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Performance Evaluation of Vertical and Horizontal Handover between Wifi and WiMax Networks

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Abstract*— A mobile network is enhanced with many new high speed technologies such as WiMax, Wifi Networks. But these high speed networks having an issue to keep the effective data transmission with the mobility as well as to provide an effective switching between the base stations as the node move outside its own coverage area. The problem becomes more critical when the network is a hybrid network and node access can be provided to any base station. In this work, a parametric decision is defined while performing the handover. In this work, we have defined a network with mobile nodes with specific node strength. The network is having different WiMax and Wifi base stations. As the node moves outside its coverage area and enter in coverage range of more than one base stations of different network in such case a poll is performed between them in terms of node feature analysis as well as the strength of the base stations. The presented work covers this dual featured analysis for both the base station and relatively to the mobile node. The base station feature analysis includes the signal strength of the base station, its capacity and the load parameters Based on these parameters the capabilities of the nodes are been analysed. The node based parameters includes the distance and the mobility speed of the nodes. In this work, the analysis is been performed between these two and drive the relative throughput, Packet loss, bit error rate and the error rate.

***Keywords*—WiFi, WiMax, HO, BS, MT, VHDA**

I. INTRODUCTION

The most basic way of describing a handover (HO) is when a phone call in progress is redirected from its current cell to a new cell. This normally happens when the mobile device making the call is in movement and detects that it is losing coverage, so it needs to "jump" to another antenna. When the HO is within the same technology, for example, between Wi-Fi cells, it is called a horizontal HO or traditional handover. If it is executed between different technologies, for example, WiMAX to Wi-Fi, then it is called vertical HO.

Horizontal HOs are easy to implement because the operation is typically made under the same operation domain. Vertical HOs, on the other hand, are typically executed between different operators and require a much more complex signaling. The main distinction between VHO and HHO is symmetry. While HHO is a symmetric process, VHO is an asymmetric process in which the MT moves between two different networks with different characteristics.

II. HANDOVER MANAGEMENT PROCESS

Different authors divide the complete VHO process into three phases: i) Handover information gathering, ii) Handover decision and iii)Handover execution. The information gathering phase is in charge of collecting relevant information from diverse context sources such as network capabilities, access points, user equipments, and user preferences.

The most critical process in a VHO process is the decision phase since, depending on the network candidate chosen, the performance of the system could improve or decrease. Once the information is gathered it is processed by the VHDA. This algorithm is in charge of making a decision about When and Where to trigger the handover. This decision should consider several parameters in order to choose the best candidate network to handover to Concerning VHDAs. In the Execution Phase Handover will be execute.

A. Implementation of Wimax

WiMAX is one of the hottest broadband wireless technologies around today. These systems are expected to deliver broadband access services to residential and enterprise customers in an economical way. Loosely, it is a standardized wireless version of Ethernet intended primarily as an alternative to wire technologies to provide broadband access to customer premises. More strictly, it is an industry trade organization formed by leading communications component and equipment companies to promote and certify compatibility and interoperability of broadband wireless access equipment that conforms to the IEEE 802.16. It would operate similar to Wi-Fi but at higher speeds, over greater distances and for a greater number of users. It has the ability to provide service even in areas that are difficult for wired infrastructure to reach and the ability to overcome the physical limitations of traditional wired infrastructure.

It is to implement the security issues in WiMAX. The application we implement is the security in WiMAX using encryption and decryption schemes. During packet transferring in WiMAX technology, security is an issue. In this dissertation we implement the data security in WiMAX. The figure 3.1 shows a simple position of base stations and

mobile stations. When packet is transferred from one mobile station of one cluster to another mobile station of another cluster, then center base station always help to transfer the packet. That means the communication between stations always pass through the center base station.

A WiMAX system consists of two major parts:

- A WiMAX base station.
- A WiMAX receiver.

1) WiMAX Base Station:

A WiMAX base station consists of indoor electronics and a WiMAX tower similar in concept to a cell-phone tower. A WiMAX base station can provide coverage to a very large area up to a radius of 6 miles. Any wireless device within the coverage area would be able to access the Internet. The WiMAX base stations would use the MAC layer defined in the standard. It is a common interface that makes the networks interoperable and would allocate uplink and downlink bandwidth to subscribers according to their needs, on an essentially real-time basis. Each base station provides wireless coverage over an area called a cell. Theoretically, the maximum radius of a cell is 50 km or 30 miles however, practical considerations limit it to about 10 km or 6 miles.

2) WiMAX Receiver:

A WiMAX receiver may have a separate antenna or could be a stand-alone box or a PCMCIA card sitting in your laptop or computer or any other device. This is also referred as customer premise equipment (CPE). Its base station is similar to accessing a wireless access point in a Wi-Fi network, but the coverage is greater.

