ENSC 427 COMMUNICATION NETWORKS

WLAN-WiMAX ANALYSIS OPNET

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FINAL REPORT

Group 8

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List of Abbreviations

WiMAX: World Interoperability Microwave Access

WLAN: wireless local area networks

WI-FI: Wireless Fidelity

DSL: digital subscriber line

IP: Internet Protocol

OFDM: orthogonal frequency division multiplexing

MAN: metropolitan access network

PMP: point to multipoint

PHY: physical layer

MAC: medium access control

FDM: Frequency division multiplexing

AODV: Ad-hoc on demand distance vector

1. Abstract

WIMAX, which means World Interoperability for Microwave Access， is the wireless technology and based on the IEEE 802.16 standards. WIMAX is dedicating to provide wireless broadband service in urban, suburban and rural environments. The WIMAX technology can support 30Mbps throughput in real world wireless communication and provides the broadband speed of a maximum of 75Mbps. WIMAX is growing faster than ever before and become the most famous and competitive technology in telecommunications industry. In this report we focus on the application of the WiMAX in our daily life. As references provide by OPNET, we build two basic component of the WiMAX-WLAN model to exam its efficiency to connection from base sever to the WiMAX client work station. We also test the single WiMAX-WLAN model for file transfer efficiency.

2. Introduction

2.1 Overview of WiMAX technology and comparison between Wi-Fi and WiMAX.

WiMAX which is based on the IEEE802.16 standard provides a wireless broadband technology. Both the technical execution and the business case show the differences between WiMAX and traditional Wi-Fi technology. As they are both wireless technology, most of the people consider WiMAX as the robust of Wi-Fi. The simple comparison shows the advantage of WiMAX in larger network coverage area and the faster transfer speed than Wi-Fi. Because of the technologies reason and standardization issues, WiMAX does not present its better performance in market position. Besides the newborn technology and the standardization issues, the relatively high price also decreases the speed of WiMAX to occupy the market.

The main differences in protocol and services are shown below:

	3G	Wi-Fi: 802.11	WiMAX: 802.16	Mobile-Fi: 802.20
Max speed	2Mbps	54Mbps	100Mbps	16Mbps
Coverage	Several miles	300 feet	50 miles	Several miles
Airwave	Licensed	Unlicensed	Either	Licensed
Advantages	Range, mobility	Speed, price	Speed, range	Speed, mobility
Disadvantages	Slow, expensive	Short range	Interference issues?	High price

Figure 1: performance of some common wireless technologies

The physical layer for WiMAX at the start stage is IEEE 802.16 which limits the physical layer will be operated in 10 GHz to 66 GHz. During go through the standard of IEEE 802.16a and IEEE 802.16e, WiMAX obtain benefits from the network coverage, self installation, power consumption, frequency reuse and bandwidth efficiency. The standard IEEE802.16d is used on WMAN fixed and IEEE 802.16e is used on WMAN Portable. The throughput for Fixed Wiamx is up to 75 Mbps with the 20MHz bandwidth while the portable WiMAX is up to 30Mbps with 10MHz bandwidth. Alao, the network coverage of fixed WiMAX and the protable WiMAX is 4-6 miles and 1-3 miles respectively.

The conflict betwen WiMAX and Wi-Fi is the resistance for WiMAX to develop. In order to extend the reach of WiMAX technology, redundant efforts have been done to cooperate with the traditional Wi-Fi. This is the only way to satisfy both the Wi-Fi supporters and those who focus on the higher speed and larger range. While the Wi-Fi is playing a smaller role in the wireless industry, the opportunity for wireless technologies to grow up and offer the high speed appears.

The following graph gives a outline of how Wi-Fi and WiMAX is integrated to work together to approach a better performance in either distance or transfer speed.

