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The Impact of Channel Dualization in A Wimax Mobile Network Using Enhanced Cognitive Radio Network

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Abstract
Long-distance wireless communication is facilitated by IEEE 802.16e, the Worldwide Interoperability for Microwave Access technology. Rather than increasing bandwidth, this research focuses on dualization, or splitting of channels to optimise handover calls during mobility. Reducing wasteful scanning and improving the handover situation on the network handover efficiency improved in locating a target base station were achieved via the implementation of an enhanced cognitive radio technology provided here. It should be mentioned that the goal of this research project was to reduce unneeded delays, reduce the number of NBSs that need to be scanned, increase throughput, and reduce the rate at which handovers fail. The intensity of the signal received, data, failures handover, and data rate all were gathered during an empirical field measurement to ascertain the signal strength from Nigeria's mobile telecommunications company, MTN. Furthermore, MATLAB was used to create a model. Simulink demonstrated through its simulations that network operators must continue to enhance network performance in order to ensure quality services. The proposed enhanced cognitive radio model is used with various mathematical assumptions as presented on this dissertation research work and was validated using MATLAB version 16.0 program. The Enhanced Cognitive Radio Technology as seen from our analysis showed greater improvement in handover failure reduction than any other radio technology. However, enhanced cognitive radio were frequencies are optimally managed through frequency dualization scheme and idle frequency borrowing scheme, were efficiently managed in this research work. a simulation was carried out which show a great improvement when analyzed on the simulated graphs.

Keywords: *Wimax, model, Enhanced cognitive radio, Simulation, Mat-lab, Channels, mobile telecommunication*

1. INTRODUCTION

According to Shivi and Qamar (2016), WiMAX, or Worldwide Interoperability for Microwave Access, is a wireless communication technology that is now the most competitive. In order to meet the demands of wireless communication systems for high-speed data capacity and spectral efficiency, WiMAX is a viable technology. In the limited spectrum, the fast expansion of wireless

applications and services has created an issue with spectrum scarcity. A new technique called cognitive radio (CR) aims to tackle this issue by making better use of available spectrum (Amzadet al, 2015). WiMAX requires channel dualization and allocation schemes in order to increase spectrum utilisation. Following a thorough drive test
Eight WiMAX BSs, several MS nodes, a backbone router, traffic flow, servers, and cognitive radio make up the topology employed for this researcht, as illustrated in Fig. [1]. Each base station has a 600 m coverage area. BS 0's placement in relation to the other 7 base stations is thoughtfully planned. Every mobile cell site has a hexagonal form. As seen in Figure 1, this cell site is related to two more cell sites.

During a call, handoff refers to the procedure of switching a mobile node's network access point without causing any data loss or disrupting the present connection. A handover mechanism allows users to continue communicating with each other when they are moving from one place to another. The service packets for the Mobile Station (MS) will be delayed and there may be a brief interruption in service when the MS moves to a different cell and completes the handover. We refer to this lag as latency time. Latency is not a problem for non-real-time services like file transfers or email. However, applications that are sensitive to delays, such streaming video services, should be delivered with a 20–25 ms delay. Real-time packets will be rejected and the likelihood of a packet loss will rise if their transmission delay exceeds the play out delay.Consequently, when an MS moves from one BS's air interface to another BS's air interface, the essential purpose of the handoff process in mobile WIMAX is to maintain connectivity. Even though handoffs are typically thought to include a serving BS changing its physical connection, this does not necessitate changing the BS. Handoffs can occasionally take place within distinct channels, which entails switching frequencies while the serving base station stays the same.

