Thesis Paper

Performance Analysis of the last mile access of WiMAX technology for a standard rural area of Bangladesh

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Statement

We hereby proclaim that this thesis is based on the results we found by our hard work. Contents of the work found by other researcher(s) are motioned by references. This thesis has never been previously submitted for any degree neither in whole nor in part.

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Abstract

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates. WiMAX is considered as an appropriate technology to provide the Last Mile Access to ICTs Infrastructure and Services in Rural Areas. Compared with other wired solution such as ADSL, or any other wireless or satellite system, WiMAX based access networks will enable operators and service providers to cost-effectively reach millions of new potential customers providing them with broadband ICTs access. In this thesis we will focus on the deployment of the last mile access of the WiMAX network model using NS3 and observe the overall performance of traffic handling between fixed and mobile nodes and the base stations for a standard rural area of Bangladesh.

Part 1: Introduction

1.1: Objectives

This is a time of communication, and internet is a base to accelerate this communication. There are a number of internet connection types, among them WiMAX technology is very efficient solution to get desirable and cost effective internet facility. Although WiMAX technology is quiet new concept, urban area in Bangladesh is already brought under its coverage. But rural area of Bangladesh is not thought to be served with WiMAX network yet. Because of infrastructure and other issues, it not done yet, so we tried to bring a solution that rural area of Bangladesh can be brought under WiMAX coverage with better performance. We have also tried to analyze and update existing algorithms to get better last mile performance of WiMAX in rural area.

To analysis last mile performance we had to test issues like vertical handoff exhaustively along side's throughput comparison, packet drop, latency etc.

Our main target was to make the last mile access of WiMAX more efficient by achieving more competent seamless handoff and incorporate bandwidth with the existing MIH algorithm.

We have tried to detect whether it is efficient we compare the handoff performance for the two proposed scenario using IEEE802.21 (MIH). The IEEE802.21 standard National Institute of Standards and Technology (NIST) provided the IEEE 802.21 add-on modules for network simulator, ns2.29. But IEEE 802.21 add-on module uses only signal strength and the interface

type for the interface selection. There are many parameters which can be consider for the interface selection, such as available bandwidth, the price of the link, the user mobility and power of the battery etc.

Part 2: Theory

2.1: Last Mile Access

First of all we need to know what last mile access is to understand our work. Last mile access is a figurative term. It does not mean the literal 'last mile'; it refers to the final leg of the telecom network delivering communications connectivity to retail customers. This is the part that actually reaches the customer. So in easy words "it YOU , are the last mile user".

The last mile is normally the speed holdup in communication networks; its bandwidth bounds the bandwidth of data that can be transported to the customer.

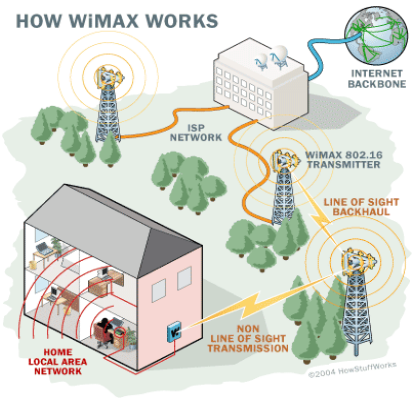


Figure 1: WiMAX Work

2.2: WiMAX

The Term WiMAX means "Wireless interoperability for microwave access". This is one of the most efficient wireless communications standard designed to provide 40 to 70 megabits-per-second data rates. It is referred by IEEE 802.16 and its extended range is 30 miles(appox.). WiMAX

is the closest technology to meet the standards of true 4G. [1]

A WiMAX system has two parts: A **WiMAX tower**- this is similar to mobile phone tower. A WiMAX tower can provide coverage up to 3,000 square miles (~8,000 square km). Secondly a **WiMAX receiver** – this receiver and antenna could be a small box or PCMCIA card, or they could be built into a laptop the way Wi-fi access is today.

2.3: Why Rural Area?

Now the question is supposed to arise why we have selected rural area for to run our research on. There are numerous reasons like more apps are being made for rural populations nowadays. For example even there are some apps to assist the farmers in agriculture that needs internet connection, but it is really tough to serve villages with internet. In recent days, we observed a lot of economic activities in village areas aside urban area. Besides those, increasing use of mobile banking, online tale-medical assistance, and insufficient work about rural area has influenced us to select a rural area to work on.

2.4: Why WiMAX?