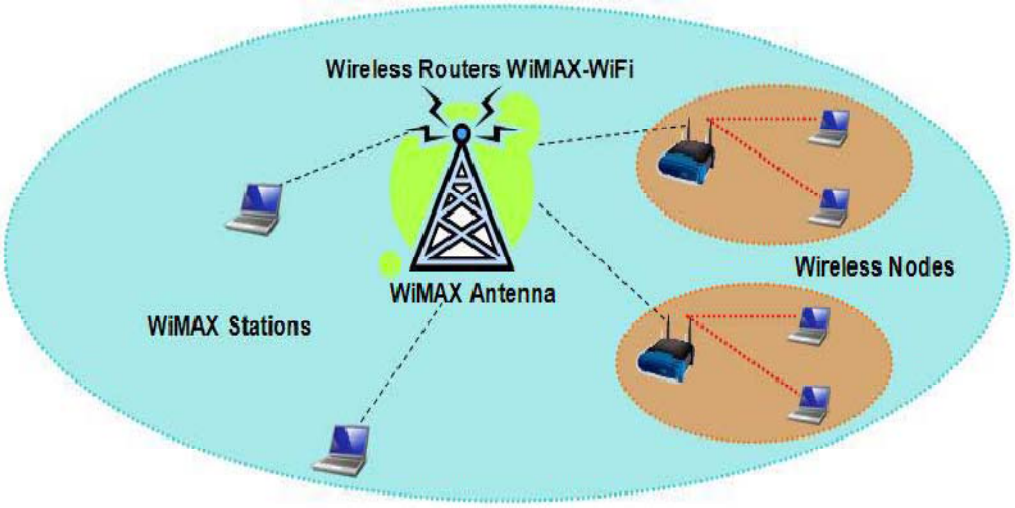

Figure 2: Wi-Fi and WiMAX network convergence

It is no doubt that there are several ways to deliver the broadband service. The next figure shows the various technologies.

WiMAX
Wireless Local Loop based on IP and OFDM, including wireless voice over IP
Satellite
Smart antenna

The next figure shows the example of wireless communication start from Wi-Fi users physically located inside traditional Wi-Fi network area to request a broadband service provided by WiMAX network.

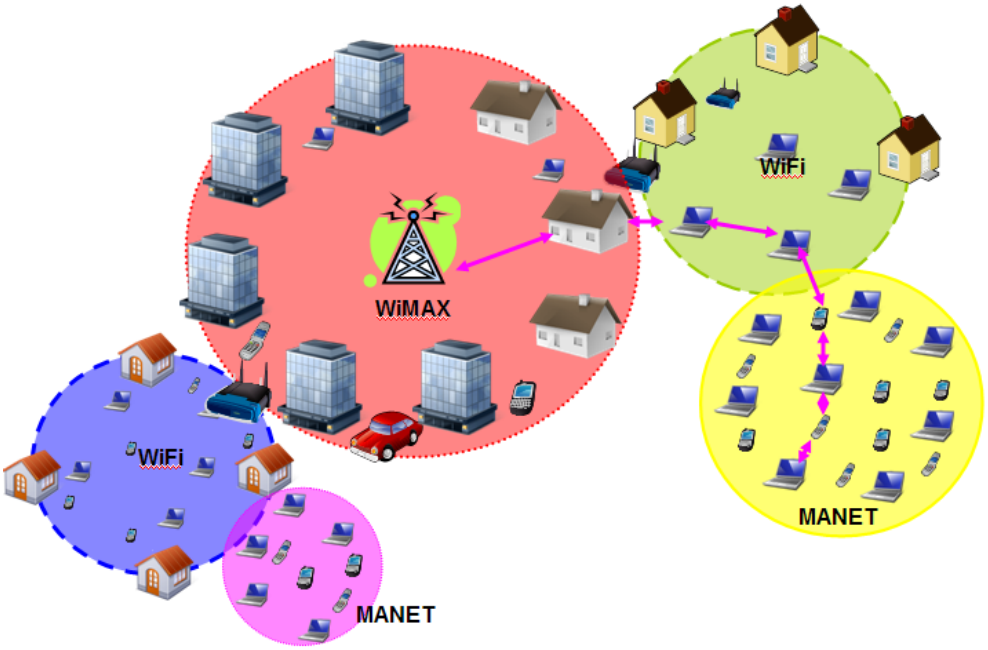

Figure 3: Service Connection in Wi-Fi and WiMAX

In this project, the main focus is to test and prove the better performance of the integrated WLAN and WiMAX network. Except the main deferences will be list blew, the detail of these two technologies will not be explained particularly. First, Wi-Fi channels use a specific band frequency while WiMAX permits users to select the channel requirements. Second, WiMAX uses licensed frequencies while Wi-Fi employs unlicensed ISM frequency bands. Third, Wi-Fi has a range of approximately 10m while WiMAX can cover several kilometers. Forth, WiMAX is a MAN protocol that provides an alternative to DSL and cable modem technologies, providing broadband access for the last mile as it acts as a backbone for W-iFi hotspots.

2.2 **Project motivation and goal**

In this project our purpose is to test the transfer efficiency of WLAN and WiMAX network by using the OPNET software. There are two models are built in this project. One is the WiMAX connection model and the other one is the WLAN and WiMAX model. The WiMAX connection model is used to test the connection efficiency between the base station and the work station while the WLAN and WiMAX model is dedicated to show the file transfer efficiency.

3. Description of overall design

3.1 Overall WLAN and WiMAX model

The overall WLAN and WiMAX network model is shown below—a WLAN-WiMAX application sample model in the opnet.

