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Original Research Article

Using System Program Embedded Approach for Quality of Service Improvement in 3G Network

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Abstract

With the ever-growing preference of the WCDMA technology, poor signal quality continues to affect the performance of 3G network. The paper uses a Solution Algorithm Embedded in a System Program (SAESP) to improve signal quality in the WCDMA network. This was done by characterizing the radio environment to identify factors that affected the Quality of Service (QoS). The parameters that triggered network snags were used to model a software based intelligent system which was done in an algorithmic approach. The result from the Solution Algorithm Embedded in a System Program (SAESP) showed an improvement of 33.60% on the signal quality of the test route.
Keywords: WCDMA; cellular network; QoS; solution algorithm; SAESP; system program.

INTRODUCTION

Wideband code division multiple access (WCDMA) is a 3rd Generation Partnership Project (3GPP) mobile communication system [1]. It provides clearer voice quality and high-speed multimedia services with a bit rate up to 2Mbps [2]. The WCDMA network is designed to perform Inter-Radio Access Technology (IRAT) with Global System for Mobile Communication (GSM) and the long Term Evolution (LTE) [3]. The WCDMA architecture is divided into three (3) parts which are the user equipment, UMTS Terrestrial Radio Access Network (UTRAN) and the Core Network (CN). Telecommunication service has gradually metamorphosed from just having a wide coverage to also providing good Quality of Service (QoS) which encompasses good signal quality.

The signal to nose ratio (Ec/No) measures the signal quality in WCDMA. The Receive Signal Code Power (RSCP), Receive Signal Strength Indicator (RSSI), Transmit Power (TxPwr), Signal to Interference Ratio (SIR) and the Block Error Rate (BLER) contributes to the Ec/No output.

Related Work

Quality of service in any network or system is the fulcrum for the sustainability of such system. This is dependent on the end users' satisfaction with the services provided by system [4, 5]. The major problems faced by mobile network operators are its ability to manage their QoS [6]. The network challenges experienced by the mobile users negates their view about the system. In the under developed world, the quality of service challenges is so alarming that most times the congestion level is likened to what happened in the olden days when local dwellers queue up in line to fetch water from a pipe borne water. These have led to mobile users subscribing to different mobile networks [6], they end up carrying several mobile lines to have access to any reliable network within their coverage area. In Nigeria, experiences abound with incessant call drops, challenges in mobile accessibility, and delay in download of data [7]. These need to be addressed as they have negative effect on the economic growth of a nation as communication is a major driver of any economy [8, 3]. Opined that congestion is a major event that leads to a deterioration of system Quality of Service (QoS), she proffered managing congestion from tripartite point of view; where there is Service Level Agreement (SLA) installed in the system of the network providers, the end users, and the monitoring body using an intelligent agent based approach. From the simulation result, the system could identify parameters leading to low quality of service and high priority customers were given priority attention by ensuring that they meet up with SLA agreement. Despite this proposition, the network parameters that triggered the drop in quality of service was not addressed, rather perceived preference was given to high networth individual which only ensures quality for only certain class of individuals. This idea did not address QoS from holistic view. Also, poorly designed handoff schemes tend to generate very heavy signaling traffic and, thereby, causes a dramatic decrease in quality of service (QoS) [9, 10]. Hong [9] proposed a handoff scheme to reduce call drop due to poor handoff, as poor handoff contributes to poor quality of service. "A Neural Network approach to GSM Traffic congestion prediction" based on multilayer perception neural networks with sigmoid activation function and Levernberg Marquardt Algorithms [11]. Proposed improving QoS by reducing the block call probability using Xie and Kuek's traffic model [12]. Tried to enhance the wireless network performance by applying "A hybrid-fail dynamic channel allocation method in GSM system", the system was able to minimize the blocking rate of the network [13]. Proposed an intelligent agent-based approach using case based reasoning, the result of their work showed that about 5.23% of software related network accessibility parameters that affected the network performance were resolved. Also [14], evaluated a fuzzy based admission control scheme to overcome measurement and traffic error. With all these proposition, the issue of quality of service in wireless network still persist. This article, presents a system program embedded approach for quality of service improvement in WCDMA.

