ENSC 427: COMMUNICATION NETWORKS

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Comparison Between Wi-Fi and WiMAX

http://www.sfu.ca/~luodil/427project.html

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Table of Content

1. **Abstract** 1

2. **Introduction** 2

3. **Main section** 3

3.1 Overview of WiMAX 3
3.2 Overview of Wi-Fi 5
3.3 Comparison between Wi-Fi and WiMAX 6
3.4 Overview Design of Wireless Network Technologies 6
3.4.1 Wi-Fi Design 6
3.4.1.1 Overview 6
3.4.1.2 OPNET Building Components 7
3.4.1.3 Test Procedure 7
3.4.1.3.1 Streaming High Resolution Video 7
3.4.1.3.2 Heavy HTTP Browsing 10
3.4.2 WiMAX Design 11
3.4.2.1 Overview 11
3.4.2.2 OPNET Building Components 12
3.4.2.3 Test Procedure 12
3.4.2.3.1 Streaming High Resolution Video 12
3.4.2.3.2 Heavy HTTP Browsing 14
3.5 Simulation Result 14
3.5.1.1 Streaming Video 14
3.5.1.2 HTTP Browsing 15

4. **Conclusion and Discussion** 17

4.1 Conclusion 17
4.2 Future Work 17

5. **Reference** 18

1. Abstract

Wireless Fidelity (Wi-Fi) is a data transmission system but is based on IEEE 802.11 standard. Worldwide Interoperability for Microwave Access (WiMAX) is wireless communication standard that is based upon IEEE 802.16. It is also a member of 4G family that is similar to well-known Long term evolution (LTE). Both Wi-Fi and WiMAX use wireless technology. They do not need a physical connection to propagate their signals. There are some differences between these two network technologies. WiMAX provides a faster and longer distance network to users than Wi-Fi. The speed of WiMAX may reach up to 70 Mbps compared to Wi-Fi that can only achieve 50 Mbps. As the radio technology develops, the speed of Wi-Fi continues to increase. The fastest speed of Wi-Fi is when using IEEE 802.11n standard, because it has doubled spectrum and bandwidth. The speed may be up to 300 Mbps. However, setup for WiMAX is more expensive than for Wi-Fi, because WiMAX needs outdoor facilities such as base stations for its implementation. The main difference between these two systems is their range. There is no doubt that WiMAX coverage is larger than Wi-Fi. WiMAX may cover up to 50 kilometers while Wi-Fi only covers 30 meters.

In order to compare the two technologies fairly, the same conditions should be applied. We plan to compare the Wi-Fi and WiMAX capabilities over the same distance, which eliminates their differences. We plan to analyze the quality of service such as jitter, data-drop rate, and interference of the two networks by having the same number of users within a same range. The comparison will be implemented by streaming a high-definition (HD) video online and heavy browsing.

2. Introduction

Both Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMAX) are wireless technologies. However, there are some notable differences between these two technologies. First of all, WiMAX covers a greater distance than Wi-Fi. The range of Wi-Fi is about 30 meters while WiMAX is 50 Kilometers. The frequencies used and the power of the transmitter are the key reasons for this huge difference. Wi-Fi is also defined as “wireless local area network (WLAN)” which is based on IEEE 802.11 standards and it is usually used in home, office and campus. WiMAX is defined as “wireless Metropolitan Area Network” which is based on IEEE 802.16. Secondly, WiMAX has a faster speed than Wi-Fi. The most popular and common Wi-Fi standard is 802.11g. It offers a speed up to 50 Mbps. WiMAX on the other hand provides 70 Mbps data rates. Thirdly, Wi-Fi could not guarantee the Quality of services (QoS) while WiMAX provide several levels of QoS. QoS is the overall performance of network which includes some common aspects such as Jitter, error rates, throughput, and delay.

The last part is also our main focus in this project. Test scenarios will be slightly adjusted for both Wi-Fi and WiMAX in order to eliminate their differences such as the scale of network. We would like to implement our performance test by streaming a heavy load video and browsing a heavy HTTP website on those two different wireless networks. The test will be simulated on OPNET 16 which is a network simulation software tool. Some statistics and graphs will be presented in simulation section to provide a better picture of the comparison result.

3. Main section

We will implement two test scenarios and collect some essential statistics on OPNET 16 in this section. By doing so, we need to review some WiFi and WiMAX concepts first in order to implement our design successfully.

3.1 Overview of WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless broadband technology, which supports point to multi-point (PMP) broadband wireless access. WiMAX has a range of up to 50 kilometers, and can deliver broadband at around 70 megabits per second.

The technology of WiMAX is developing and evaluating under the cooperated effects in the WiMAX Forum and IEEE 802.16. The road map of WiMAX evolution is shown in Figure 1 [9]. The Long with the widely developing of the WiMAX network, the key following key technical concepts and objectives are applied [9]:

- Orthogonal frequency-division multiple access (OFDMA)-based multiple access with scalable bandwidth in downlink and uplink
- Advanced antenna technologies allowing beam forming and diversity through space time coding and spatial multiplexing (SM)
- Adaptive physical layer (PHY) design using fast link adaptation combined with fast time and frequency scheduling
- All-IP flat network architecture supporting different deployment models and enabling both traditional operator-managed as well as new open Internet services
- Open standard interfaces enabling over-the air as well as network interoperability in multivendor deployments

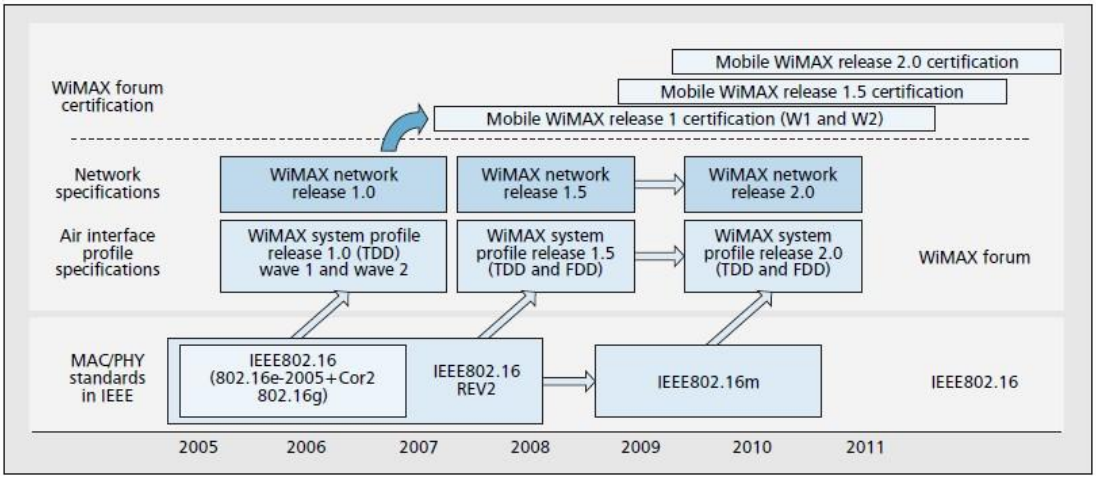

Figure 1: Mobile WiMAX technology and network evolution roadmap

The architecture of mobile WiMAX network is shown in Figure 2 [9]. In order to meet the requirements of WiMAX network while maximizing the use of open standards and IETE protocols, the baseline network reference model (NRM) is used to

identify key functional entities and reference points. The WiMAX NRM differentiates between network access providers (NAPs) and network service provider (NSPs) [9].

