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Improving Cell Capacity to Reduce Call Drops During Handover in Mobile Wimax Radio Using Cognitive Radio

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ABSTRACT

The main objective in any communication network is to provide uninterruptable service during wired or wireless communication system. The research focuses on how to improve the performance of wireless WiMAX network during a mobile handover communication system. Since handover is simply the movement or the process of moving from one based station to another without termination the ongoing call, for this objective to be achieved a cognitive radio network technology was employed. The cognitive radio model was developed and used intelligently to recover idle channels, expand the cell capacity that helped eliminate ping pong during handover and sign in ongoing calls during mobility. A simulink WiMAX model embedded with enhanced cognitive radio was developed and used for simulation in the current 18.0version MATLAB environment. With the simulated model of WiMAX Network, handover delay using Cognitive Radio Based Handover Technique, the average WiMAX handover delay of 2.52secs was achieved. However, the outputs were compared and percentage calculated showed an improvement in the performance rating of the technique. This was impressively high as an improvement of 20% was achieved. The channel availability, received signal strength which were earlier compromised affecting the radio network were then found to be reclaimed. Therefore, the application of a Cognitive Radio Technology was used to reduce excessive scanning and improve handover scenario on the network and frequent ping pong was also eliminated, and cell capacity increased.

Keynote:Wimax, Cognitive Radio, Matlab, communication, Simulink, Technology

INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX) is a wireless communication technology, which plays the best competitive role in the present world (Shivi and Qamar, 2016). WiMAX is a promising technology for achieving the high speed data capacity and spectral efficiency requirements for wireless communication system. Rapid growth of wireless applications and services demand, in recent times has placed great pressure on the limited exhaustible channel space in the spectrum, occasioning spectrum scarcity. Cognitive radio (CR) is an emerging technology attempting to resolve this problem through improved utilization of spectrum (Amzadet al, 2015). Channel allocation scheme is an important requirement in WiMAX for increasing utilization of spectrum.

Following the increase market emergence of new mobile phones brands demanding internet connectivity for data, video and voice calls etc, and the development of WiMAX technology to compete on urban and remote locations effectively for fast connectivity, handover failure has continued as a challenge. This is due to either insufficient or unavailability of channels. Signal drops mostly beyond threshold frequency which brings about excessive scanning for target base station and most times frequent dropping of voice call, video and data arising during handover

During handover, the , mobile Station scans for the base stations that has the best signal strength, called the target base station, and hands over. Obviously, the success at this as stated above has been a very big problem in telecommunication network since the launch of mobile communication because often times there is always a break in transmission or call drop during the process and subscribers suffer a lot. This challenge has led to occasioning a need for quality service enhancement to go in search of improvement, through and using the cognitive radio. Cognitive Radio Technology (ECRT) was found to be the best solution which could work for the conflicts between spectrum underutilization and growing demand for spectrum, as well as full use of channels allocated.

OVERVIEW

In the modern generation, mobile communication systems are extremely involved in every life. Worldwide Interoperability for Microwave Access (WiMAX) is the emergent wireless system which uses IEEE standard 802.16. The introduction of WiMAX technology can overcome the shortfall of the existing wireless communication network like short coverage area, lack of security and low data rate (Nongjun, 2011; Varade and Ravinwender, 2018).

The Institute of Electrical and Electronics Engineers, IEEE standard, 802.16 specifying WiMAX, is aimed at providing wireless network over a variety of ways at a long distance.

The heavy bandwidth of WiMAX make it suitable for the following potential applications such as connecting Wi-Fi hotspots with each other and Internet; providing a wireless alternative to DSL and cable for long distances broadband access; providing high-speed data and telecommunications services; providing a diverse source of Internet connectivity as part of a business continuity plan and also, providing nomadic connection(a network technology that provides wireless connectivity to devices via antenna. Fig. 2.1 gives a pictorial display of the operation of a WiMAX technology.

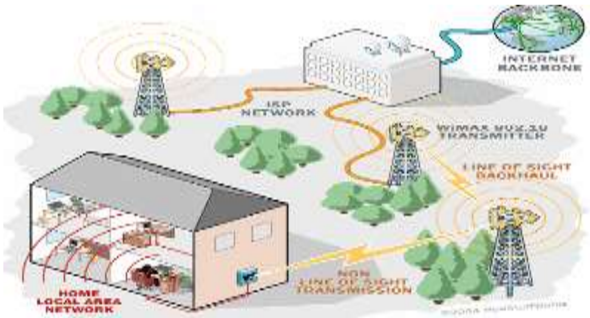


Figure 2.1: Overview of WiMAX Technology (Source: Paramveer, 2015)

With reference to Pareitet.al (2012), WiMAX technology was based on the Institute of Electrical and Electronic Engineering (IEEE 802.16) standard, which is also called Wireless LAN. The IEEE 802.16 group was formed in 1998 to develop an air interface standard for wireless broadband, targeting the growth of a point-to-multipoint wireless broadband based framework for operation in the 10GHz–66GHz millimeter forming a range of wavelengths falling between two given limits, used to transmit to a diverse array of media technologies.

Based on the network each point of attachment belong to, the handover can be either vertical or as well horizontal.(Ashish and Anil, 2014). In horizontal handover, a mobile subscriber moves within the network from one base station (BS) to the other one, while in vertical handover a mobile subscriber can move across different networks, that is to say that a mobile subscriber can move from one BS one GLO network to the other BS two Airtel Network as the case may be. Figure 2.4 shows the scenario of horizontal and vertical handover.

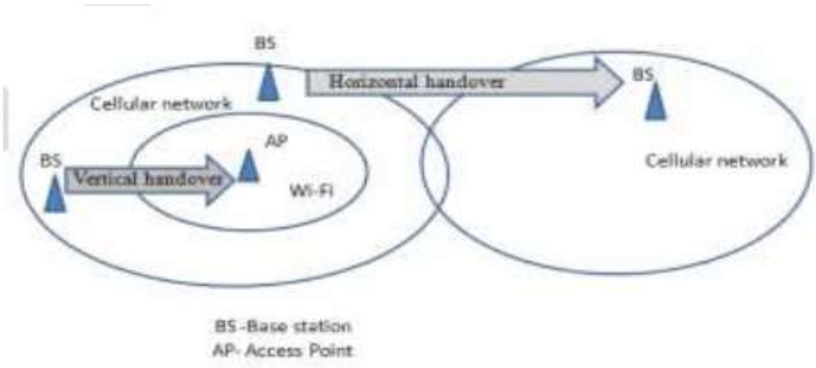


Figure 2.4: Horizontal and Vertical handover (Source: Prchil. Patil, 2015)

2.3 Call Drops in Cellular Systems/Networks

In telecommunications, the rate of drop call (RDC) due to technical hitch that affects both parties and ends their discussion abruptly (Prashant and Poonam (2016) . The total number of all drop calls is used to calculate the percentage drop calls. Call setup procedure is initiated when there is a call attempt and a complete call results when it is connected through. It is possible to terminate a connected call for a technical ground before the parties making the call would wish to do so (in ordinary phone calls this would mean before either of the parties has ended). Such calls are classified as dropped calls (Shivi and Qamar, 2016). In cellular network, call dropping occurs when a base station failed to provide free channels to allocate a mobile subscriber. It may be for a new call attempted by a mobile user or a call which is ongoing and mobile station is in moving state and trying for handover for continuing of call (Vinay, 2014; Sudhindra and Sridhar, 2011;Jatin, 2016).

