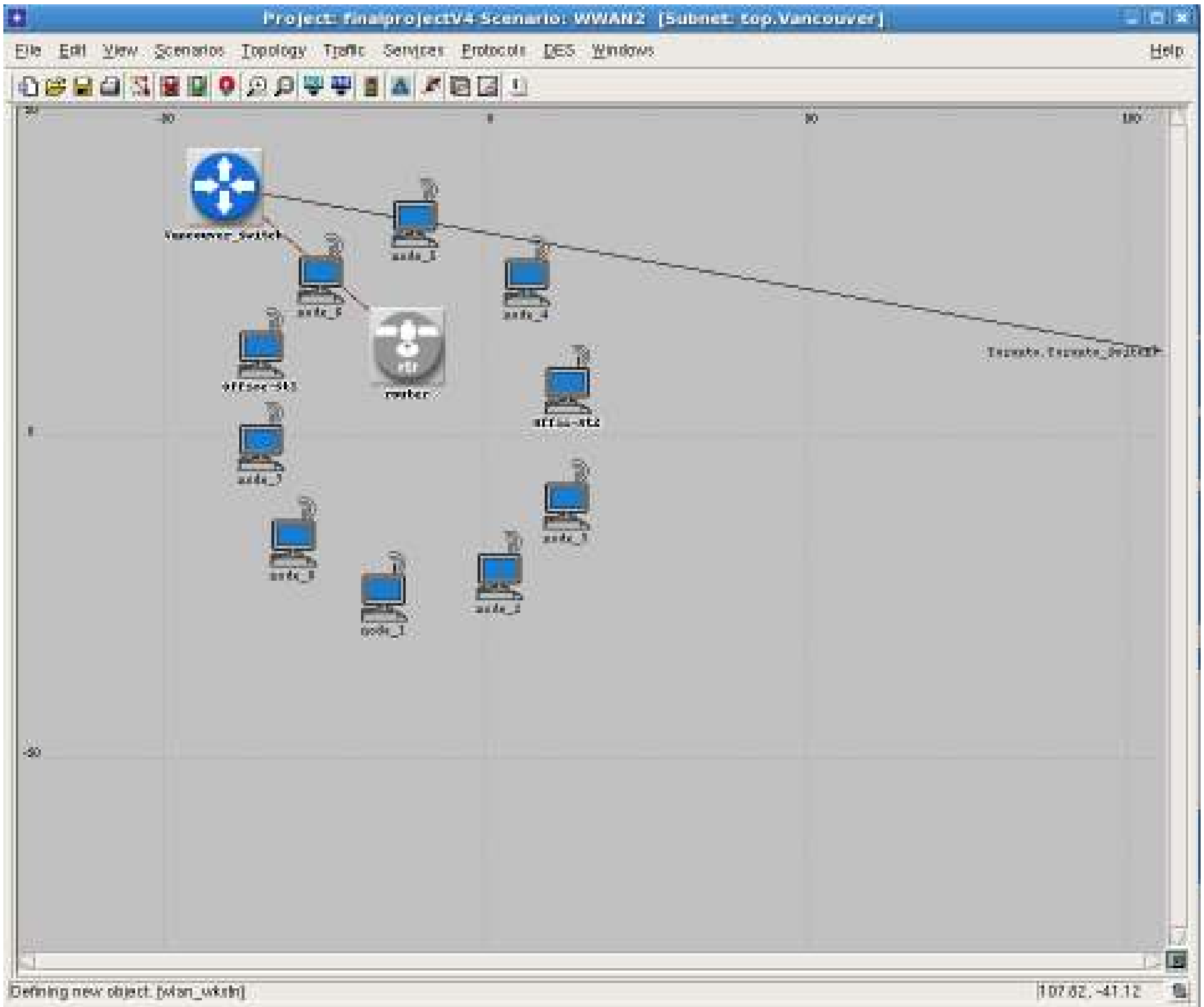


**Figure 8 WWAN configuration: Vancouver Subnet**

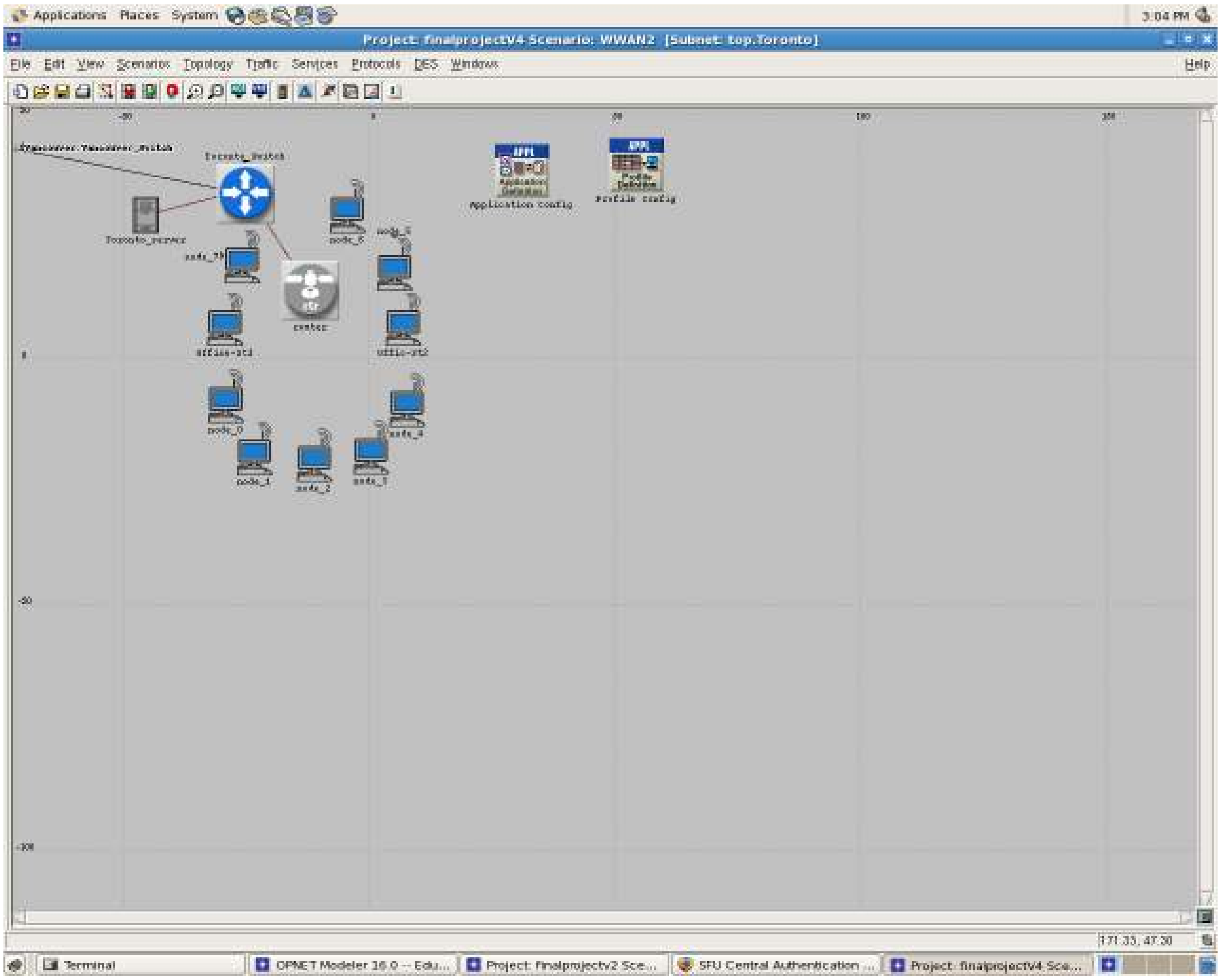


**Figure 9 WWAN Configuration: Toronto Subnet**

**Simulation Results**

We have simulated the result for 10 min simulation time.

**EthernetLAN scenario**

Jitter: as shown in the figure below jitter for the office scenario is almost 0. However the average jitter for the WAN scenario peaks at 13ms. Looking at the standard table provided the ideal quality was estimated to have less than 20ms of jitter. This result falls into the ideal estimated category.