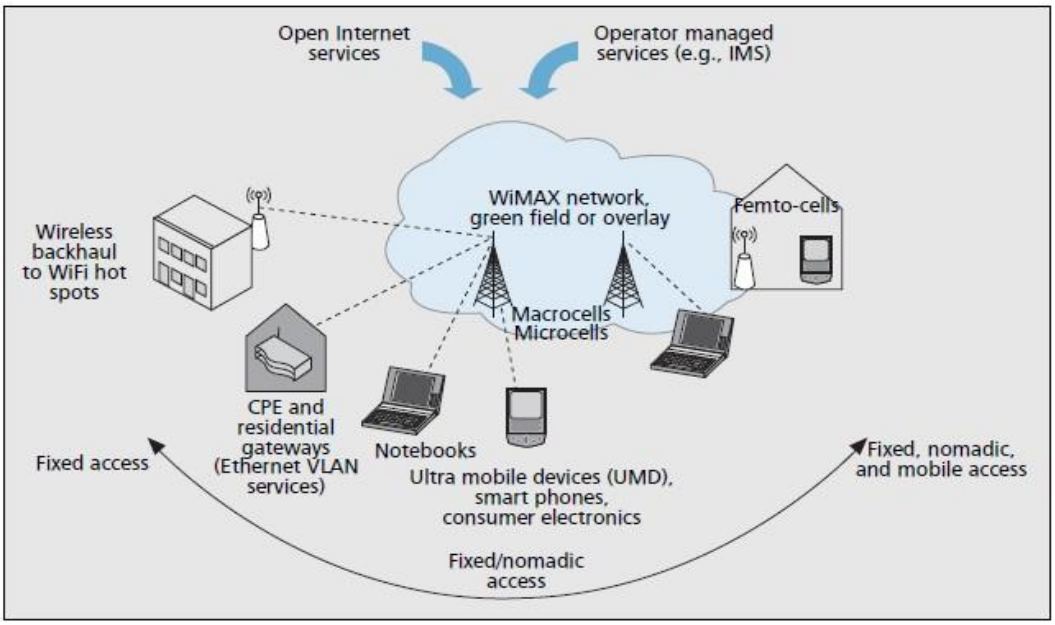

Figure 2: Mobile WiMAX enabling a variety of usage model in the same network

Several network entities are deployed in the WiMAX NRM (Figure 3) [9]: MSs, an access service network (ASN), and a connectivity service network (CSN), and their interactions through reference points R1–R8. Each MS, ASN, and CSN represents a logical grouping of functions as described in the following [9]:

- Mobile station (MS): generalized user equipment set providing wireless connectivity between a single or multiple hosts and the WiMAX network.
- Access service network (ASN): represents a complete set of network functions required to provide radio access to the MS.
- Connectivity service network (CSN): a set of network functions that provide IP connectivity services to WiMAX subscriber(s).

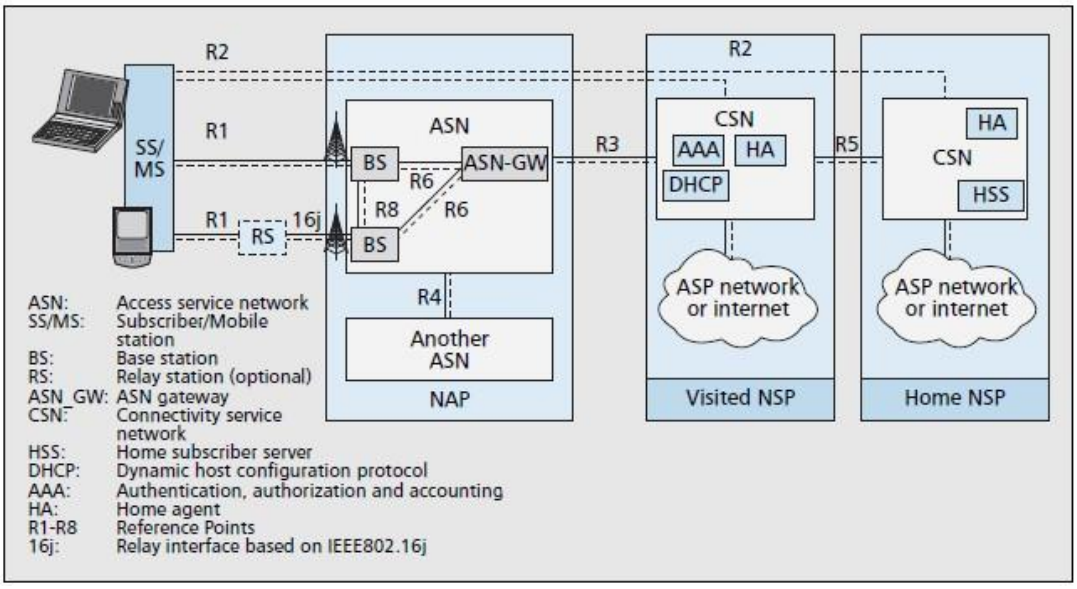

Figure 3: WiMAX network reference model

3.2 Overview of Wi-Fi

Wi-Fi (Wireless Fidelity) corresponds to the name of the certification given by the Wi-Fi Alliance, formerly WECA (Wireless Ethernet Compatibility Alliance), the group which ensures compatibility between hardware devices that use the 802.11 standard [7]. The IEEE 802.11 specification is an international standard for a WLAN (wireless local area network). Wi-Fi is able to establish and create high-speed WLAN, and make connections between mobile stations and access point(s) in certain distance. The radius of a promising Wi-Fi network between mobile stations and an access point is up to 30 meters. The speed for Wi-Fi networks can reach to 50Mbps. The road map of evolution for Wi-Fi network is shown in Figure 4 [8].