2.4 Techniques for Reducing Handover Delay in Mobile WiMAX

This section describes methods that can help reduce long handover delay in mobile WiMAX.

2.4.1 Neighbor Advertisement message Technique

In the technique, Neighbor Advertisement message contain the information like number of neighbouring Base Station and also contain some information that can be helpful for selecting Target Base Station (TBS) i.e. list of neighbouring Base Station, number of real-time flows each of these have and free bandwidth of each neighbouring Base Station etc. There are varied vital criteria with respect to neighbour Base Stations e.g. Physical information or physical layer and channel information can be sent to serving BS through backbone and then transmitted to Mobile Station via MOB_NBR-ADV message. This approach releases mobile stations from regulating the transmission of Base Stations. It also enhances the overall effectiveness of the handover processes.

Amzad et.al, (2015) investigated the performance of allocation of channels scheme namely Reserved Channel and Non Prioritized Scheme in WiMAX network. Their results were compared in terms of failure in handover, forced terminal probability, probability of incomplete calls, and probability of blocked calls.

They thereby proposed new channel allocation scheme namely Cognitive Radio Based Channel Scheme (CRBCS) for improving utilization of radio spectrum. The planned arrangement makes use of cognitive radio technology. From the simulation result for CRBCS channel allocation scheme, it was observed that the performance variables gave average values.

Malathy and Muthuswamy (2016) presented a work using a buffer regime using guard channels such that, both new calls and handover calls are queued. With regard to this, a certain sum of guard channels is kept for handover calls and when the new calls are full, a channel from the guard channels is used.

Ebenezer et al (2018), investigated and evaluated a handover scheme exchange among two secondary users (SUs) moving in different directions over the handover region of proximate cell.

They furthermore presented a sub-optimal approach for solving distance calculation of mobile node over the space which reduces both on-line plus off-line complexity to the huge extent and to diminish signaling transaction for the period of handover practice using Global Position System (GPS) in the direction of performing handoff soonest.

Here a low complexity mask compliant pre-coder for OFDM based cognitive radio was designed. It can engender spectrum efficient waveforms with much less computational complexity.

Simulation results illustrate that plot out performs existing schemes in terms of complexity and BER (Bit Error Rate) recital. It provides grand flexibility to adapt shape of the spectrum according to desired requirements. It is also a suitable choice for multiuser scenario.

In all cognitive radio is robust and a better option to handle the handover delay experienced in a WiMAX Network. This is because it makes maximum use of the available channels to achieve a better result..

3.METHODOLOGY

3.1 RESEARCH METHODOLOGY

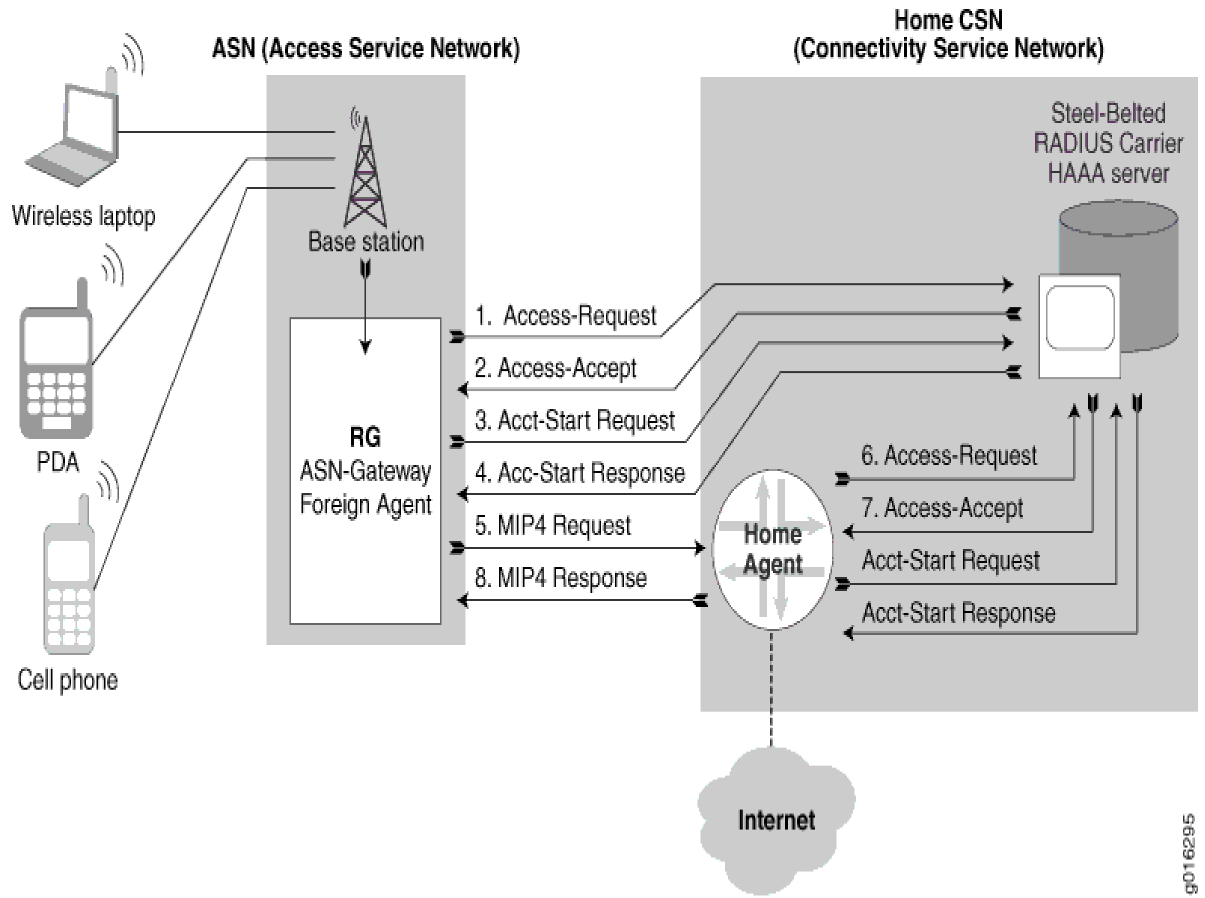
This work focuses on improving handover in a mobile wimax network by reducing unnecessary scanning to the target base station. A propose a handover method based on cognitive radio network scheme in WiMAX network. The proposed method relies on a simple management scheme by utilizing all the idle cells in the WiMAX network and expanding the other channel through modulation scheme. On the other hand, the cognitive radio network will select the idle cells for an effective hand over process. Therefore, WiMAX provider needs to learn and adapt the intelligent radio parameters to the environment for effective performance. Note that this algorithm does not depend on the users' behavior modeling. The main goal is to decrease Handover delay time by canceling unnecessary scans during the Hand over process. Traditional schemes perform the handoff necessity estimation and trigger the network selection process based on a single metric such as received signal strength (RSS). These schemes are not efficient enough, as they do not take into consideration the traffic characteristics, user preferences, network conditions and other important system metrics.