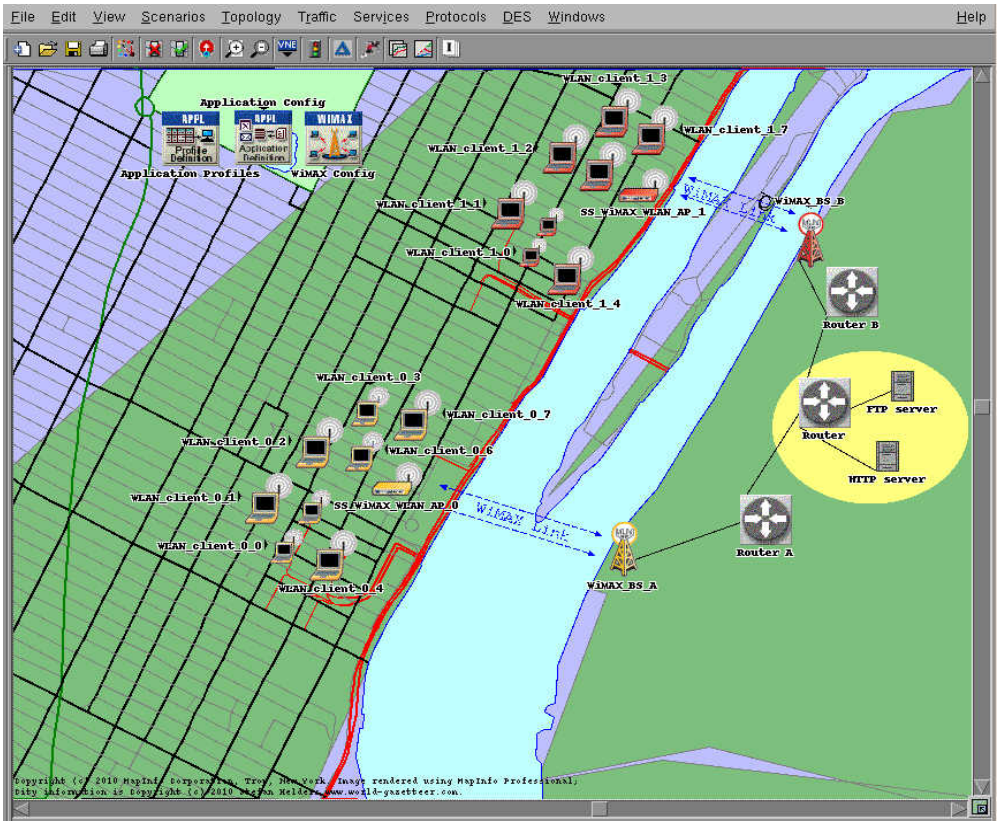

Figure 4: WLAN-WiMAX application network

In this project, the whole network model is decomposed into two parts: WiMAX connection model and the WLAN and WiMAX network model.

3.2 **WiMAX Connection model**

The basic components of WiMAX connection station is the wireless work station and WiMAX base station. The most common connections of Wiamx are PMP which means point to multipoint. The PMP topology, where a group of subscriber terminals are connected to a base station separately, is the best choice for most of the users to who do not need the entire bandwidth and extremely high speed.

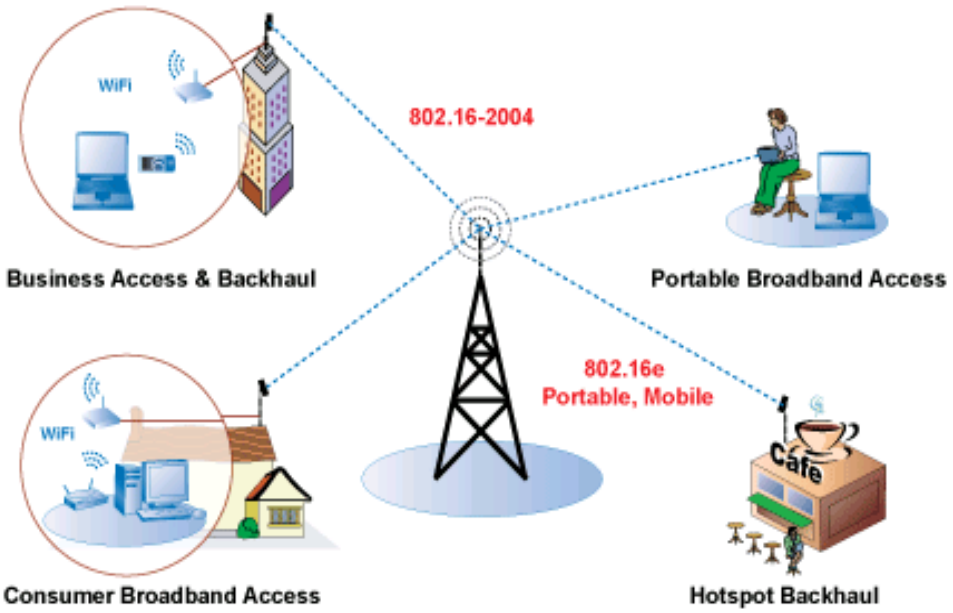

Figure 5: Basic Fixed WiMAX station

3.3 details of model configuration

The basic WiMAX connection model we built is show below:

In this model, the models we used are list below:

WiMAX config
WiMAX base station
4 WiMAX workstations

The global configuration object is used to configure parameters such as service classes and PHY profiles. In the WiMAX configuration object, the contention parameters, efficiency mode and MAC service class Definitions are chosen.