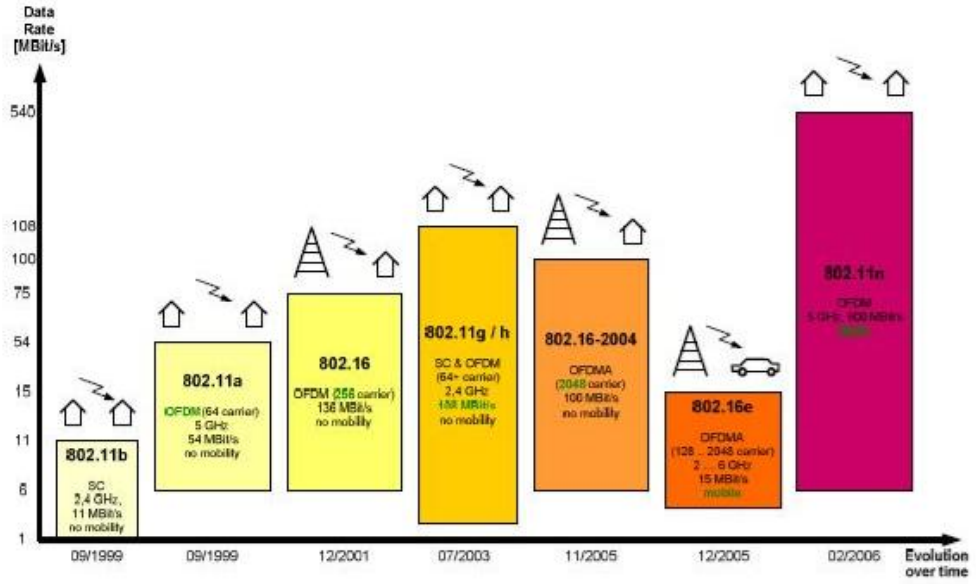

Figure 4: Standard overview of Wi-Fi networks

Today, the WLANs run in two radio spectrums, which are 2.4 GHz and 5GHz. The 2.4 GHz frequency is already crowed-it has been allocated for several purposes besides WLAN service [10]. The 5GHz spectrum provides a much larger bandwidth, higher speeds, greater reliability, and better throughput. The WLAN can be implemented by many ways as following [10]:

- Peer-To-Peer: A peer-to-peer network is a WLAN in its most basic form.
- Client & Access Point: In a Client & Access Point network, users not only benefit from extended range capabilities, they are also able to benefit from server resources, as the AP is connected to the wired backbone.
- Multiple Access Points: Although coverage ranges in size from product to product and by differing environments, WLAN systems are inherently scalable.

3.3 Comparison between Wi-Fi and WiMAX

Although some basic differences between Wi-Fi and WiMAX have been introduced in introduction section, it is not enough to implement our design now. We need to continue digging out the differences between those two wireless technologies with more details. Below is a graph that compares WiMAX 802.16a with Wi-Fi 802.11b [6].

Feature	**WiMAX (802.16a)**	**Wi-Fi (802.11b)**
Primary Application	Broadband Wireless Access	Wireless LAN
Frequency Band	Licensed/Unlicensed 2 G to 11 GHz	2.4 GHz ISM
Channel Bandwidth	Adjustable 1.25 M to 20 MHz	25 MHz
Half/Full Duplex	Full	Half
Radio Technology	OFDM (256-channels)	Direct Sequence Spread Spectrum
Bandwidth Efficiency	<=5 bps/Hz	<=0.44 bps/Hz
Modulation	BPSK, QPSK, 16-, 64-, 256-QAM	QPSK
FEC	Convolutional Code Reed-Solomon	None
Encryption	Mandatory- 3DES Optional- AES	Optional- RC4 (AES in 802.11i)
Mobility	Mobile WiMAX (802.16e)	In development
Mesh	Yes	Vendor Proprietary
Access Protocol	Request/Grant	CSMA/CA

3.4 Overview Design of Wireless Design Technologies

3.4.1 Wi-Fi Design

Overview:

We plan to perform two test scenarios in this project: streaming high resolution video and heavy HTTP browsing. Some components are needed in order to build the Wi-Fi network on OPNET (Figure.5)

- Access Point: Wireless access point (Wi-Fi router) acts like a transceiver of

wireless signal.

- Server: Provide network services upon network users' requests (Figure.6)
- Gateway: A router can transfer data packets between networks on different layers. A switch is a simple version of gateway, which connect input to specified output
- Workstations: Wireless devices that can receive and transmit data packet of requested service.

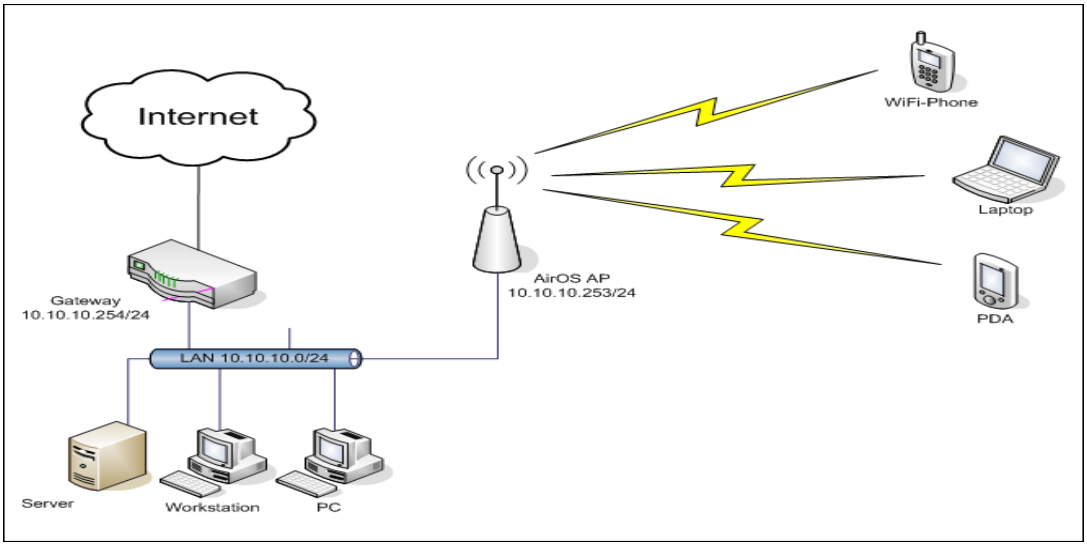

Figure 5: Wi-Fi network structure

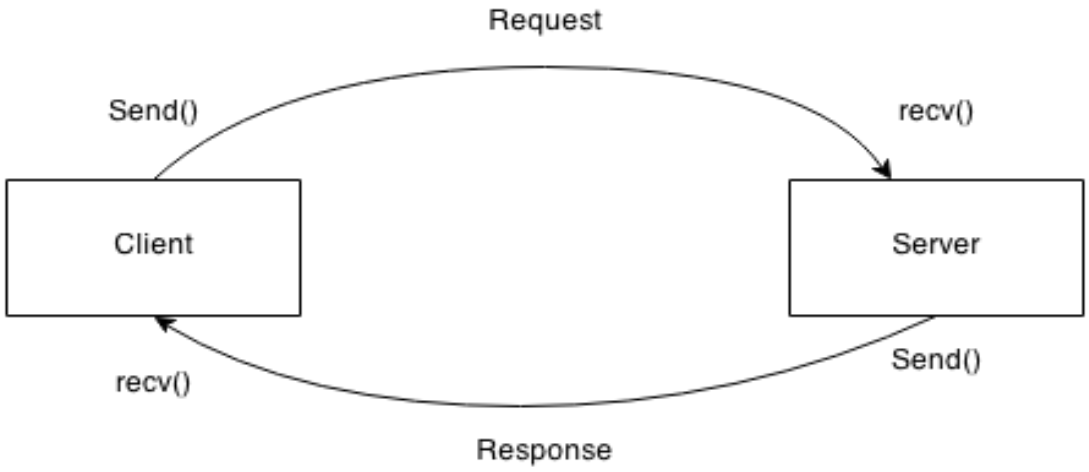

Figure 6: Client and server model

OPNET Building Components:

