

**ENSC 427: Communication Networks
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**Final Project
HTTP 1.1 Over WiMAX
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Abstract

WiMAX is IEEE Standard 802.16 [1]; a wireless technology that uses radio waves to transmit data. WiMAX is short for “Worldwide Interoperability for Microwave Access.” It is similar to Wifi technology, but has advantages such as a substantially longer range capability and a faster transfer rate. Because of these advantages, WiMAX has the capability to replace DSL wire lines. Using OpNet Modeler version 15, we evaluate the performance of heavy Internet browsing using HTTP 1.1 on a WiMAX network. Our network is composed of two subnets connected by an Internet cloud. Our server subnet contains the HTTP server. The client subnet contains a WiMAX base station, three fixed WiMAX clients, and a Point-to-Point Protocol (PPP) client (for comparison purposes).

Performance factors include end-to-end delay and downlink signal-to-noise ratio (SNR). The SNR of the WiMAX clients deteriorate with increased distance, but is still at an acceptable level at a distance of 8km from the base station. We find that the PPP client has a faster page response time and a lower end-to-end delay. However, a WiMAX network may be a good option, if implemented with careful planning. Future work on this model can include adding background traffic, more WiMAX client nodes, or using mobile client nodes.

1.0 Introduction

1.1 WiMAX

WiMAX is the acronym used for Worldwide Interoperability for Microwave Access. WiMAX is also known as IEEE Standard 802.16 [1]. It is a wireless technology that uses radio waves to transmit data. This is similar to WiFi technology. However, the greatest advantage of WiMAX over WiFi is its long range capabilities. A WiMAX tower can transmit up to a 50km radius for fixed stations and about 15km for mobile stations [2]. Wifi, on the other hand, can reach a radius of about 100m. WiMAX also has a fast data transfer rate. Theoretically, WiMAX can transmit data up to 75 Mbps per channel [2]. With this long range capability and fast transfer rate, WiMAX has the potential to replace Digital Subscriber Lines (DSL). This could reduce the cost of Internet access, since service providers would not need to set up or repair physical DSL connections.

There are two methods of transmitting data that the WiMAX base station towers implement: line of sight and non-line of sight. High frequencies are used for line of sight transmission, while low frequencies are used for non-line of sight transmission. The frequency bands used by WiMAX are 2-11 GHz and 10-66 GHz [3]. The reason for this is because the high frequencies are easily blocked by obstacles. Line of sight transmission produces less errors than non-line of sight transmission because there is less interference in the higher frequencies. The line of sight connection between two WiMAX towers is called "backhaul".

A WiMAX network can consist of one or more transmission towers and one or more WiMAX receiver nodes. The towers are connected in a one-to-one fashion. However, multiple receiver nodes can connect to a tower. WiMAX is meant for use in connecting to Internet Protocol (IP) networks.

1.2 HTTP 1.1

HTTP 1.1 stands for Hyper-Text Transfer protocol 1.1. It is defined in the Internet Engineering Task Force (IETF)'s Request for Comments (RFC) 2616 [4]. HTTP is an application layer protocol that usually runs on Transmission Control Protocol (TCP) over IP, but can also be run on User Datagram Protocol (UDP) over IP. HTTP is used everyday by users all around the world to browse the Internet.

The quality of service factors involved in using HTTP include end-to-end delay, packet loss, and throughput. End-to-end Delay is defined as the time interval from when a packet is sent to when its received. It can be broken down into processing delay, propagation delay, and queuing delay. Packet loss is the number of dropped packets. Throughput refers to the amount of data received by the client. We will be looking at these factors in our network.

1.3 Simulation Overview

Our goal is to model a WiMAX network and analyze its performance. We will be using OpNet Modeler version 15 to create our network model. As an initial step, we created an entirely wired network. Using this simple setup, we were able to configure our application and verify that it performed as expected. Next, we added a WiMAX base station and a single WiMAX client. Finally, we add two additional WiMAX clients to our model. All nodes and links were found in the OpNet model libraries and no changes were made to the models.