The fixed WiMAX base station node model with router functionality, this node has Ethernet interfaces and WiMAX interfaces. For the 4 WiMAX SS (Subscriber Station) workstations, stand for the mobile subscribe station node model with workstation functionality.

On base station node models and the subscriber station node models, all of the parameters needed to specify to match the attributes included in the WiMAX configuration. The MAC address is auto assigned and distance based, PHY profile is OFDM.

One important characteristic of WiMAX is OFDM, which is based on modulation by multiple carriers and Frequency Division Multiplexing. In OFDM, the bandwidth is divided into

parallel subcarriers with different channels. OFDM uses subcarriers that are mathematically orthogonal and the information is sent in parallel to the different sub channels.

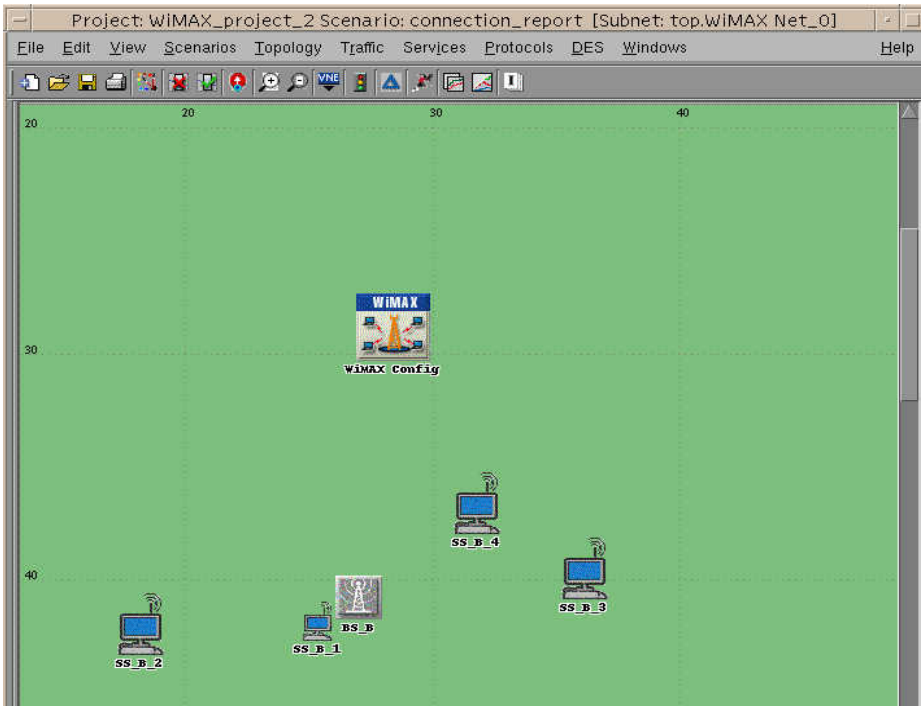

Figure 6: WiMAX connection model

3.4 **WLAN-WiMAX network model**

In order to improve the performance of WiMAX and Wi-Fi network, these two technologies are integrated by a WiMAX/W-iFi gateway that enables to connect the users in both technologies area. By the WiMAX/Wi-Fi gateway, the workstations in WiMAX network area can access to Wi-Fi services that are not belong to WiMAX region by employing the multiple hops of MANET which is Mobile AD Hoc Network. This integrated technology is the most practical way to perform the large scale wireless networks in cities.

The figure below shows the model we build to test the file transfer performance, the nodes we used is list below:

Application config

Profile config

WiMAX config

WiMAX base station

Application server

WiMAX WLAN router

4 WiMAX work stations

Profile Configuration is used to choose the applications using for correspond to different scenarios. The Wiamx configuration defines the contention parameters, efficiency mode and MAC service class Definitions. The WiMAX base station performs the same work as last graph, and application server which is the mobile subscriber station node model offers the functionally server. The new icon appears in the following picture is the mobile subscriber station node mobile can route the signal transferred from the WiMAX base station functionally to the 4 wireless work stations.