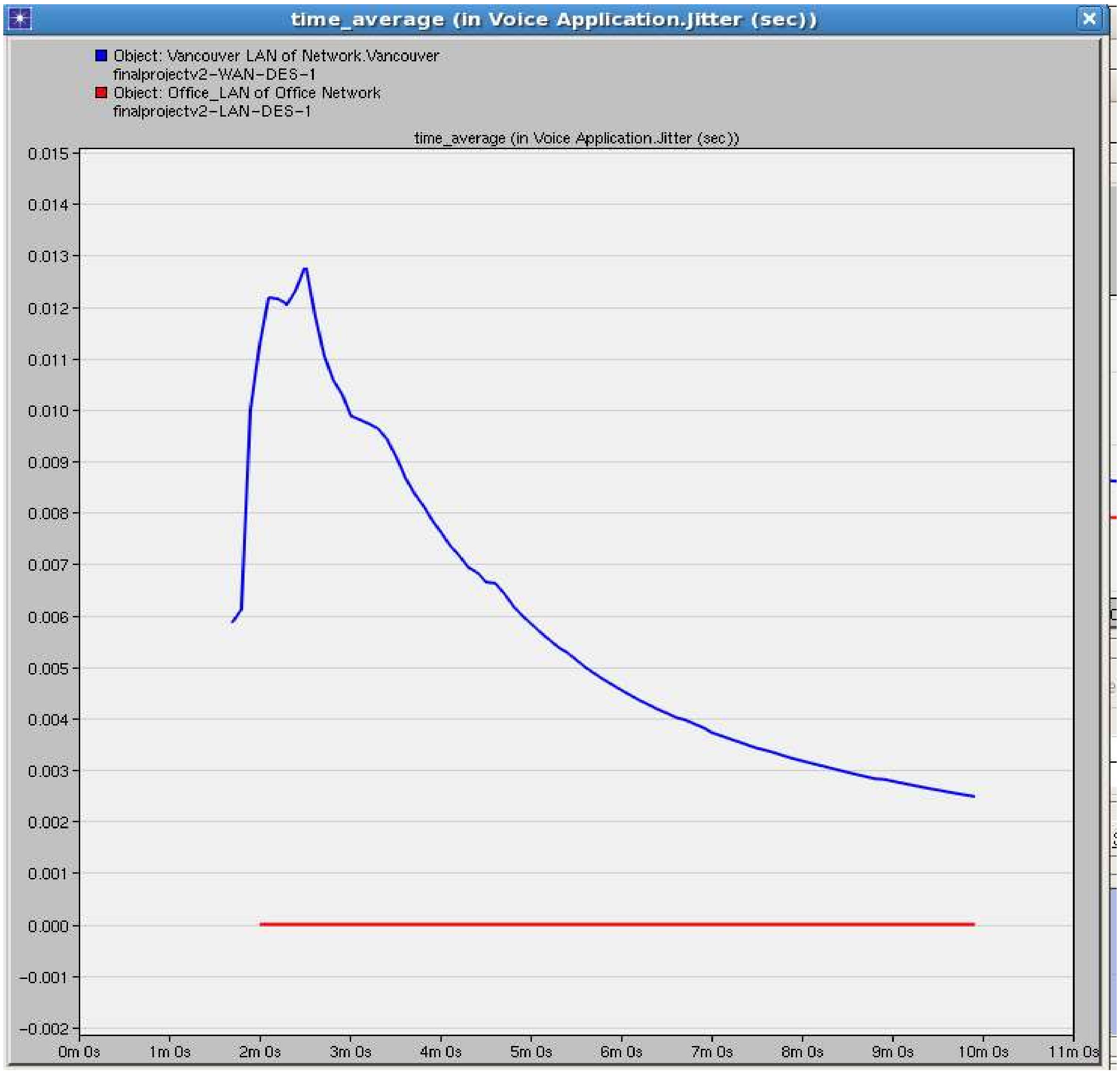


Figure 10 LAN vs. WAN: Jitter

MOS: the average MOS value for the Office network has been estimated to 3.69, and for the wide area it plateaus at 3.67. According to the standard chart they both fall between fair to good connections.

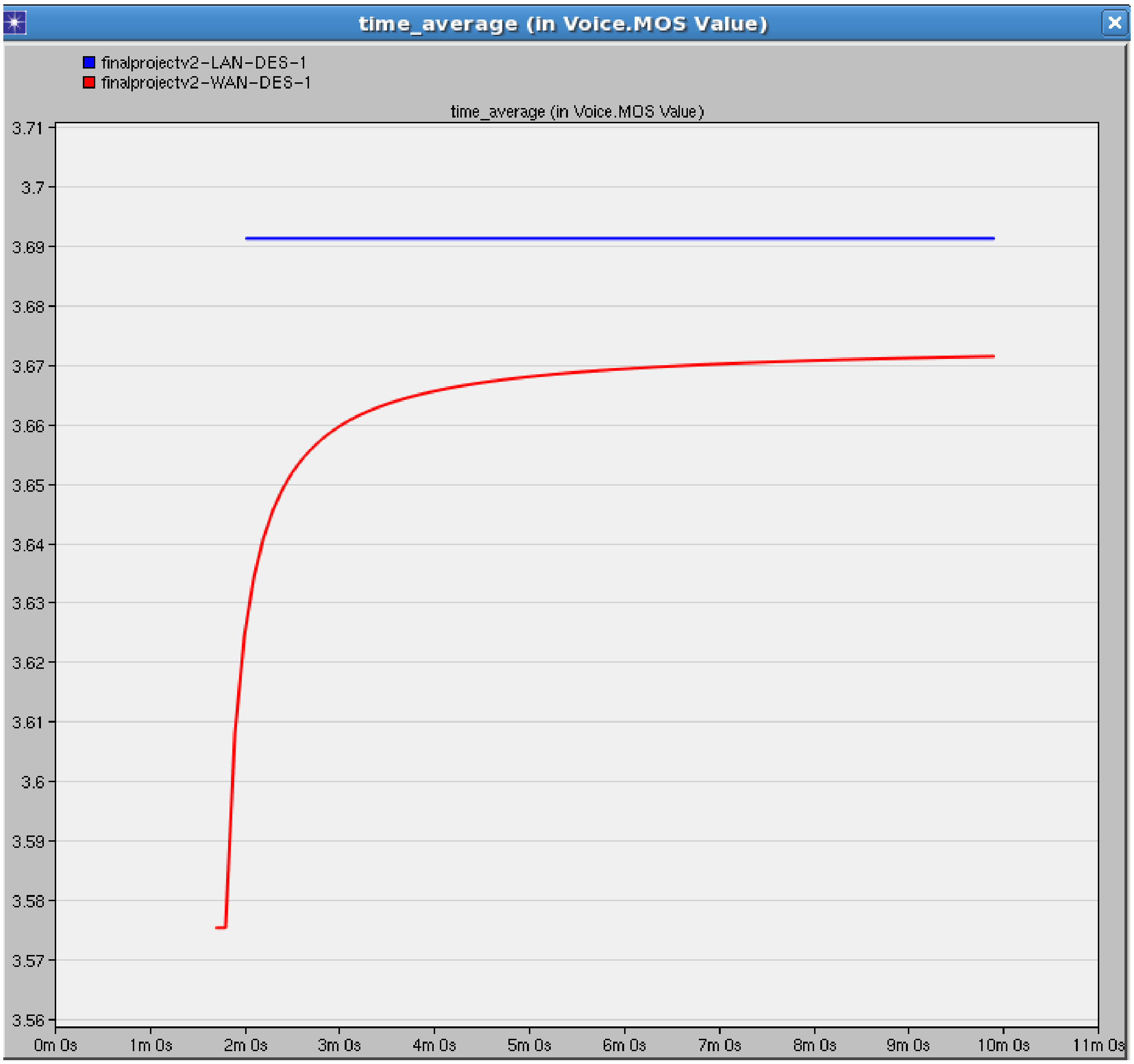


**Figure 11 LAN vs. WAN: MOS**

End-to-End Delay: this data parameter is much larger than expected value of 150ms for the Wide area network. However the office setting seems to have minimal delay. The average for LAN network was around 400 ms which is still larger than 150 ms. Since this is just a simulation and many factors are not taken into account, the delay is shown to be worst case scenario.

