ENSC 427: COMMUNICATION NETWORKS

Performance analysis of mobile VoIP calls over WIMAX network

Spring 2010
FINAL PROJECT

Group 10
http://www.sfu.ca/~jsa48/

Ahn, Jin Sun	Kim, Tae-Hoon	Seo, Wooseouk
Jsa48@sfu.ca	Tkim2@sfu.ca	wws@sfu.ca

Table of Contents

List of Figures

List of Tables

List of Acronyms

NLOS:	Non Line of Sight
PCM:	Pulse Code Modulation)
QAM:	Quadrature Amplitude Modulation
QoS:	Quality of Service
QPSK:	Quadrature Phase Shift Keying
VoIP:	Voice over IP
Wi-FI:	Wireless Fidelity
WiMAX:	Worldwide Interoperability for Microwave Access

1. Abstract

As wireless network technology is advanced, the range of the wireless signal becomes one of the key issues of factors that affect the quality of signal. Since WIMAX has been developed due to its broad coverage or long range wireless network, voice over IP (VoIP) has become an alternative application over WIMAX network. This project will investigate the environment variables that affect the Quality of Service (QoS) on internet protocol telephony over WIMAX based mobile network station.

2. Introduction

2.1 Background and Motivation

Recently, wireless networks have been developed massively. There are simply two types of wireless network model categorized by its bandwidth or transmission range, respectively, short range wireless network, Wireless Fidelity, also known as, Wi-Fi (*IEEE. 802.11*) and long range wireless network, Worldwide Interoperability for Microwave Access, known as, WIMAX (*IEEE 802.16*). Due to its broad bandwidth and range transmission of signal, WIMAX becomes new alternative technology on the VoIP application. To investigate the performance of the WIMAX network, we will be focused on the factors that could affect QoS are mobility of the caller node and WIMAX cell coverage.

2.2 Project Idea and Goals

The main goal of our model will be based on NLOS requirements to analyze the performance of mobile VoIP calls on WIMAX network and the effects of environment variables on Quality of Service.

In Non Line of Sight condition, the transmitted signal is disturbed by obstacles, simply it undergoes reflection, diffraction, scattering, and polarization changes while Line of Sight condition is proportional to its distance from the base station [4].

Setting the WIMAX cell radius base on the NLOS specification, which is about 1 – 2 km, we are going to model our scenarios as the same trajectory running on one single cell for first case and seven cells for second case. As dealing with voice traffic encoded in G.729a scheme and uplink/downlink modulation of 64 -QAM, we are concerned about packet losses, end-to-end delay and jitter during transmission. Significant packet losses will be observed at the boundary of the WIMAX cell when the caller node trespasses to another cell. As simulating VoIP calls over WIMAX network, we will be able to collect the statistics: packet losses, end-to-end delay and jitter.

3. Simulation Design

Two main scenarios implementing VoIP calls are built by using OPNET Modeler 14.0. Each scenario has a conversation pair such that a mobile caller moving along the trajectory attempts to communicate with a fixed callee. In addition, one large hexagonal cell and 7 smaller cells with a honey-comb pattern are deployed for the first and second scenario, respectively. Since cell areas are established based on the density of subscribers, the large cells (first scenario) are used in rural areas, and small cells (second scenario) are used in urban areas.

3.1 Single Cell Scenario

The network topology of the first scenario is shown below in Figure 1.