However, before the continuation lets explain what handover is all about by definition. In cellular **telecommunications**, the terms **handover** or **handoff** refer to the process of transferring an ongoing call or data session from one channel connected to the core network to another channel. Or A handover is a process in telecommunications and mobile communications in which a connected cellular call or a data session is transferred from one cell site (base station) to another without disconnecting the session. Cellular services are based on mobility and handover, allowing the user to be moved from one cell site range to another or to be switched to the nearest cell site for better performance. Handovers are a core element in planning and deploying cellular networks. It allows users to create data sessions or connect phone calls on the move. This process keeps the calls and data sessions connected even if a user moves from one cell site to another. But if this process is altered that means the handover is not properly executed which is most cases caused by on availability of channels

TYPES OF HANDOVERS:

- Hard Handover: An instantaneous handover in which the existing connection is terminated and the connection to the destination channel is made. It is also known as a break-before-make handover. The process is so instantaneous that the user does not hear any noticeable interruption.
- Soft Handover: A substantial handover where the connection to the new channel is made before the connection from the source channel is disconnected. It is performed through the parallel use of source and destination channels over a period of time. Soft handovers allow parallel connection between three or more channels to provide better service. This type of handover is very effective in poor coverage areas.

3.2 Home Network Communication Flow shows a successful example of a WiMAX home network communication flow.



igure 3.1: Home Network Communication Flow

For initial entry into the network, a mobile station uses a base station to attach itself to the network through the ASN-GW in the access service network (ASN). After the mobile station is attached to the network, the following communication flows occur:

1. The ASN-GW acts as the foreign agent and must authenticate the mobile device and its user by using an EAP-specific method (EAP-TTLS, EAP-TLS, or EAP-AKA). The ASN-GW also needs to obtain cryptographic keys. To retrieve the cryptographic keys, it sends a RADIUS Access-Request message to the SBR Carrier HAAA server in the home CSN (connectivity service network).
2. The SBR Carrier HAAA server receives the Access-Request message from the ASN-GW. Then, the HAAA server sends successful RADIUS Access-Accept and EAP-specific method messages back to the ASN-GW. Additionally, it sends the AAA-session-ID to use for the session (assigning the home agent) and the following cryptographic keys: MSK (master session key), MN-HA-MIP4-KEY, and MN-HA-MIP4-SPI. For more details about the EAP methods and cryptographic keys, see EAP Authentication Methods and EAP-Derived Cryptographic Keys.

To start the accounting process for the session, the ASN-GW sends an Acct-Start Request message to the HAAA server. The accounting may be IP-session-based or flow-based.

3.3 Materials /Equipment Used Are:

Computer system Laptop

Two Phones with TEMs software installed

A GPS Global positioning system for coordinate locations

An Inverter (that converts DC to AC in our vehicle to laptop

A Compass to take azimuth of the cell, to locate were the antenna is connected

A Vehicle this was used for mobility

A Camera to take pictures where necessary

A TEMs and WiMAX software

3.4: Development of Algorithm for Increasing Cell Capacity to Eliminate Ping Pong

An algorithm was developed from the flowchart as presented in figure 3.7 for increasing cell capacity to eliminate ping pong, this is shown on the algorithm as we proceed.

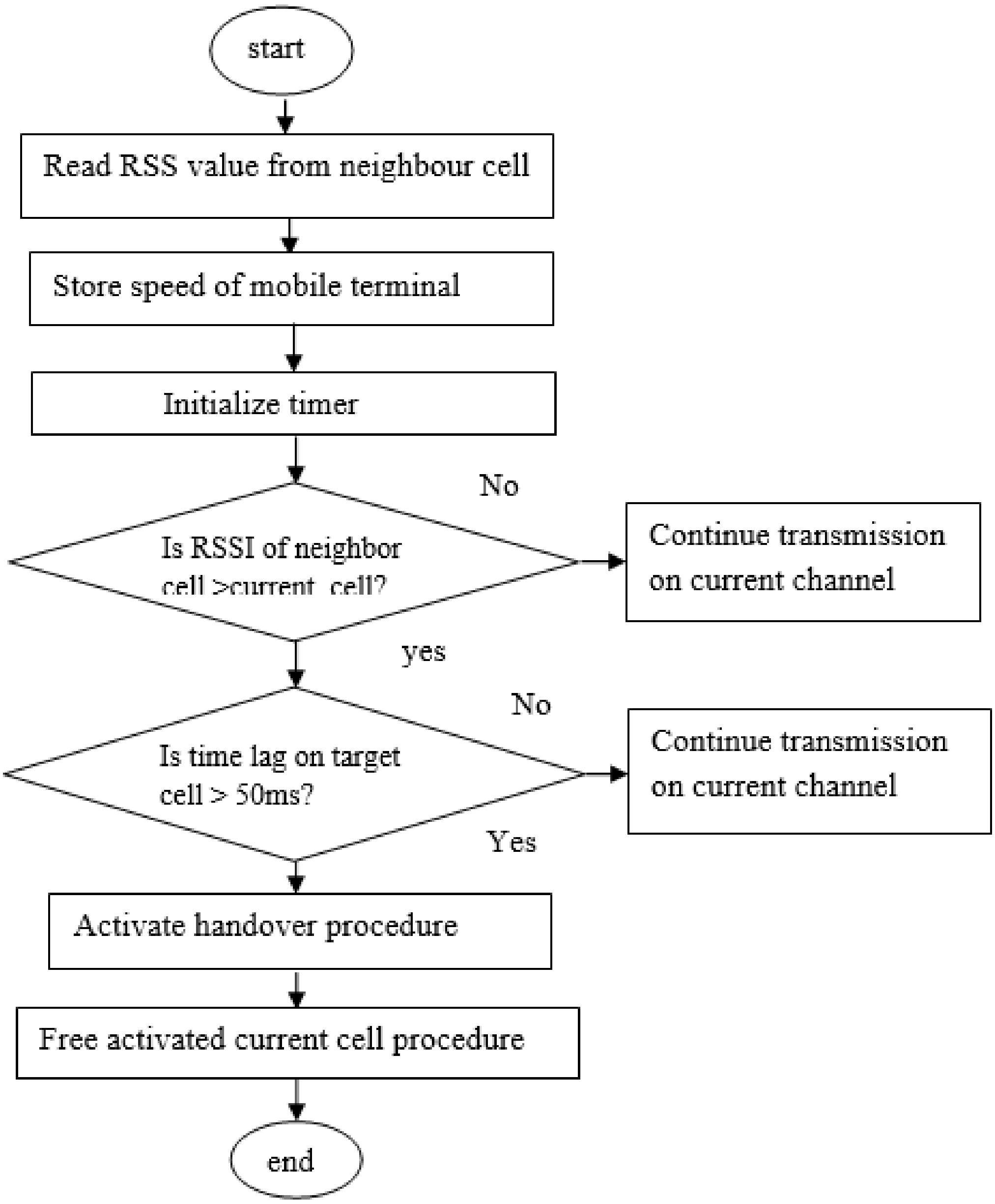


Figure 3.2 A Flow diagram for increasing cell capacity to eliminate ping pong

3.4 HARD WARE OF A WIMAX BASED STATION

The objective was to build a WiMAX system using an off-the-shelf WCDMA radio. For this project, I built a common hardware platform for both base station and user equipment and also developed WiMAX physical layer algorithms.

Fig. 3.3: Picture of hardware of the WiMAX base station.