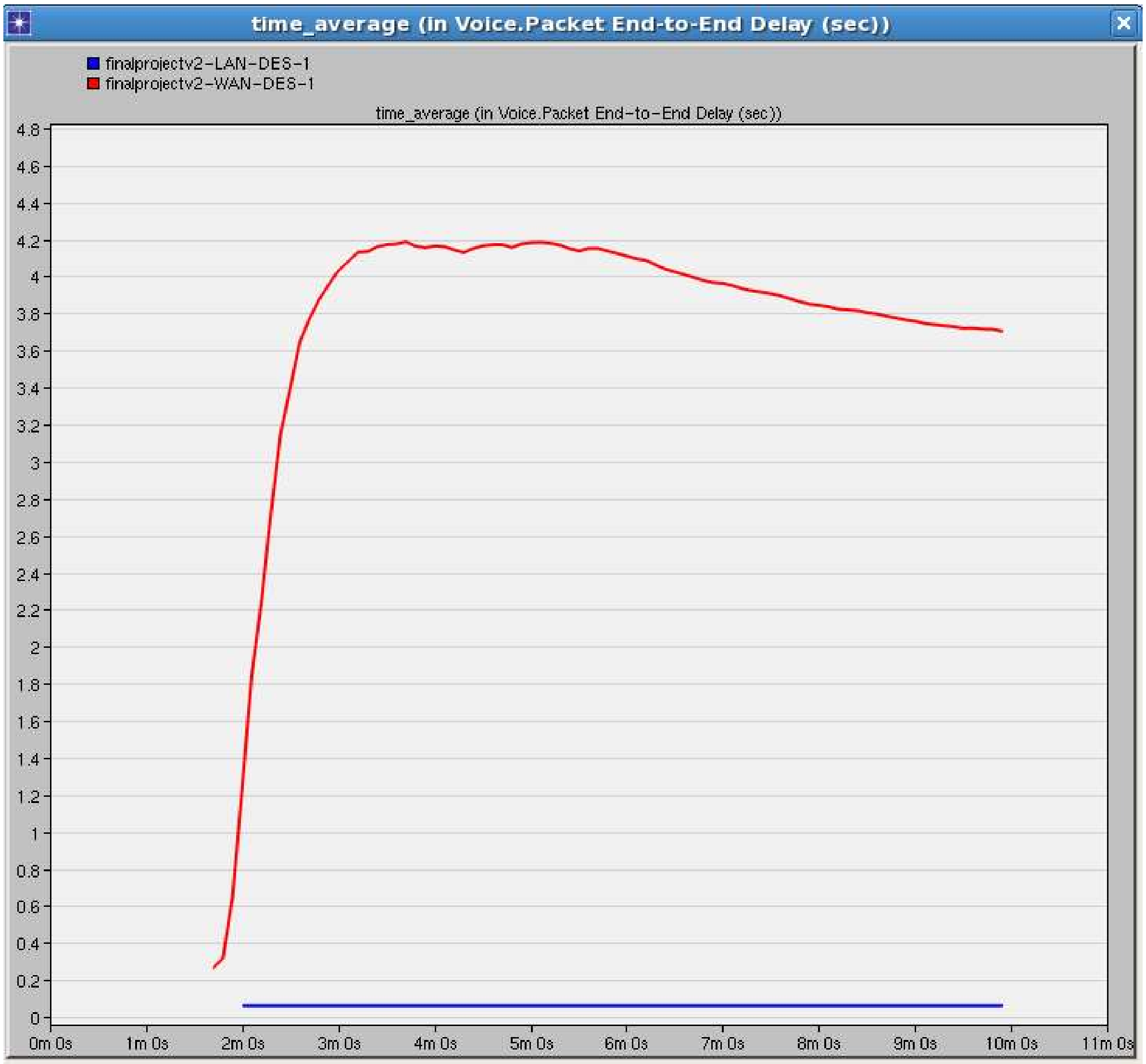


Figure 12 LAN vs. WAN: End-toEnd Delay

Packet Loss:

As it is seen form the figure below the packet sent by the office server and packets received by one of the office client nodes closely follow each other (light blue and green colors) meaning there has been minimal packet loss. However the packets sent by receiver from Toronto and the packets arrival by clients in Vancouver shows a large amount of packet loss happening over the wide area connection.