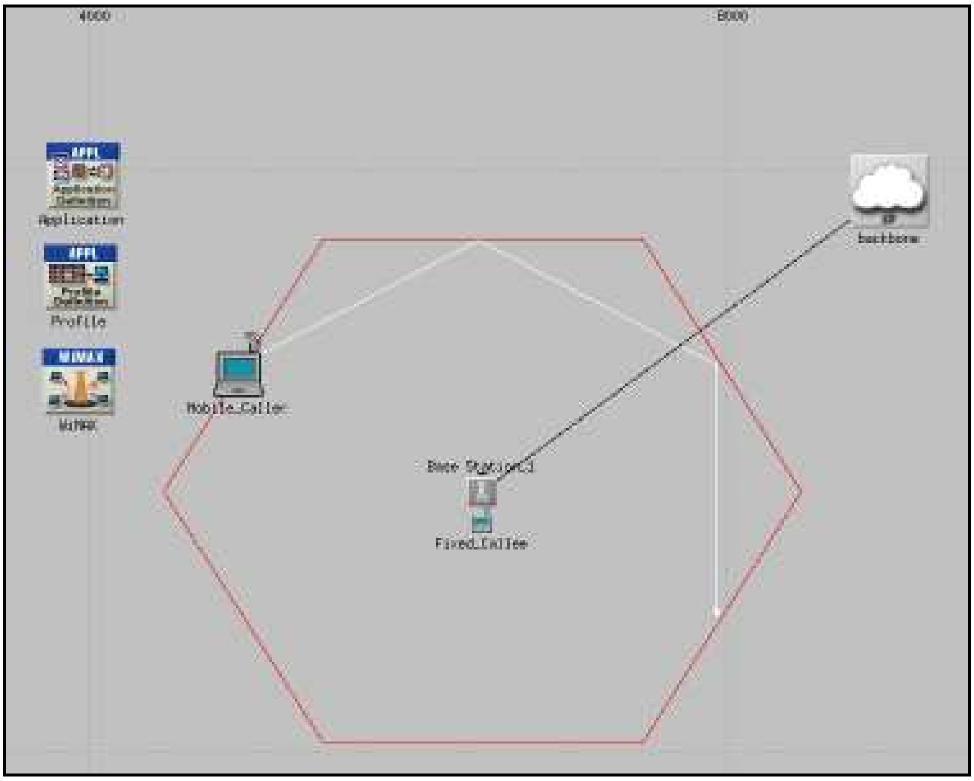

Figure 1: Single Cell Topology

The single cell scenario has a base station which is placed at the center of the cell. Moreover, Mobile Caller and Fixed Callee are placed 1,734 m and 200 m away from Base Station respectively. The white line in Figure 1 represents the trajectory of Mobile Caller which moves clockwise.

The WIMAX network can be deployed in the topology section of OPNET Modeler and its configuration is shown as in Figure 2.

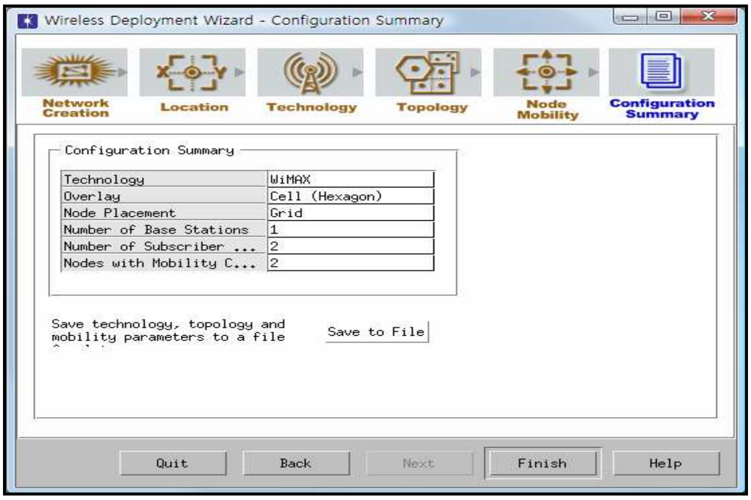

Figure 2: Specifying the Parameters for Single Cell Scenario of the WIMAX Network

The important parameters of WIMAX network are to define service classes which are set as Silver for voice traffic and it is associated with service flows on the caller and callee nodes. In addition, configuring efficiency mode also plays a crucial role in WIMAX network model which are set as Mobility and Ranging due to the mobility characteristics of the node.

According to the NLOS requirement [4], the radius of the cell is required to be between 1km and 2 km. In this scenario, the radius of the cell is chosen as 2 km.

The WIMAX parameters such as Antenna Gain (dBi), Classifier Definitions, and Maximum Transmission Power (W) are changed for the base station and workstations (Mobile Caller and Fixed Callee). (Note that the remaining WIMAX parameters are kept as default). Table 1 shows the WIMAX parameters of the base station and workstations, respectively.

