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ENSC 427: COMMUNICATION NETWORKS

Video and Voice Backup over Mobile WiMAX

Group 6

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Abstract

Most of vehicle black boxes use their own internal auxiliary data storage device to record the images and data (such as, Global Positioning System location and speed of the vehicle) at the time the accidents happen. The saved data and video provide significant and crucial information for the road accident victims. The problem occurs when the crash is severe and the internal data storage gets destroyed. The backing up of the black box information to main server will take care of this matter. The mobile WiMax (WiBro) IEEE 802.16e supports the connection across the hotspots while the fixed WiMax IEEE 802.16d does not guarantee the connection. Mobile WiMAX offers maximum transfer rate of 10 Mbps and maximum cover range of 1 km under the movement speed of 120 km/h [1]. The specification of the mobile WiMAX suits for the network that requires the high transmission rate and the flexible mobility. We will be applying the information backups from the vehicle black box using mobile WiMAX technology.

1.0 Introduction

1.1 Mobile WiMAX Overview

Worldwise Interoperability for Microwave Access (WiMAX) is under IEEE 802.16e standard supporting high-speed (up to 75 Mb/s) wireless Internet technology over wide area (up to 50 km) [2]. Although it covers broad area, it is a fixed system, which is not suitable for use of Internet service in a moving vehicle.

During the development of IEEE 802.16 standard for fixed WiMAX, it was decided that mounting mobility support should also be considered. Thereafter, Mobile WiMAX is developed under IEEE 802.16e standard with Orthogonal Frequency Division Multiple Access (OFDMA) as its physical layer [3]. Mobile WiMAX guarantees smooth and decent data transfer speed (10 Mb/s) for a moving vehicle (up to 120 km/h) from one BS to another with regional region service. Furthermore, the technology can be accessed through portable Universal Serial Bus (USB) that converts BS signal into Wireless Fidelity (WiFi) signal. To make it handy, the system can pre-installed inside devices [4].

Mobile WiMAX and fixed WiMAX are both under Metropolitan Area Network (MAN) range that covers up to 50 km from base station (BS). However, only Mobile WiMAX guarantees connection from migration between two hotspots. Since BS control hotspots, Quality of Service (QoS) has to be implemented efficiently. Under Mobile WiMAX QoS classes, Real-Time Variable Rate (RT-VR) suits flawlessly for this project. It supports real-time applications with variable-size data packet bursts, providing better throughput by "bursting" more than one packet at a time to reduce wait time duration. An example application of RT-VR is video and audio streaming. To ensure connection between a mobile subscriber (MS) and a BS, they must "form a unidirectional connection between their respective Media Access Control (MAC) layers" sharing same QoS parameters [3].

1.2 Handover Overview

Handover is a term that is used to describe the mechanism when connection of a mobilizing subscriber station gets transferred from a BS to another. This mechanism of handover was first adopted in IEEE 802.16e (Mobile WiMAX) in September 2005, where the "old version" IEEE 802.16-2004 only supported fixed and nomadic connections [1]. Here, fixed connection only supports stationary users in the network and nomadic connection allows movements of users only inside the cover range of a BS's.

There are mainly two different types of handovers that are correspondingly used in various situations: Hard handover and Soft handover. In detail, the Soft handover includes Macro Diversity Handover (MDHO) and Fast Base Station Switching (FBSS). Hard handover is applied to the low speed vehicles or to the walking users while Soft handover is used for very fast-moving users with speed up to 160 km/h [6]. Since the Hard handover is the simplest mechanism among the three and the backing up of the data from moving vehicles does not require the Soft handover's high-speed supports, we will be using Hard handover throughout our simulations.

In the case of Hard handover, the MS only accesses to one BS. So the connection should be ended before setting up the connection to a neighboring BS, which gives the reason why the Hard handover is also called "before-make handover" [3]. The inevitable packet drops occur during the procedure because of this behavior. The handover occurs when the Signal-to-Noise Ratio (SNR) of neighboring BS exceeds that of current serving BS [6].