3.5 DESIGNED MODEM ALGORITHMS FOR 4 MODEM.

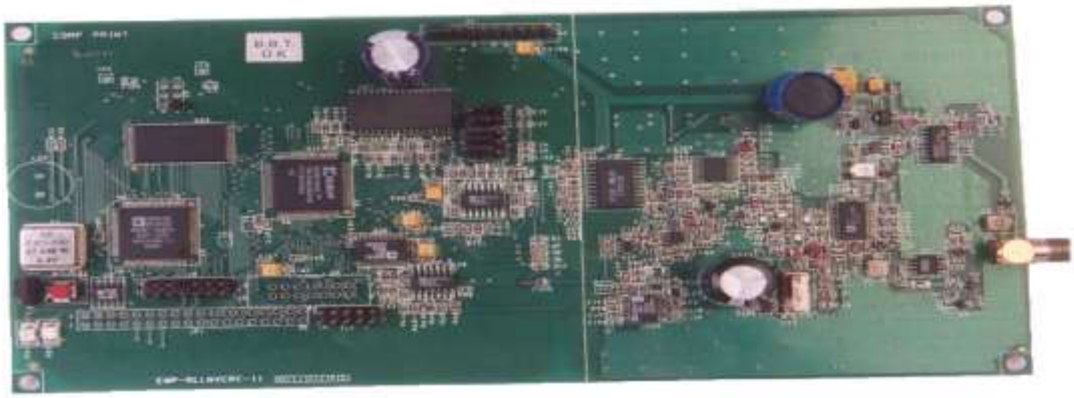


Fig. 3.4: Picture of hardware of the 4G mobile station.

3.6 WIMAX NETWORK REFERENCE MODEL

FIGURE 3.5 shows the WiMAX network reference model containing links (interfaces or reference points) and functional entities.

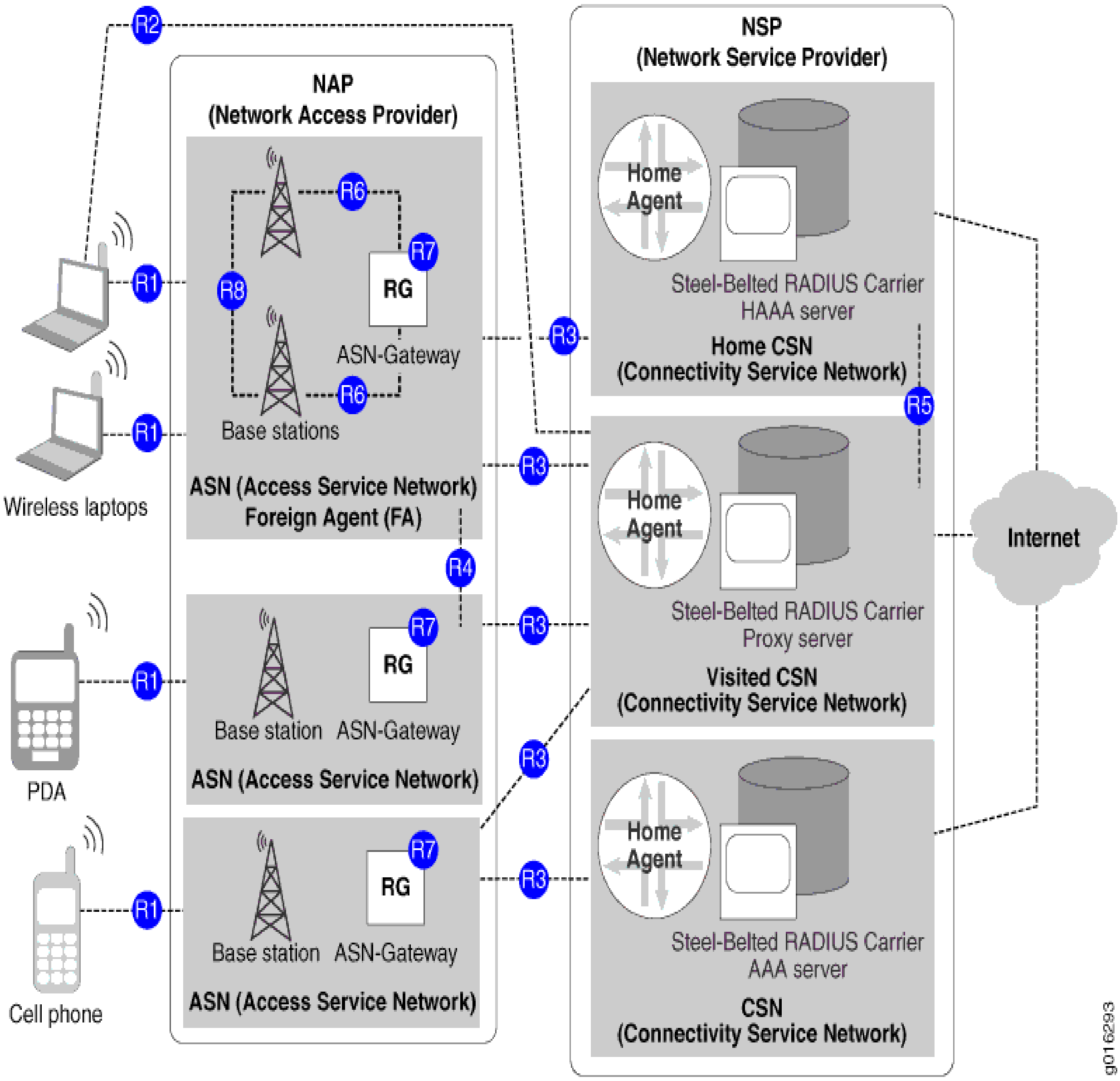


Figure 3.5: WiMAX Network Reference Model

The WiMAX network reference model is composed of four logical parts:

- Mobile Stations (MS)—Comprises all user (subscriber) mobile devices, such as cell phones, PDAs, and wireless laptops, and software needed for communication with a wireless telephone network.
- Network Access Provider (NAP)—Provides radio access functionality. Contains the logical representation of the functions of a NAP. Some of the functions included in the NAP are: access service network (ASN), 802.16 interface with network entry and handover, ASN-GW (gateway), base stations (wireless towers), foreign agent (FA), QoS and policy enforcement, and forwarding to a selected CSN. A NAP may have contracts with multiple NSPs.
- Network Service Provider (NSP)—Provides IP connectivity services. Contains the logical representation of the functions of the NSP. Some of the functions included within the NSP are: connectivity service network (CSN), home agent, Visited and Home Authentication, Authorization, and Accounting servers (VAAA or HAAA), connectivity to the Internet, IP address management, authentication, authorization, and accounting, and mobility and roaming between ASNs. An NSP may have a contract with another NSP and may also have contracts between multiple NAPs.

- Internet—Provides Internet content to a user/subscriber and connectivity to a NSP.

Reference points (for example, R1 or R2) are conceptual links that connect two functional entities. Reference points represent a bundle of protocols between peer entities (similar to an IP network interface). Interoperability is enforced through reference points without dictating how vendors implement the edges of those reference points.

- R1—Represents the interface between the wireless device and the base station.
- R2—Represents the link between the MS (mobile station) and the CSN (connectivity service network). EAP traffic from the mobile station to the AAA server traverses R2 and R3.
- R3—Represents the link between the ASN (access service network) and the CSN. RADIUS traffic between the ASN-GW and the AAA server traverses R3.
- R4—Represents the link between an ASN and another ASN.
- R5—Represents the link between a CSN and another CSN.
- R6—Located within an ASN and represents a link between the BS (base station) and the ASN-GW.
- R7—Located within the ASN-GW and represents internal communication within the gateway.
- R8—Located within an ASN and represents a link between two base stations.