Table 1: WIMAX Base Station and Workstations Parameters

	Base Station	**Workstations**
Antenna Gain (dBi)	15	15
Classifier Definitions	Silver	Silver
Maximum Transmission Power (W)	10	0.5
Downlink Service Flows (Modulation)	64-QAM	64-QAM
Uplink Service Flows (Modulation)	64-QAM	64-QAM

In order to keep the scenario realistic, the Maximum Transmission Powers (W) for Base Station and Workstations are set as 10 and 0.5 W respectively [6]. The downlink modulation of the base station is configured with 64-QAM scheme due to its high transmission power. However, for the uplink modulation of the workstations, 64-QAM scheme can be also acceptable to use since Fixed Callee is only 200m away from Base Station to achieve reasonable resulting performance.

3.2 Seven Cells Scenario

As shown in Figure 3, seven hexagonal cells are deployed instead of one cell in the previous scenario.

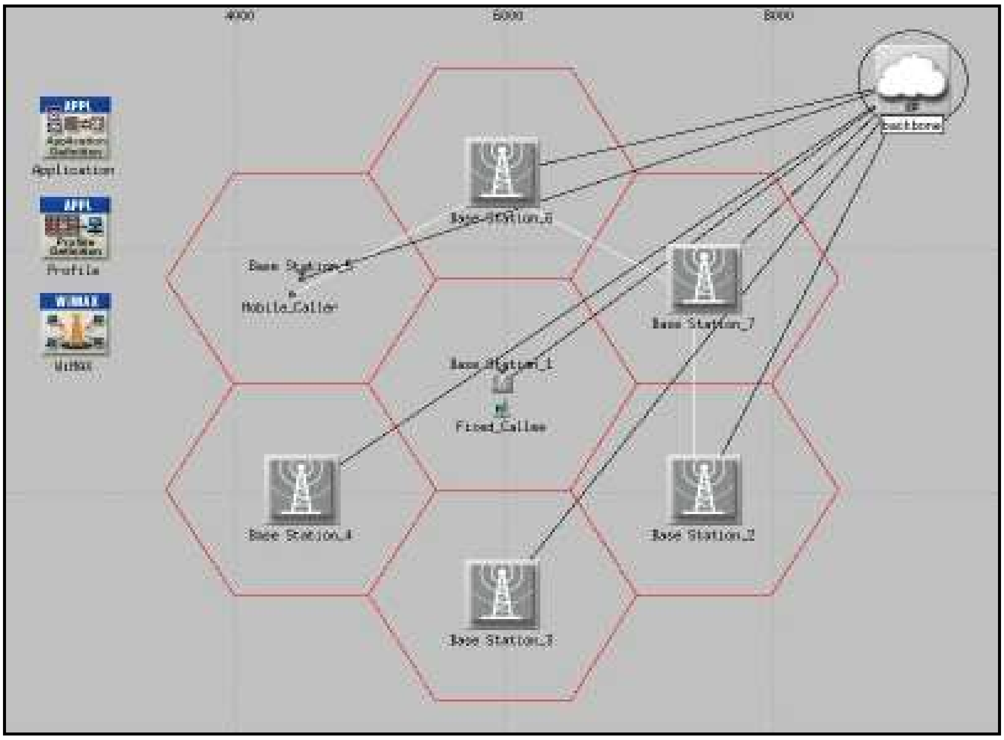

Figure 3: Seven Cells Topology

All the parameters are kept same as the single cell scenario except the radius of the cell is decreased to 1 km. Fixed Callee is also placed 200 m away from Base Station 1. Moreover, the identical trajectory of Mobile Caller is used as the previous scenario. However, as Mobile Caller moves along the trajectory, subsequently Mobile Caller enters to an adjacent cell. This procedure is called as handover which transfers the connection from one Base Station to the other, allowing the call to continue without interruption. This handover is expected to increase packet losses, End-To-End delay, and jitters. The detail analysis regarding the effect of the handover will be discussed in the simulation results section.

3.3 Traffic Model

As shown in Figure 4, IP Telephone is chosen for the voice application in order to simulate VoIP calls. PCM (Pulse Code Modulation) which converts a voice signal into a signal form is used since it provides high reliability in reducing noise interference. Moreover, the encoder scheme is set as G.729.A which transmits 100 packets/sec (8,000 bytes/sec).