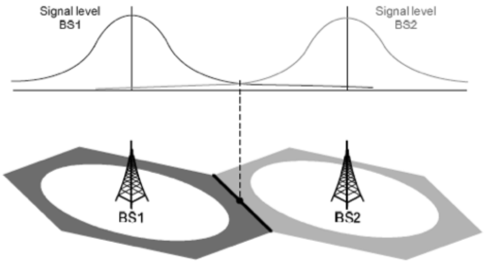

Figure 1: Hard Handover Realization [6]

For the MDHO, both BS and MS maintain a set called "Diversity Set". It is a list of the BS's that the MS can communicate. When downlink is set, the entire BS's in the list send the traffic to MS's and combination of received data gets carried out. For uplink, the MS sends to all the BS's in the list and selection diversity of received data is performed [6].

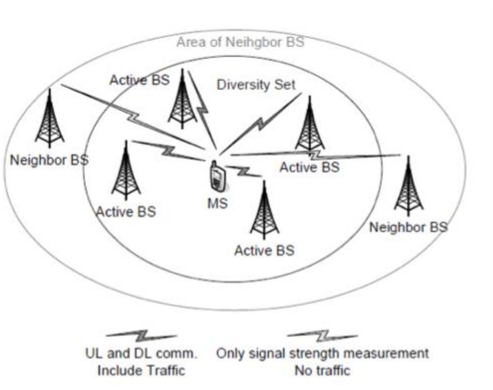

Figure 2: Macro Diversity Handover [6]

Similar to MDHO, MS continuously scans the BS's in the diversity set in (FBSS). However, MS connects with only one of the active BS and defines an "Anchor BS". Then MS communicates only with the Anchor BS for all uplink and downlink traffic. However, the Anchor BS can be switched over to other Active BS under diversity set from frame to frame depending on parameter that MS uses to choose Anchor BS [6].

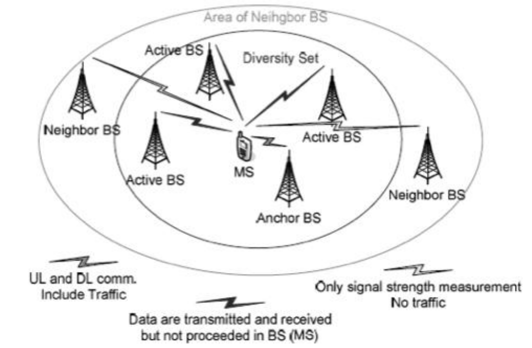

Figure 3: Fast Base Station Switching [6]

1.3 OPNET MODELER Overview

OPNET Modeler is a C/C++ language based discrete-event simulation with Graphical User Interface (GUI) [7]. Simulations with GUI can be easily interpreted, hence convenient to develop networks. For that reason, 3 different scenarios of mobile WiMAX are simulated in OPNET version 15 for the project.

2.0 Network Topology

For our network topology, we adopted a topology from the past report of W. Hrudey's [8]. The top-level network topology consists of an Internet protocol (IP) cloud that connects a server subnet and a client subnet with PPP-DS3 link. For the convenience, configurations for application, profile, and WiMax are placed in the same level as in Figure 4.

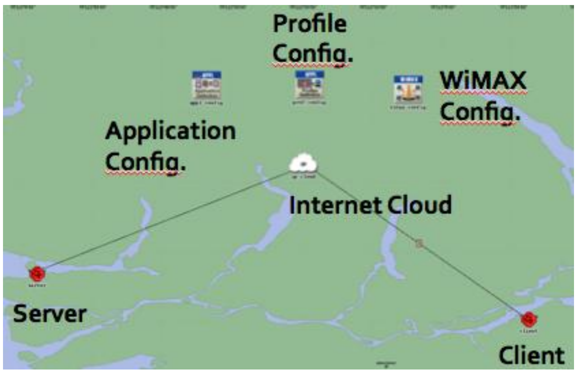

Figure 4: Main Topology

Inside server subnet, a network switch connects Ethernet server and a Cisco 7200 Router with 100baseT link where the router is linked with IP Cloud. The server contains video and voice profiles that are previously defined in the application and profile configurations. It is important to define the server and clients with same profile to communicate.