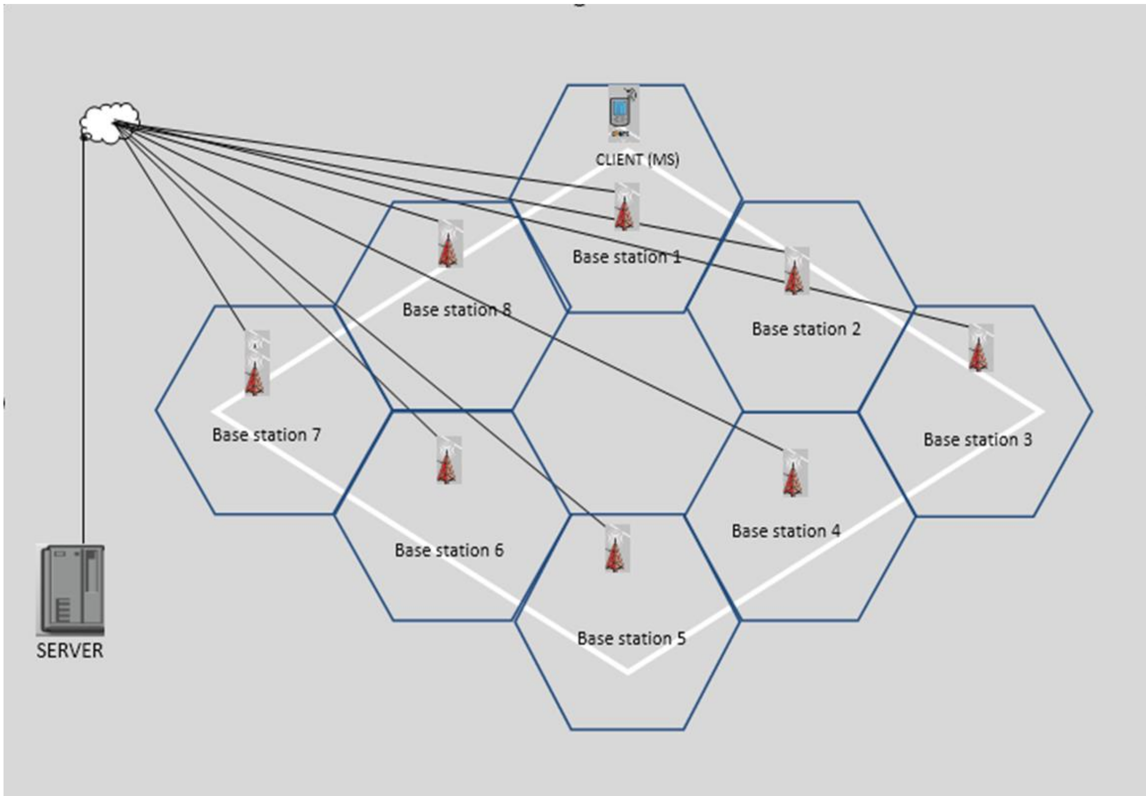

Figure 1: Topology of the Handover Process Performance in a wimax network

2. A REVIEW

Wireless communication technologies are used in every aspect of life in the modern world. The forthcoming wireless system, called WiMAX (Worldwide Interoperability for Microwave Access), makes use of IEEE standard 802.16. We can get beyond the drawbacks of current wireless communication, such as poor data rates, insecure networks, and small coverage areas, by utilising WiMAX technology (Nongjun, 2011; 1. Varade and Ravinder, 2018).The goal of WiMAX, sometimes referred to as the IEEE 802.16 wireless metropolitan area network, is to enable wireless data transmission over extended distances using a range of methods, including point-to-point links and full mobile cellular typeaccess (Shuang and Biju, 2014). This wireless digital communications system is designed for "metropolitan area networks" that use wireless technology. For permanent stations, this technology can give broadband wireless access (BWA) up to 50 kilo meter about 30 miles and for mobile stations, it can reach distances of 3 to 10 miles (5 to 15 km).

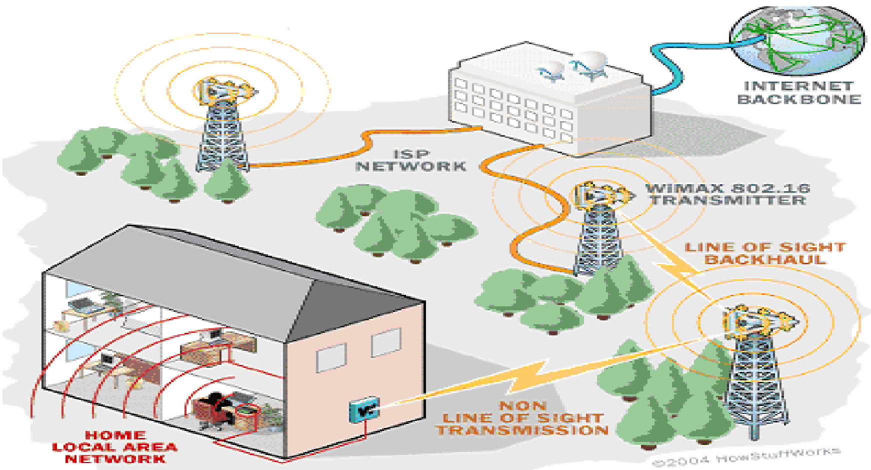

Figure 2.: WiMAX Technology an Overview (Source: Paramveer, 2015)

A visual representation of a WiMAX technology's operation is provided in Figure 2.1. a summary of WiMAX HANDOVER Technology has been given, along with information on its network architecture, MAC layer characteristics, and handover types that it supports. Actions connected to mobility and handover in cellular networks. It should be emphasised that the goal of this research project is to reduce undesired delays, reduce the number of NBSs that need to be scanned, increase throughput, and minimise the packet loss ratio caused by redundant scanning activities during Mobile WiMAX handover operations.

In order to accomplish vertical handover between LTE WiFi and vice versa without adding any new entities, Bukhari J et al. (2016) presented a cross-layer methodology. Their suggested method included a cross-layer methodology for vertical handover, using MSCTP messages for handover management and MIP messages for location management. The VHO delay, QoS scores, VHO signalling cost, and WiFi blocking likelihood are taken into consideration when comparing the suggested technique with the WiFi first approach. SNR, service class, and service quality are taken into consideration when making the handover decision in this job. Since SNR captures the true power of mobile signals, they have taken it into consideration. The mobile terminal looks through the nearby networks, selects two that have good signal-to-noise ratios (SNR), and compares the SNR to a predetermined threshold. Handover is initiated if the measured SNR exceeds the threshold and is postponed otherwise.

Enhancing Handoffs with Mobile Agents Through a scanning process, the MS looks for a target BS or BSs that are appropriate to be included to the diversity set during the handover. The neighbourhood is scanned at intervals that coincide with the MS's regular operations. When the handoff is initiated, the MOB-MSHO-REQ message contains the results of the scanning procedure.

The channel parameters—CINR (Carrier Interference + Noise Ratio) is typically employed as a HO trigger—and the quality of service offered by potential target base stations (BSs) are taken into consideration when choosing the target BS during the cell reselection process. In addition to CINR, other factors that might be considered while making a HO decision include RSSI (Received Signal Strength Indicator), relative delay, and RTD (Round Trip Delay). The HO procedure can

begin when the neighbouring BS reaches one of these criteria. By establishing suitable threshold values, the technique uses Recorded Agent Information (RAI) at the conclusion of the handoff process to enhance subsequent handoffs.Additionally, a set of threshold values for each type of application—voice, data, video, web, etc.—is produced by taking into account both the threshold values and the applications.Each MS will choose the threshold based on the active services it offers, with values announced by BS. Next, those values are changed in an effort to prevent "congestion" at the BS level by sending handoff requests concurrently. This upgrade is divided into two sections:
Based on cell current status (i.e., number of mobile stations categorised by application kinds), BS Agent derives threshold values for the parameters involved in the handoff process and communicates those values to BS MAC Layer. Next, BS transmits all thresholds via the air interface.

3. METHODOLOGY

3.1 PROPOSED DUALIZATION IN WIMAX NETWORK

The channels are dualized for both high and low pitch voices, the enhanced cognitive radio monitors the voice and assign appropriately at different frequencies. However, the female pitch always occupies the voice with a frequency range of 181hz to 300hz because of its high pitch in nature, while the male voice pitch occupies the frequency range of 0hz -180hz. In this case all the voice channels are being split into two parts of high and low pitch as the case may be. The enhanced cognitive radio appropriately and simultaneously assigns the difference voices in different ranges. This brought about an optimal utilization of the voice channels.

From borrowing of channels and splitting of channels in this research work help in fast handover of calls that is been affected earlier due to unavailability of channels during handover. This helped to improve handover calls during mobility. Figure 3.1 shows dualization of a channels for different voice channels to occupy and figure 3.2 and 3.3 show the flow graphs.