Attribute	Value
name	Application
⊟ Application Definitions	(...)
Number of Rows	1
⊟ Voice over IP Call (PCM Qual...	
Name	Voice over IP Call (PCM Quality)
⊟ Description	(...)
Custom	Off
Database	Off
Email	Off
Ftp	Off
Http	Off
Print	Off
Remote Login	Off
Video Conferencing	Off
Voice	IP Telephony

Figure 4: Configuration of the Voice Application

4. Simulation Results

The simulation runs for 3 minutes in order for Mobile Caller to complete its trajectory with the speed of 100 km/h. The main statistics we are interested in this project are packet losses, End-To-End Delay, and Jitter.

4.1 Packet Loss

Figure 5 and 6 shows the received packets of Fixed Callee for Single and Multiple Cells Scenarios respectively.

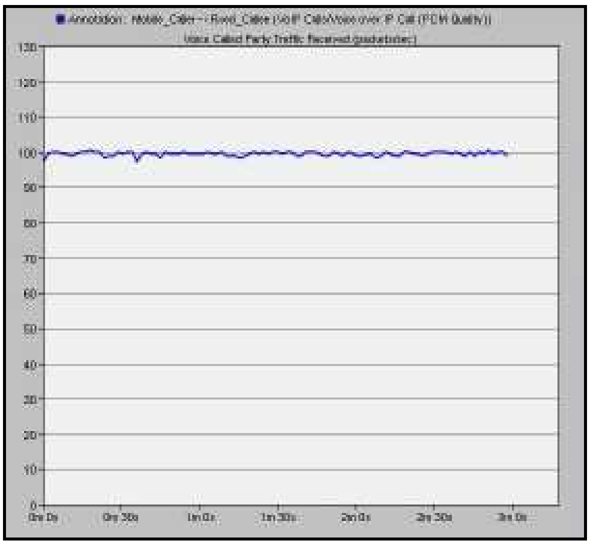

Figure 5: Packet Loss of Single-Cell Scenario

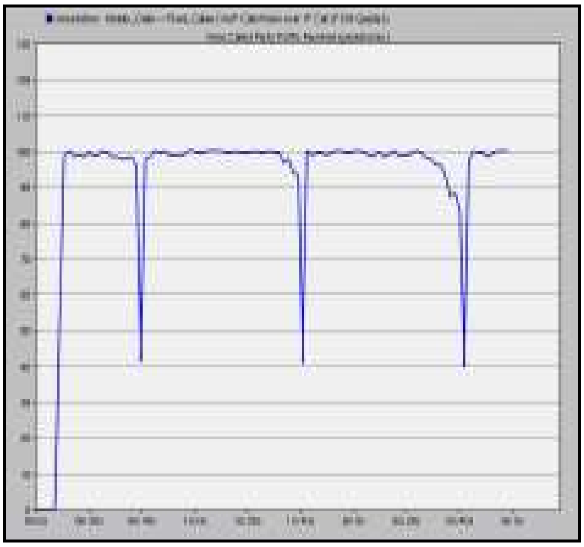

Figure 6: Packet Loss of Multiple-Cell Scenario

As expected, Fixed Callee in the first scenario approximately receives 100 packets/sec for the simulation time. For the second scenario, rapid drops (3 times) in packet losses occur due to the handover when Mobile Caller moves into the adjacent cells. However, once Mobile

Caller attains a new connection establishment with the new Base Station, the packet losses reduces and Fixed Callee receives approximately 100 packets/sec again.

4.2 End-To-End Delay

Figure 6 shows the End-To-End delay between Mobile Caller and Fixed Callee for the 2 scenarios. The red dots represent the End-To-End delay of Single Cell scenario, and the blue dots for Multiple Cells scenario.