There are many options of picking up those components on OPNET. Here are our choices:

- Access Point: WLAN_ethernet_slip4_adv (Fixed node)
- Gateway: Ethernet4_Slip8_gtwy (Fixed node)
- Server: Ethernet_server (Fixed node)

- Workstation: WLAN_skstn_adv (mobile node)
- Link Model: 100BaseT

Test Procedure (Streaming High Resolution Video):

Step 1: Place access point, gateway, server and seven workstations on the workspace and connect first three components by using 100BaseT (Figure.7)

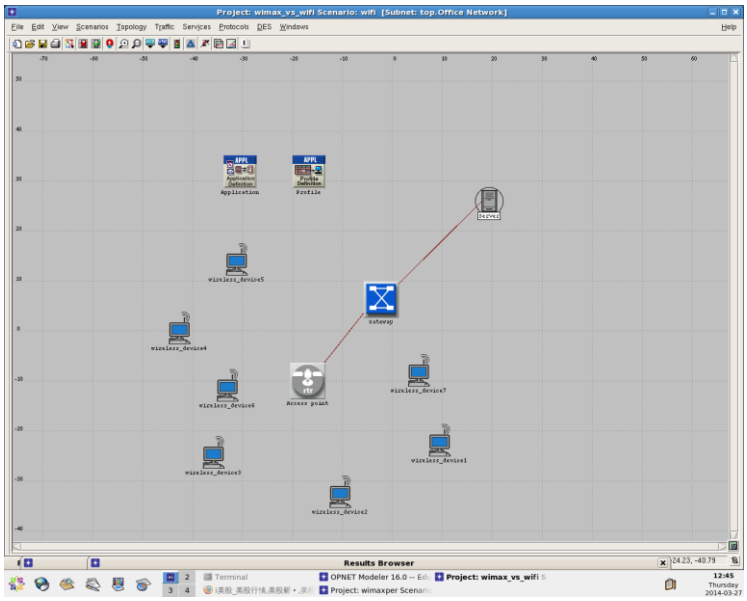

Figure 7: Wi-Fi structure on OPNET

Step 2: Set proper names on each component for convenience

Step 3: Place “application configuration” and “profile configuration” on the workspace to specify our test scenarios.

Step 4: Right click on “application configuration” and choose edit attribute (Figure.8). From application definition:

- Add the number of rows to 1
- Change its name to “Video”
- Select video conference option and choose high resolution video

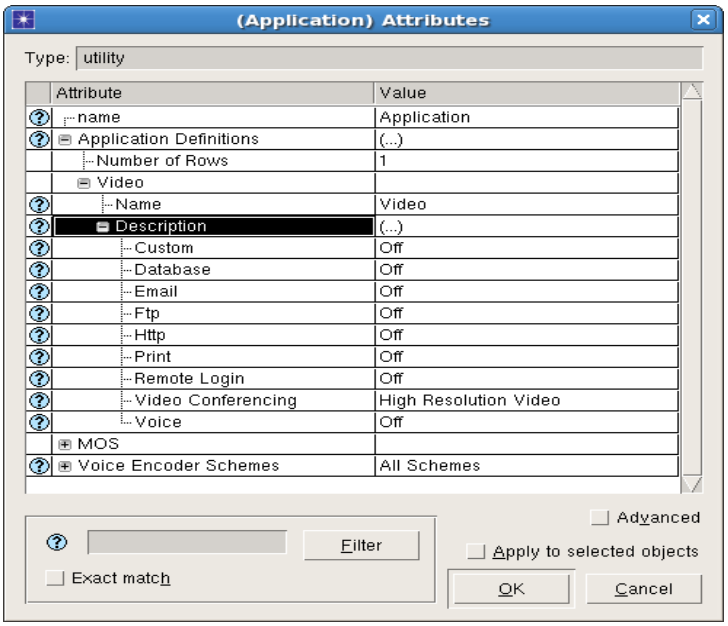

Figure 8: Wi-Fi application configuration (High Resolution Video)

Step 5: Right click on profile configuration and choose edit attribute (Figure.9). From profile configuration,

- Change the profile name
- Add number of rows to 1
- Match its name to “Video” which is created in application configuration
- Change start time to “Constant” and its mean value to “0” in order to start the simulation immediately

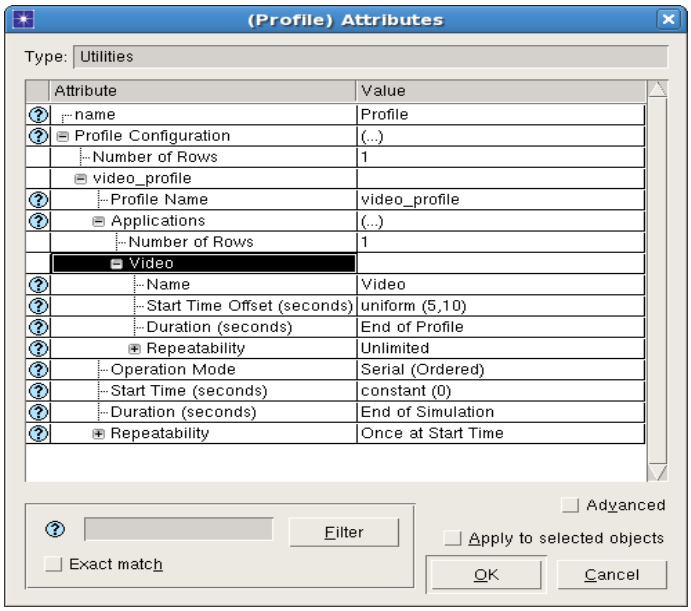

Figure 9: Wi-Fi profile configuration

Step 6: Right click on server and choose edit attribute (Figure.10).

- Set application: supported profile to the profile we just created
- Set application: supported service to all

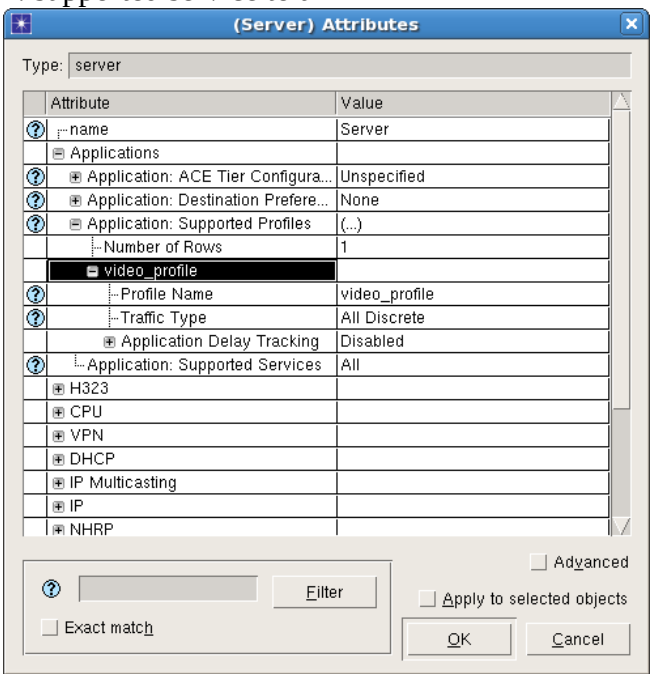

Figure 10: Wi-Fi server configuration

Step 7: Edit mobile workstations' attributes in order to achieve a better data transmission performance (Figure.11). From application,