Why do we say WiMAX : The best way to serve rural area? Because using cable is costlier in village. In villages scattered places are to be served, and WiMAX has additional range. WiMAX is also a good combination of low cost and flexibility. Some other advantages include few wireless base stations gives huge coverage, multifunctional application and WiMAX has the ability to interoperate across various network types.

2.5: Handoff:

When a mobile device move away and enters one new cell coverage from another, the connection is also transferred to the new cell, this process is called handoff. Handoff maintain the user's active session when it is moving. The performance of last mile largely depends on handoff, so the handoff issues are being monitored strongly when we have done our work.

When handoff occurs, packet drop is a usual issue, so we have tried to figure out a feasible handoff policy that will decrease packet drop and increase the throughput.[2]There are two types of handoff.

2.5.1: Horizontal Handoff: When the handoff occurs between same networks, then it is called horizontal handoff.

2.5.2: Vertical Handoff: When the handoff occurs between two different networks, then it is called horizontal handoff.

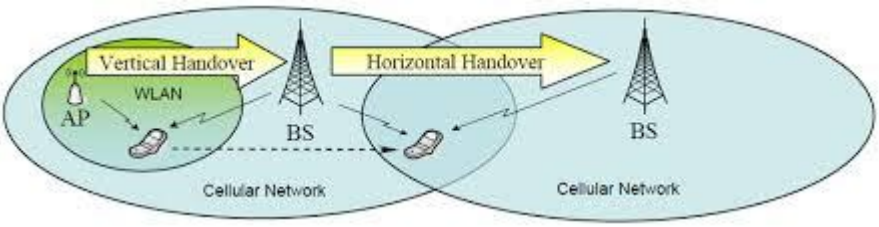


Figure 2: Handoff

We will focus mainly on vertical handover.

VHO process can be divided into three main steps, namely system discovery, handoff decision and handoff execution. During the system discovery step, the MN equipped with multiple interfaces has to determine which networks can be used and the services available in each network. These wireless networks advertise the supported data rates for different services. During the handoff decision step,

The mobile device determines which network it should connect to. The decision will depend on various parameters or handoff metrics including the available bandwidth, delay, access cost, transmit power, current battery status of the mobile device, and even the user's preferences. Finally, during the handoff execution step, the connections need to be re-routed from the existing network to the new network in a seamless manner. This step also includes the authentication and authorization, and the transfer of user's context information among networks.

A handover from WiMAX to WLAN network is triggered after a better radio condition is perceived with WLAN. The MN associates with the WLAN AP, perform authentication, obtain IP address if needed, and set up all the QoS for the data session. During this process, WiMAX connection is kept active and data traffic streams through WiMAX network. After WLAN connection is successfully established, the MN starts switching to the semi-idle mode by sending a DREG-REQ (deregistration request) with a semi-idle mode signal to the BS. The BS retains all the MN context information. MN and BS release all the connections assigned to MN except the elementary Connection, but keeps the other MN context such as service flow data.

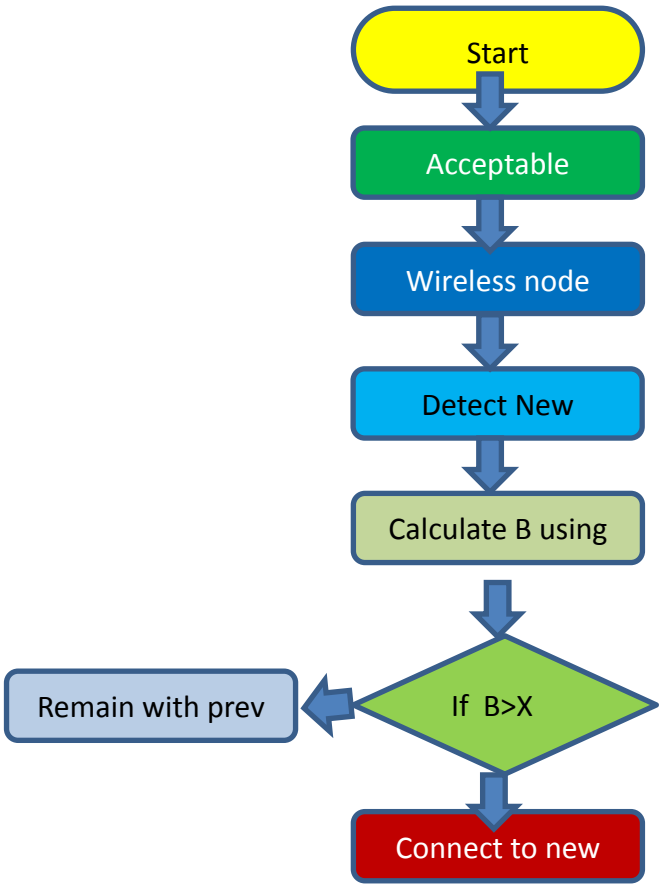
When handover from WLAN to WiMAX network is activated, the MN initiates network re-entry with the target BS. The target BS can be the same BS that the MN was connected with before or a different one. If the target BS still has the valid background information for the MN, it shall notify the MN seeking network re-entry and omitting certain procedures by sending a RNGRSP with HO process optimization TLV and completing the fast network reentry process accordingly; otherwise, it shall obtain the MN context from the paging controller. While the MN stays in WLAN, there will be new session established, or existing session could be modified or released. The service flow management procedures are combined together with ranging procedure.[3]