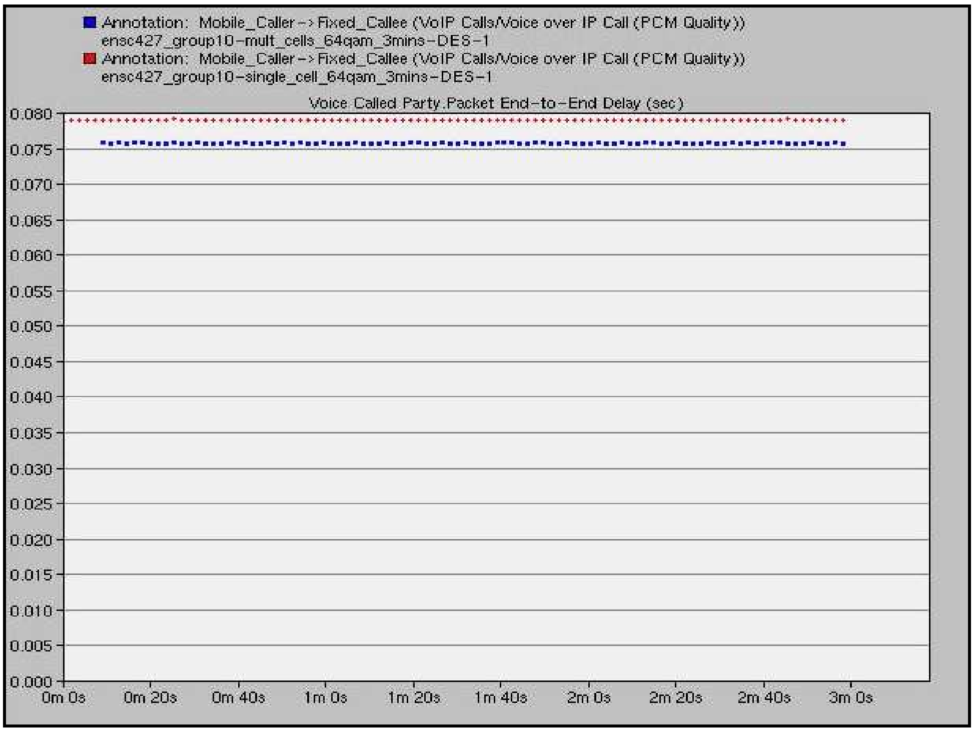

Figure 7: Comparing End-To-End Delay between single and 7 cells scenario

At first we expected switch over of the base stations would cause more End-to-End delay. However, we get opposite result as shown in Figure 6. We believe this due to sharing of base station in scenario 1 and no sharing in scenario 2. In scenario 1 two mobile stations are send and receive packet through single base station, more wait time for queuing. In scenario 2 each mobile station uses only one designated base station, so line traffic will be less.

We did not conduct simulation for multi mobile stations. So it is still quite early to say the End-To-End delay is totally unaffected by switching handover. At this test level with single pair of connection, the End-to-End delay is not affected by switching handover.

4.3 Jitter

Jitter is defined as the time variation between packets arriving from Mobile Caller. Figure 7 shows the overlaid results of Jitter for both scenarios. (Note that red dots represent Single Cell scenario and blue dots for Multiple Cells scenario)