Using this final model, we can conduct some comparisons between WiMAX and ADSL. We can expect a wired client to have better results, but our goal is to see how WiMAX performs in comparison. As well, we can observe some WiMAX quality factors, such as signal-to-noise ratio (SNR)

2.0 OpNet Modeler version 15 Modelling and Simulation

Our WiMAX configuration and node configurations are based on Will Hruday's WiMAX model created for OpNet version 14 [5]. Our model of the WiMAX network consists of two subnets. We place the server subnet in Montreal and the client subnet in Vancouver. Using the DS3 link model, we connect the two subnets to the Internet cloud. Our Internet cloud is configured to introduce 0.001s of delay and has a packet discard ratio of 0.001%. Figure 2-1 displays our overall network.

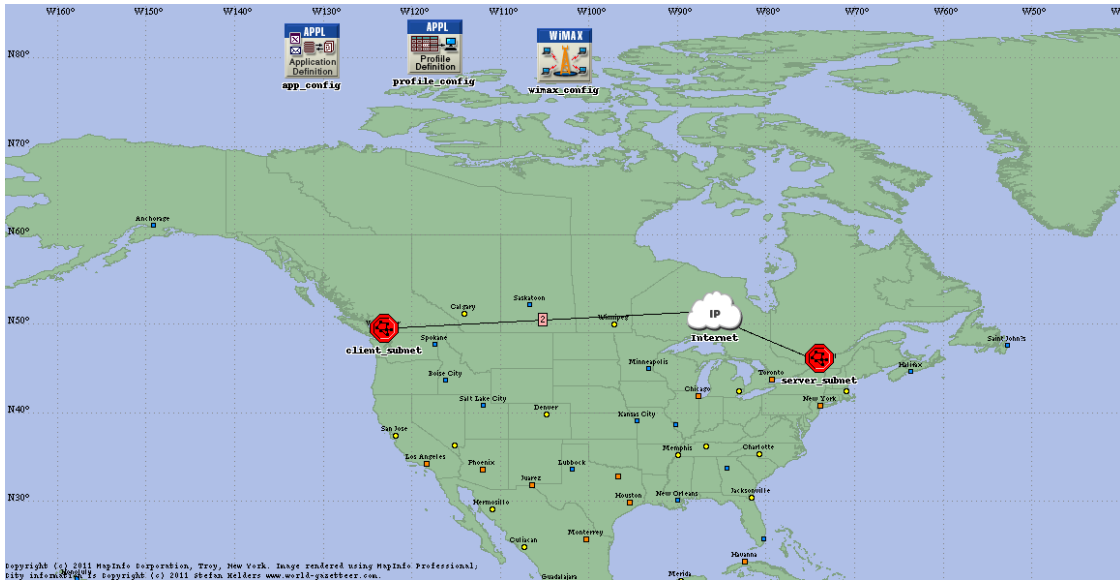


Figure 2-1: Overall Network

We configure an application definition called HttpApp. We are assuming that the users are using heavy Internet browsing. Using this application definition, we create a profile definition, HttpProfile.

On the server side, we have our Ethernet server acting as the HTTP host. It is configured to serve HTTP requests. The server is connected to a Bay Networks Accelar1050 switch, which is connected to Cisco's 7200 router. The links used within the server subnet are 100BaseT links. Figure 2-2 displays our server subnet.

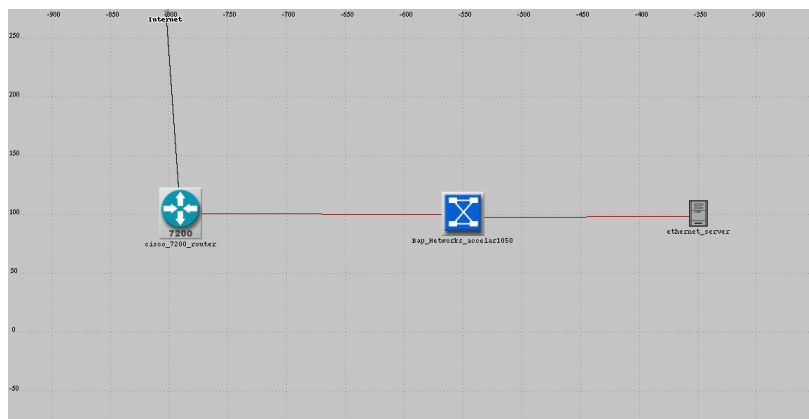


Figure 2-2: Server Subnet

On the client side, we have our WiMAX base station and 3 fixed WiMAX clients. The first client is placed 4km from the base station, the second client is placed 6km from the base station, and the third client is placed 8km from the base station. Our clients are configured to use 16-QAM $\frac{1}{2}$ modulation for both downlink and uplink data

transfer with the base station. We use the suburban pathloss model with flat terrain and light tree densities. In addition to our WiMAX nodes, we also create a Point-to-Point Protocol (PPP) workstation client that is connected to the Internet through a router. This is used for comparison purposes. We configure the clients to use the HttpProfile we created earlier. Figure 2-3 displays our client subnet.