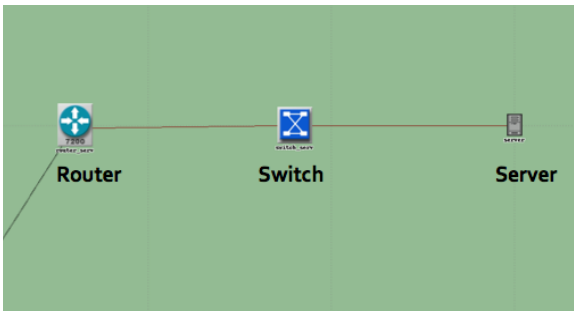

Figure 5: Server Subnet

Recalling the application configuration from main topology, low quality video (15 fps with low resolution) and voice streaming are defined. Since the idea of vehicle black box is to back up recorded scene of the accident as evidence, high quality is not required. Using this application, 2 identical profiles are added to each MS in the client subnet to compare only handover attributes keeping other configurations the same. In order to keep the scenarios simple, 3 BS's and 2 MS's are placed in the client subnet. Yellow circles in Figure 6 indicate maximum coverage for each BS, where it was 26 km in radius using Quadrature Phase Shift Keying (QPSK) modulation.

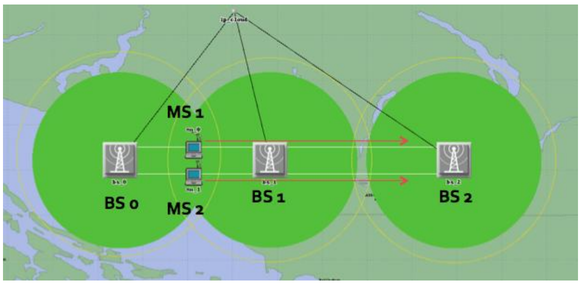

Figure 6: Client Subnet

Following tables are kept as it is throughout the scenarios.

Table 1: Application Configuration Attributes

Table 2: Profile Configuration Attributes

Table 3: Base Station Attributes

Table 4: Mobile Subscriber Attributes

3.0 Simulation Data & Results

3.1 Scenario 1 – Differing Speed of MS's and Distance between MS's and BS's

For the first scenario, with all the other attributes remained unchanged, we varied the speed of MS's and distances of MS 1 and MS 2 from the BS's. Figure 7 shows graphical representation of this scenario. By doing so, we expected to watch the different amount of traffic exchanged among MS's and BS's.

- Distance from MS 1 to BS's: 5 km
- Distance from MS 2 to BS's: 15 km
- Speed of MS 1: 120 km/h
- Speed of MS 2: 80 km/h

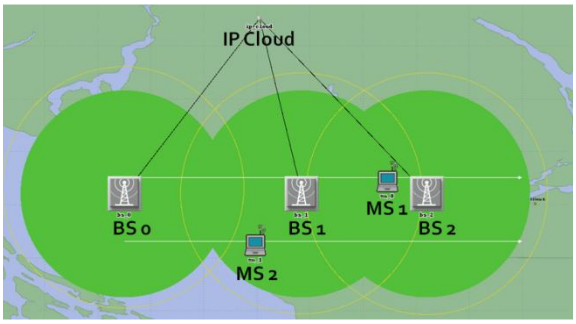

Figure 7: Network Setup – Scenario 1

Results of the traffic sent and serving BS ID (Base Station Identification) of MS 1 and MS 2 were observed as expected. BS ID is the MAC address (Media Access Control address) of each BS's and it gives us the idea which BS the MS is connected and communicate with. We focused on the traffic sents from MS's because we were implementing the data backups from vehicles to the main server. As can be observed from Figure 8, when two MS's are sharing first BS (with BS ID = 0), the amount of traffic sent is roughly halved from the maximum amount it can send. As soon as MS 1 gets handover to second BS (where the vertical line is), the amount of traffic sent from each MS is maximized since they are now using different BS's.