METHODOLOGY

The study uses a solution algorithm embedded in a system program system to improve signal quality during traffic session on the WCDMA network. The research procedure is divided into two (2) parts: The network characterization that studies the network to understand the root causes of poor signal quality, and the system program network simulation that implements solutions to the studied root causes of poor signal quality.

Network Characterization

The method of drive test was used to characterize the network using the experimental setup shown in Fig-1. The experimental setup uses a Testing Equipment for Mobile System (TEMS) software license V13.0 install on the laptop, a Testing Equipment for Mobile Systems (TEMS) mobile phone, a GPS and a power inverter. Voice calls were made for 120secs on the Mobile Telecommunication Network Nigeria (MTNN) network by the mobile phone. The test covered the Enugu metropolis in Enugu State, Nigeria. This technique was adopted to evaluate in real time, the areas of poor signal quality of the network under study during the research timeframe with an aim of studying the causes of poor signal quality and proffering solutions to them. Long calls lasting 10minutes were made during the test.

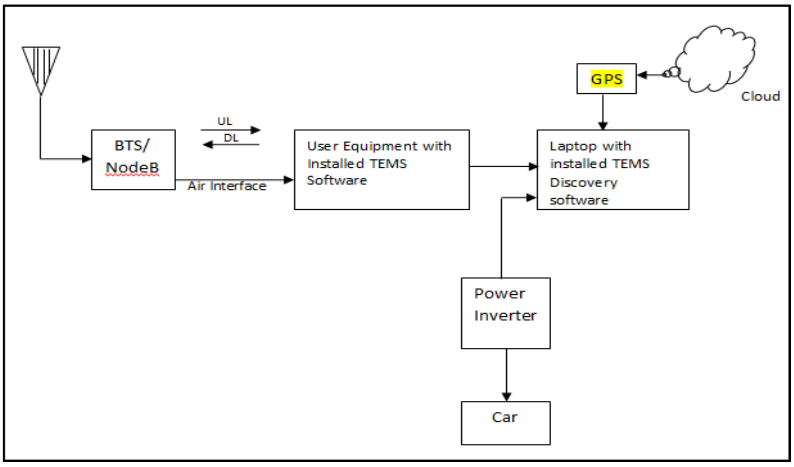

Fig-1: Drive test experimental setup

Network Characterization Parameters

During network characterization (drive test), voice calls are made from the originating to the terminating device respectively. The signal quality received at the terminating end is measured by the Ec/No. The Ec/No is the ratio of the energy per chip (Ec) of the pilot channel (PCH) to the total noise power density (No) simply put as the ratio of Received Signal Code Power (RSCP) to the Received Signal Strength Indicator (RSSI). It shows the kind of signal quality received at the terminating end during a traffic session and measured in dB. It ranges from 0 to -30dB.

Table-1 shows an abridged network characterization output from TEMS Discovery

Table-1: Abridged network characterization result

Time	Date	Latitude	Longitude	Ranked Ec/Io: Top 1	Ranked Ec/Io: Top 2	Ranked Ec/Io: Top 3	Ranked Ec/Io: Top 4	Ranked PSC: Top 1	Ranked PSC: Top 2	Ranked PSC: Top 3	Ranked PSC: Top 4	Lack of Dominant Pilot	Poor Active Set Pilot Quality	Strong DL Interference Alert	Weak Pilot Alert
08:44:33.000	10/1/2016	6.5010350	7.5145050	-11.6	-12.3	-12.6	-13.2	503	247	231	70				
08:44:35.000	10/1/2016	6.5010350	7.5145050	-12.0	-12.8	-13.1	-13.5	503	247	231	70				
08:44:36.587	10/1/2016	6.5010350	7.5145050									Lack of Dominant Pilot			
08:44:36.699	10/1/2016	6.5010350	7.5145050									Lack of Dominant Pilot	Poor Active Set Pilot Quality		
08:44:37.000	10/1/2016	6.5010350	7.5145050	-9.9	-13.3	-13.6	-14.3	385	70	503	247				
08:44:37.080	10/1/2016	6.5010350	7.5145050												
08:44:38.146	10/1/2016	6.5010350	7.5145050										Poor Active Set Pilot Quality		
09:55:09.000	10/1/2016	6.4820000	7.4865380	-14.6	-13.3	-11.9	-21.2	388	23	90	372				
09:55:09.744	10/1/2016	6.4819903	7.4865541												Weak Pilot Alert
09:55:10.063	10/1/2016	6.4819868	7.4865621										Poor Active Set Pilot Quality		Weak Pilot Alert
09:55:10.715	10/1/2016	6.4819794	7.4865782										Poor Active Set Pilot Quality	Strong DL Interference Alert	Weak Pilot Alert