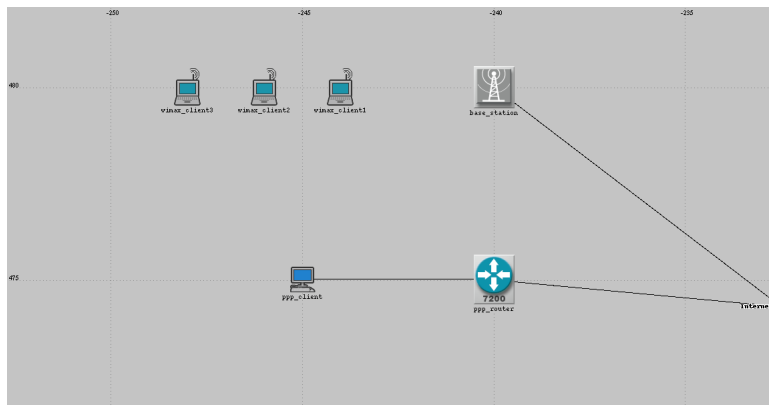


Figure 2-3: Client Subnet

Our WiMAX configuration, WiMAX base station configuration, and WiMAX client configuration can be seen in Appendix A. We configure our simulation to simulate 6 hours, which takes about 6-8 minutes to complete.

3.0 Discussion and Conclusion

After running our simulation, we can see that the average number of packets received by each client node is pretty similar, as seen in figure 3-1. Discrepancies between the amount of received data can be attributed to packet loss throughout the system. Packet loss can occur at multiple stages. The Internet cloud is configured to drop packets. The WiMAX physical layer also has impairments that can contribute to packet loss for the WiMAX clients. Surprisingly, the throughput of the closest WiMAX node was greater than the PPP client. This can be attributed to the data transfer limits of the wire links connecting the PPP client to the network.

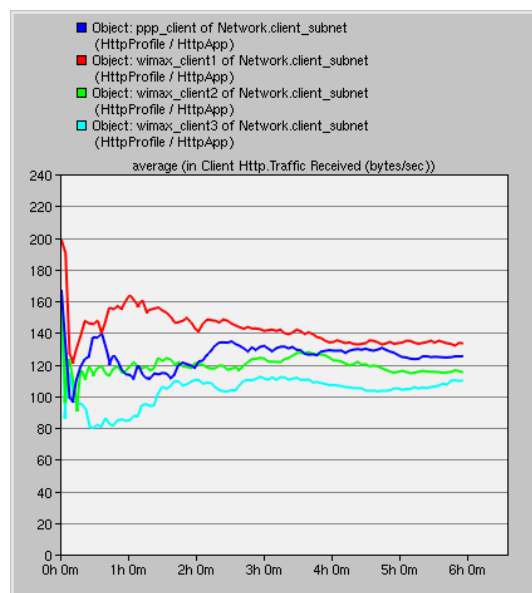


Figure 3-1: Traffic Received

We can also observe the end-to-end delay. As expected, the PPP client has a substantially lower delay time in comparison to the WiMAX clients. Figure 3-2 displays the end-to-end delay of our client nodes.

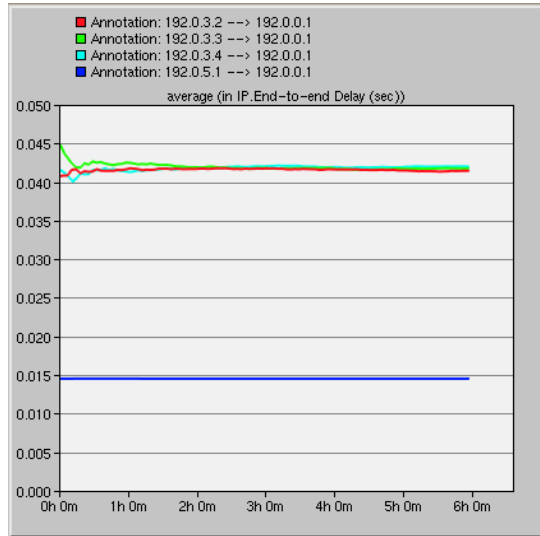


Figure 3-2: End-to-End Delay

We can also look at the page response time, the time required for a page to load. Figure 3-3 displays the average page response times of each client. Again, as expected, the PPP client has a faster page response time. The three WiMAX nodes have comparable page response times.