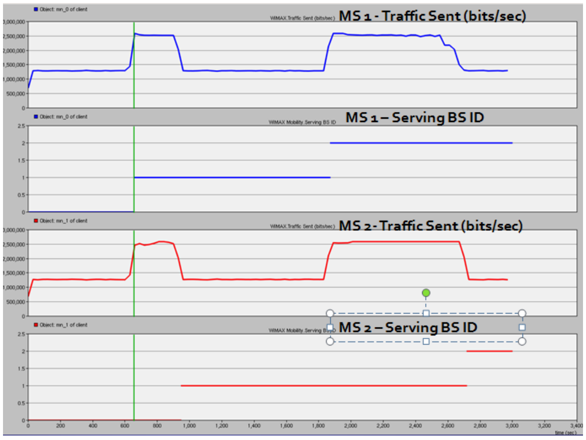

Figure 8: Traffic Sent and BS ID of MS's

Figure 9 show data drops that occurred at MS's. The result was as expected because the distance between MS 2 and BS's were three times further than that of MS 1.

Figure 9: Data Drops of MS's

Average traffic sents of MS's are shown at Figure 10. Clearly, the traffic sents from MS 1 was higher than that of MS 2.

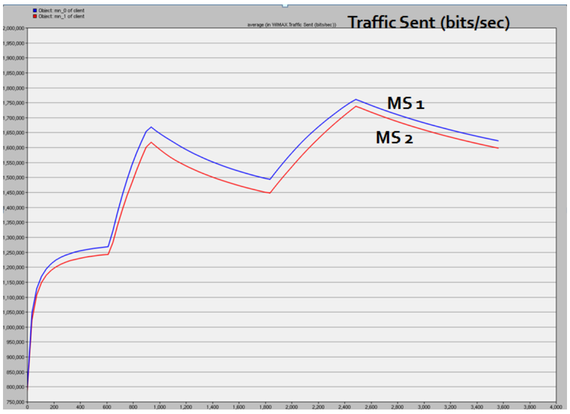

Figure 10: Traffic Sents from MS's

3.2 Scenario 2 – Differing Scanning Threshold

In the previous scenario, we focused on how the throughputs change by varying the distances from BS and by sharing and not sharing a single BS. In this scenario, scanning thresholds for both MS's are varied: 39 dB and 48 dB respectively. To keep the comparison simple and clear, both MS's shared equal attributes except for the threshold.

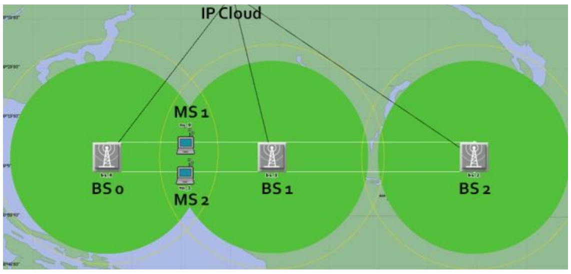

Figure 11: Scenario 2 (Differing Scanning Threshold)

In order to do a handover, MS's scanning has to be triggered to seek for another BS before serving BS's signal is lost. The further the MS moves away from the BS, the weaker the signal it gets. Hence the MS can be configured to turn the scan on as the signal get reduces under certain threshold: scanning threshold. In addition, we are assuming the multi-lined Signal to Noise Ratio (SNR) is created due to pre-defined antenna size in the MS. Thus, we concerned with the strongest signal (top SNR) for this project.