WCDMA poor signal quality causes considered are:

Lack of Dominant Pilot

This happens when there are three (3) or more cells in the active set with an RSCP difference above -5dBm serving a particular area (pilot pollution). Since there is no strongest or dominant performer/cell, the signal quality is affected by the pollutants.

Poor Active Set Pilot Quality

This happens in areas of limited or no coverage from the operator. The Pilot or active set is far from the affected area. In an area of limited or no coverage, there's bound to be no or affected quality.

Strong DL Interference Alert

In WCDMA, the kind of interference experienced is the external interference where there is no or affected Line of Sight (LoS) for signal propagation between the antenna and the User Equipment (UE). Where there is no LoS, the signal quality is highly affected. Also, presence of a water-body affects the signal quality.

Weak Pilot Alert

Weak pilot alert occurs on a cell with alarm on it. The radio environment appears to be very poor at a distance below 150metres away from the cell.

Network Characterization Result

Three major ranges were set to capture and interpret the transmitted signal quality. They are Good (-1 to -14), Poor (-14 to -18) and No Quality (-18 t0 -30).

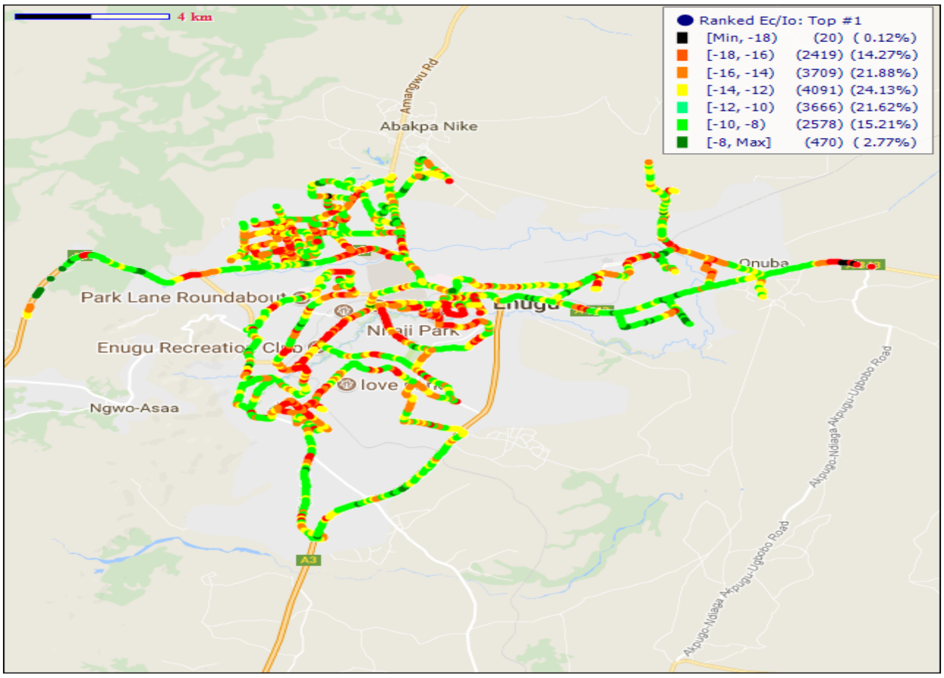

Fig-2: Signal quality plot from network characterization in Enugu Metropolis

Table-2: Signal quality count from network characterization

CPICH EcNo STATUS			STATISTICS		
CPICH Ec/No Range	Samples	% Contribution	Cumulative %	%	Remarks
[-10, Max]	470	2.77%	2.77%	63.73%	GOOD
[-10, -8]	2578	15.21%	17.98%		
[-12, -10]	3666	21.62%	39.60%		
[-14, -12]	4091	24.13%	63.73%		