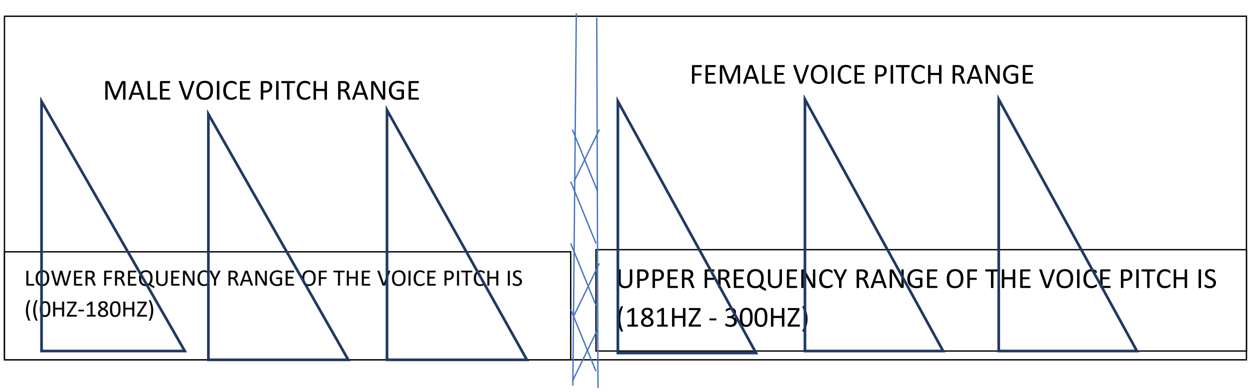

FIG 3.1 A BLOCK DIAGRAM OF A DUALIZED VOICED CHANNEL WITH DIFFERENT GENDER FREQUENCY RANGE

However, here the enhanced cognitive radio do assign a low pitch voice to the lower frequency and high pitch voice to the upper frequency as shown on the diagram of figure 3.1. 60Hz- 180Hz stand for lower frequency while 181Hz to 300Hz stands for high frequency. The voice of male beings is usually deep, bold and low and as such occupies the low frequency. Conversely, the voice of female beings usually occupies high frequency part as they are tiny having high pitch. This is shown on the algorithm of figure 3.2