B. Working of WiFi

The current WiFi (wireless fidelity) systems based on IEEE 802.11a/g support a peak physical-layer data rate of 54Mbps and typically provide indoor coverage over a distance of 100 feet. Wi-Fi has become the de facto standard for last feet broadband connectivity in homes, offices, and public hotspot locations. Systems can typically provide a coverage range of only about 1,000 feet from the access point. Wi-Fi offers remarkably higher peak data rates than do 3G systems, primarily since it operates over a larger 20MHz bandwidth but Wi-Fi systems are not designed to support high-speed mobility.

III. SIMULATION SETUP

To work with WiMAX network we need to define a hybrid network with n number of nodes and m number of clusters. Some cluster will represent the WiMAX network and some will represent the WiFi network. For this we need to collect the information about the network scenario. The scenario includes the information like

- No of Nodes
- Mobility
- Cluster Definition
- Channel Type
- Propagation
- Transmission Speed
- Packet Size

To represent all these parameters we need to collect relevant scenarios. We can collect these scenarios either from some existing literature Surveys or by studying the network definition. We need to collect information about the parameters that can help to decide the cluster head selection such as distance, load etc. These parameters will be decided by study the existing literature.

A. Vertical Handover

When we work with hybrid networks there are number challenges we face while performing the communication over the network regarding the network security and the efficiency. In such network when a mobile node move outside its current cluster, then there is the requirement of some cluster selection mechanism to elect as the next head for that mobile node. This process is called vertical handover. In this present work, the vertical handover optimization is performed in case of wimax and wifi networks. The selection of the handover is defined based on some parameteric values. These parameters includes the response time, distance and the throughput analysis.

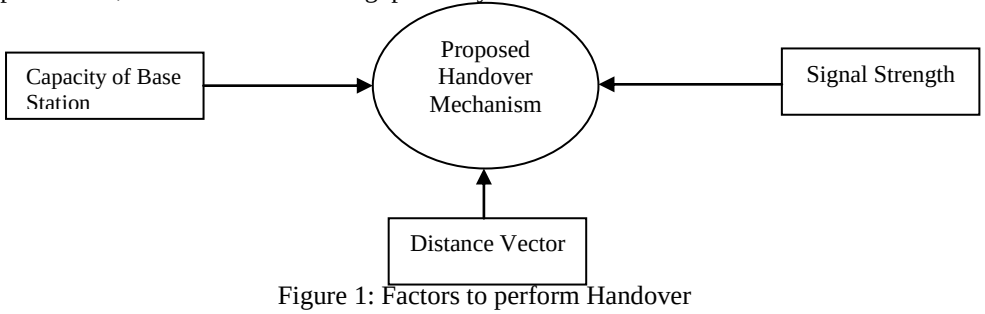

Figure 1: Factors to perform Handover

In our decision algorithm the decision factor for each candidate BS depends on both factors: idle capacity and signal strength. We have combined the two factors into a weighted target cell decision function as shown in figure 4.1.
The vectors that will give the effective handover are shown as

1) BS Maximum Capacity Evaluation:

The first and the foremost task to take the handover decision is to find the base station capacity accurately. The capacity depends on the physical characteristics of the network. To perform this analysis it is required to analyze the OFDM singal over the network and respective parameters. These parameters include the bandwidth, number of carriers, subcarrier, transmission rate etc. We also have to analyze the symbol time that depends on the throughput time and the guard time.

To calculate total number of OFDM symbols transmitted per frame, first we have to calculate OFDM symbol duration which is given as:

TD_{OFDM} = useful symbol time + guard time

TD_{OFDM} = useful symbol time + G × useful symbol time

$$\mathbf{TD_{OFDM} = [1 / (f_s / N_{FTT})] * (1 + G)} \quad \text{- (1)}$$

NFTT-total no. of sub carriers for OFDM

G-cyclic prefix (CP) ratio

fs (sampling factor) = (bandwidth×144/125)

2) Idle Capacity Advertisement

Once the capacity is evaluated accurately the next work is to analyze the throughput over the network. The throughput is based on the current signal strength that is again affected by different parameters. These parameters include the load or the congestion over the network. On the bases of these two parameters the idle time is calculated for the base station and the network. Through statistics a BS is also aware of the current data traffic throughput. Therefore, each BS could obtain the effective idle capacity is given as:

$$\mathbf{C_i = C_{effective} - C_{throughput}} \quad \text{-- (2)}$$

3) Handover Trigger

The handover triggering refers to the concept of shifting the control of a mobile node from one base station to other. There are different decision parameters are suggested by different researchers to perform the handoff process. Most common parameters used by the researchers is distance vector. It means the base station which is closer to the mobile node will get the control over the node. It also signifies the lesser the distance more clear and strong the signal will be. Another parameter is the throughput. The throughput represents the output driven by the mobile node during the handover process. It depends on the load on the base station. The congestion vector also influences the handover triggering. In this work we have taken these all parameters collectively to perform the decision making.