2.6: MEDIA INDEPENDENT HANDOVER

The Media Independent Handover is a standard proposed by IEEE 802.21 working group for enabling handover in heterogeneous wireless networks. It provides link-layer intelligence and other network related network information to upper layers to optimize handovers between heterogeneous networks. This includes media types specified by Third Generation Partnership Project (3GPP), 3G Partnership Project 2 (3GPP2), and both wired and wireless media in the IEEE 802 family of standards.[4][5]

2.6.1: MEDIA INDEPENDENT HANDOVER Algorithm:
$wl_node base-station [AddrParams addr2id [$bstation node-addr]] ;#attach mn to basestation
$wl_node set X_ 300.0
$wl_node set Y_ 40.0
$wl_node set Z_ 0.0
set HAaddress [AddrParams addr2id [$bstation node-addr]]
[$wl_node set regagent_] set home_agent_ $HAaddress
$ns at 15.0 "$wl_node setdest 750.0 40.0 5.0"
$ns at 100.0 "$wl_node setdest 100.0 40.0 5.0"
[$wl_node set mac_(0)] set-channel 0
set $bandwidth 0.0
Set $Acptband 0.0
set $capapcity 54.0
set $SNR 0
set $NoiseRatio 0
	$wl input $Acptband
	$detect wl $int fa0{new}
	$ctrl detect $N
	set $NoiseRatio=10/[log -1 {$N}]
	set $SNR=log2{(1+ $NoiseRatio)}
	set $bandwidth ={$capacity/$SNR}
	if $bandwidth>$Acptband then
	[$wl_node set int_(1)] set int_fa0
	else
	[$wl_node set int_(1)] set int_fa0
	end
	[$wl_node set mac_(0)] set-diuc 1
	[$wl_node set mac_(0)] setflow UL 10000 BE 275 2 0 0.05 15 1 0 0 0 0 0 0 0 0 0 0 ;# setting up static flows
	[$wl_node set mac_(0)] setflow DL 10000 BE 275 2 0 0.05 15 1 0 0 0 0 0 0 0 0 0 0 ;# setting up static flows

2.6.2: Simplified Flow Chart for MIH Algorithm:



PART 3: Methodology

Our work has been progressed in different levels. That include:

- Topology Collection
- NS2 Simulation on Map
- Tested both WiMAX and Wi-fi Network
- Data Analysis
- Result

3.1: Topology Collection

To find a "standard rural area of Bangladesh" we picked up several places to work on. Among them, Sirajgong, Faridpur and Gazipur were in our consideration. But to run our research we had to select one distinct place to work on. Considering all aspects like distance from Dhaka, weather, transportation and height of buildings, we have finalized Gazipur as our test-area for research. As Gazipur is a large area, we decided to work only a part of that area named 'Maona-Telihatti Union Parishad'.

3.2: NS2 Simulation

NS2 is Network Simulator. We have used NS2.29 with patch to simulate WiMAX topology. As stated earlier we have considered two scenarios to run our research.

3.3: Simulation Setup

To setup the simulation, we have fixed some parameters for our problem. Based on those parameter we have simulate our two scenarios. The fixed parameters were:

- Number of mobile device-1
- Model two-ray ground
- Wired links All wired links support 100Mbps
- WiMAX coverage 500 m
- WiMAX Parameters
    - Technology: 16QAM (10 Mbps)
    - BS Tx power: 15 W (41 dBm) @ 3.5 GHz
    - RX Thresh : 1.215 e-9 W (∼−60 dBm)
    - CSTresh : Level 80% of RX Thresh
- Wi-Fi coverage 100 m
- Wi-Fi parameters
    - Technology: 802.11 b (11 Mbps)
    - AP Tx power: 100 mW (20 dBm) @ 2.471 GHz
    - RX Thresh: 0,989 e-9 W (∼ −60 dBm)
    - CSThresh : Level 90% of RX Thresh
    - pr limit : 1.2

3.4: Scenario 1

WiMAX Tower -1

Access Points- 15

We have used single WiMAX tower with 15 access point to extend network coverage.