3.2 ALGORITHM DEVELOPMENT FOR CHANNEL DUALIZATION TO ENHANCE CHANNEL UTILIZATION

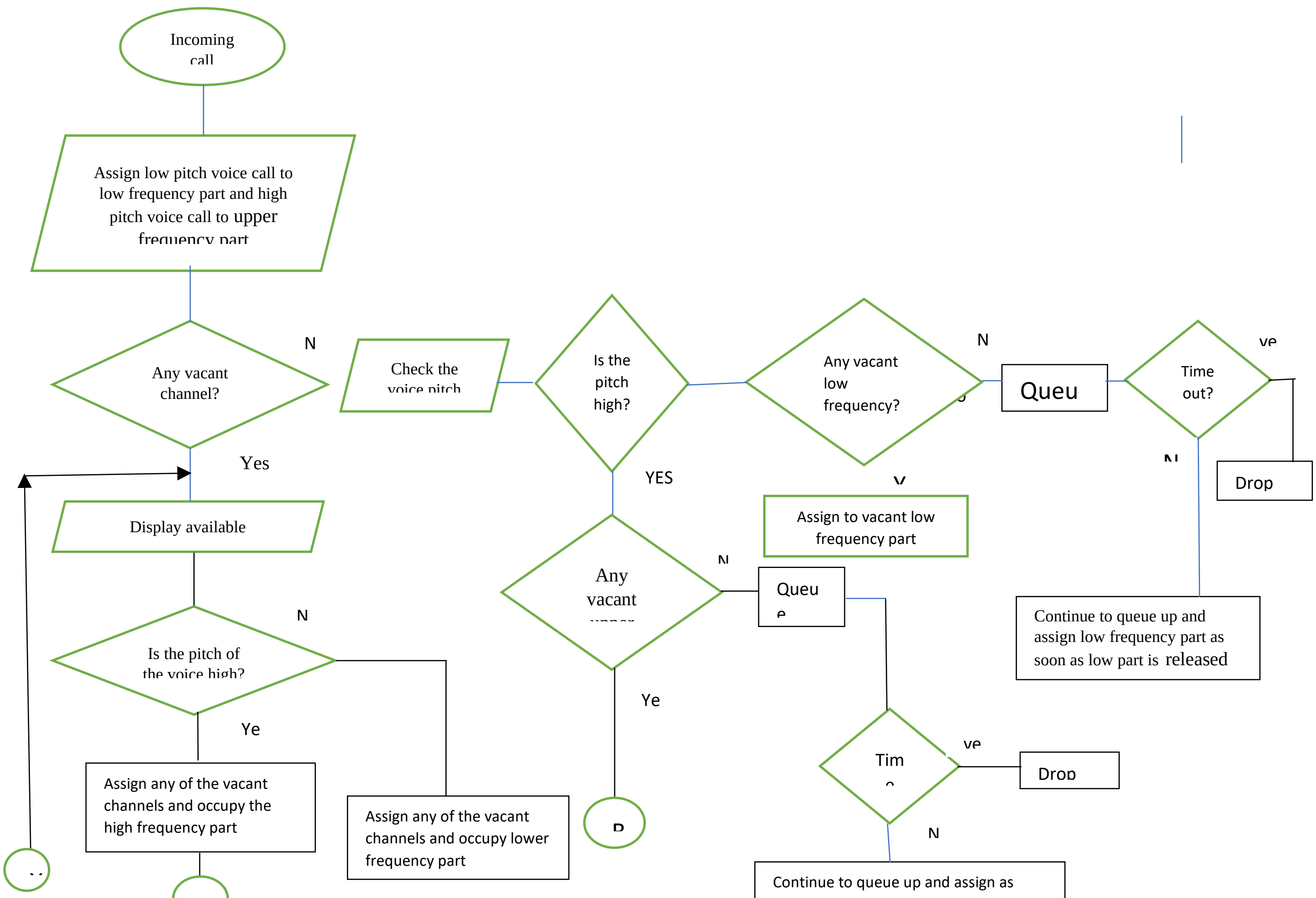

Figure 3.2 flow graph of channel dualization

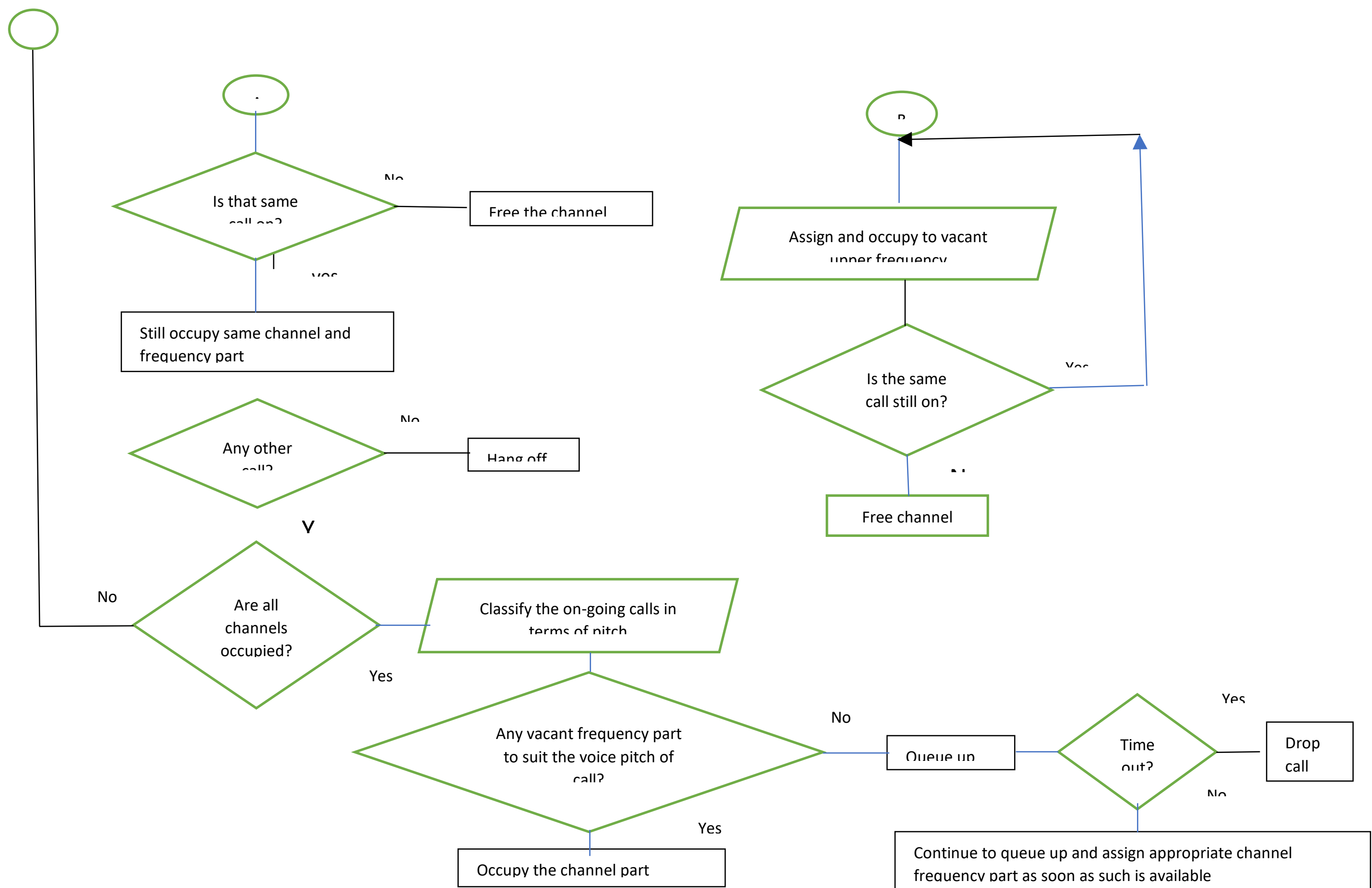

Figure 3.2 flow graph of channel dualization

3.2 System Model
MODELS TO INPUT;

For dualization of channels,

The number of channels available per cell (Nca1) = 96;

Knowing that not all channels are dualized, assume ¼ of the channels are dualized, the number of channels available becomes;

$$N_{ca2} = \left(N_{ca1} \times \frac{1}{4}\right) + N_{ca1}$$

For blocking probability;

$Pb = \frac{1}{100N_{ca2}}$ (1)

Where Pb is the call probability

$Nd = N_4 \times \frac{N_5}{100}$ (2)

Where N_d is the number of drop call per minutes, N5 is the number of call attempts in busy hour, and N4 signifies the drop call rate. The different conditions of N4 are specified below

- At the system without cognitive radio, N_4 is 1.7616188
- At the system with cognitive radio, N_4 is 1.13326
- At the system with cognitive radio and handover booster in form of converter, N_4 is 0.177158.

Then the number of drop calls per cell becomes;

$N_{dc} = \frac{N_d}{N_{AC}}$ (3)

Where N_{dc} is the number of drop calls per cell, N_d is the number of drop calls per minute and N_{AC} is the number of active base stations.

To determine the traffic intensity per cell T_{ipc},

$T_{ipc} = \frac{N_T}{N_{AC}}$ (4)

Where N_T is the traffic intensity in the MSC per day

To determine the channel utilization Cu;

$Cu = \frac{1}{Esg}\frac{T_{ipc}}{N_C}$ (5)

Where E_{sg} I the statistical gain, N_c being the number of channels per day.

To determine the call attempts in busy hour per cell (N_{bh})

$N_{bh} = \frac{N_{ca}}{N_{AC}}$ (6)

Where N_{ca} is the number of call attempts in busy hour

For call arrival rate in busy hour Cab;

$C_{ab} = \frac{N_{bh}}{3600}$ (7)

For handoff call arrival rate Har;

$H_{ar} = \frac{C_{ab}}{N_{cr}}$ (8)

Where N_{cr} is the new call arrival rate.