3.7 Mathematical model

summarized mathematical models of enhanced cognitive

S/N	Parameter Description	Scheme I : Existing Non-Priority Non-Cognitive Radio Based Handoff (NPNCRBH) Scheme	Scheme II : Proposed Non Prioritized Cognitive Radio Handoff (NPCRBH) scheme with booster (converter)
1	Statistical gain factor	$g_e = 1$	$g_e = 1+\varepsilon_e$
2	Statistical gain factor for New Call	$g_N = g_e = 1$	$g_N = g_e = 1+\varepsilon_e$
3	Statistical gain factor for Handoff Call	$g_H = g_e = 1$	$g_H = g_e = 1 + \varepsilon_e$
4	The offered traffic or traffic intensity	$\rho = \frac{\lambda}{\mu} = \frac{(\lambda_N + \lambda_H)}{(\mu_N + \mu_H)}$	$\rho_{a(NPCRH)} = \frac{\rho}{g_e}$
5	Active handoff call	$\rho_{eH(NPNCRBH)} = \frac{\lambda_H(1 - PBH_{(NPNCRBH)})}{\mu_H}$	$\frac{(g_e)\lambda_H(1 - PBH_{(NPNCRBH)})}{(\mu_H)C}$
6	Average Number of Ongoing Calls in the Borrowed Idle State	0	$\rho(1 - PBN_{(NPNCRBH)})(g_e - 1)$
7	Average Waiting Time in the Borrowed Idle State	0	$(1 - \delta_e)T = (1 - \delta_e)\left(\frac{1}{\mu}\right)$
8	Average Delay Or Average Time Spent in the System	$\frac{1}{\mu}$	$\frac{1}{\mu} = T$
9	Average Actual Time Spent in the System (Excluding Borrowed Idle State)	$\frac{1}{\mu}$	$\frac{\rho_e}{\mu} = \delta_e(T)$
10	Average Available Idle State Time Not Borrowed	$\left(\frac{1}{\mu}\right)(1 - \delta) = W_{TB(NPNCRBH)}$	$\left(\frac{1}{\mu}\right)(\delta_e - \delta) = (\delta_e - \delta)T$

4. DATA PRESENTATION AND ANALYSIS IN WIMAX

4.1 Parameters for Simulation

Various parameters have been used in all simulation scenarios to analyze the handover behavior under specific circumstances both homogeneously and heterogeneously. The simulation parameters that are used in this research are listed in Table 4.1. The speed of mobile nodes during handover process is between 20KM/H to 120KM/H; the size of the field is 1500m x 1500m. During the simulation, all nodes start performing handover from 0 second until the time of simulation ends (25s).

Performance can be analyzed using parameters like throughput, Handover latency, and average end- to-end delay.

In this simulation, various performance of WiMAX handover is used Matlab simulator. The proposed scheme focused on improving the handover performance firstly in terms of reducing the scanning situations, hence reducing handover time (delay) and in choosing the best target base station (TBS) for handover.

Table 4.1: **Simulation parameter**

Parameter	**Value**
Traffic	Constant Bit Rate (CBR)
Simulation area	1500x1500 m
Speed	0-10mps, 0-20mps
FFT	1024
Channel frequency	2.4 GHZ
Channel Bandwidth (MHZ)	20
Frame Duration (ms)	20
BS Transmitted Power (dbm)	20
SS Transmitted Power (dbm)	20
Antenna Type	Omni-directional
Base Station Antenna Height	32 m
MS Antenna Height	1.5 m
Neighbour BS Scanning RSS Trigger	-76
Handover RSS Trigger(dBm)	-78
Cyclic Prefix Factor	8
Service Flow Timeout Interval	15 seconds
Simulation Time	500 Seconds
No of packet sent	30
MS's Movement Speed	20 Km/h - 120 Km/h

4.2 DATA PRESENTATION

4.2.1 Results and Discussions for Distributed Load Balancing

The high rate of drop calls of about 38 along Elelewo (RV05522H) in Port Harcourt Rivers State was a big challenge during drive test. As shown in the following result shown on table 4.3.

Figure 4.1, 4.2,4.3 shows the output results of the drive test conducted during the drive test