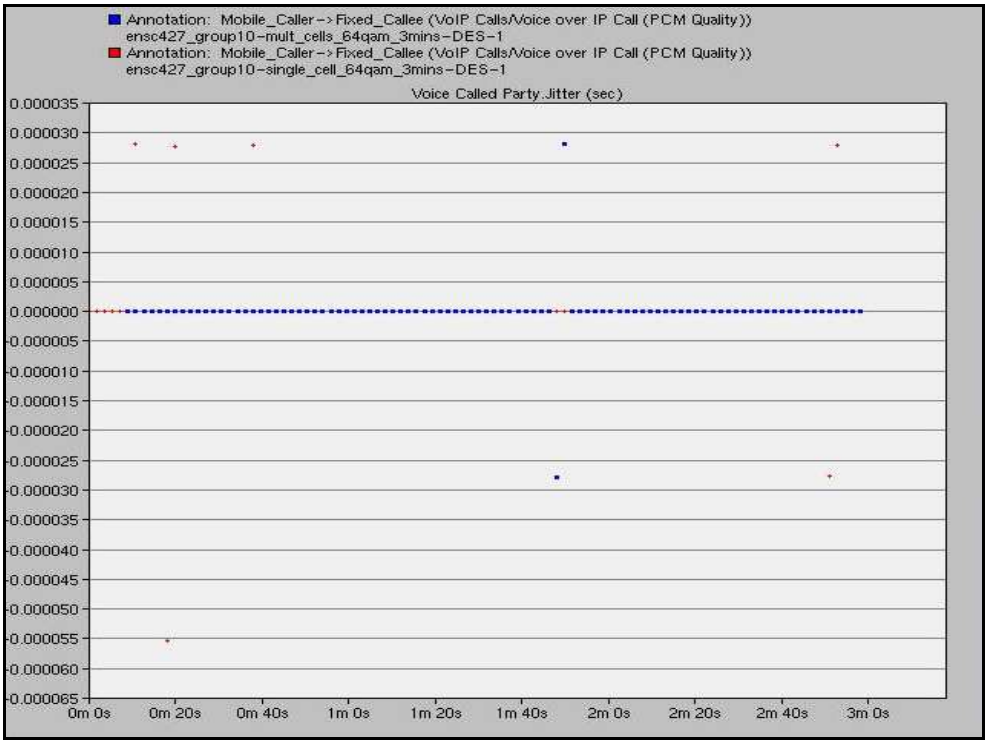

Figure 8: Comparing Jitter Delay between single and 7 cells scenario

Only a maximum of approximately 28 μs and 56 μs are present for Single and Multiple Cells scenario respectively. Moreover, theses presences of jitter will not have a significant effect on the quality of VoIP Calls. Although there is no significant jitter for WiMAX network [6], Figure 7 shows that the handover in Multiple Cells scenario causes the increase of jitter comparing to Single Cell scenario.

5. Conclusions and Future Work

In this project we built WIMAX network model to determine which factors can alter Quality of Service of VoIP application using OPNET simulator. The network model is analogous to making phone call connection between a mobile phone user and a home phone user. However, in our model we are using WIMAX technology. The statistics for packet loss, end-to-end delay and jitter were collected to determine the voice call quality.

There are two scenarios. First one is with base station handover and the second scenario is without base station hand over. The simulation result shows that the one with base station hand over is more vulnerable to packet loss during hand over process. The jitter and end-to-end delay time is also affected by hand over but the deviation is within a tolerance level.

Our first motivation of project was to determine whether the speed of the mobile node can affect the QoS or not. After several simulation tests we conducted with various speed of mobile node, we conclude that the speed itself is not a matter of fact, but combined with mobile path it took and the consequence of base station hand over affects voice quality.

We suggest the additional determiner, which is signal power, to minimize packet losses. Currently, the packet loss is the single variable that measured and compared to predefined threshold so to handover followed when the measured value is below threshold level. If we set the threshold level too high the mobile station attempt to find new base station more frequently. However, this may introduce unwanted handover attempt when the signal strength is not stable due to noisy environment. The signal power is proportionally related to the distance between base station and mobile station. So by measuring signal power along with higher threshold for packet loss will ensure to minimize packet losses.

The project result raised some issues possibly doable in future work. With current OPNET model WIMAX does not have Remote Node Controller that can control hand over between mobile station and base station. WIFI has a RNC so more sophisticated method of hand over is possible. We are not sure whether we can still use RNC WIFI node for WIMAX. We leave this as a future work. The other issue that can be studied further is the relationship between the power of base station and signal propagation distance. We do not have enough time to study this.

The most difficult part of this project is implementation on OPNET simulator. Even after we have completed more than twenty hours of tutorial lessons, it required extra effort to run a simple wireless network and get proper results.

From this project we have learned how the wireless network is being used to benefit our life and draw a picture of next generation of the wireless network will be.

6. References

[1] J. G. Andrews, Fundamentals of WIMAX : understanding broadband wireless networking / Jeffrey G. Andrews, Arunabha Ghosh, Rias Muhamed, Upper Saddle River, N.J. Prentice Hall, 2007.

[2] R. K. Rao, WIMAX : a wireless technology revolution / G.S.V. Radha Krishna Rao, G. Radhamani, Boca Raton, Auerbach Publications, c2008

[3] M. Baratvand, M. Tabandeh, A. Behboodi, and A. F. Ahmadi, "Jitter-Buffer Management for VoIP over Wireless LAN in a Limited Resource Device," IEEE Fourth International Conference on Networking and Services, Tehran, Iran, March 2008, pp 90-95.

[4] E. Crozier and A. Klein. (2007) WIMAX¡¯s technology for LOS and NLOS environments. [Online]. Available: http://www.WIMAXforum.org

[5] Breeze Wireless Communications Ltd. (2003) Radio Signal Propagation. [Online]. Available: http://didier.quartier-rural.org

[6] J. Yoo (2009) Performance Evaluation of Voice Over IP on WIMAXand Wi-FiBasedNetworks. [Online]. Available: http://www.sfu.ca/~jty/ensc427/