- Set application: supported profile to profile we created
- Set application: supported service to all
- Increase mobile stations transmit power to 0.1W
- Change the Buffer Size to 64000 bits
- Promote the data rate to the highest level

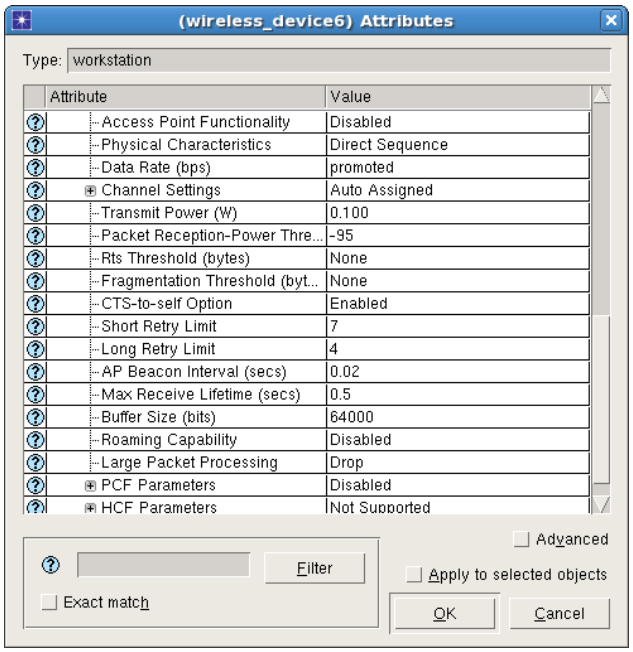

Figure 11: Wi-Fi mobile station configuration

Step 8: Right click on access point and choose edit its attribute

- Make sure access point functionality is enable
- Do the same changes as we did in mobile stations (data rate, transmit power and buffer size)

Step 9: Select "wireless_lan" and "video conferencing" as our results from "choose individual DES statistics" on each mobile station

Step 10: Set time period to 1 hour and run simulation

Step 11: After simulation is done, right click on work space and choose "view result" in order to view the graphs of those key parameters such as throughput, delay and data packet dropped.

Test Procedure (Heavy HTTP Browsing)

Step 1: Change the application configuration in step 4 (Figure.12)

Step 2: Add "wireless_lan" from "choose individual DES statistics"

Step 3: Go through step5 – step 11 again (Change the simulation time to 30 minutes)

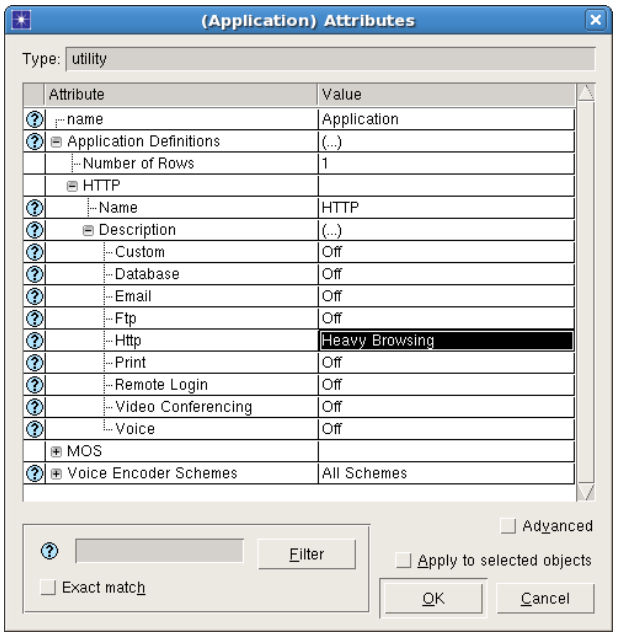

Figure 12: Wi-Fi application configuration (HTTP browsing)

3.4.2 WiMAX Design

Overview:

The architecture of WiMAX consists of three main parts: mobile stations, access service network (ASN), IP network (IP backbone) and connectivity service network (CSN) (Figure 13).

- Access service network (ASN): It is a transition part in order to connect those mobile stations or wireless devices to internet service provider
- Connectivity service network (CSN): Provide management and control for those WiMAX subscribers with services
- IP backbone: Interconnect network and core routers on the internet

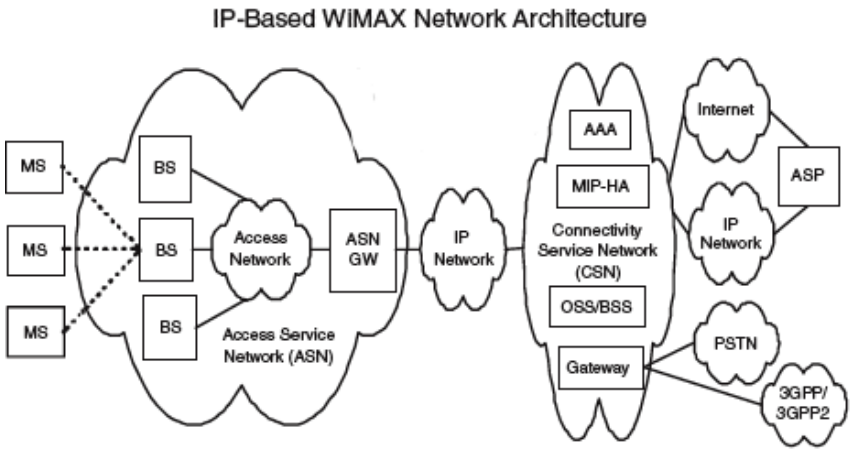

Figure 13: Architecture of WiMAX network

OPNET Component:

Following components are picked in order to implement WiMAX network on OPNET

- WiMAX Base Station: WiMAX_bs_ethernet4_slip4_router
- Gateway: Ethernet4_Slip8_gtwy (Fixed node)
- Server: Ethernet_server (Fixed node)
- IP backbone: Rounter_slip64_dc
- Workstation: Wlan_skstn_adv (mobile node)
- Link Model: 100BaseT

Test Procedure (Streaming High Resolution Video):

Step 1: Place WiMAX station, 9 mobile stations, gateway, and Ethernet server on the workspace and connect WiMAX base stations with gateway and server by using 100baseT (Figure 14).