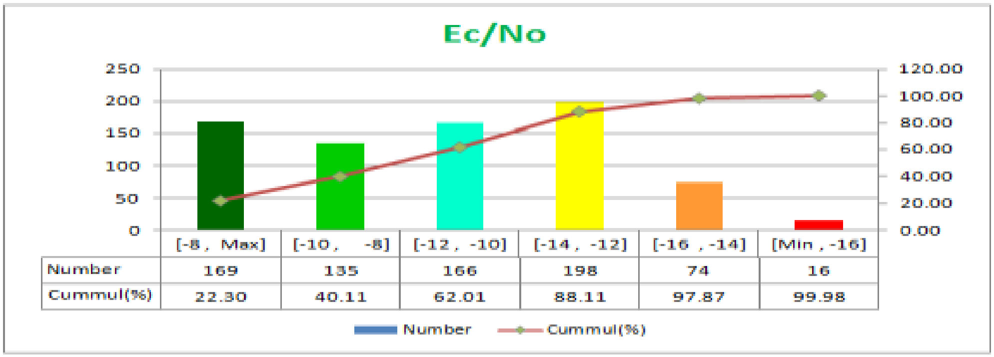


Figure 4.1

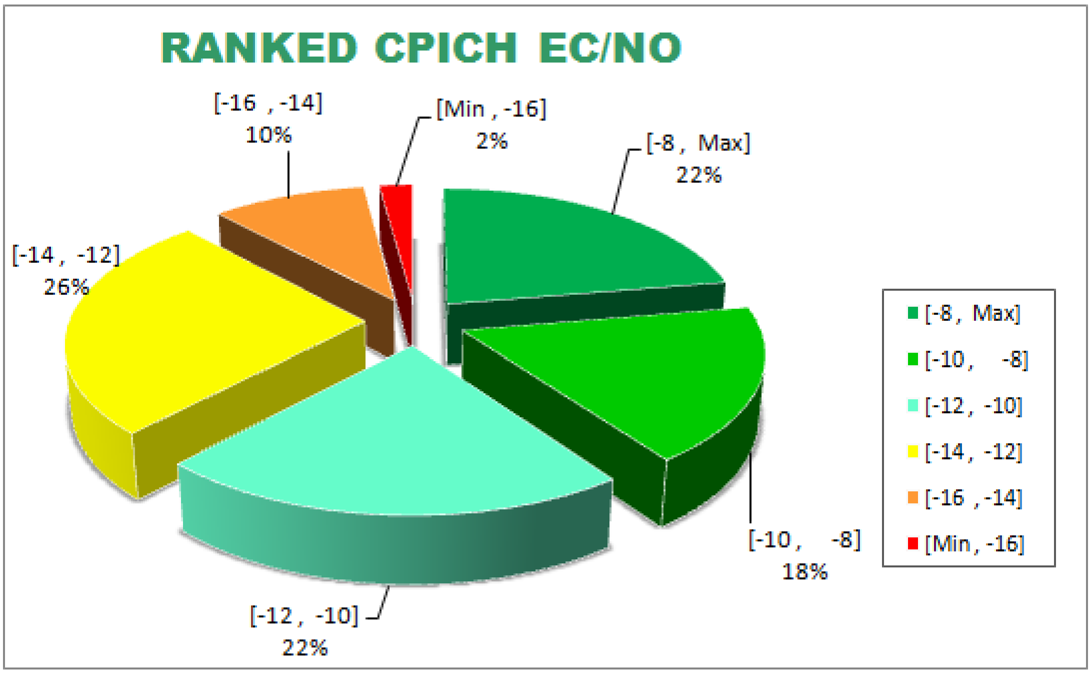


Figure 4.2

Figure 4.3 Drive Test Routes

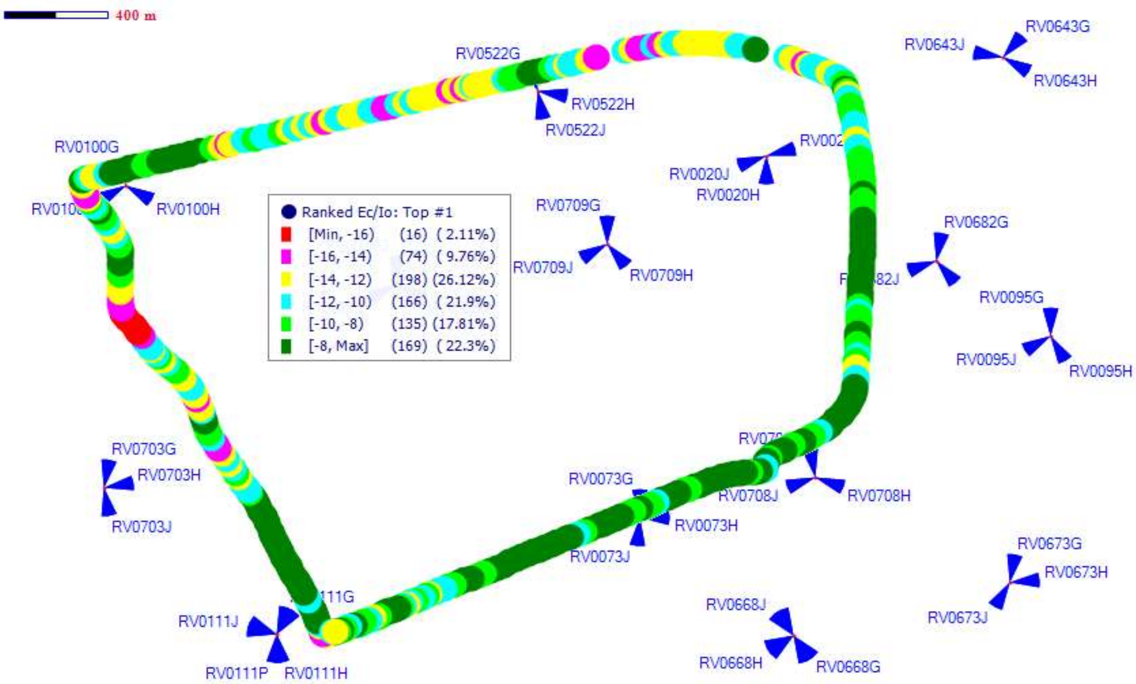


Figure 4.3 shows the drive test routes of the analysis done during the drive, the roots with green colour shows strong signal while the yellow indicates very poor signal

Table 4.2

CPICH EC/NO	COUNTS	PERCENTAGE (%)	CUMMULATIVE (%)	EC/NO >=-12
[-8 , Max]	169	22.30	22.30	62.01
[-10 , -8]	135	17.81	40.11	
[-12 , -10]	166	21.90	62.01	
[-14 , -12]	198	26.12	88.13	
[-16 , -14]	74	9.76	97.89	
[Min , -16]	16	2.11	100.00	
	758			

Ranked Ec/Io: Top #1

[Min, -16)	(16)	(2.11%)
[-16, -14)	(74)	(9.76%)
[-14, -12)	(198)	(26.12%)
[-12, -10)	(166)	(21.9%)
[-10, -8)	(135)	(17.81%)
[-8, Max]	(169)	(22.3%)

Table: 4.3 Showing Daily Handover Call Drops in four Base Station of Elelewo (MSC RV 05522H) for a Period of three Months

Handover call drops (RV0522h) for 3 months					
Date	BS1	BS2	BS3	BS4	Daily average call drop for the four base stations
5/2/2018	39	38	39	40	39
6/2/2018	38	37	37	39	38
7/2/2018	36	37	36	39	37
8/2/2018	37	38	39	38	38
9/2/2018	38	39	38	41	39
10/2/2018	37	38	40	38	38
12/2/2018	39	38	39	40	39
13/2/2018	38	37	37	39	38
14/2/2018	36	37	36	39	37
15/2/2018	37	38	39	38	38
16/2/2018	38	39	38	41	39
17/2/2018	37	38	40	38	38
19/2/2018	39	38	39	40	39
20/2/2018	38	37	37	39	38
21/2/2018	36	37	36	39	37
22/2/2018	37	38	39	38	38
23/2/2018	38	39	38	41	39
24/2/2018	37	38	40	38	38
26/2/2018	39	38	39	40	39
27/2/2018	38	37	37	39	38
28/2/2018	36	37	36	39	37
1/3/2018	37	38	39	38	38
2/3/2018	38	39	38	41	39
3/3/2018	37	38	40	38	38
5/3/2018	39	38	39	40	39
6/3/2018	38	37	37	39	38
7/3/2018	36	37	36	39	37
8/3/2018	37	38	39	38	38
9/3/2018	38	39	38	41	39
10/3/2018	37	38	40	38	38
12/3/2018	39	38	39	40	39
13/3/2018	38	37	37	39	38
14/3/2018	36	37	36	39	37
15/3/2018	37	38	39	38	38
16/3/2018	38	39	38	41	39
17/3/2018	37	38	40	38	38
18/3/2018	39	38	39	40	39
19/3/2018	38	37	37	39	38
20/3/2018	36	37	36	39	37

21/3/2018	37	38	39	38	38
22/3/2018	38	39	38	41	39
23/3/2018	37	38	40	38	38

24/3/2018	39	38	39	40	39
26/3/2018	38	37	37	39	38
27/3/2018	36	37	36	39	37
28/3/2018	37	38	39	38	38
29/3/2018	38	39	38	41	39
30/3/2018	37	38	40	38	38

31/3/2018	39	38	39	40	39
2/4/2018	38	37	37	39	38
3/4/2018	36	37	36	39	37
4/4/2018	37	38	39	38	38
5/4/2018	38	39	38	41	39
6/4/2018	37	38	40	38	38
7/4/2018	39	38	39	40	39
9/4/2018	38	37	37	39	38

The overall average for the three months on the Mobile switching center (MSC) of the four Base station on Elelewo (RV0522H) is 39+38+37+38+39+38 =229/6 = 38.16 = 38 drop calls

Table 4.4: Table showing Empirical data of site and Received Signal Strength (dBm) (RSS)