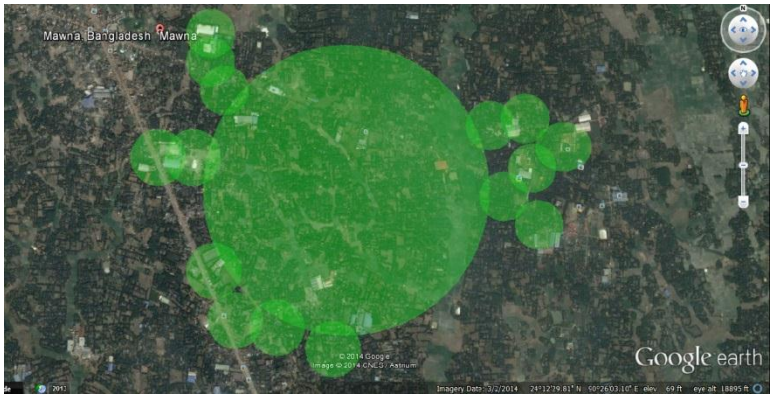


Figure 3: Map for Scenario 1

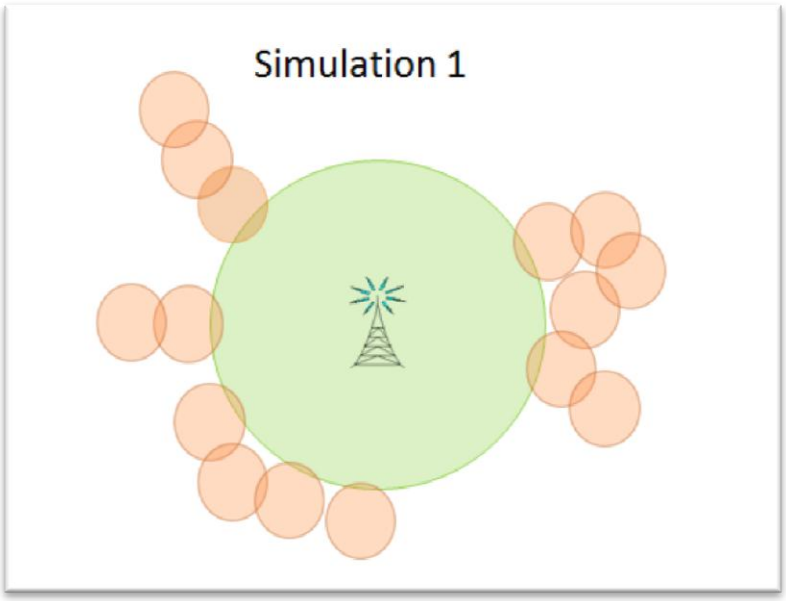


Figure 4: Topology for Scenario 1

3.4: Scenario 2

WiMAX Tower -2

Access Points- 7

In this scenario we have set two WiMAX towers and seven access points to extend network.

Figure 5: Map for Scenario 2

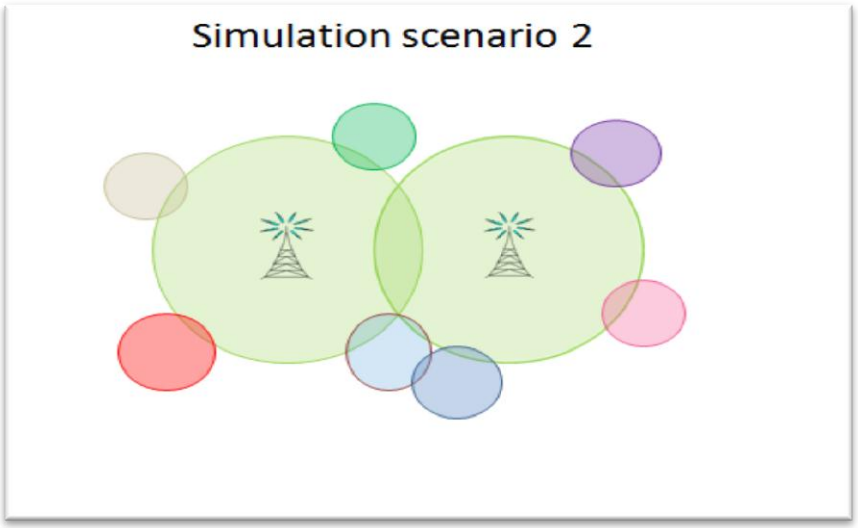


Figure 6: Topology for Scenario 2

Part 4: Results and Discussions

We have studied our achieved data in 4 different parameters. They are discussed below.