The remaining models are summarized in the presented below

Table 3.1

S/N	Parameter Description	Scheme I : Existing Non-Priority Non-Cognitive Radio BasedHandoff (NPNCRBH) Scheme	Scheme II : Proposed Non Prioritized Cognitive Radio Handoff (NPCRBH) scheme with booster (converter)
1	**Statistical gain factor**	$\mathbf{g}_e = 1$	$\mathbf{g}_e = 1+\varepsilon_e$
	Statistical gain factor for New Call	$\mathbf{g}_N = \mathbf{g}_e = 1$	$\mathbf{g}_N = \mathbf{g}_e = 1+\varepsilon_e$
	Statistical gain factor for Handoff Call	$\mathbf{g}_H = \mathbf{g}_e = 1$	$\mathbf{g}_H = \mathbf{g}_e = 1 + \varepsilon_e$
2	**The offered traffic or traffic intensity**	$\rho = \frac{\lambda}{\mu} = \frac{(\lambda_N + \lambda_H)}{(\mu_N + \mu_H)}$	$\rho_{a(\mathbf{NPCRH})} = \frac{\rho}{\mathbf{g}_e}$

A simulink model was developed for the above research work which was used to simulate our work in a matlab environment

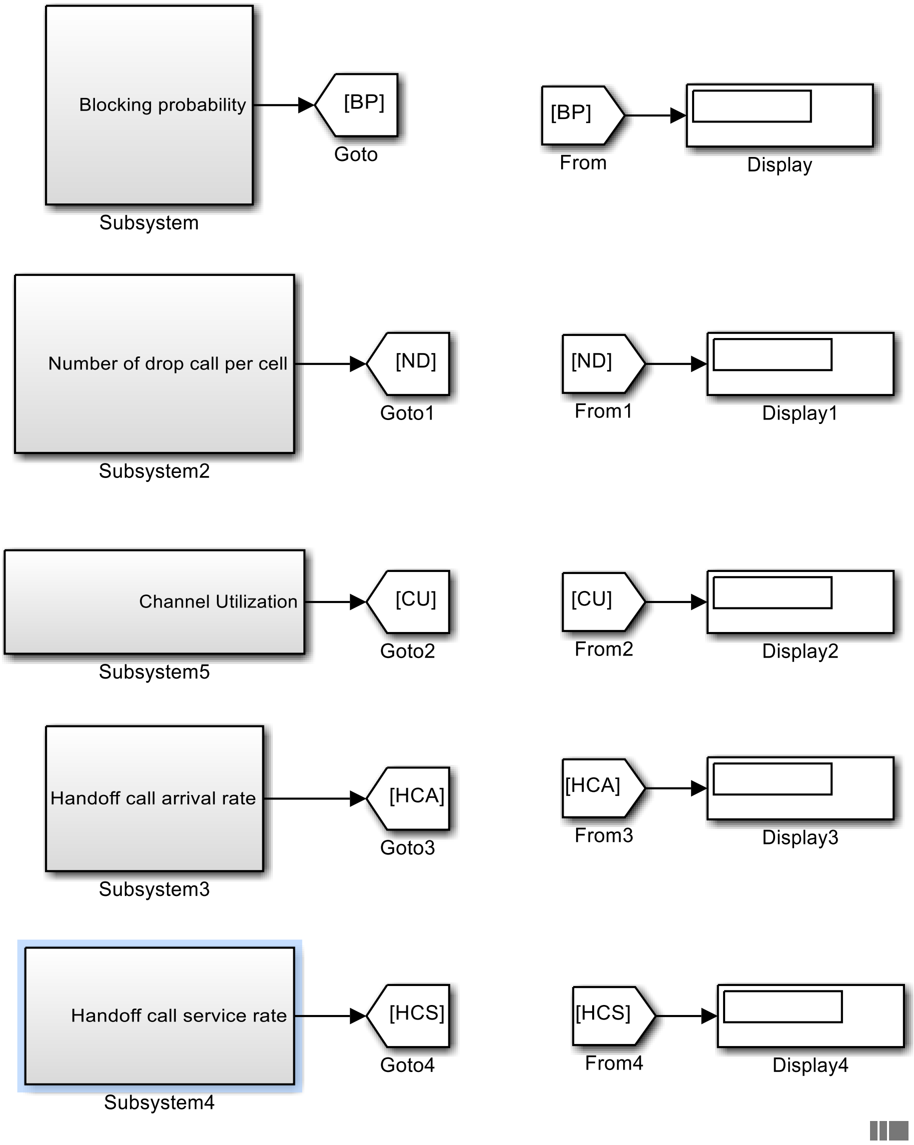

Figure 3.4 A simulink model for the proposed work

4. SIMULATION STUDY AND RESULTS

4.1 SIMULATION OF ENHANCED COGNITIVE RADIO USING MAT LAB SIMULINK

Table 4.1 Simulations parameter

parameter	values
Channel Bandwidth	12
System Loading	100%
Channel frequency 2.4 GHZ	Channel Bandwidth (MHZ) 20
Channel frequency 2.4 GHZ	Channel Bandwidth (MHZ) 20
BS antenna height	37
MS antenna height	1,8

Power of BS Transmitted (dbm)	40
Duration Frame (ms)	40
Transmitted Power	20(dbm)
Simulation Time	600 Seconds
Number of sub-channel per	20
Handoff Gain (dB)	4.5
HARQ Gain (dB)	4
Gain (dB)	0
Margin of the inference (dB)	3
Penetration Loss (dB)	21
Signal to noise ratio (dB)	-175
Rx Density Noise (KHZ)	543.14
Bandwidth Noise (HZ)	67.40
Bandwidth Noise (dB)	-105.70
Receiver Noise Power (dB)	-105.70
Receiver Sensitivity (dB)	

Here we used matlab simulators to validate our results , one from drive test gotten from field test and the simulated work done in the laboratory and we compare our results to see the improvement. The field result is termed Without ECD, which stands for without enhanced cognitive radio and with ECR , which stands for enhanced cognitive radio

Table 4.2: Displaying network of wimax channel utilisation (CU) comparison between Absence of Enhanced CR and Presence of Enhanced CR

STATION	ABSENCE Enhanced CR	USING Enhanced CR
RIVERS 0120B	79.00	84
RIVERS 0130B	86.00	85
RIVERS 0142B	78.00	84
RIVERS 0153B	84.00	83
RIVERS 0165B	88.00	89
RIVERS 0178B	87.00	91
RIVERS 0183B	84.00	87
RIVERS 0191B	85.00	86