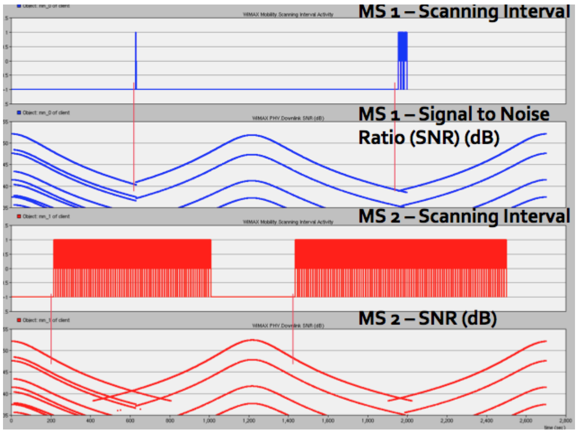

Figure 12: Scanning Interval due to the Threshold

It is crucial not to trigger the scanning too fast as it increases packet drops, decreasing the throughput. As mentioned above, MS 1 (39 dB) had lower scanning threshold than MS 2 (48 dB), which means MS 1 had less packet drops due to less scanning interval. As shown in Figure 13, scanning interfered the signal, increasing the packet drops. At the same time, other MS that is sharing the same BS gets better throughput.

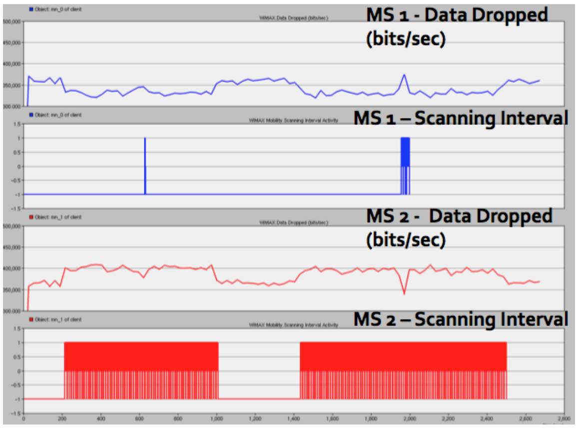

Figure 13: Packet Drops due to Scanning

Overall, MS 1 clearly had better traffic sent, having the scanning triggered only at the time it required.

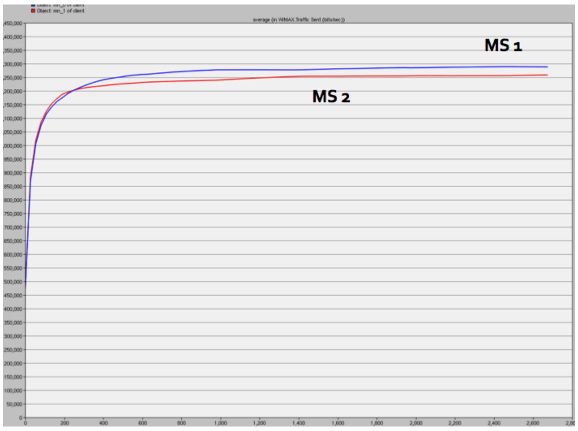

Figure 14: Average Traffic Sent for MS's

3.3 Scenario 3 – Differing Handover Thresholds of MS's

Scenario 3 uses same geometric network setup as the previous scenarios and it is shown on Figure 15. But in this time, we varied handover thresholds at MS's.

- Handover Threshold of MS 1: 0.5 dB
- Handover Threshold of MS 2: 3.0 dB

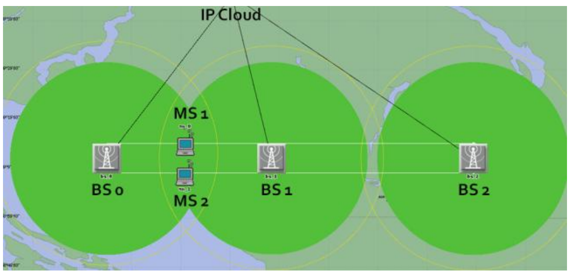

Figure 15: Network Setup – Scenario 3

Handover threshold can be regarded as sensitivity. The handover is carried out when the neighboring BS's SNR is higher than the SNR of serving BS by the amount specified at handover threshold.

From Figure 16, we can observe that MS 2 had only one handover where MS 1 had two handovers throughout the simulation time. The reason of missing MS 2's second handover is because the SNR of the third BS was not higher enough (not more than 3 dB) than the SNR of the second BS. If the SNR of third BS was more than 3 dB higher than that of second BS, the handover might have occurred.