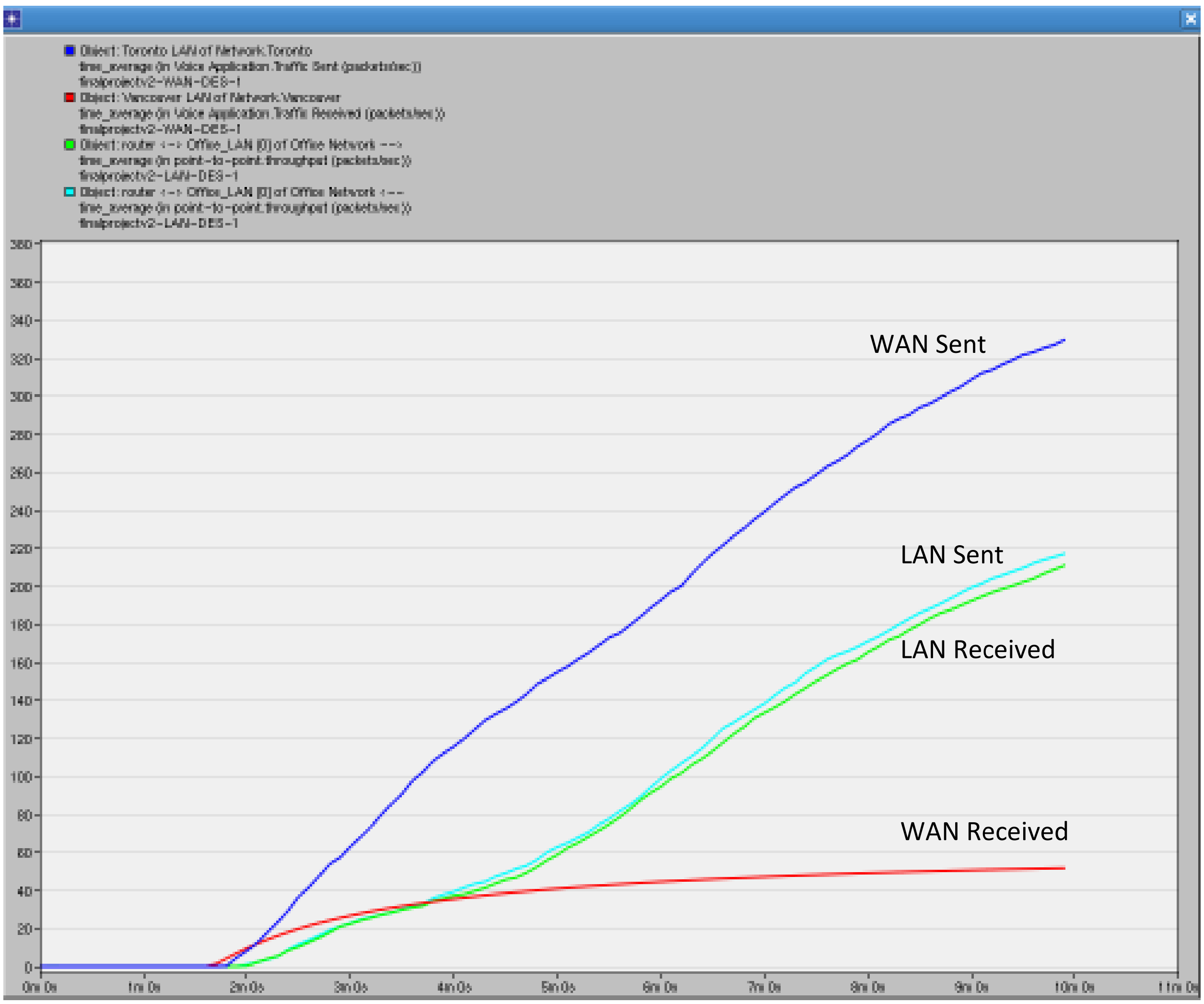


Figure 13 LAN vs. WAN: Packet Loss

**Wireless-LAN:**

Jitter: the WWAN model peaks at 18ms which falls into the average quality category from the standards table. The WLAN jitter is almost 0 to 1ms which is ideal quality.