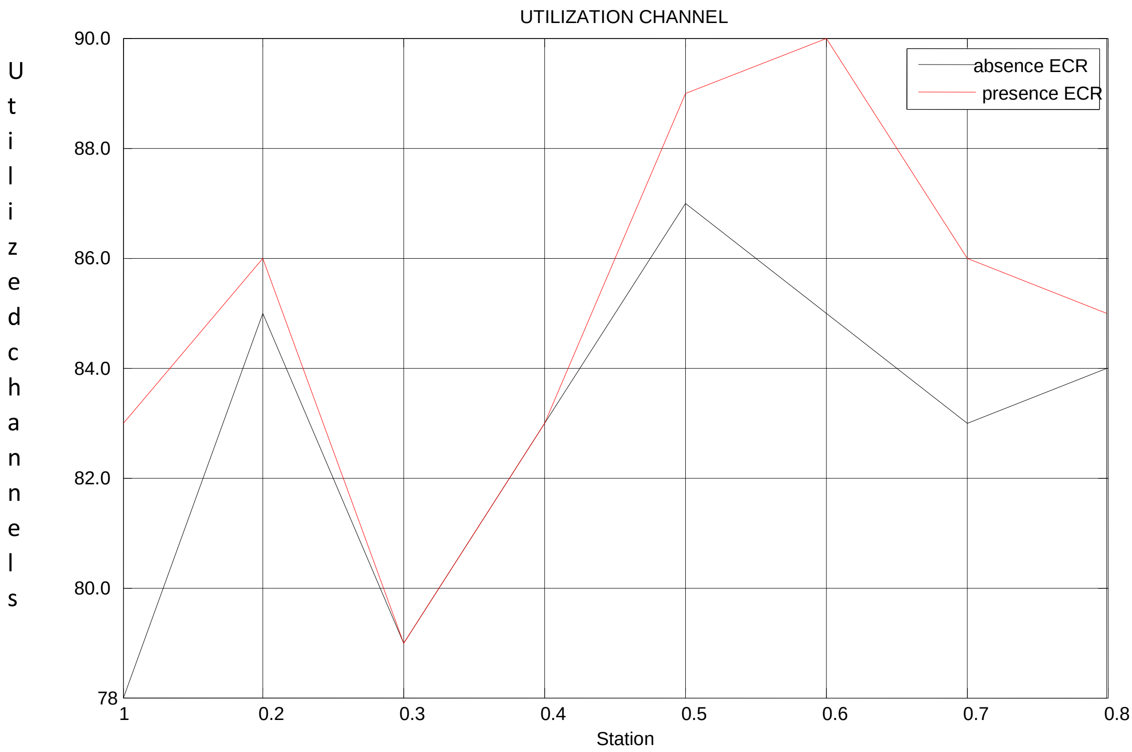

Figure 4.1: Channel utilisation (CU) with and without enhanced cognitive radio, graph represented

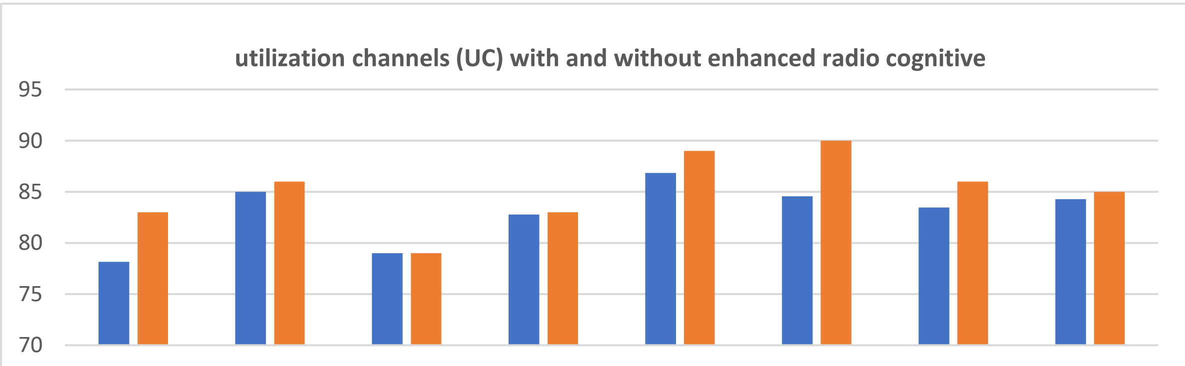

Figure 4.2: Percentage channel ultilization

simulated graphs are displayed in fig 4.1 and 4.2, as shown. According to these findings, compared to the empirical result, the enhanced cognitive radio demonstrated a comparatively higher percentage of channel utilisation because every channel was being used to its full potential.

Table 4.3 : displaying the handover delay (HOD) results for a wimax network both with and absence of improved cognitive radio.

STATION	ABSENCE Enhanced CR	USING enhance CR
RIVERS 0120B	10.67	7.64
RIVERS 0130B	10.46	0.67
RIVERS 0142B	16.43	0.93
RIVERS 0153B	10.32	1.198
RIVERS 0165B	10.27	3.41.
RIVERS 0178B	10.35	2.07
RIVERS 0183B	10.02	4.34
RIVERS 0191B	10.47	0.07