We have tested whether incorporation of bandwidth made any changes to the overall thoughput in case of both the scenarios.

4.1: Comparison of Throughput-Scenario 1

Velocity(m/s)	With BW (KBPS)	Without BW (KBPS)
2	570	553
4	566	550
6	562	548
8	565	546
10	567	545
12	567	543

Table 1: Comparison of Throughput-Scenario 1

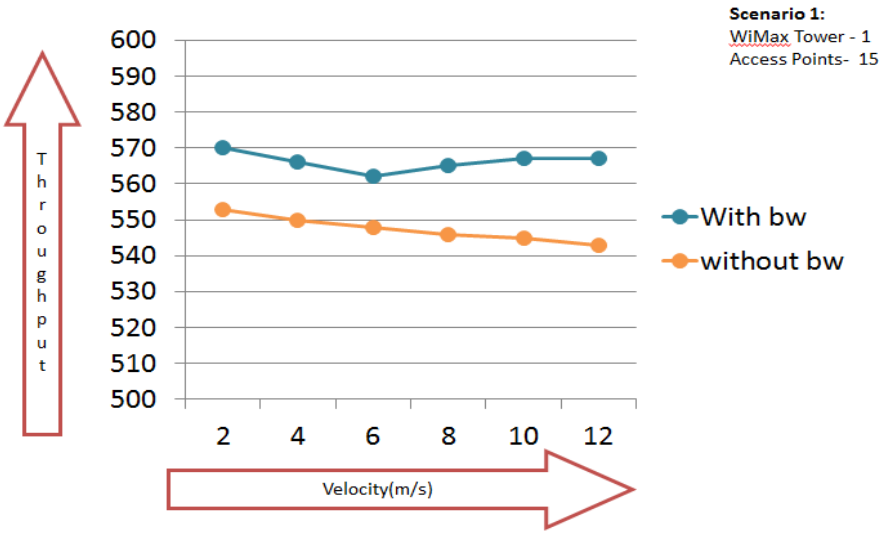


Figure 7: Comparison of Throughput-Scenario 1

As you can see the throughput after adding bandwidth has improved to a significant notable amount. Besides as before, the MIH module only considered the signal strength only, so there continuous decrease in throughput with the increase of movement of MN. After adding the BW, the MN now takes BW while deciding a HO and HO takes place considering network that offers more BW. So throughput does not decrease as much as before.

4.2: Comparison of Throughput-Scenario 2

Velocity(m/s)	With BW (KBPS)	Without BW (KBPS)
2	465	436
4	460	433
6	463	430
8	458	428
10	457	428
12	450	425

Table 2: Comparison of Throughput-Scenario 2

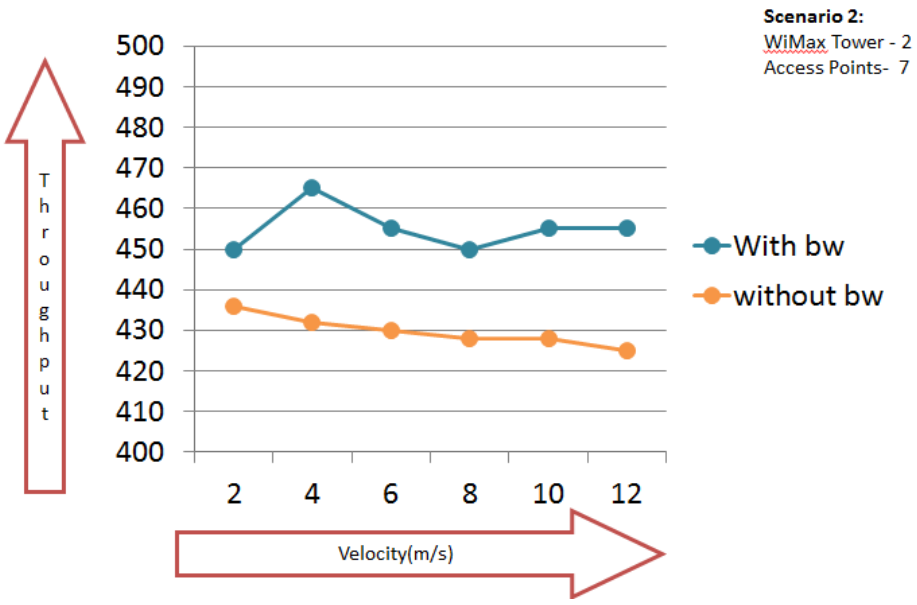


Figure 8: Comparison of Throughput-Scenario 2

The result is same in scenario 2 as you can see the throughput is high after adding the BW.