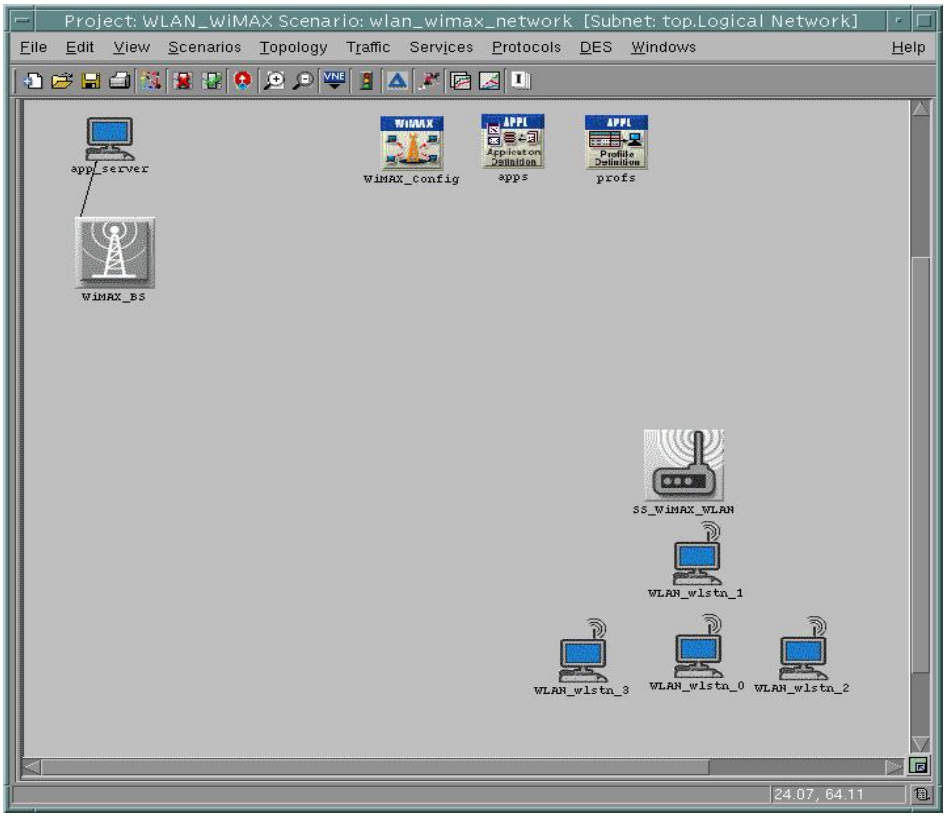

Figure 7: WLAN-WiMAX network model

3.5 R**outing Algorithm.**

Usually the source packet will reach its destination node of the WiMAX/Wi-Fi gateway when the request packet is sent by the source node. The route algorithm is constructed on Ad-hoc

protocol model. The retransmission request packet will be sent by the access point if the destination node is beyond of network coverage area of Wi-Fi or WiMAX.

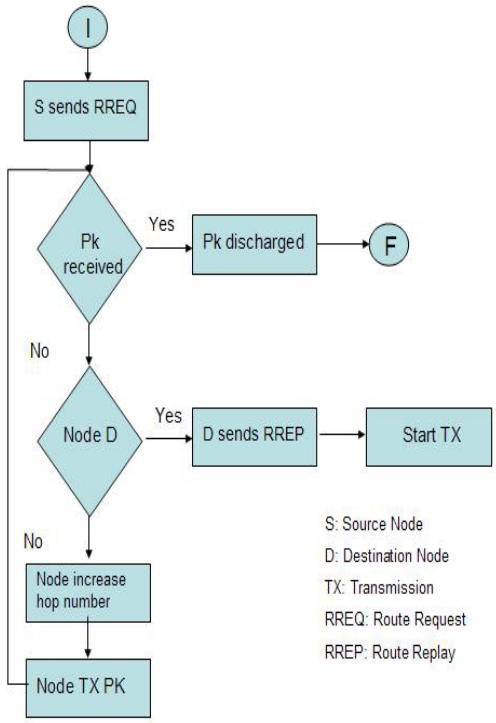

Figure 8: Flow Diagram of the route Discover for AODV protocol

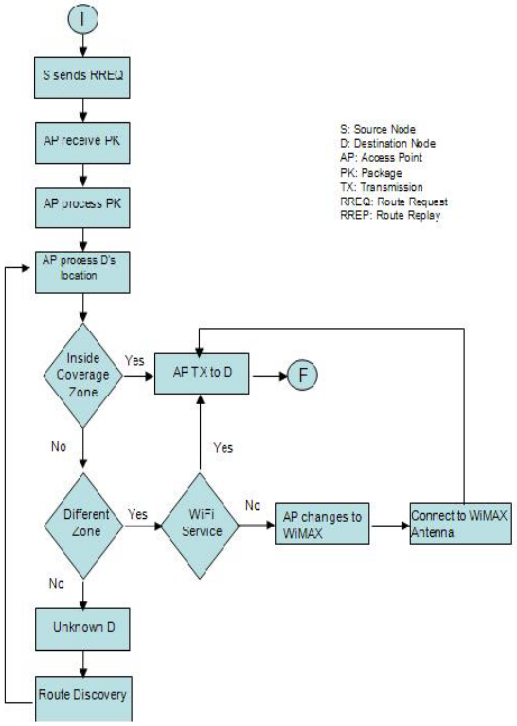

Figure 9: Flow Diagram of the algorithm

4. Opnet implementation

4.1 General step to construct the WiMAX network

The typical configuration steps to build WiMAX in network model include four steps:

Creating the Topology
Configuring Node Mobility
Adding Traffic to the WiMAX Network Model
Configuring WiMAX Parameters

While we adding traffic to the WiMAX network model, the standard application models such as FTP, Email, and custom application is implement in the WiMAX subscriber workstation

and WiMAX application server. In order to run the simulation, the service class, configure efficiency mode, and some other parameters need to be defined.