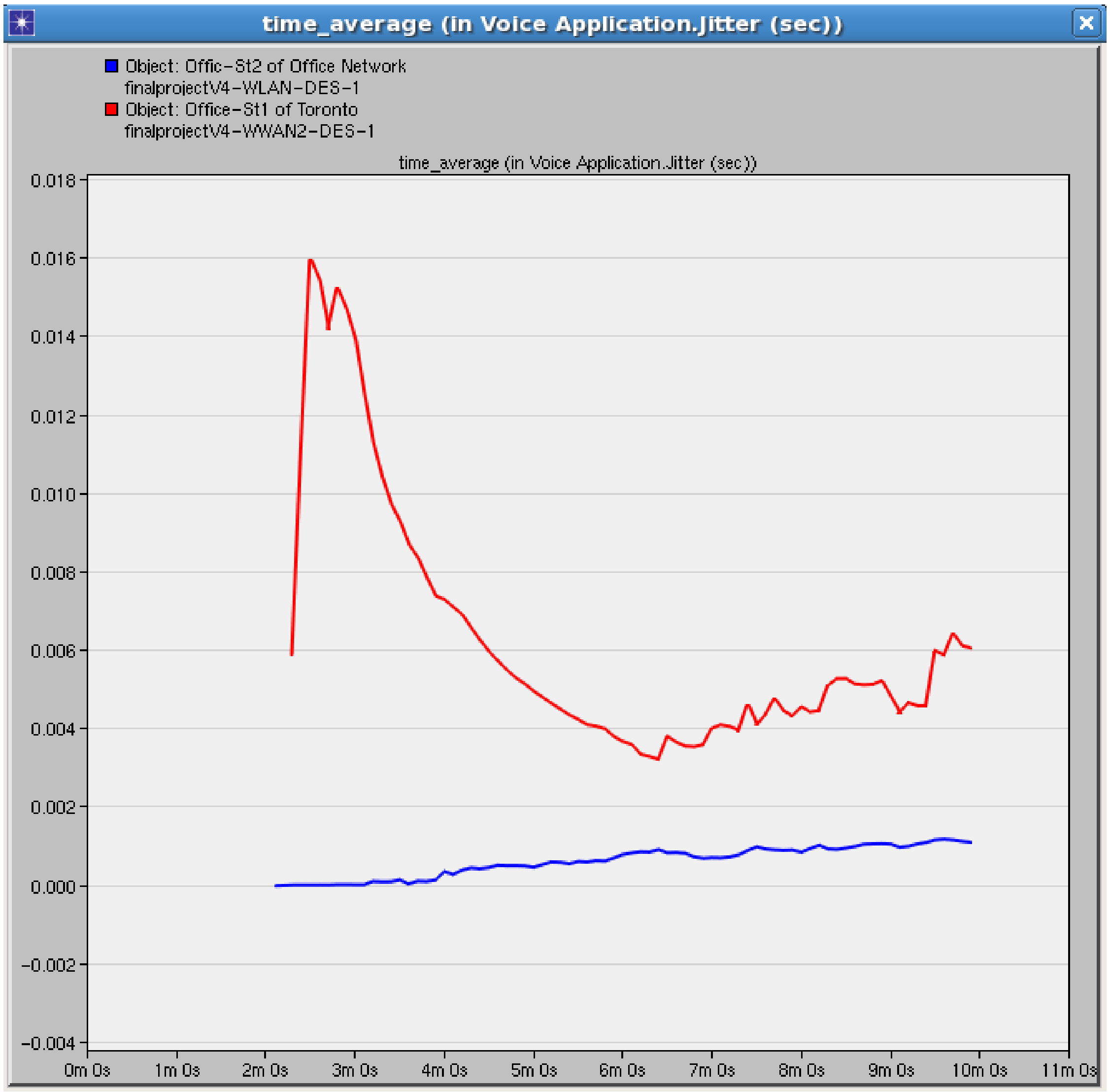


Figure 14 WLAN vs. WWAN: Jitter

MOS: the average MOS value for WLAN connection in office setting is about 3.7, however this average plateaus at 3.6 for the wireless wide area connection between Vancouver and Toronto.