Site / distance(m)	**RSS (dBm)**
1	-90
2	-75
3	-70
4	-68
5	-99
6	-72
7	-88
8	-75

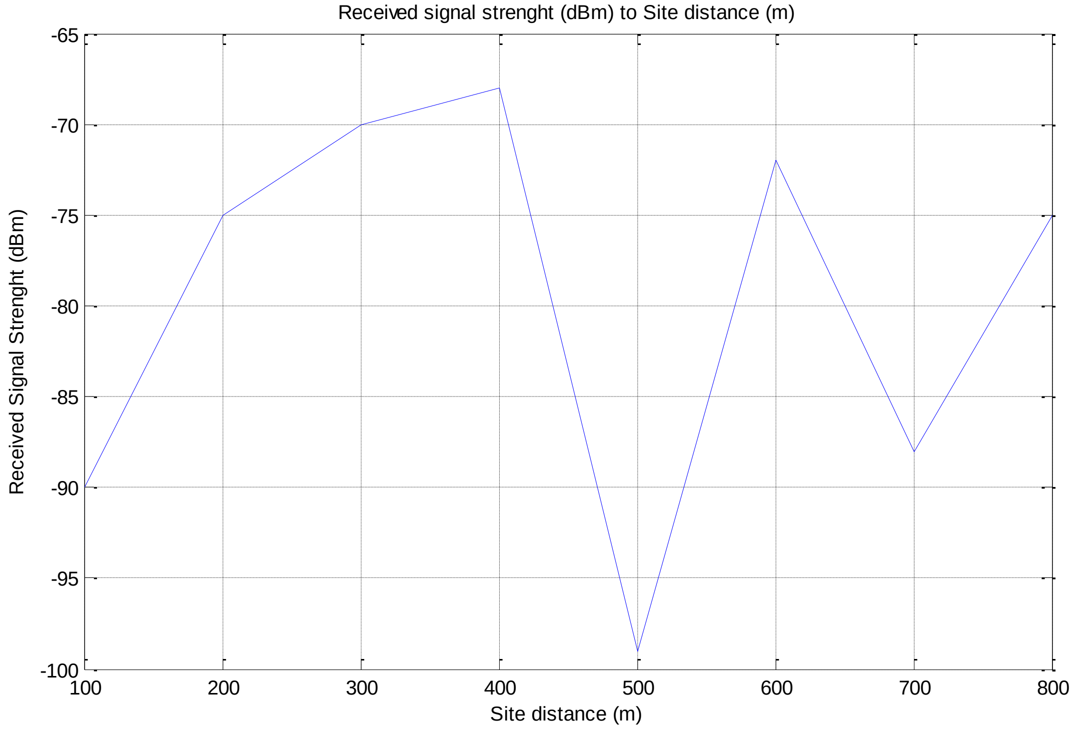


Figure. 4.4: Graphical Representation of Empirical Data Site and RSS (dBm)

From the measurement carried out from eight different cell sites, the signal strength obtained was tabulated as shown in Table 4.4 and the simulation graph presented in figure 4.4. The simulation result shows that most of the cell sites under study maintained received signal strength of -68 to -99 dBm which is a little bit erratic or fluctuating, strong and weak signal was observed. Since our threshold is -89dBm. The ones such as sites one and five had a weak signal of -90dBm and -99dBm and the other ones are between ranges, as shown on the graph in figure 4.4.

Table 4.5: Table showing Empirical data of site and handover drop calls

Site	**HO Drop calls Per Cell (mili sec)**
1	26
2	23
3	38
4	23
5	24
6	21
7	25
8	26

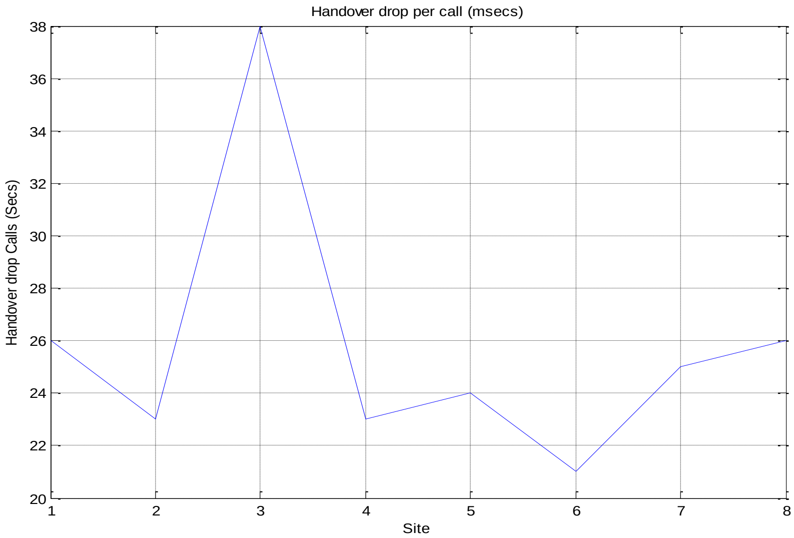


Figure. 4.5: Empirical data of site and HO drop calls

From the measurement carried out from eight different cell sites, the average Drop calls Per Cell obtained was tabulated as shown in Table 4.5 and the simulation graph presented in figure 4.6. The simulation result shows that all the cell sites under study had Dropped Call Rate (DCR) above 2% which is considered high as the NCC benchmark for DCR is 2%. But the worrisome site is on (MSC3) which have an average of 38 drop calls. This is as a result of poor signal strength, unavailability of channels, or traffic intensity on the cell sites.

Table 4.6: Showing result of a WiMAX network on channel utilization (CU) with cognitive radio

Site	Channel Utilization (bit)s
RV0100H	83
RV0020H	86
RV0522H	84
RV0643H	83
RV0095H	89
RV0708H	90
RV0073H	86
RV0111H	86

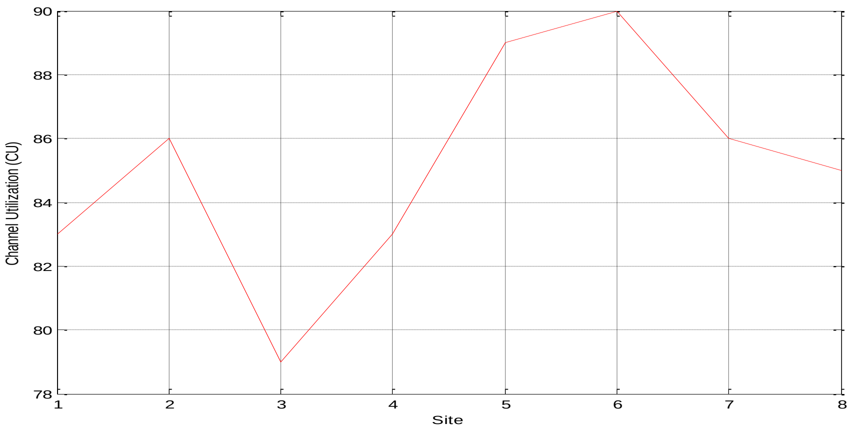


Figure 4.6: A simulated graph showing channel utilization (CU) with cognitive radio

From the data and graph on Table 4.6 and figure 4.6 shows that all the available channels allocated to each base station was fully utilize. This shows that enhanced cognitive radio is a good technology to mange any channel allocated to Base Station.

Table 4.7: Showing result of WiMAX network on received signal strength (RSS) with cognitive radio and without enhanced cognitive radio

SITE	RSS WITHOUT ECR	RSS WITH ECR
RV0100H	-90	-72
RV0020H	-75	-71
RV0522H	-70	-74
RV0643H	-68	-73
RV0095H	-99	-72
RV0708H	-72	-75
RV0073H	-88	-70
RV0111H	-75	-73