When we do the analysis of the WLAN and WiMAX network model, the statics can be collected includes:

Global statics: delay, load, throughput

WiMAX node statistics: data dropped, delay, load, throughput

4.2 Implementation details

4.2.1 WiMAX Connection model:

For this model, we build three different topologies showing as figures below:

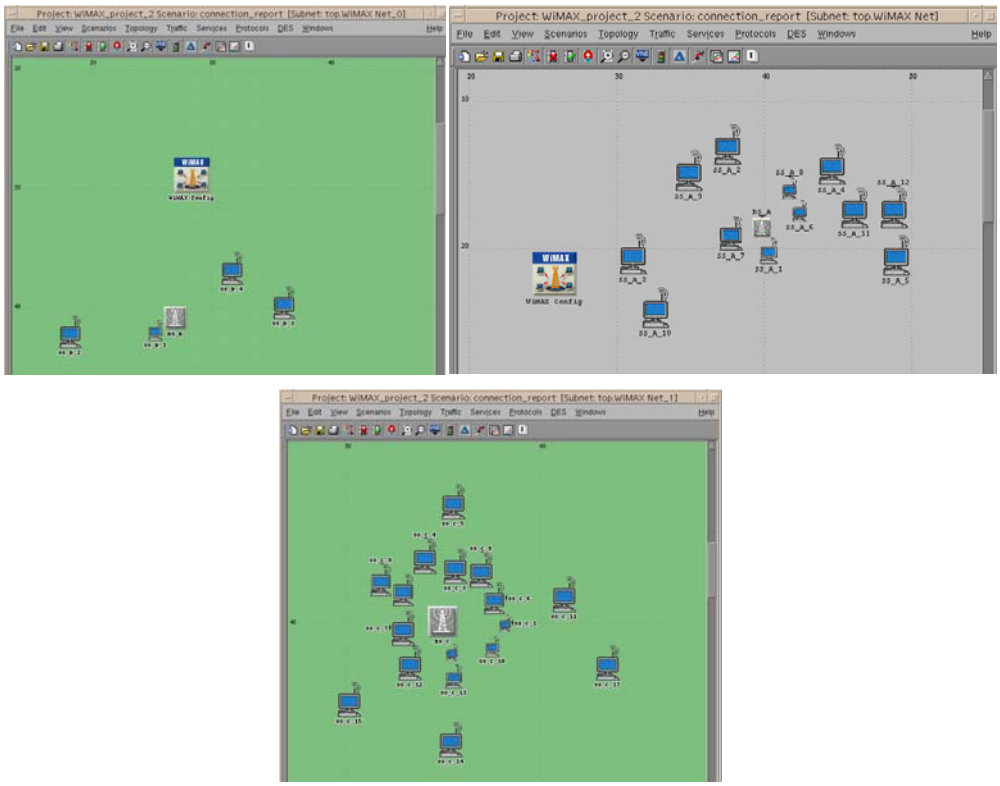

Figure 10: Three different topologies of WiMAX connection model

For the first model, we build only 4 work stations around a WiMAX base station. For the second model, we build 12 work stations randomly spread in the area. For the third model, we set 17 work stations around a base station but more concentrate to the work station. By comparing the connection result of those models, we could analysis the connection efficiency of a WiMAX base station.

4.2.2 WLAN-WiMAX Network Model

After we build the connection model, we try to analysis the file transfer performance of a WLAN-WiMAX model. The WLAN-WiMAX network Model is build for this reason.