4.3: Average Throughput

Velocity(m/s)	Scenario 1(kbps)	Scenario 2(kbps)
2	570	465
4	566	460
6	562	463
8	565	458
10	567	457
12	567	450

Table 3: Comparison of Average Throughput

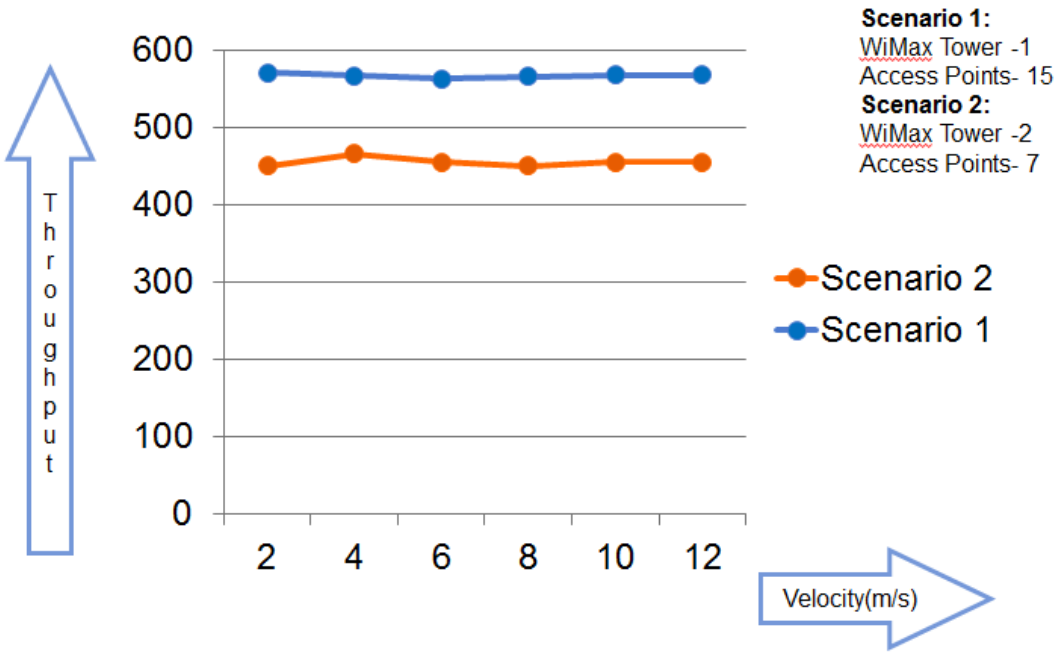


Figure 9: Graph of Average Throughput vs. Velocity of MN

The graph above shows average throughput vs. velocity of Mobile node. As you can see, the performance in case of scenario 1, i.e. Having 1 BS and More AP's performs better. This is due to the face that more Wi-Fi to Wi-Fi and WiMAX to Wi-Fi Handover has occurred here. Whereas the scenario having less AP, number of Wi-Fi to Wi-Fi handoff is less and the WiMAX to WiMAX and WiMAX to Wi-Fi is more …which has decreased the throughput. So having less BS and more

AP to serve a locality is a better option.

4.4: Handoff Latency

Velocity (m/s)	Wi-fi to wi-fi (s)	WiMAX to Wi-fi(s)	WiMAX to WiMAX(s)
2	0.28	0.62	0.55
4	0.32	0.64	0.53
6	0.33	0.65	0.56
8	0.32	0.69	0.56
10	0.35	0.75	0.58
12	0.48	0.75	0.65