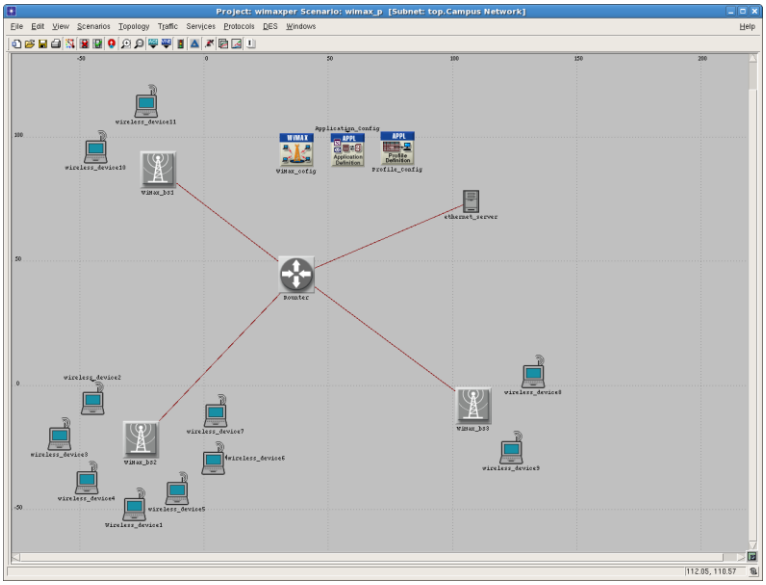

Figure 14: WiMAX network architecture

Step 2: Set proper names on each components for convenience

Step 3: Now place application configuration, profile configuration and WiMAX configuration on workspace to specify our test scenarios

Step 4: Right click on application configuration and profile configuration and choose edit attribute. Do the same procedures as we did on Wi-Fi part

Step 5: Right click on WiMAX configuration and edit its attribute. Change efficiency mode to "Physical Layer Enabled" to apply different level of Quality of Service (QoS) (Figure 15).

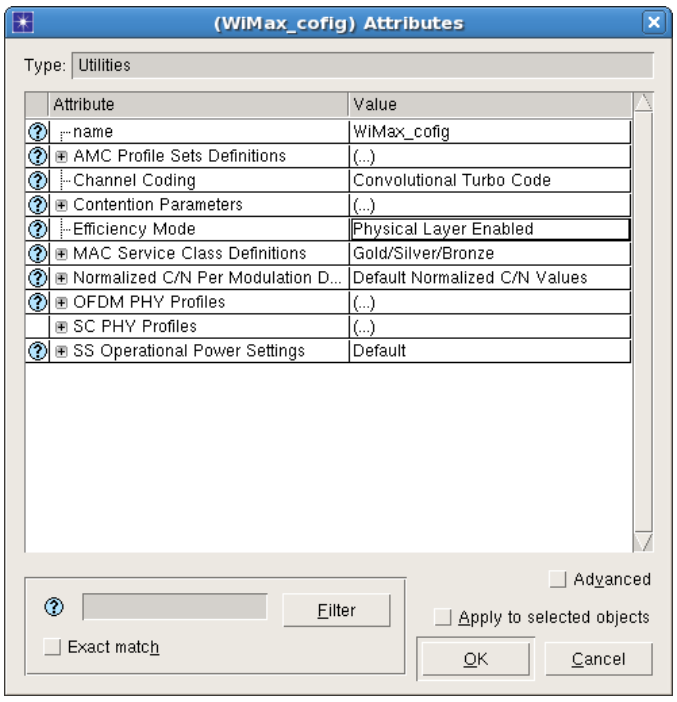

Figure 15: WiMAX configuration

Step 6: Right click on server and change its attributes same as we did in Wi-Fi part.

Step 7: Edit mobile workstations' attribute (Figure.16).From application,

- Set application: supported profile to profile we created
- Set application: supported service to all

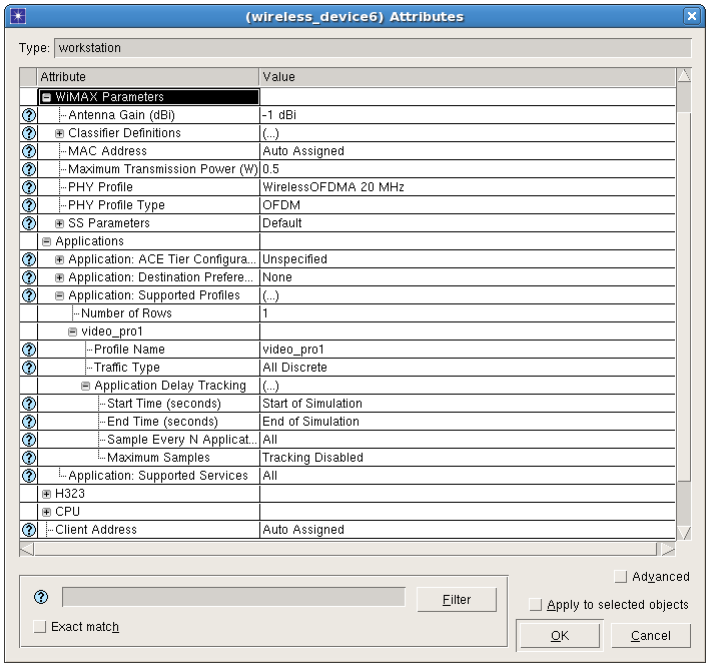

Figure 16: WiMAX mobile station configuration

Step 8: Right click on those seven mobile stations on the left bottom corner and select "WiMAX" and "Video conferencing" from "choose individual DES statistics"

Step 9: Set time period to 1 hour and run the simulation

Step 10: After simulation is done, right click on work space and choose "view result" in order to see graphs of those key parameters such as throughput, data packet dropped and delay.

Test Procedure (Heavy HTTP browsing):

Step 1: Change the application configuration to “HTTP Heavy browsing” (Figure.12)
Step 2: Add “wireless_lan” from “choose individual DES statistics”
Step 3: Go through step5 – step 11 again (Change the simulation time to 30 minutes)

3.5 Simulation Result

Streaming Video

We would like demonstrate the graphic results and make comparison between Wi-Fi and WiMAX network on their data transmission performance in this section. The first test scenario is streaming high resolution video. WiMAX provides a lower data dropped rate and delay then Wi-Fi as we can see from graphs (Figure.17 and Figure.18), because WiMAX has several levels of QoS to ensure its transmission performance and high signal strength. WiMAX also has higher throughput rate than Wi-Fi as we talked about in introduction part (Figure.19), because it uses a more advanced IEEE 802 wireless standard than Wi-Fi.