4) Target Cell Decision

In this proposed work we have taken the following parameters

- Distance as the Probabilistic parameter
- Load on the Base Station
- Signal Strength
- Throughput
- Delay analysis

In this present work we have taken these parameters collectively. Some parameters are directly considered and some are being concerned as the hidden parameters such as congestion ratio etc. The main concern here is the delay analysis. The delay analysis is based on the network capacity and the load. Respective to that the throughput is analyzed and the delay is estimated.

IV. RESULTS

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A. Network Setup

The simulation scenario consists of a test area covered by WiMAX BS, and MSs which are randomly dispersed in the test area with overlapped contiguous areas. The position of each MS is random but there are ten MS served by each BS. The traffic model that each MS requests is a non real time Polling Service (nrtPS) at 50 kbps. Table 1 lists the main parameters of the simulation scenario.

Table 1: Simulation Parameters

PARAMETER	**VALUE**
Frequency Band	5 MHz OFDM
Modulation Scheme	1/2 BPSK
No. of BS	2
No. of MS	10
Simulation duration	20 s

Requested data rate	50 kbps
BS coverage	1000 m
Frame duration	20 ms
MS Speed	20 m/s

In the present scenario standard 5 MHz OFDM frequency is used with requested data rate of 50 kbps. OFDM is a frequency division multiplexing technique (FDM) scheme used as a digital multicarrier modulation method. Frequency division multiplexing method (FDM) is a technology that transmits multiple signals simultaneously over a single transmission path, such as a cable or wireless system. Each signal travels within its own unique frequency range (carrier), which is modulated by the data (text, voice, video etc.). Orthogonal FDM's (OFDM) spectrum technique distributes the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the orthogonality in this technique which prevents the demodulators from seeing frequencies other than their own. The data is divided into several parallel streams or channels, one for each sub-carrier. Each sub-carrier is modulated with a conventional modulation scheme at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. The benefits of OFDM are high spectral efficiency, resiliency to RF interference and lower multiple channels (i.e. the transmitted signal arrives at the receiver using various paths of different lengths). Since multiple versions of the signal interference with each other (inter symbol interference (ISI)) it becomes very hard to extract the original information. OFDM is sometimes called multi-carrier or discrete multitone-modulation.

B. Results

The figure 5.1 is showing the WiMAX and WiFi networks with n number of nodes and two base stations. To show the concept of heavy load we have taken a multicast communication. The node will move from one network to other and the handoff will be performed.

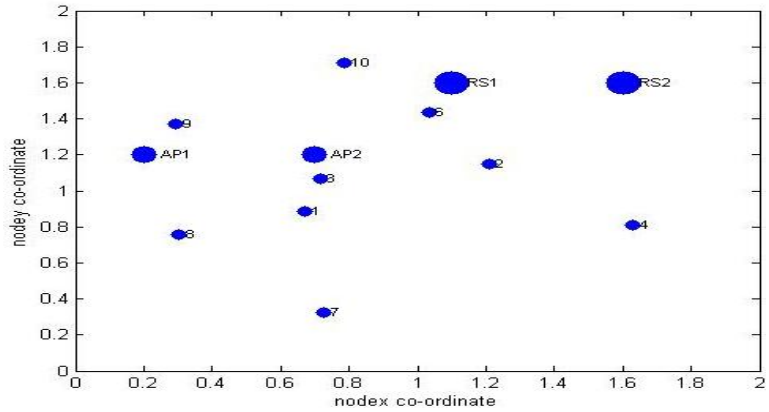

Figure 2: Network Setup

As we can see the hybrid network with n mobile stations and 2 base stations one for the wifi network and WiMAX network. The basic parameters considered here for the handoff analysis are Mobile Node Speed and the Distance vector. The results are driven in the form of error, BER, Packet Transmitted, Packet Received and Packet Lost detection for the network.

1) Signal Strength for WIMAX and WiFi Networks:

In this particular network the MS is moving outside the network (BS) at speed 10m/s and enters a WiFi network, the probabilistic vector for the distance is (.1) 100 m. As the MS moves away the signal strength goes on decreasing from higher value of -80dbm w.r.t. vector distance. Handover occurs to WiFi network when the signal strength of BS decreases considerably to a lower level approx. -94dbm and when the signal strength of WiFi network is higher than the WiMAX network. The obtained results show a throughput error value 19 and BER value is 0.0586.