[-16, -14]	3709	21.88%	85.61%	35.15%	POOR
[-18,-16]	2419	14.27%	99.88%		
[Min, -18]	20	0.12%	100.00%	0.12%	NO QUALITY

The current state of the network shows that there is degraded signal quality in more than 30% of the areas in Enugu metropolis as at the time the drive test was carried out and causes count are shown in Table-3 below.

Table-3: Poor signal quality causes contribution (network characterization)

Poor Signal Quality Causes	Count
Lack of Dominant Pilot	1412
Poor Active Set Pilot Quality	86
Strong DL Interference Alert	1785
Weak Pilot Alert	117

From the network characterization, most of the causes of poor signal quality are software-related (poor active set plot quality and strong DL interference alert).

Research Target

The paper uses system programs at improving signal quality in the WCDMA network using a solution-algorithm embedded in a system program system. The good signal quality (63.73%) transmitted falls short of the regulatory threshold 0f above 90% and as such the need for optimization of the network

System program Procedure

Figure-3 illustrates the solution structure/flowchart of the system program used to improve the network signal quality. The UE camps on the WCDMA technology, goes through the process of initiating a call and starts a traffic session. When there is poor signal quality transmitted over the network, the software quickly identifies the cause, performs the assigned solution and evaluates the performance of the network.

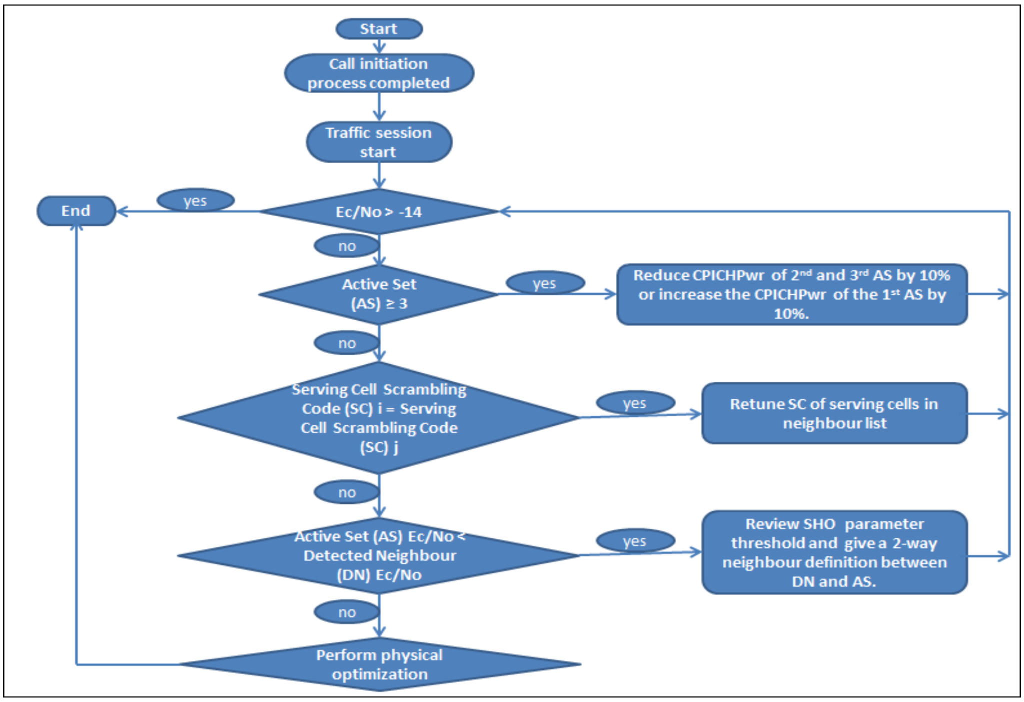

Fig-3: System program flowchart

The proposed software is installed on systems in the Mobile Switching Centre (MSC) to avoid software-related causes of poor signal quality as shown in Fig-4.