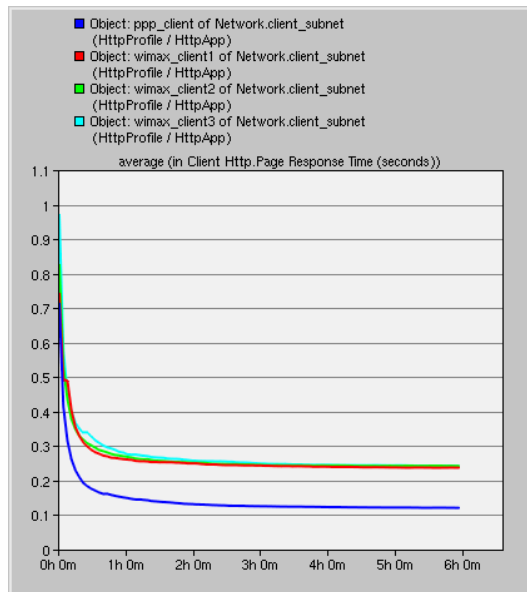


Figure 3-3: Page Response Time

For the WiMAX client nodes, we compare the downlink signal-to-noise ratios (SNRs). This is the SNR when transferring data from the base station to the node. As expected, the closer the node is to the base station, the higher the SNR. Figure 3-4 displays our resulting average SNR for each WiMAX node.

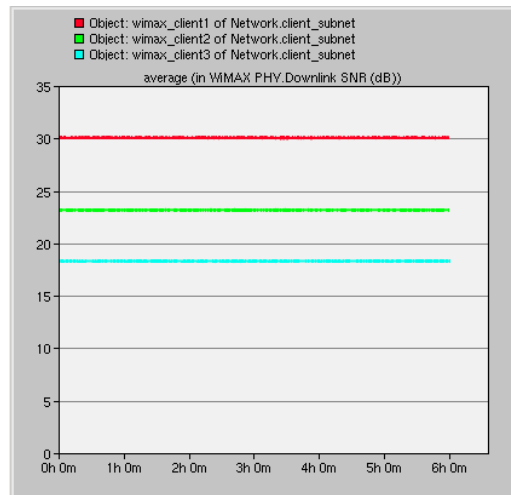


Figure 3-4: Downlink SNR

Future work on this model can include using mobile WiMAX workstations instead of fixed clients. Background traffic can also be simulated to increase the realism of our model. We can also experiment with multiple WiMAX towers to simulate backhaul. This would introduce higher delay and potentially more packet loss in the WiMAX network. A larger number of WiMAX clients can also be added to create a greater strain on the network.

From our simulation results, we can conclude that a wireless WiMAX network may not perform as well as a wired network. For example, in terms of delay, PPP has a much lower delay time. However, if implemented correctly, a WiMAX network can be a good option. Factors, such as the cost of implementation, must be put into consideration. From our SNR simulation results, we can see that the distance between base stations must also be put into careful consideration in order to avoid packet loss and maintain strong signal strength. A more sophisticated model may shed more light on if WiMAX should be implemented in specific situations.

References

- [1] IEEE Standard for Local and Metropolitan Area Networks, IEEE Standard 802.16, 2009.
- [2] WiMax.com: 4G Wireless Broadband Solutions [Online]. Available: <http://www.wimax.com/> (Feb. 2011).
- [3] Free WiMax Info.com [Online]. Available: <http://www.freewimaxinfo.com/index.html> (Feb. 2011).
- [4] Hypertext Transfer Protocol -- HTTP/1.1, IETF RFC 2616, 1999.
- [5] W. Hruday and L. Trajkovic, "Streaming Video Content Over IEEE 802.16/WIMAX Broadband Access," *OPNETWORK 2008*, Washington, DC, Aug. 2008.