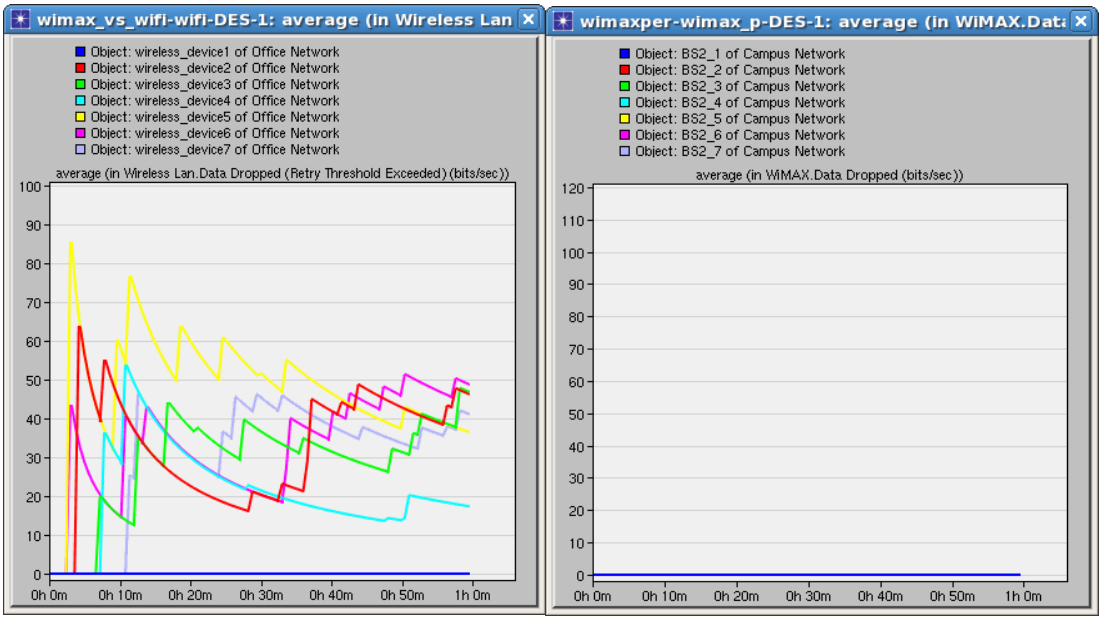

Figure 17: Data dropped rate of streaming video on WiMAX and Wi-Fi

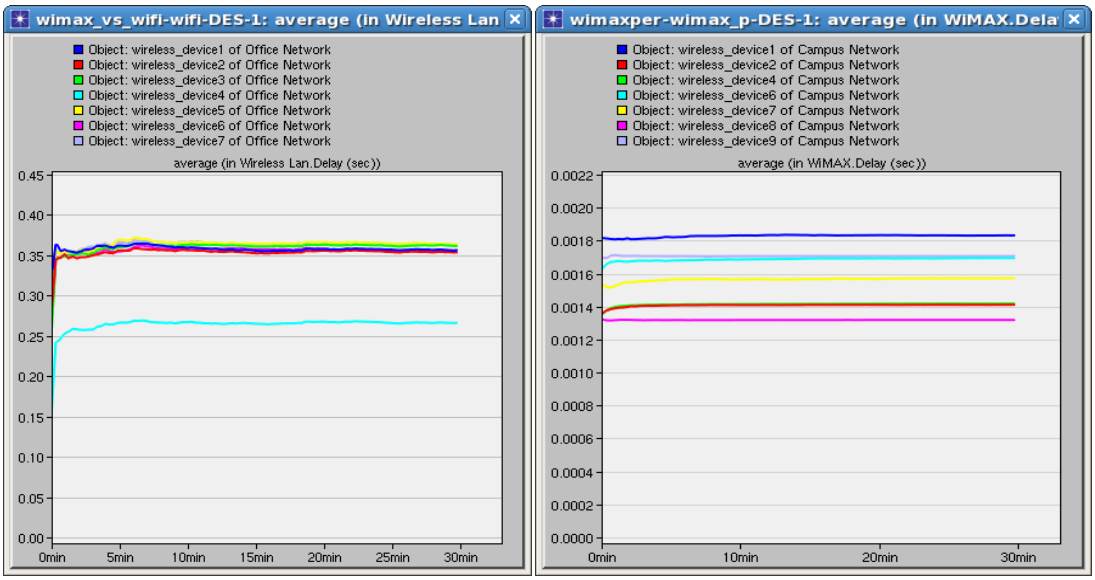

Figure 18: Delay of streaming video on WiMAX and Wi-Fi

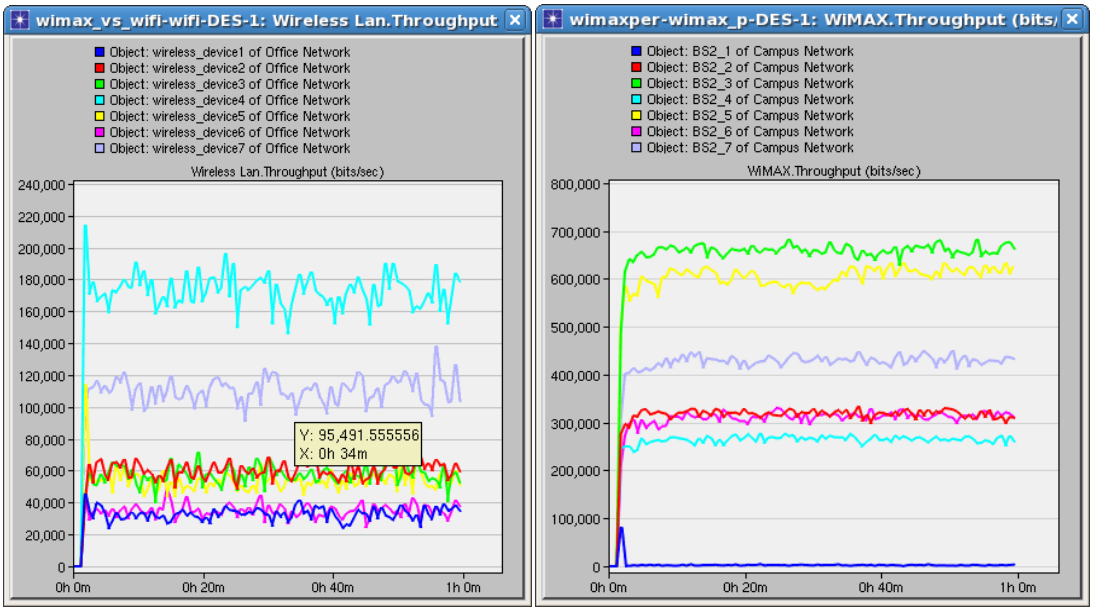

Figure 19: Throughput of streaming video on WiMAX and Wi-Fi

HTTP Browsing

The second test scenario is heavy HTTP browsing. Both WiMAX and Wi-Fi provide a similar result on data dropped rate (Figure.22) and throughput (Figure.20) because HTTP browsing requires a very low data transmission rate compared to streaming high resolution video. However, in this example, Wi-Fi has lower delay rate (Figure.21) than WiMAX, because we turn the QoS off in order to see the difference.