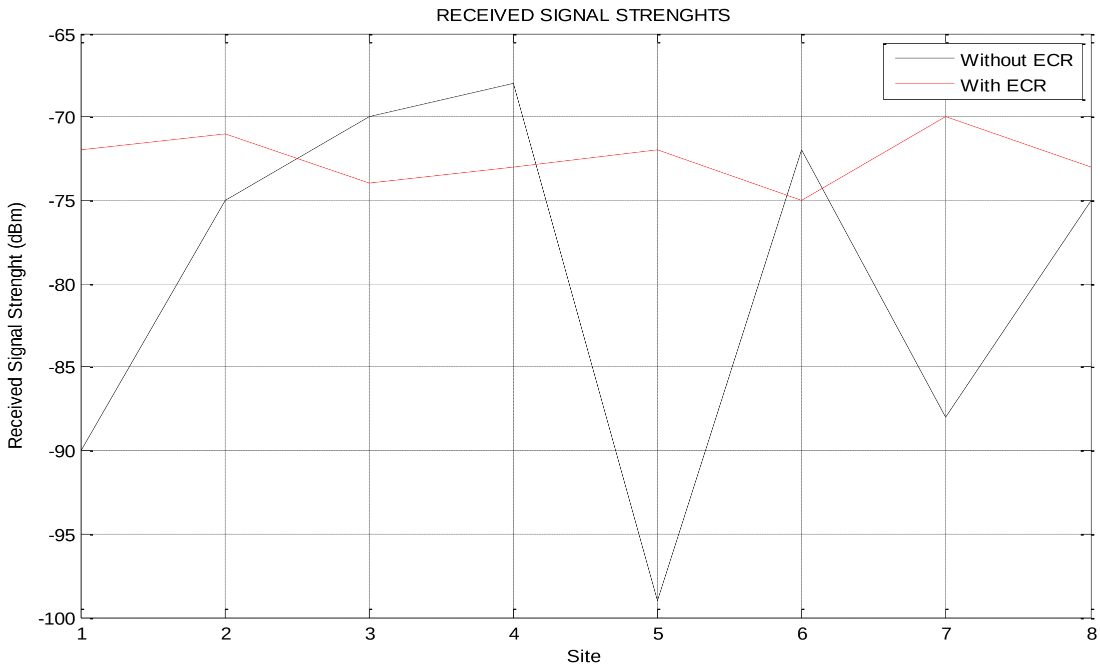


Figure 4.7: A simulated WiMAX network graph showing received signal strength (RSS) with enhanced cognitive radio and without enhanced cognitive radio

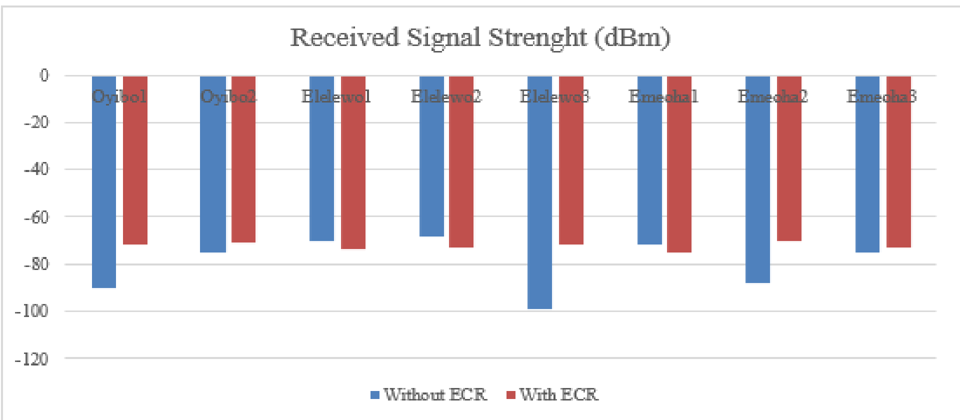


Figure 4.8A bar chart showing Received signal strength of a WiMAX network with cognitive radio and without cognitive radio

From the simulated model of WiMAX network, received signal strength using enhanced cognitive radio-based handover technique. The total received signal strength both on the empirical and with enhanced cognitive obtained was tabulated in Table 4.7 and the simulation graph presented in figures 4.7 and 4.8 respectively which is represented with a graph and a bar chart. Results shows that with the enhanced cognitive radio the signal strength was maintained within the range of -70 to -75dBm which is a strong signal while that of the empirical, the fluctuation was so erratic that it even exceeds the threshold of -89dBm as shown on the two graphs. This shows that with enhanced cognitive radio (ECR) a standard signal was maintained all through the handover process.

Table 4.8: Showing result of a WiMAX network on handover drop calls (HODC) with cognitive radio and without enhanced cognitive radio.

SITE	Without ECR	With ECR
RV0100H	26	5
RV0020H	23	5
RV0522H	38	3
RV0643H	23	2
RV0095H	24	3
RV0708H	21	2
B RV0073H	25	3
RV0111H	26	2

Figure 4.9:A simulated graph showing handover drop calls (HODC) with cognitive radio and without enhanced cognitive radio

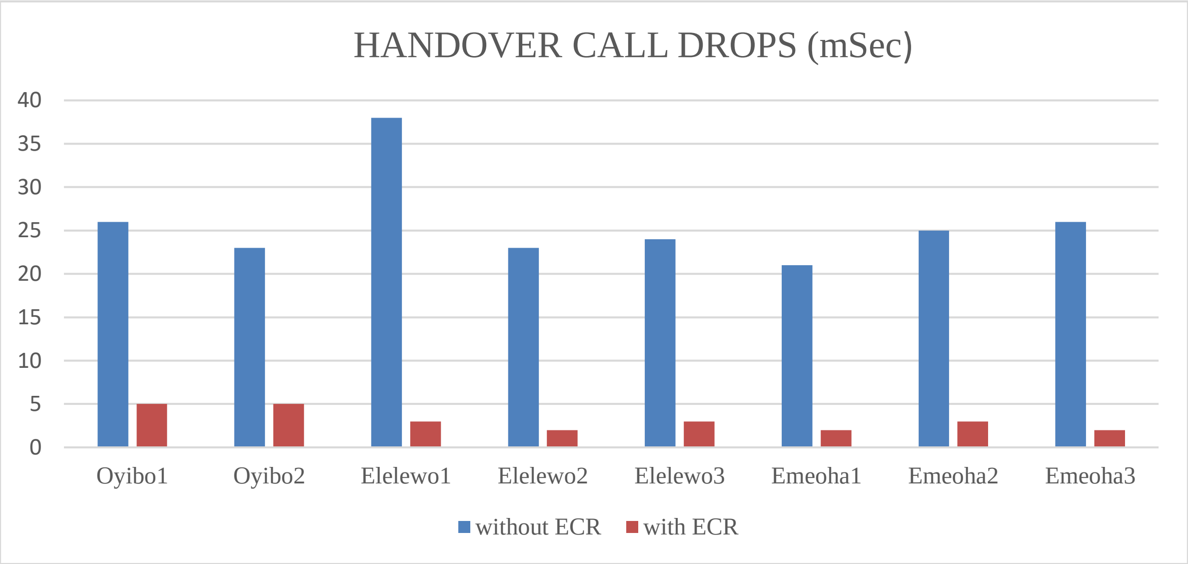


Figure 4.10: A Bar graph showing handover drop calls (HODC) with cognitive radio and without cognitive radio

From the simulated model of WiMAX network as shown in Table 4.8. The percentage handover drops calls using enhanced cognitive radio-based handover technique was presented. The simulation graph was also presented in figures 4.9 and 4.10 respectively. Results show that with the enhanced cognitive radio the handover drop calls was reduced within the range of 1-5 drop call (s) compare to the empirical result that ranged between 21-38 drop call (s) which show a good reduction in the percentage handover drop calls of 5.25% against 14.71%. This shows that with enhanced cognitive radio (ECR) percentage handover drop calls is reduced to the barest minimum.

4.7 DISCUSSION

The purpose in wireless communications is to give uninterrupted services during handover. The research work is targeted towards improving handover performance to achieve this stated objective; the cognitive radio technology was used in mobile WiMAX network base on the result

5. CONCLUSION

5.1: Conclusion

The study is on improving cell capacity to reduce call drops in mobile WiMAX radio Network with cognitive radio technology. One of the factors responsible for degradation of a network is unavailability of channels and poor signal quality during handover.

Therefore, cognitive radio technology proposed here had reduced excessive scanning and improve handover scenario on the network, thereby, making network operators to accommodate more subscribers per base station and handover efficiency improved. From our result a good percentage improvement was achieved using the technology.

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