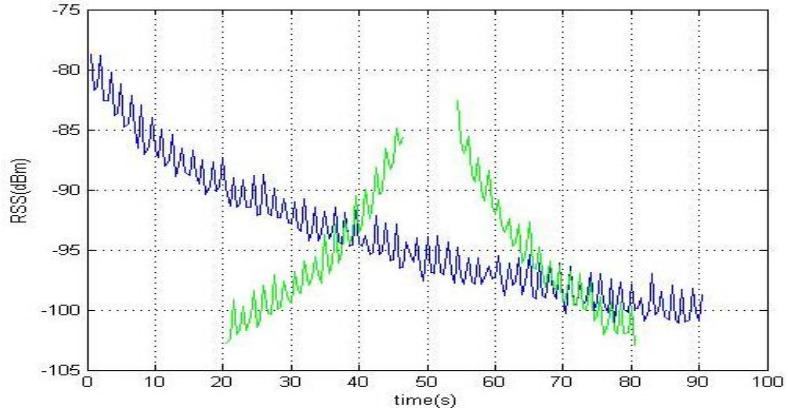

Figure 3: Signal Strength for WiMAX and WiFi Network

The strength of the signals for the WiFi and the WiMAX network is shown in figure. Here the green line shows the signal strength of local WiFi network and blue line shows the WiMAX Network. As soon as the MS remains in this WiFi network the signal strength does not drops further as the signal strength of WiFi network is higher than WiMAX network.

We have performed the vertical handoff at different speed of mobile nodes and different distance vectors and derive the results in the form of throughput, error and the BER ratio. The analysis is here presented:

Teble 2:Input Parameter and Results

Parameters		Results				
MS Speed	Distance Vector	Error	BER	Packet Transmitted	Packet Loss	Packet Received
10	.1	19	0.0586	432000	32000	400000
15	.2	25	0.0772	432000	32000	400000
20	.3	28	0.0864	432000	24000	408000
25	.4	20	0.0617	432000	21333	410667
30	.5	24	0.0741	432000	30666	401334
35	.6	25	0.0772	432000	26666	405334

2) Result Analysis

We have performed the vertical handoff at different speed of mobile nodes and different distance vectors and derive the results in the form of throughput error and the BER ratio. The analysis is here presented in the form of bar graph.

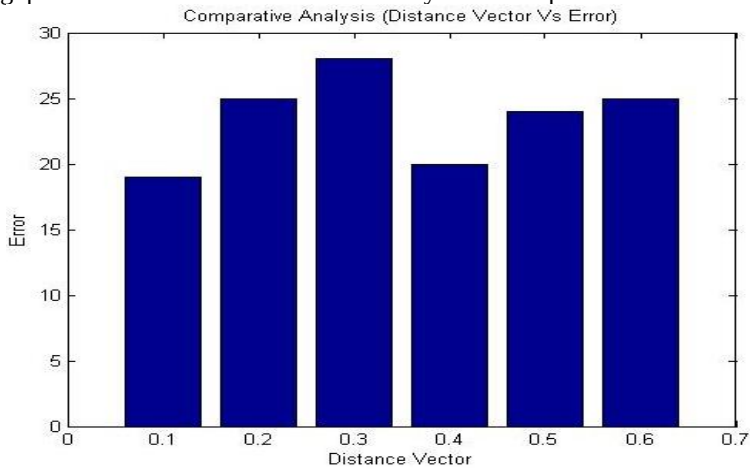

Figure 4:Error Analysis

As we can see in figure the result is analyzed at different mobile speed and the distance vectors. As we can see, as the handover process is performed to a strong signal wimax network the error rate is reduced.

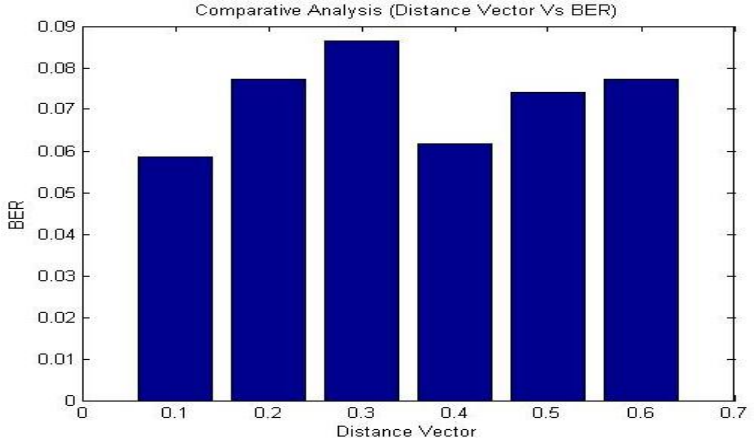

Figure 5:Bit Error Rate

As we can see in figure the result is analyzed at different mobile speed and the distance vectors. Here we can see that at the initial stage when the node is present in parent network having higher signal strength the BER (Bit Error Rate) is very small but as the distance vector increases and the node starts moving away the BER value increases. It means if the network is having the strong signals, the speed and distance ratio will not increase the BER rather than with successful handover the BER will be decreased.