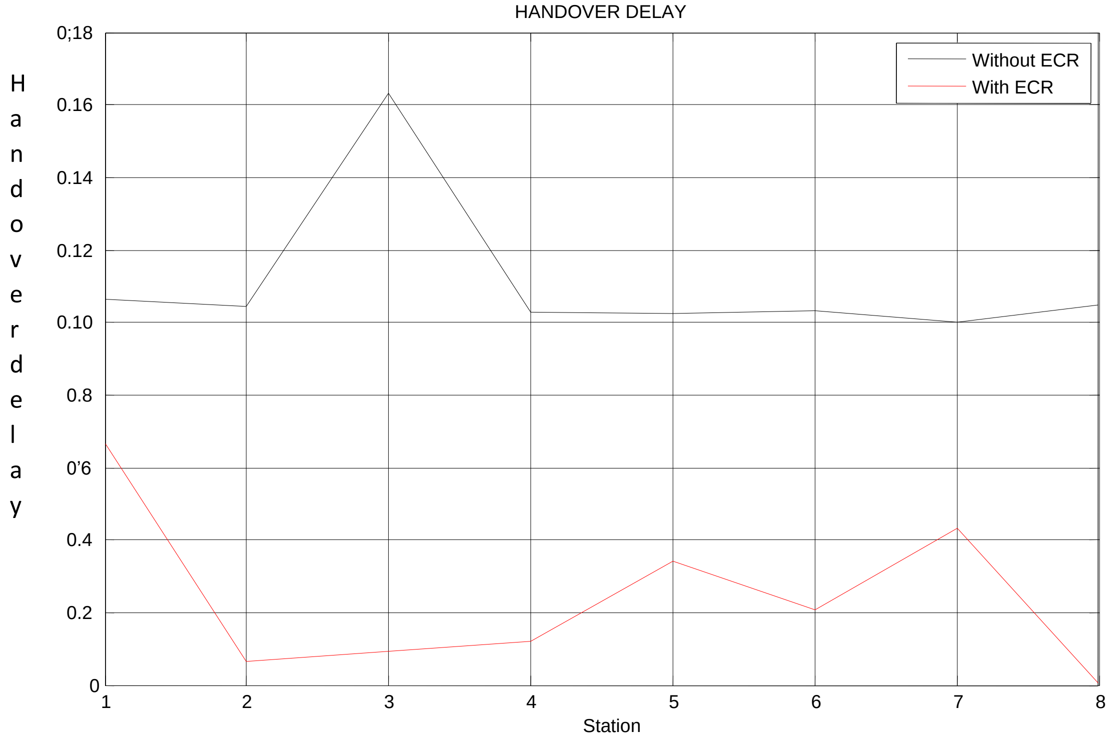

Figure 4.3: A hypothetical graph that compares the percentage of handover delays (HOD) using ECR and absence of enhanced cognitive radio

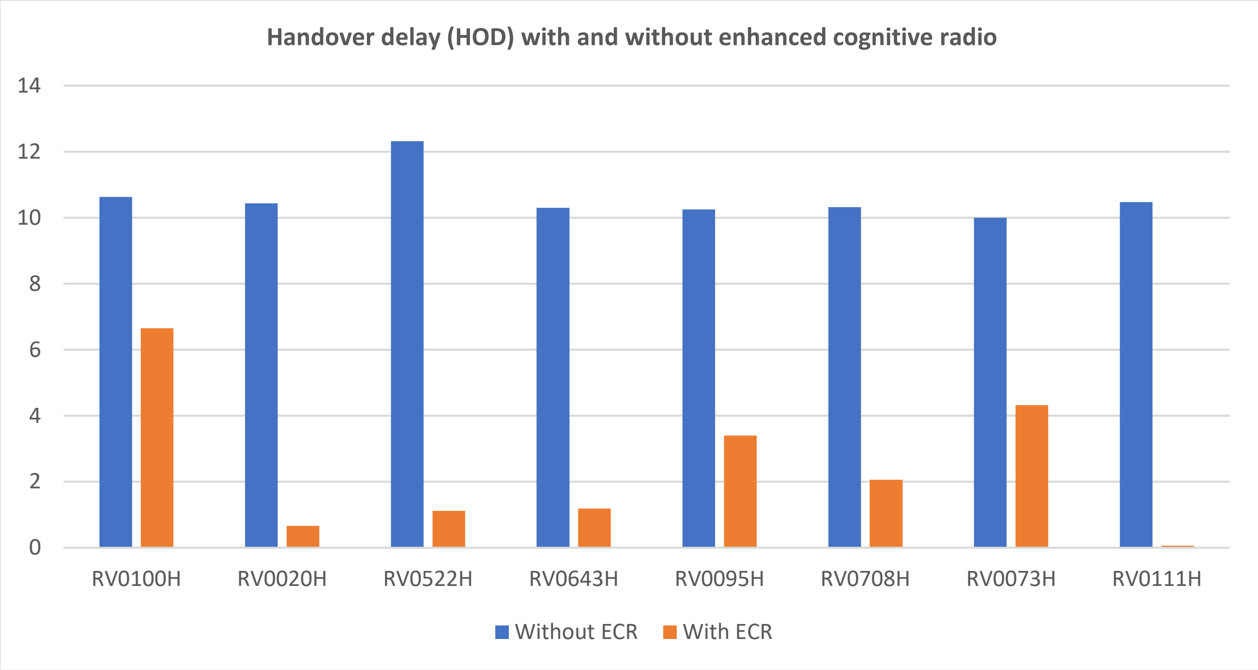

Figure 4.4 handover delay with and without enhanced cognitive

nique was used to illustrate the handover latency. Additionally shown in figures 4.3 and 4.4, respectively, was the simulation graph. The results demonstrate a good reduction in the handover latency, with the enhanced cognitive radio reducing the handover delay within the range of 0.06-6.56(S) compared to the empirical result, which ranged between 10.00-12.32 (S). This demonstrates that, when compared to the empirical method, changeover delay is much decreased with enhanced cognitive radio (ECR). Nonetheless, the suggested technique's performance rating was high, and an improvement was made.

Table 4.4: displaying the handover call service rate (HOCSR) results for a wimax network both with and without improved cognitive radio.

STATION	ABSENCE ECR	USING ECR
RIVERS 0120B	0.01711	0.878
RIVERS 0130B	0.01842	0.667
RIVERS 0142B	0.01523	0.723
RIVERS 0153B	0.01424	0.59
RIVERS 0165B	0.01675	0.42
RIVERS 0178B	0.01586	0.56
RIVERS 0183B	0.01657	0.51
RIVERS 0191B	0.01378	0.67