Appendix A: WiMAX Node Configuration

(wimax_config) Attributes

Type: Utilities

Attribute	Value
AMC Profile Sets Definitions	(...)
Channel Coding	Convolutional Turbo Code
Contention Parameters	(...)
Efficiency Mode	Physical Layer Enabled
MAC Service Class Definitions	(...)
Number of Rows	7
Row 0	...
Row 1	...
Row 2	...
Row 3	...
Row 4	...
Row 5	...
Service Class Name	Silver_DL
Scheduling Type	Best Effort
Maximum Sustained Traffic Ra...	5 Mbps
Minimum Reserved Traffic Rat...	3000000
Maximum Latency (millisecon...	30.0
Maximum Traffic Burst (bytes)	0
Traffic Priority	Not Used
Unsolicited Poll Interval (millis...	Auto Calculated
Row 6	...
Service Class Name	Silver_UL
Scheduling Type	Best Effort
Maximum Sustained Traffic Ra...	1 Mbps
Minimum Reserved Traffic Rat...	640000
Maximum Latency (millisecon...	30.0
Maximum Traffic Burst (bytes)	0
Traffic Priority	Not Used
Unsolicited Poll Interval (millis...	Auto Calculated
Normalized C/N Per Modulation D...	Default Normalized C/N Values
OFDM PHY Profiles	(...)
Number of Rows	1
Row 0	...
Profile Name	WirelessOFDMA 20 MHz
Frame Duration (milliseconds)	5
Symbol Duration (microsecon...	102.86 (n=28/25, delta_f = 10.94 k...
Number of Subcarriers	512
Frame Structure	(...)
Duplexing Technique	TDD
TC Sublayer Overhead Factor	0
Frequency Band	(...)
Frequency Division	(...)
SC PHY Profiles	(...)

Advanced

Exact match Filter Apply to selected objects

OK Cancel

(base_station) Attributes

Type: router

Attribute	Value
name	base_station
IP	
IP Routing Protocols	
IP Multicasting	
WIMAX Parameters	
Antenna Gain (dBi)	15 dBi
BS Parameters	(...)
Maximum Number of SS Nodes	100
Received Power Tolerance	(...)
CDMA Codes	(...)
Backoff Parameters	(...)
Mobility Parameters	Default
Channel Quality Averaging P...	4/16
Number of Transmitters	SISO
ASN Gateway IP Address	Disabled
DL AMC Profile Set	Default DL Burst Profile Set
UL AMC Profile Set	Default UL Burst Profile Set
CGICH Period	Accept SS Configured Value
Normalized C/N Profile	Default Normalized C/N Table
Reserved DL Subframe Capa...	No Reservation
Reserved UL Subframe Capa...	No Reservation
UL Loading Factor	1.0
DL Loading Factor	1.0
Classifier Definitions	(...)
MAC Address	Auto Assigned
Maximum Transmission Power (W)	10
PHY Profile	WirelessOFDMA 20 MHz
PHY Profile Type	OFDM
PermBase	0
Reports	
Performance Metrics	
VPN	
System Management	
Security	
L2TP	
MPLS	
RSVP	
SRP	

Advanced

Exact match Filter Apply to selected objects

OK Cancel

(wimax_client1) Attributes

Type: workstation

Attribute	Value
name	wimax_client1
AD-HOC Routing Parameters	
WIMAX Parameters	
Antenna Gain (dBi)	14 dBi
Classifier Definitions	(...)
MAC Address	Auto Assigned
Maximum Transmission Power (W)	2.0
PHY Profile	WirelessOFDMA 20 MHz
PHY Profile Type	OFDM
SS Parameters	(...)
BS MAC Address	Auto Assigned
Downlink Service Flows	(...)
Uplink Service Flows	(...)
Control Connections	(...)
Multipath Channel Model	Disabled
Pathloss Parameters	(...)
Ranging Power Step (mW)	0.25
Timers	Default
Contention Ranging Retries	16
Mobility Parameters	Default
HARQ Parameters	(...)
Piggyback BW Request	disabled
CQICH Period	3
Contention-Based Reservatio...	16
Request Retries	16
Uplink Power Control	Disabled
Power Saving Parameters	Disabled
Applications	
Application: ACE Tier Configura...	Unspecified
Application: Destination Prefere...	None
Application: Supported Profiles	(...)
Number of Rows	1
HttpProfile	
Profile Name	HttpProfile
Traffic Type	All Discrete
Application Delay Tracking	Disabled
Application: Supported Services	None
H323	
CPU	
Client Address	Auto Assigned
IP	
Servers	
TCP	

Advanced

Apply to selected objects

Exact match

Filter

OK Cancel