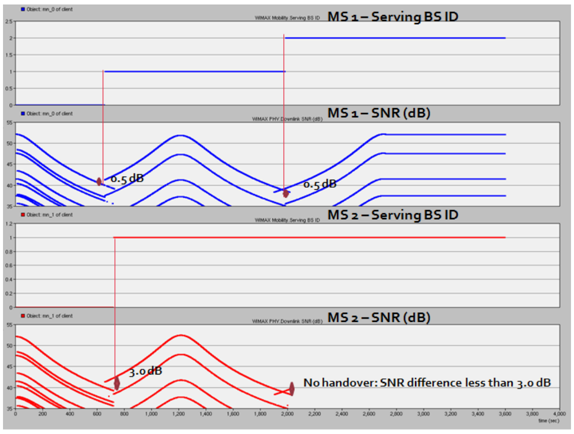

Figure 16: BS ID and SNR of MS's

4.0 Summary and Future Work

In this project, OPNET Modeler v.15.0 was used to analyze the functionalities of data backups over the mobile WiMAX. Given with wide cover range (up to 50 km) of mobile WiMAX, three scenarios were implemented to examine the practicality in various cases. For each scenario, two MS's and three BS's were included. Since we were simulating the cases with vehicles moving across the wide area, the occurrences of handover among BS's were considered as a key mechanism we must observe.

The different amount of traffic was observed as the distances between the BS's and MS's were set diversely. The further the distance, the less traffic was made along the connection. The reason for this was discovered that the more data drops at the MS's arose for the farther distances.

The adverse effect caused by the period of MS's scanning for BS's was observed from the simulations. Data drops occurred when the scanning was in progress thus, the need for minimizing the scanning period arose in building networks with MS's. This can be achieved by setting the scanning threshold at MS's appropriately. But attention should be made because insufficient threshold can cause the scanning not to be initiated.

The important role of the handover threshold in BS switching was also discussed. The handover threshold must be also considered with the scanning threshold at MS's. With too high threshold, the handover is less likely to occur and with too low threshold, unnecessary handovers might occur when a MS moves along the edges of BS cells.

With the appropriate settings of attributes and proper considerations of BS's positioning, the mobile WiMAX will be a competent technology for roaming users in the community.

Future work involves expanding the simulator with more complex situation: addition of clients sharing same BS and random movement trajectory rather than a straight-line motion. Also, it is crucial to work on financial problems on streaming of data every second. Overflow of data flow can be expected, therefore, the video record should be turned on and record only at an instance of accidents.

5.0 References

[1] H. Kim; "Introduction to WiBro (mobile WiMAX)" Seoul, Korea, Sep. 2005; [Online]. Available: http://www.apnoms.org/2005/special/SS1_3.pdf (Mar. 2012)

[2] M. Brain and E. Grabianowski; "How WiMAX Works"; [Online]. Available: http://computer.howstuffworks.com/wimax2.htm (Apr. 2012)

[3] J. Pinola and K. Pentikousis, "Mobile WiMAX", VTT Technical Research Centre of Finland; [Online]. Available: www.ciscosystems.com/web/about/ac123/ac147/archived_issues/ipj_11-2/112_wimax.html (Apr. 2012)

[4] O. Malik; "By 2012 Koreans Will Get 1Gbps Broadband Connections"; [Online]. Available: http://gigaom.com/2009/02/01/by-2012-koreans-will-get-a-gigabit-per-second-broadband-connection/ (Apr. 2012)

[5] IEEE 802.16-2004: "Air Interface for Fixed Broadband Wireless Access Systems", October 2004

[6] Z. Becvar and J. Zelenka, "Handovers in the Mobile WiMAX", Czech Technical University Department of Telelcommunication Engineering Technicka 2, Praha 6, 166 27, Czech Republic

[7] J. Kim, J. Lee, K. Park, J. Kim, H. Chang, G. Lim, Y. Chang, and H. Kim, "WiBro (Wireless Broadband): An 802.16d/e Simulation Model", Telecommunication System Division, Samsung Electronics, Suwon Korea, PP. 2.

[8] W. Hrudey, "Streaming Video Content Over IEEE 802.16 / WiMAX Broadband Access", April 2008.