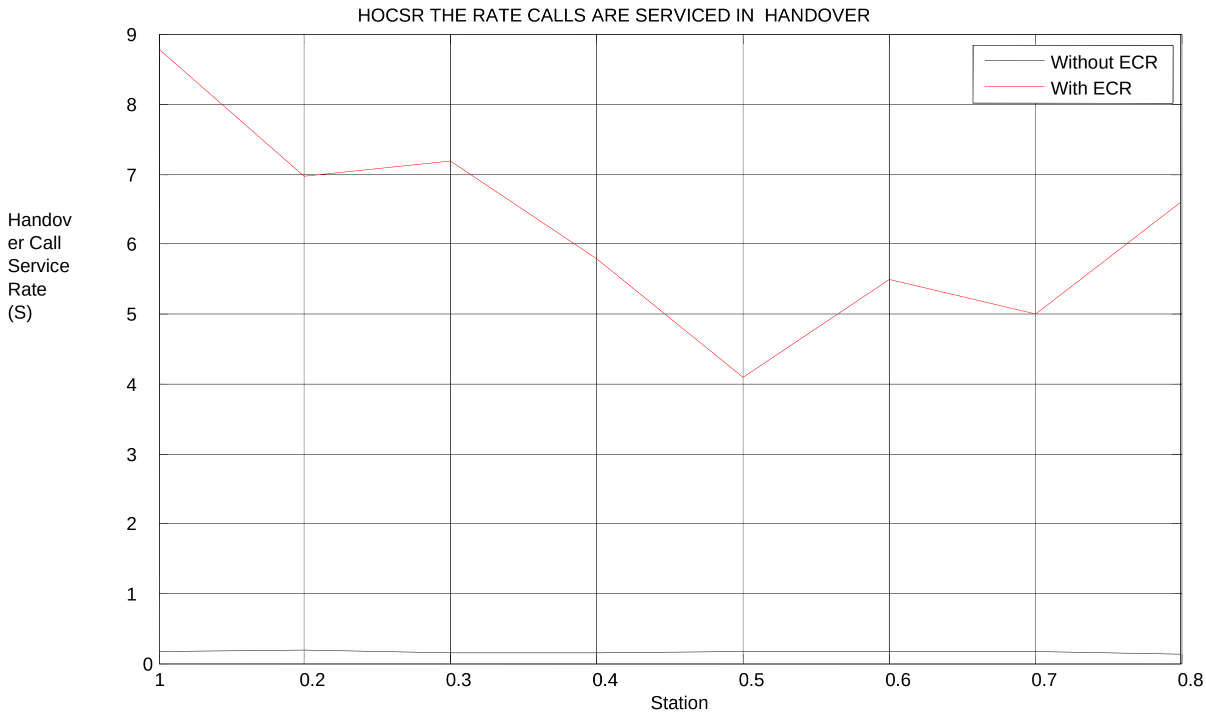

Figure 4.5: A fictitious graph that compares the handover call service rate (HOCSR) using ECR and absence of enhanced cognitive radio

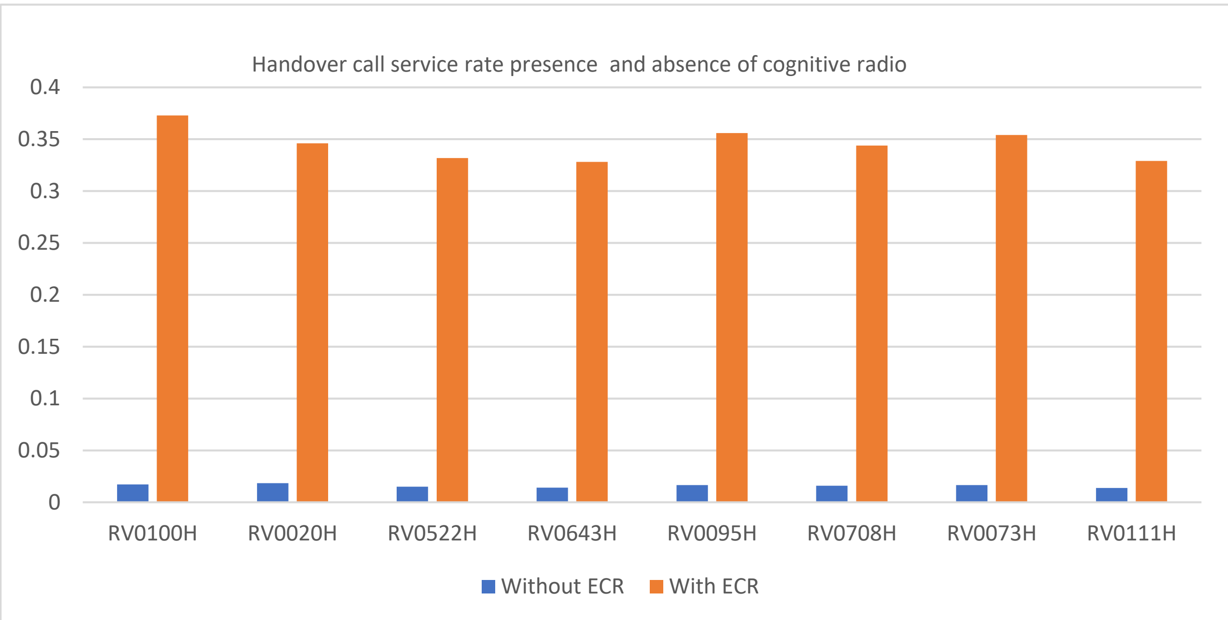

Figure 4.6 Handover call service rate presence and absence of cognitive radio

According to the handover call service rate data shown in table 4.3, there was a rise in the rate of handover calls with enhanced cognitive radio. Furthermore, figures 4.5 and 4.6, respectively, display the simulation graphs. In contrast to the empirical finding, which varied between 0.0137 and 0.0184 (s), the enhanced cognitive radio technique demonstrated a high percentage handover call service rate (between 0.329 and 0.373 (s)) based on the collected results. These findings suggest that, when compared to the empirical technique, the percentage handover call service rate increased significantly with enhanced cognitive radio (ECR). Because of this, enhanced cognitive radio (ECR) is now the technology of choice for handover analysis.

5. CONCLUSION AND RECOMMENDATION

By dualizing channels using improved cognitive radio technology, the study aims to improve handover in mobile WiMAX radio networks. Lack of channels during handover and poor signal quality are two things that contribute to a network's bad degradation. These handover errors can happen at any time, but they are more common around holidays like Christmas, Sala, convocation, matriculation, and other celebrations.
However, from all the analysis presented we observed that there was a great improvement when enhanced cognitive radio network was used on the dualized channels. The percentage improvement is above 20% therefore we suggest that channels can be dualized to manage any available channel already installed. Enhanced cognitive radio plays the intelligent rule on the network.

In addition, our mobile radio communication network will experience fewer handover failures if the NCC standard is used or implemented with 100% compliance. However, observations reveal that network operators' primary goal is to increase subscriber base without even taking into account the potential negative effects on existing subscribers.
The proposed enhanced cognitive radio model is used with various mathematical assumptions as presented on this dissertation research work and was validated using MATLAB version 16.0 program. The Enhanced Cognitive Radio Technology as seen from our analysis showed greater improvement in handover failure reduction than any other radio technology.

Thus, the enhanced cognitive radio technology that is being suggested here will lessen excessive scanning and enhance the network's handover scenario, This will help network operators to accommodate more subscribers per base station thereby enhance efficiency in handover calls.

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