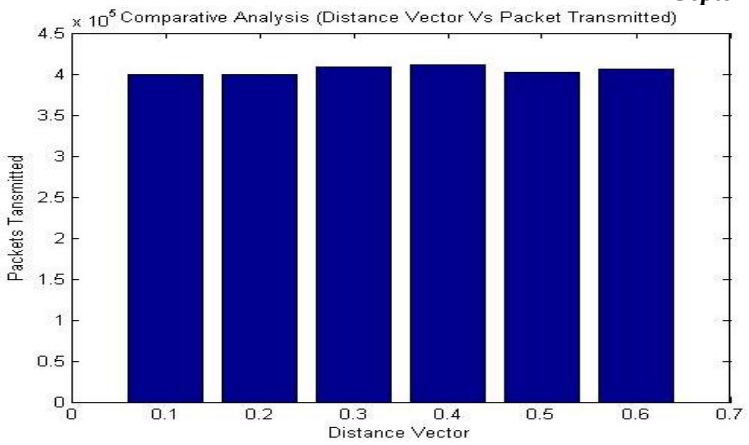

Figure 6:Throughput

As we can see in figure the result is analyzed at different mobile speed and the distance vectors. As we can see, there is slight change in the throughput during the handover process. The throughput is been maximum when the mobile node is moving at an high speed of 35 to 35 m/s. But when the speed is less or the more than that some data loss occur during the handover process. We can here conclude that the mobility of the node is not the major factor if a strong signal base station is there.

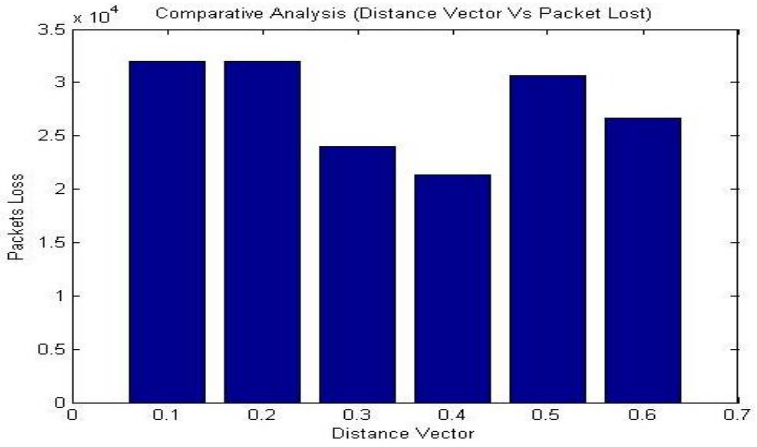

Figure 7:Packet Loss

As we can see in figure the result is analyzed at different mobile speed and the distance vectors. As we can see, there is slight change in the packet loss during the handover process. The throughput is been maximum when the mobile node is moving at an average Speed of 25 to 35 m/s. But when the speed is less or the more than that some data loss occur during the handover process. We can here conclude that the mobility of the node during the handover process will be decreased if the strong signal base station is there.

3) Overall Analysis

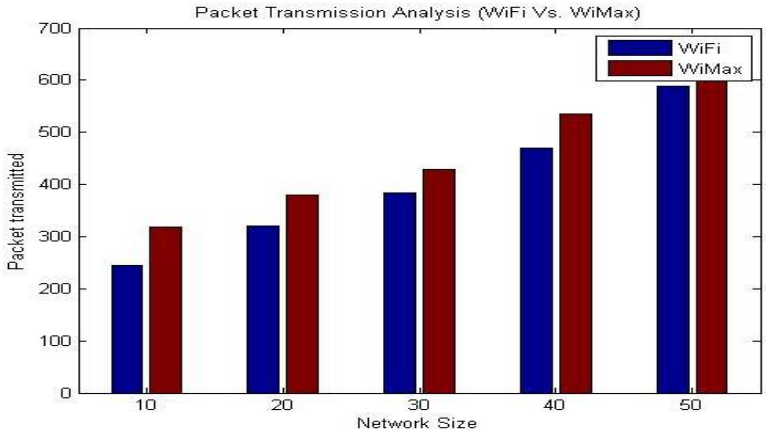

Figure 8: Network Size Vs. Throughput

Here figure is showing the analysis of this Wifi and Wimax based handover approach respective to Throughput analysis. Here the analysis is been done under different number of nodes. As we can see, the WiMax approach has improved the network commuication.and improved the network reliability