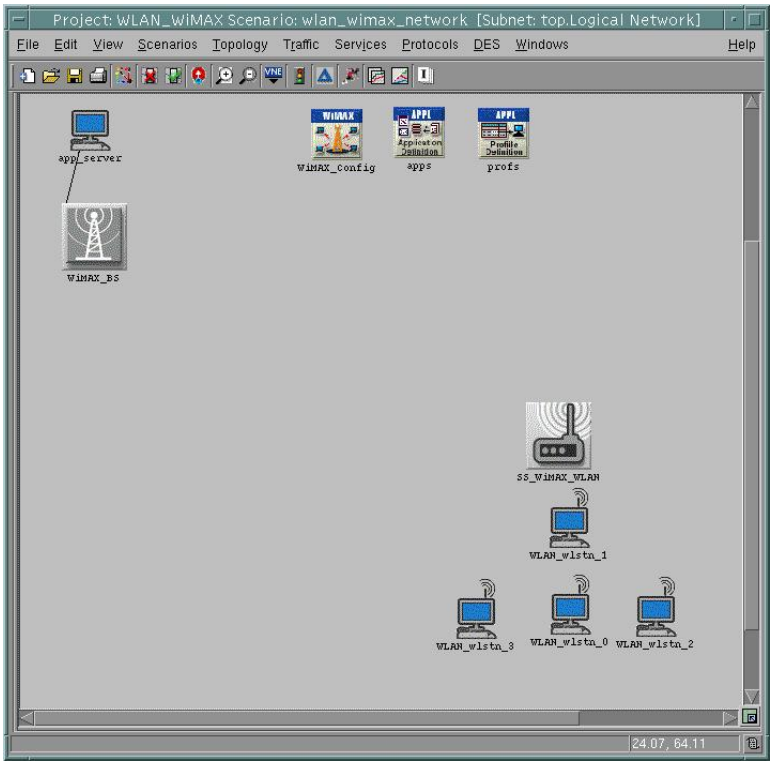

Figure 11: WLAN-WiMAX Network Model

This network model is fairly simple. Only a single work station, a WiMAX-WLAN router and 4 work stations was built in.

In this model, we are comparing the throughput between WiMAX base station and WLAN-WiMAX router and the delay between each work stations to analysis the file transfer performance in a single connection.

In the connection model, if we use a WLAN-WiMAX router with several works station instead. The whole network will become an applicable solid WLAN-WiMAX network similar to the sample model.

5. Result and Conclusions

5.1 WiMAX Connection model:

For this model, we simulate a connection report to reveal the connection efficiency of the WiMAX:

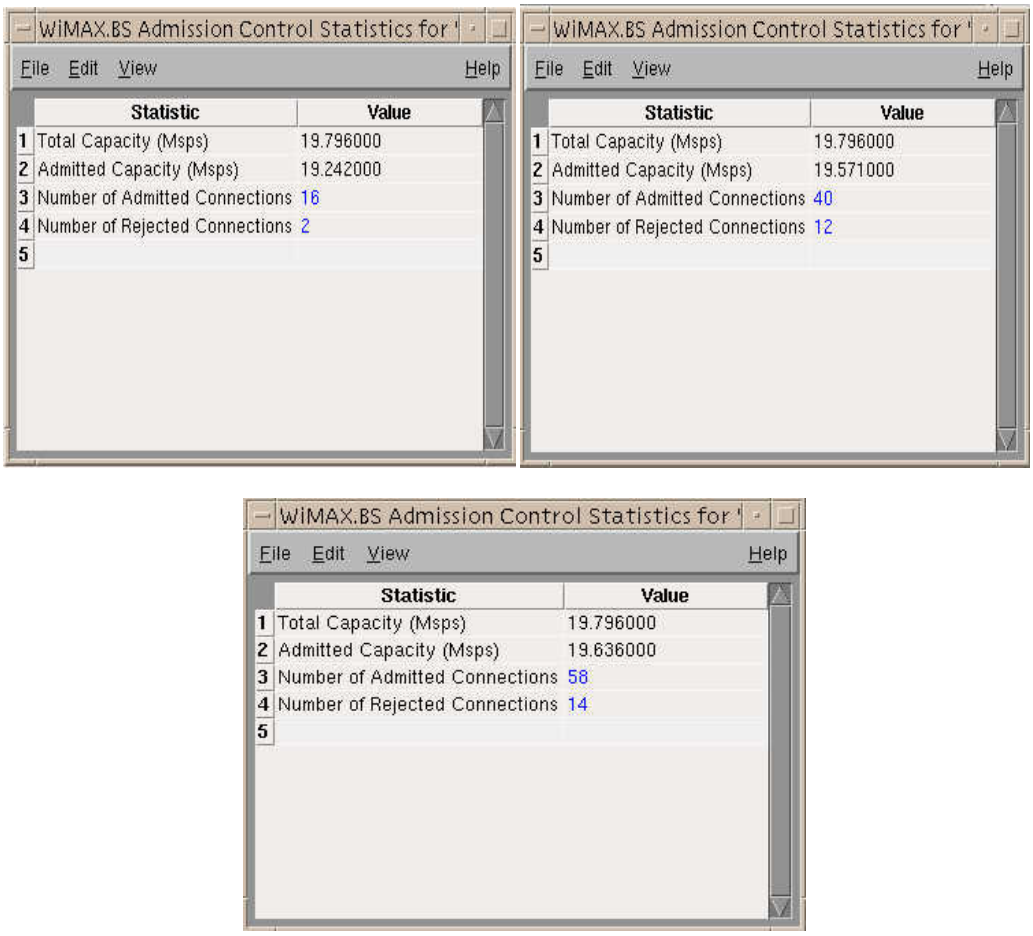

Figure 12: result of WiMAX connection model

The upper left result is for the 4 work-stations model, the upper right report is for the 12 work-stations model, the bottom one is for the 17 work-stations model.