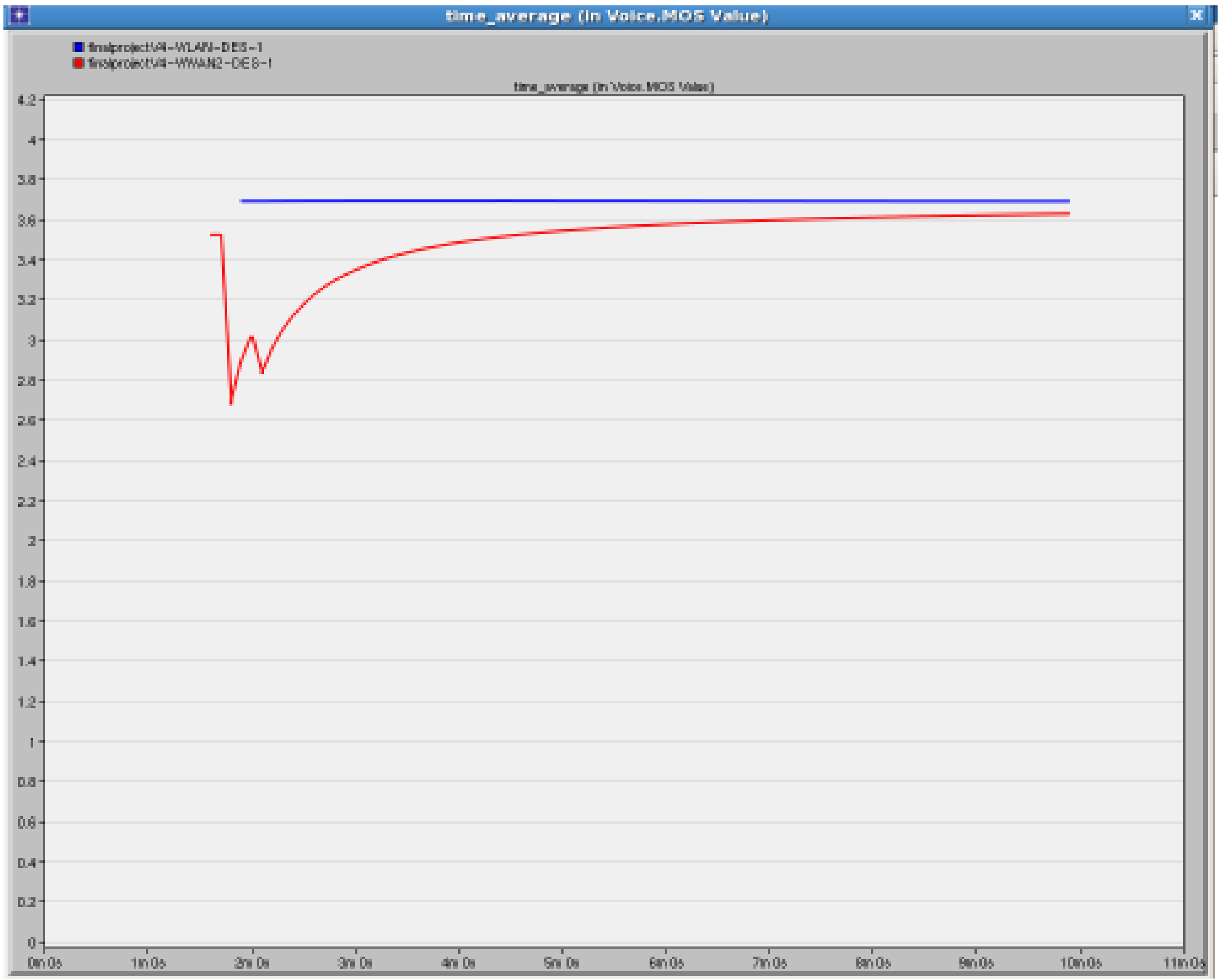


Figure 15 WLAN vs. WWAN: MOS

End-to-End Delay: The average end-to-end delay for wireless wide area connection is higher than 150ms. From the graph it shows that the delay is peaks at 5.3s. This value for the wireless LAN connection is maxed at 300ms. This result is consistent with the wired project scenario and shows that we have been consistent with the settings and profiles. However this is not a realistic simulation.

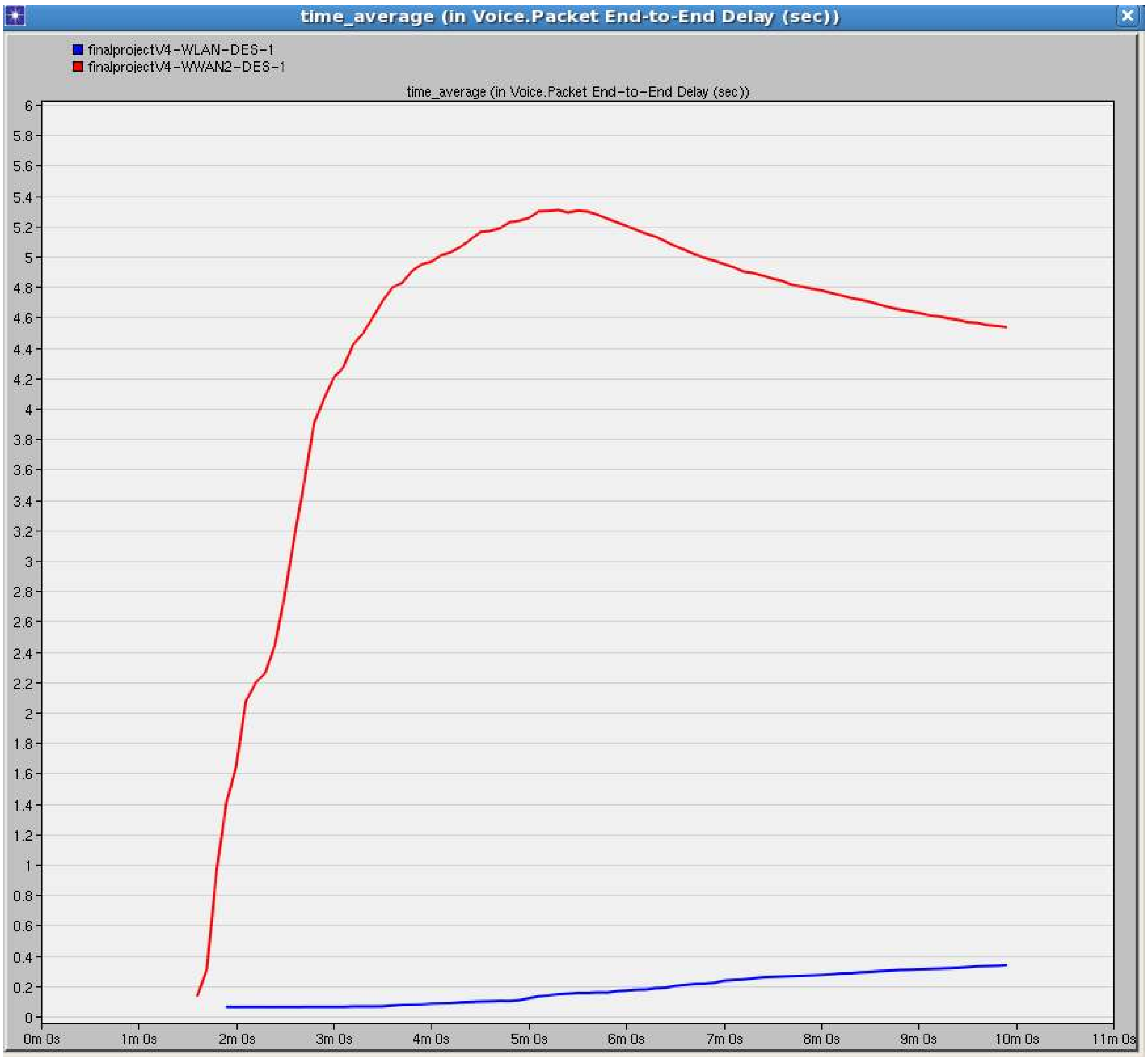


Figure 16 WLAN vs. WWAN: End-toEnd Delay

Packet loss: In the diagram below we have compared the packet send and received from Toronto servers to Vancouver clients with the office setting. As we can see in the office setting the packets sent and received from servers to clients follow closely. That means the amount of packet loss is low. However there is a greater amount of packets sent by Toronto servers and the clients in Vancouver show less amount of packets received. This means that the packet loss in wireless wide area connection is higher than wireless local area connection.