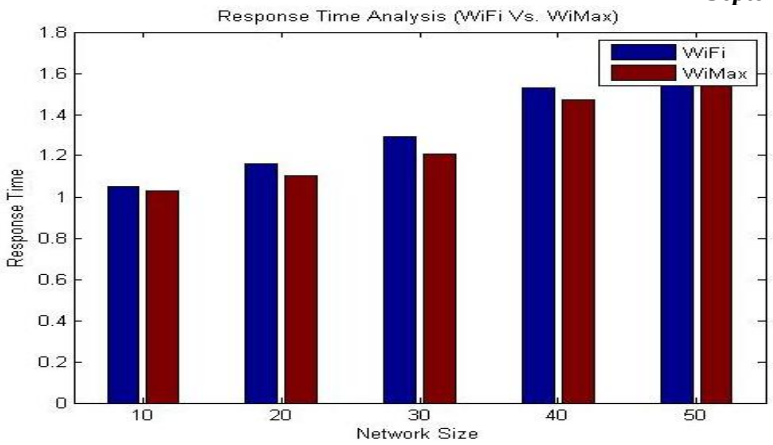

Figure 9: Network Size Vs. Response Time

Here figure is showing the analysis of this Wimax and Wifi based handover approach respective to Response Time analysis. Here the analysis is been done under different number of nodes. As we can see, the Wimax approach has reduced the network response time and improved the network efficiency.

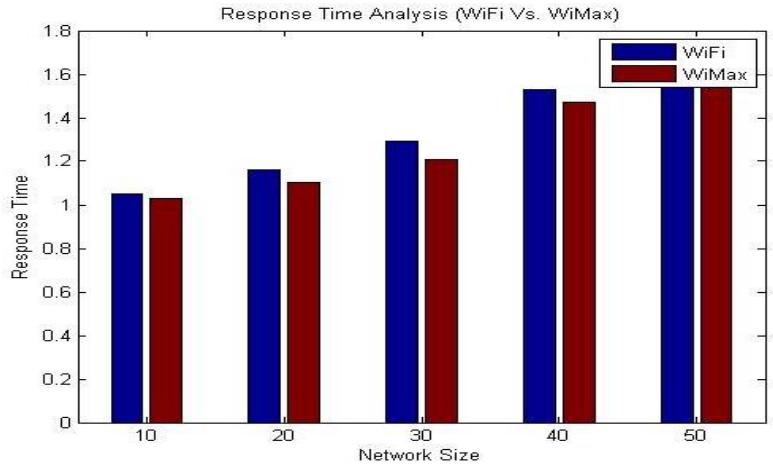

Figure 10: Network Size Vs. Network Delay

Here figure is showing the analysis of this WiMax and WiFi based handover approach respective to Network Delay analysis. Here the analysis is been done under different number of nodes. As we can see, the wimax has reduced the network delay and improved the network efficiency and reliability.

C. Horizontal handover

Theere is showing the network with two wimax networks with n number of nodes and two base stations. To show the concept of heavy load we have taken a multicast communication. The node will move from one network to other and the handoff will be performed.

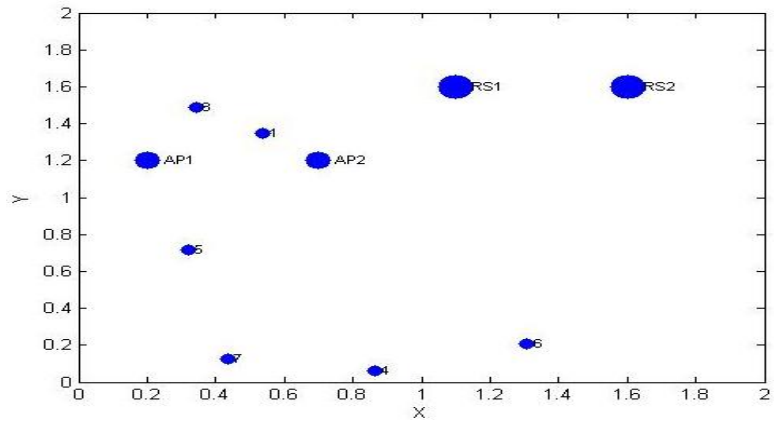

Figure 11 :Network Setup

As we can see the hybrid network with n mobile stations and 2 base stations of WiMAX network. The basic parameters considered here for the handoff analysis are Mobile Node Speed and the Distance vector. The results are driven in the form of error, BER, Packet Transmitted, Packet Received and Packet Lost detection for the network.