5.1.1 Connection Efficiency

Calculate the connection efficiency by the following function:

Connection Efficiency = admitted connections/total connections

Model 1: 88.9%

Model 2: 76.9%

Model 3: 80.56%

5.1.2 Conclusions

By comparing the result, we found that the connection performance is best for the least work-station topology. And the model with more (17 work stations) concentrate in to the base station is even having a better performance than the model (14 work stations) has a less work stations.

Therefore, the tow factor effect the connection efficiency is 1): the numbers of the work stations, less work stations give a better performance. 2): the distances of each work station between base stations, less distances give a better performance.

5.2 WLAN-WiMAX network model

5.2.1 throughput between Base Station and WLAN-WiMAX router

The result we compare for this model is the throughput between Base Station and WLAN-WiMAX router.

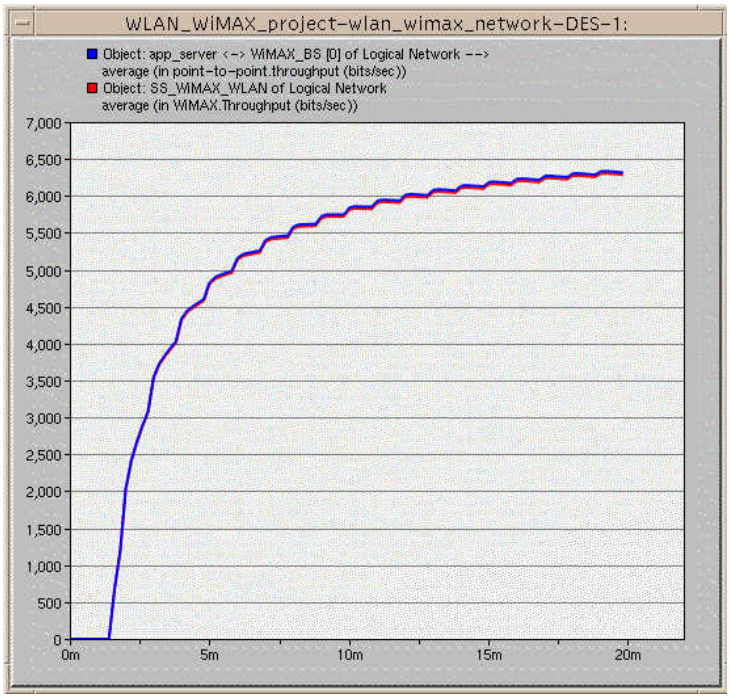

Figure 13: throughput between Base Station and WLAN-WiMAX router

The throughput between the WiMAX Base Station and a WLAN-WiMAX router is nearly the same. Therefore the information lost is very low in WiMAX signal transmitted send by WiMAX Base Station.

5.2.2 load and delay between two work stations

The next figure shows a load and delay between two work stations 0 and 3 with different distance between WLAN router.

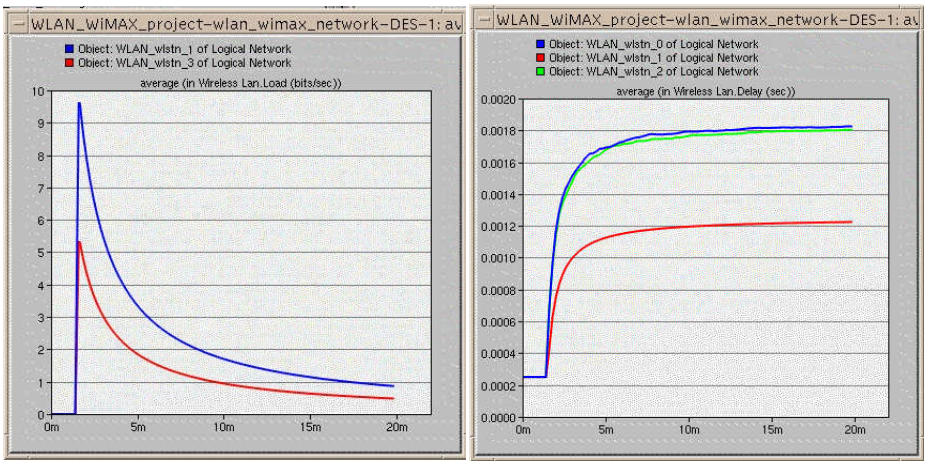

Figure 14: load and delay between two work stations

5.2.3 Conclusions

The file transfer performance drop dramatically when distance between work station and WLAN routers increases. But the WiMAX file transfer performance in this area is nearly perfect. Therefore in this model, the limitation of this network is the WLAN transfer performance. By improve the overall performance of the network, we could use a WiMAX work station instead the WLAN router with WLAN work stations.

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