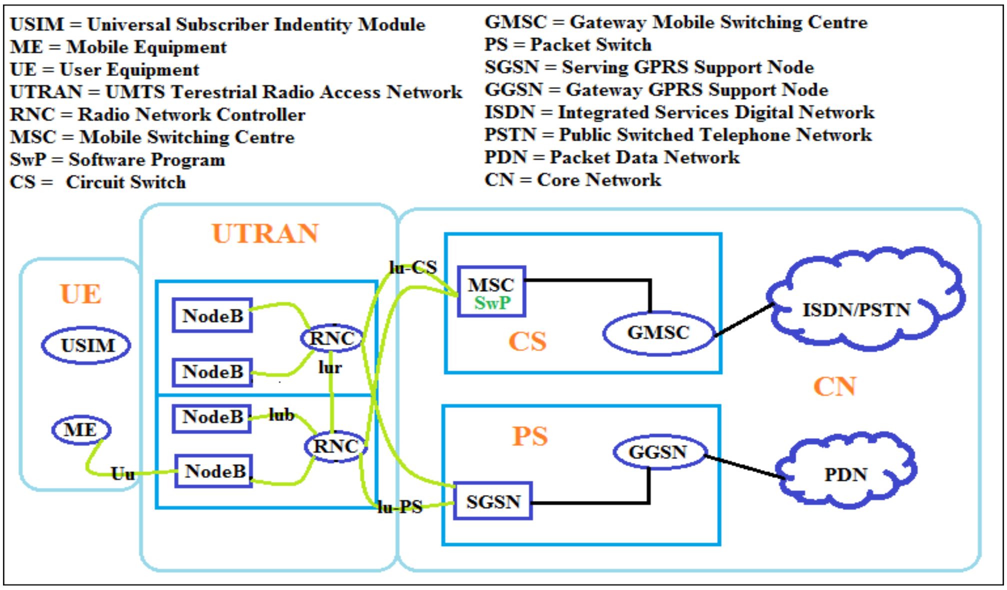

Fig-4: Proposed WCDMA Network Architectural Design

RESULT AND ANALYSIS

The MSC receives prompts of poor signal quality then uses the system program to stop the prompt from continuing. The performance of the system program is measured by the number of prompts it gets before it acts.