1) Signal Strength for Two WIMAX Networks:

In this particular network the MS is moving outside the network (BS) at speed 10m/s and enters a WiMax network, the probabilistic vector for the distance is (.1) 100 m. As the MS moves away the signal strength goes on decreasing from higher value of -80dbm w.r.t. vector distance. Handover occurs to WiMax network when the signal strength of BS decreases considerably to a lower level approx. -94dbm and when the signal strength of WiFi network is higher than the WiMAX network. The obtained results show a throughput error value 25 and BER value is 0.0772.

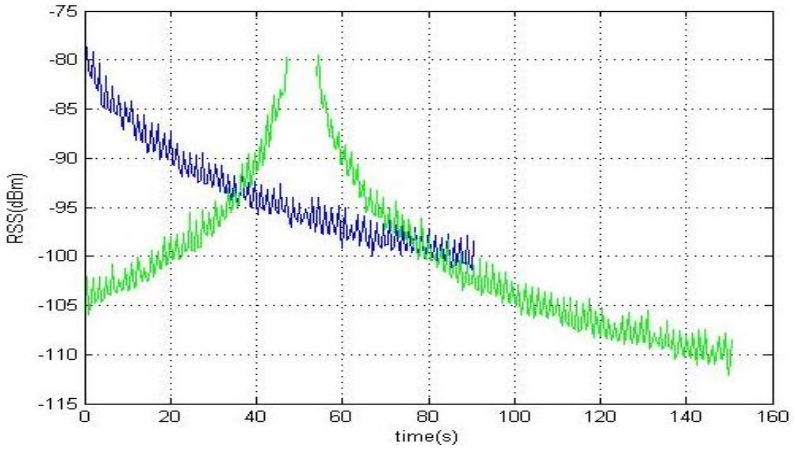

Figure 12: Signal Strength for WiMAX and WiFi Network

The strength of the signals for two WiMAX network is shown in figure. Here the green line shows the signal strength of Current WiMax network and blue line shows the New WiMAX Network. As soon as the MS remains in this WiMax network the signal strength does not drops further as the signal strength of New WiMax network is higher than Current WiMAX network.

We have performed the Horizontal handoff at different speed of mobile nodes and different distance vectors and derive the results in the form of throughput, error and the BER ratio. The analysis is here presented:

Teble 3:Input Parameter and Results

Parameters		Results				
MS Speed	Distance Vector	Error	BER	Packet Transmitted	Packet Loss	Packet Received
10	.1	25	0.0772	432000	33333	398667
15	.2	25	0.0772	432000	33333	398667
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25	.4	17	0.0525	432000	22666	409334
30	.5	18	0.0556	432000	24000	408000
35	.6	20	0.0617	432000	26666	405334

D. Result Comparision of Horizontal and Vertical Handover

- Parameters
  - Distance Vector : .6
  - Speed : 35

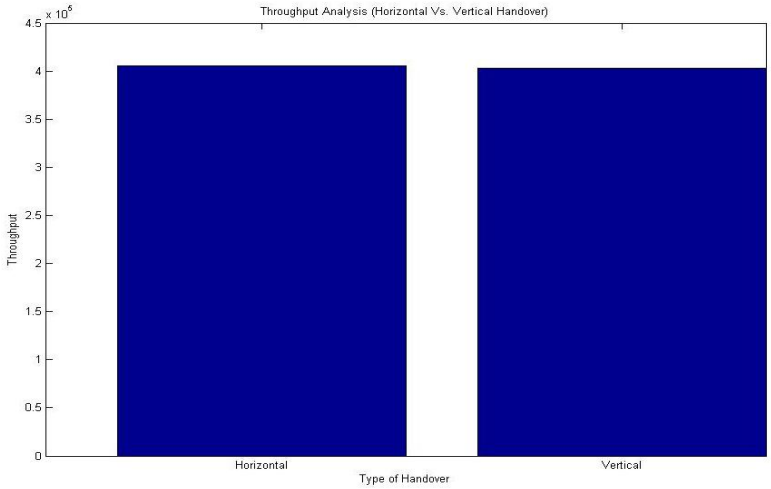

Figure 13 :Throughput Analysis (Horizontal Handover Vs. Vertical Handover)

The figure 13 is here showing the throughput analysis on horizontal and vertical handover. The horizontal handover is here on the basis of wimax network whereas the vertical handover is hybrid network with wimax and wifi networks. The results shows the horizontal handover is more effective than vertical if all network types are wimax.