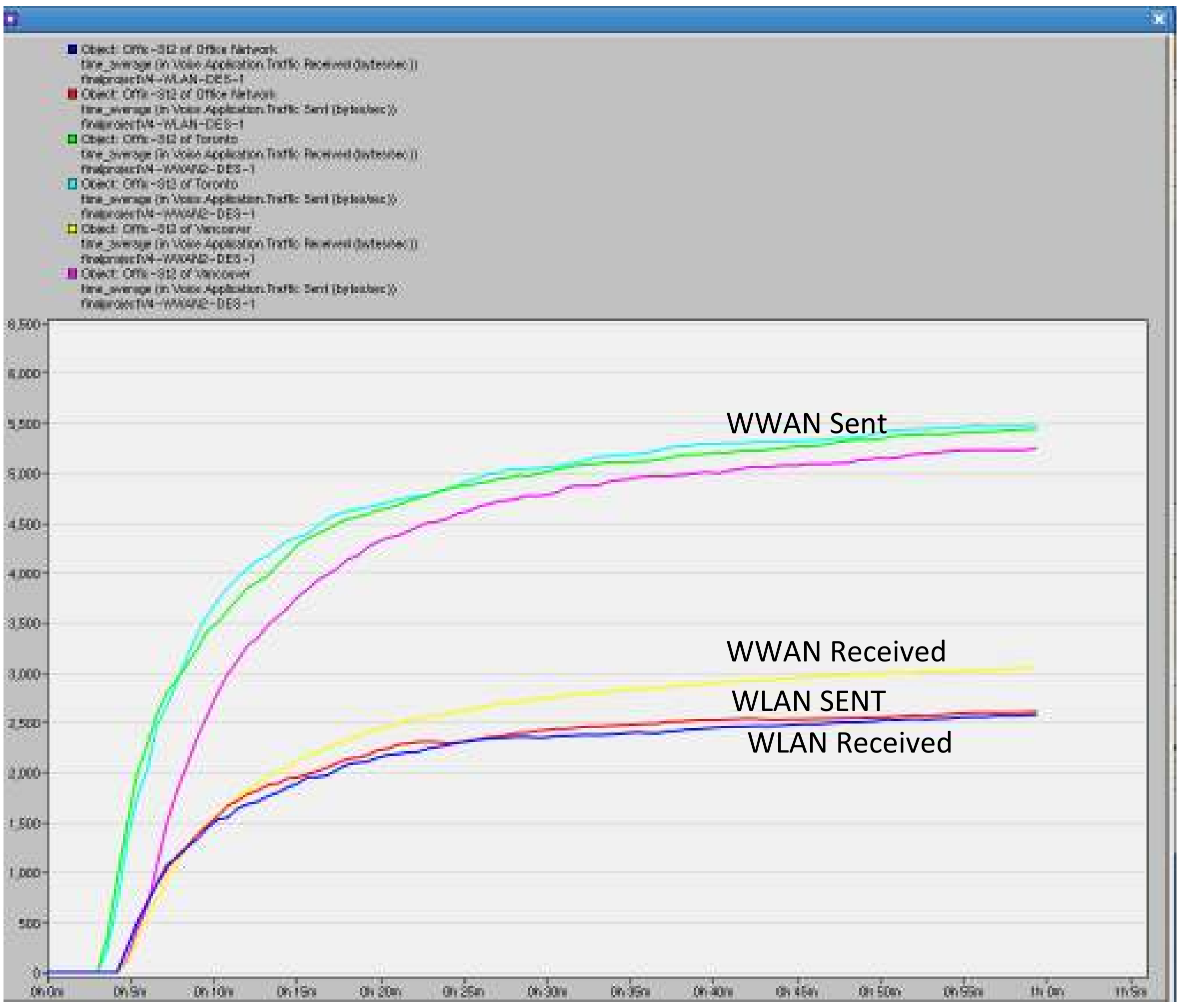


**Figure 17 WLAN vs. WWAN: Packet Loss**

**Conclusion**

In this Project we have compared the quality of service of VoIP in local area networks vs. wide area network. We have implemented these both on wired and wireless LAN model.

We have chosen 4 essentials in determining quality of voice, namely packet loss, jitter, MOS and end-to-end delay.

We have simulated 4 scenarios (2 for Ethernet LAN modules and 2 for Wireless LAN) on OPNET 16, Using existing OPNET LAN modules.

The simulation result obtained from the OPNET shows the following deduction:

- Ethernet LAN scenario has lower jitter compared to Ethernet WAN, however both were considered to have values of ideal connection for jitter.
- Ethernet LAN scenario has better MOS value compared to Ethernet WAN, however both are considered as fair to good connections
- Ethernet LAN scenario has lower end-to-end delay compared to Ethernet WAN, however the delay for WAN connection exceeded dramatically over the specified rage for a good quality of service.
- Ethernet LAN scenario has lower packet loss than the WAN scenario.
- All conclusions for Ethernet LAN vs Ethernet WAN applies to Wireless LAN scenario vs. Wireless WAN, however is all cases wireless had worse quality of service over wired connections

We believe that the results overall were reasonable and it was expected that wireless connections have worse quality than wired connections since the connections in wireless scenario depends on the distance and if any of the nodes are moving around.

## References

1. Mehta, Princy, and Sanjay Udani. "Voice over IP." *IEEE Potentials* 20.4 (2001): 36-40.
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