Table 4: Comparison of Handoff Latency

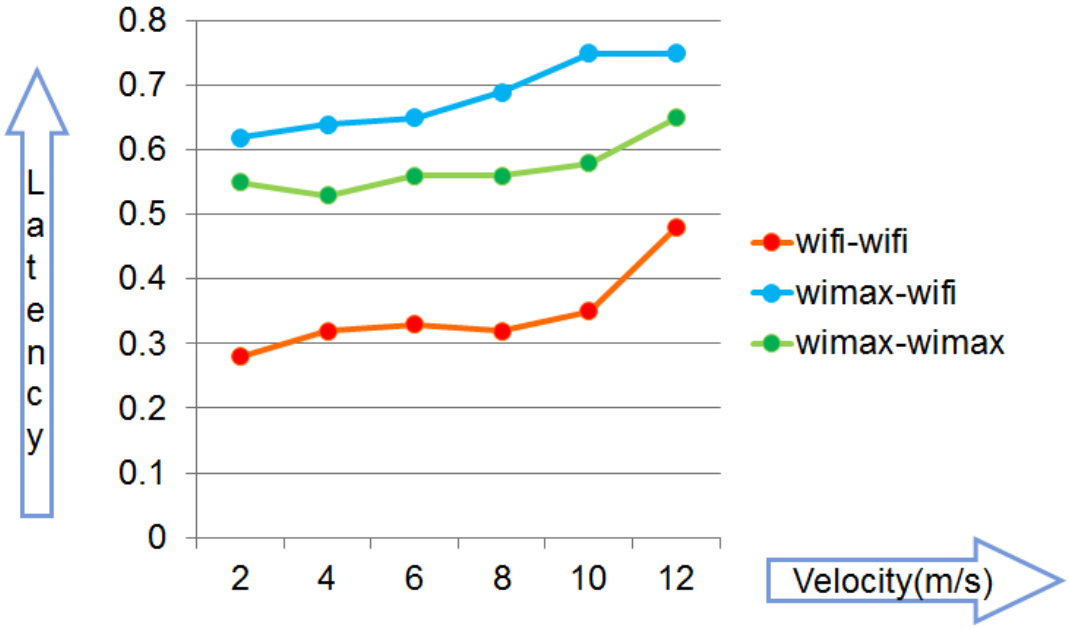


Figure 10: Graph of Handoff Latency vs. Velocity of MN

Handoff Latency is the duration of HandOff initiation to HO completion. Which is equal to the time when the device is disconnected from the old BS and it receives first packet from the new BS?

Here, handoff latency in case of WiMAX – WiMAX; Wi-fi- Wi-fi and WiMAX-Wi-fi is shown. And from the graph you can see the handoff latency for Wi-fi to Wi-fi is much lower than that of WiMAX-WiMAX and WiMAX to Wi-fi. The reason behind such result is horizontal handoff is occurring in wi-fi to wi-fi where as Its Vertical handoff that takes place between WiMAX to Wi-Fi. And in that both L2 and L3 handoff delay occurs here. L2 delay is due to the new network scanning and entry procedure L3 delay is for the new access router discovery and router update. However though, in case of WiMAX to WiMAX handoff, horizontal handoff occurs here, still the latency is much higher because WiMAX uses Hard Handover when moving to another BS. That means the connection is cutoff from the outgoing BS before new connection is made with new BS. So seamless handoff can't be realized here hence the latency is high.

Now let's find out which scenario is better for hand off. As you can recall the first scenario has 1 BS and more APs and the second scenario has 2 BS and less APs. If thought generally, it will seem that the topology with 2 BS will provide better service. Let's see if that's the situation.

4.5: Packet Drops

Velocity(m/s)	No of Packet Dropped-scenario 1	No of Packet Dropped-scenario 2
2	0	0
4	40	50
6	45	55
8	55	100
10	50	55
12	48	53