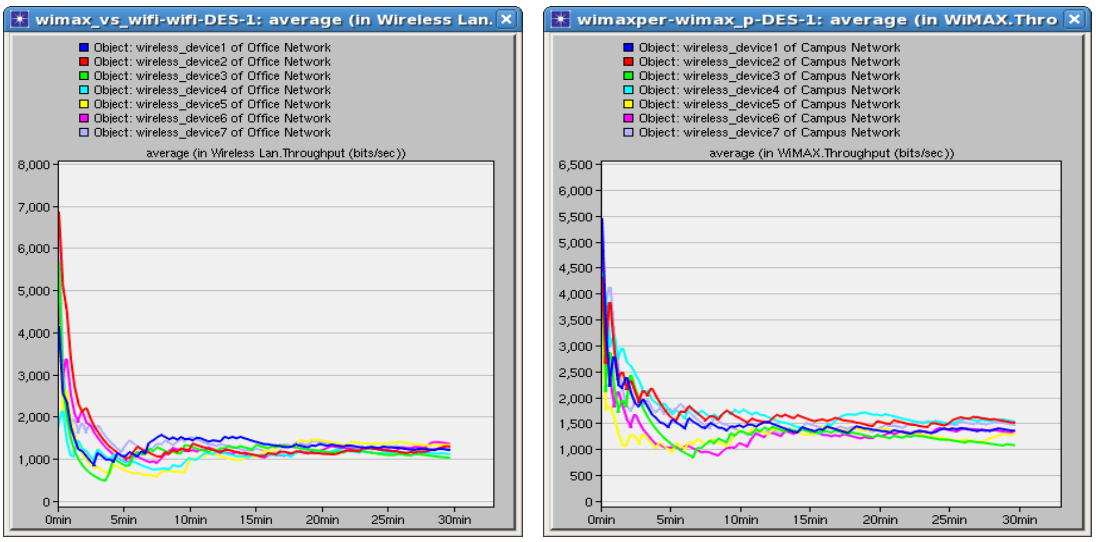

Figure 20: Throughput rate of heavy HTTP browsing on WiMAX and Wi-Fi

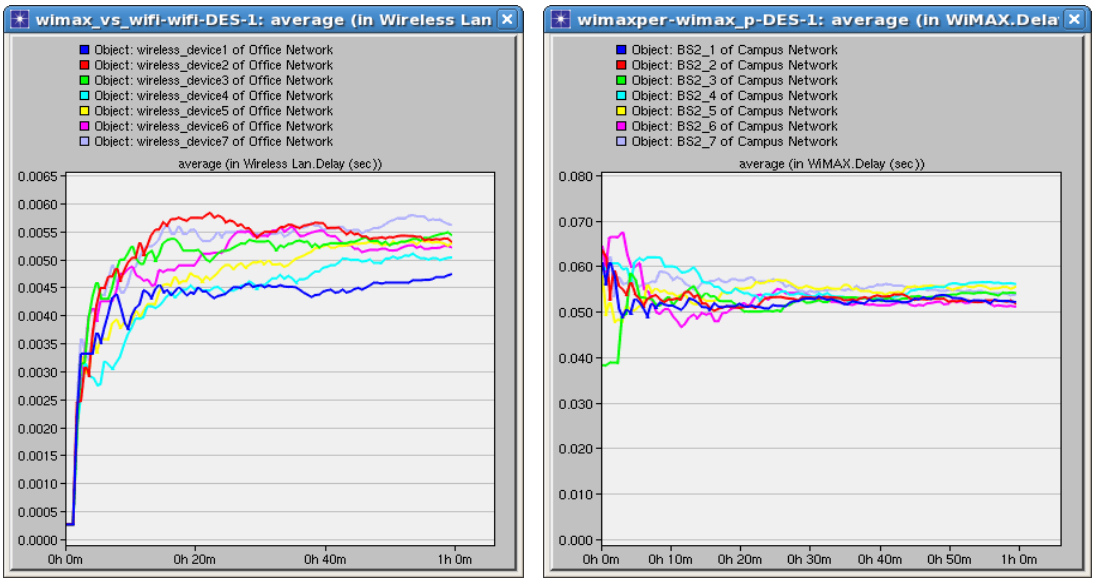

Figure 21: Delay of heavy HTTP browsing on WiMAX and Wi-Fi

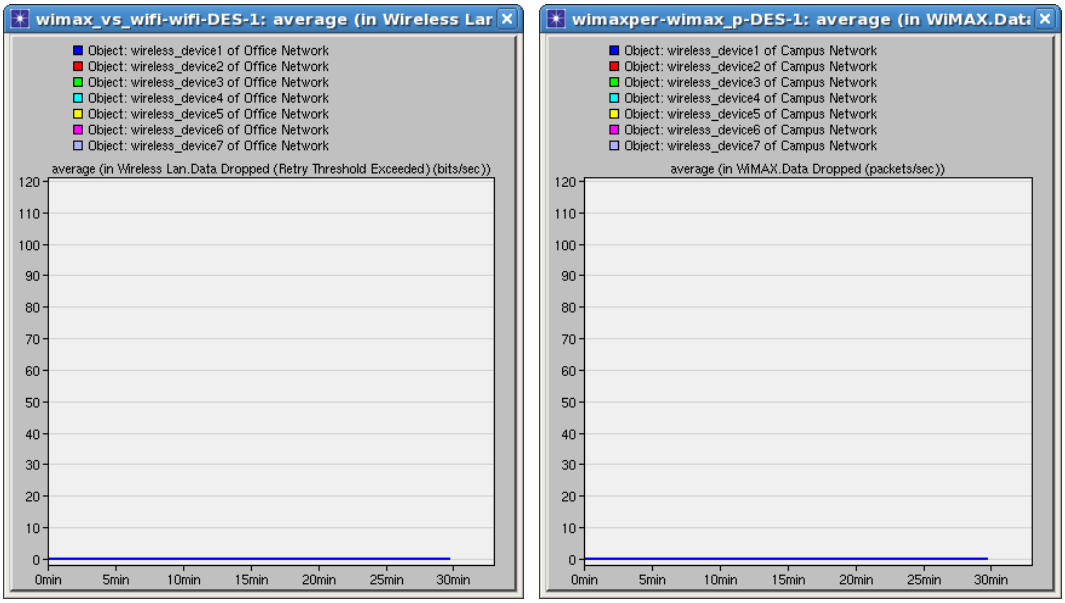

Figure 22: Data dropped rate of heavy HTTP browsing on Wi-Fi and WiMAX

4. Conclusion and Discussion

4.1 Conclusion

Although these wireless devices are very close to access point or WiMAX base station, we can still see some differences or outstanding results on each graph especially on throughput result. That is because multipath effects. Multipath effects will make radio signals reaches mobile station by different paths due to refraction and reflection of the atmosphere [12]. From those graphs in the previous simulation result part, we believe that WiMAX has an overall better performance than Wi-Fi mainly because of Quality of Service (QoS). The goal of QoS is to ensure high data transmission performance such as data dropped rate, throughput and delay can be achieved [11]. We have proved this result in our simulations for both streaming high resolution video and heavy HTTP browsing.

4.2 Future Work

After comparing those key data transmission parameters, we conclude that WiMAX outperforms Wi-Fi. However, we can still see some shortage on WiMAX compared to Wi-Fi nowadays. Most of our current mobile devices do not have WiMAX capability. Therefore, wireless users are not able to enjoy the advantages of using WiMAX network technologies. The solution of this problem is to integrate Wi-Fi and WiMAX technologies together in order to maximize their performance. This can be done by connecting a WiMAX WLAN router to a WiMAX base station. That is also what we want to implement in our future simulation. Moreover, we would like to see the data transmission performance on WiFi and WiMAX when a large number of users are using network at a same time.

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