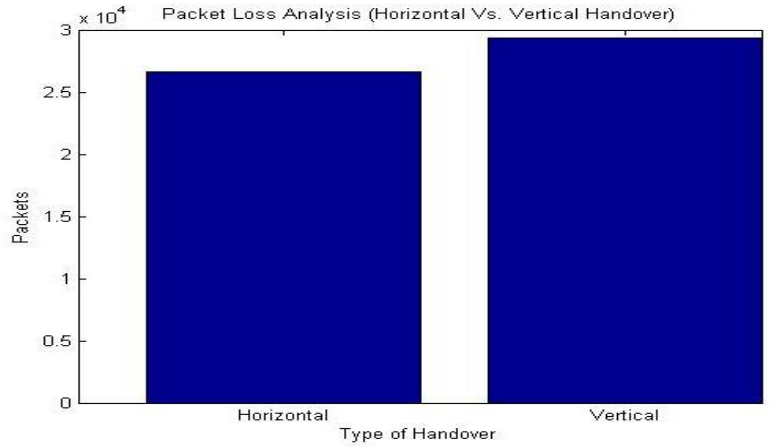

Figure 14:Packet Loss Analysis (Horizontal Handover Vs. Vertical Handover)

The figure 14 is here showing the Packet Loss analysis on horizontal and vertical handover. The horizontal handover is here on the basis of wimax network whereas the vertical handover is hybrid network with wimax and wifi networks. The results shows the horizontal handover is more effective than vertical if all network types are wimax.

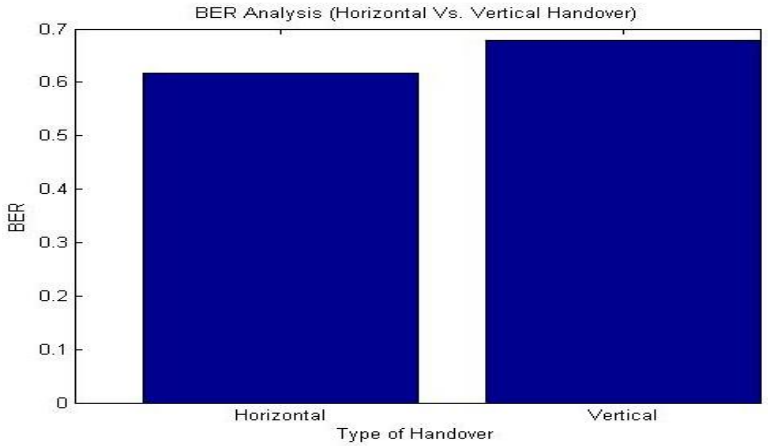

Figure 15 :BER Analysis (Horizontal Handover Vs. Vertical Handover)

The figure 15 is here showing the BER analysis on horizontal and vertical handover. The horizontal handover is here on the basis of wimax network whereas the vertical handover is hybrid network with wimax and wifi networks. The results shows the horizontal handover is more effective than vertical if all network types are wimax.

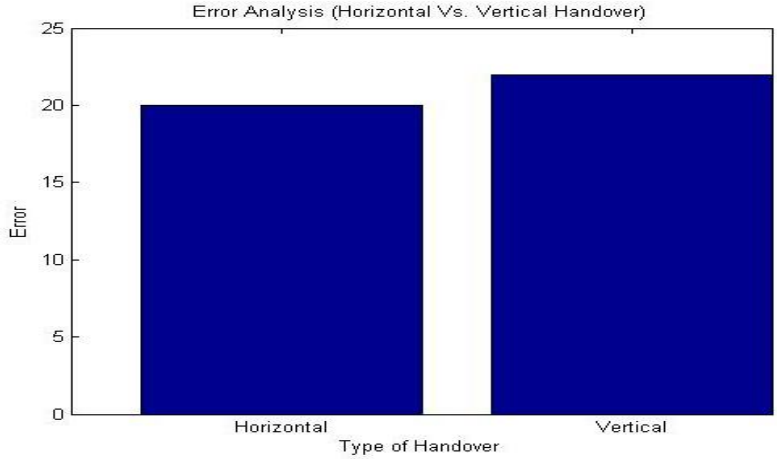

Figure 16 :Error Analysis (Horizontal Handover Vs. Vertical Handover)

The figure 16 is here showing the throughput analysis on horizontal and vertical handover. The horizontal handover is here on the basis of wimax network whereas the vertical handover is hybrid network with wimax and wifi networks. The results shows the horizontal handover is more effective than vertical if all network types are wimax.

V. CONCLUSION

A Hybrid network architecture supports all usage models (fixed, mobile & nomadic). It is also support high capacity real time and non real time voice, data and multimedia services while maintaining the appropriate QoS. Moreover it supports idle mode operation and paging for the mobile station. Its network reference model support interoperability.

we have performed the work on both the horizontal handover and the vertical handover with effect of distance, speed etc. The result analysis is driven in terms of packet transmitted, packet lost, BER and the error rate.

We can see that the always a strong signal Base station take the charge of the node that moves outside its coverage area. Either it is a Wifi or the Wimax Network. The effect of the mobility and the distance is observed very carefully in this work. As we can see, as the speed of the mobile node increases, the error rate is also increased.

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