Table 5: Comparison of Packet Drops

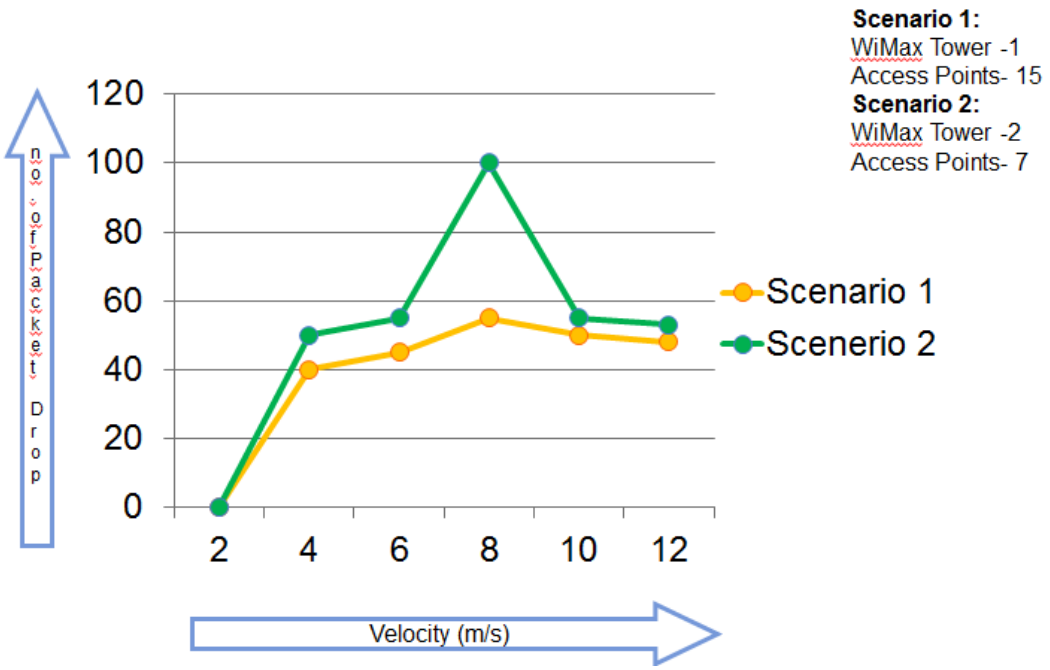


Figure 11: Graph of Packet Drop vs. Velocity of MN

Now let's compare the packet drops in case of both the scenario. As from the name you understand it measures the number of packets dropped during the simulation. and the graph exhibits the packet drop vs velocity in both the scenario. and it shows amount of packet drop is higher in scenario 2

4.6: End to End Delay

Velocity(m/s)	End to end delay-scenario 1(m/s)	End to end delay-scenario 2(m/s)
2	0.035	0.023
4	0.038	0.023
6	0.034	0.024
8	0.034	0.025
10	0.035	0.024
12	0.036	0.024

Table 6: Comparison of End to End Delay

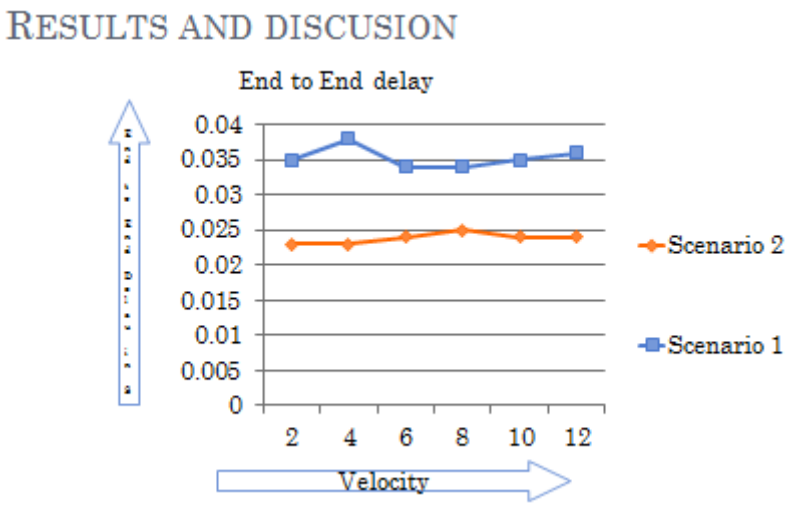


Figure 12: Graph of End to End Delay vs. Velocity of MN

End to End delay refers to the time taken for a packet to be transmitted across a network from source to destination.

The graph above shows that end to end delay in case of scenario 1 and 2. The end to end delay is higher in scenario 1. This is due to the fact that the capacity of AP is much less the the WiMAX BS. More the AP, more the handover between Wi-fi to Wi-fi. During handover of AP more packets are routed for router discovery and connection acceptance. That's why as the number of AP increases, end to end delay increases.

Part 5: Conclusion

5.1: Suggestions

So from the results we see that when the handover in a heterogeneous network occurs taking Bandwidth into consideration, the hand-off between WLAN to WLAN occurs more as WLAN provides better bandwidth, which in turns makes the seamless handoff more efficient.

So, we suggest that for make the rural internet communication better, More WLAN access points can be placed inside the WiMAX active zone. So that the amount WiMAX – WiMAX handoff will occurs less and wi-fi – wi-fi handoff will happen more.

That will not only decreases the handoff latency but also reduce the amount of packet drops in time of WiMAX to WiMAX handoff because the packets can be routed through the APs rather than sending them directly to longer distance.

5.2: Issues

The real life simulation was not conducted. Also we assumed that the WLAN are open to public, that not home or private hotspots.

Refference

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