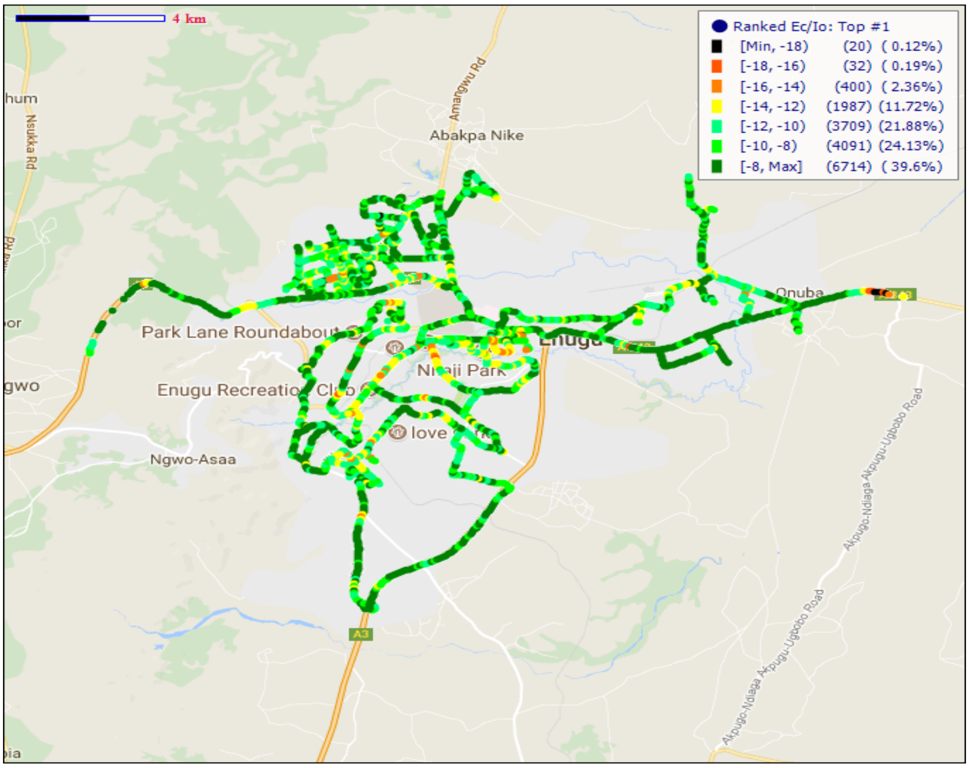

Fig-5: Signal quality plot from system program

Table-4: Signal quality count from system program

CPICH EcNo STATUS			STATISTICS		
CPICH Ec/No Range	Samples	% Contribution	Cumulative %	%	Remarks
[-10, Max]	6714	39.60%	39.60%	97.33%	GOOD
[-10, -8]	4091	24.13%	63.73%		
[-12, -10]	3709	21.88%	85.61%		
[-14, -12]	1987	11.72%	97.33%		
[-16, -14]	400	2.36%	99.69%	2.55%	POOR
[-18,-16]	32	0.19%	99.88%		
[Min, -18]	20	0.12%	100.00%	0.12%	NO QUALITY

Table-5: Poor signal quality causes contribution (system program)

Poor Signal Quality Causes	Solutions	Count
Lack of Dominant Pilot	Reduce CPICHPwr of the 2nd and 3rd AS or increase the CPICH of the 1st AS by 10%	25
Poor Active Set Pilot Quality	Physical Optimization	86
Strong DL Interference Alert	a.) Retune PSCs of SCs in neighbour list b.) Review SHO threshold and give a 2-way neighbour definition between Detected Neighbour (DN) and Active Set (AS)	21
Weak Pilot Alert	Physical Optimization	117

Table-6: Abridged system program result

Time	Date	Latitude	Longitude	Ranked Ec/Io: Top 1	Ranked Ec/Io: Top 2	Ranked Ec/Io: Top 3	Ranked Ec/Io: Top 4	Ranked PSC: Top 1	Ranked PSC: Top 2	Ranked PSC: Top 3	Ranked PSC: Top 4	Lack of Dominant Pilot	Poor Active Set Pilot Quality	Strong DL Interference Alert	Weak Pilot Alert	Software Action/Output
08:44:33.000	10/1/2016	6.5010350	7.5145050	-11.6	-12.3	-12.6	-13.2	503	247	231	70					Increase CPICHPwr of Top1 by 10% to aviod poor signal quality.
08:44:35.000	10/1/2016	6.5010350	7.5145050	-12.0	-12.8	-13.1	-13.5	503	247	231	70					
08:44:36.587	10/1/2016	6.5010350	7.5145050									Lack of Dominant Pilot				
08:44:36.699	10/1/2016	6.5010350	7.5145050									Lack of Dominant Pilot	Poor Active Set Pilot Quality			
08:44:37.000	10/1/2016	6.5010350	7.5145050	-9.9	-13.3	-13.6	-14.3	385	70	503	247					Perform physical optimization
08:44:37.080	10/1/2016	6.5010350	7.5145050													
08:44:38.146	10/1/2016	6.5010350	7.5145050										Poor Active Set Pilot Quality			
09:55:09.000	10/1/2016	6.4820000	7.4865380	-14.6	-13.3	-11.9	-21.2	388	23	90	372					Give a 2-way neighbor definition between cell s PSC: 388 and PSC: 90.
09:55:09.744	10/1/2016	6.4819903	7.4865541												Weak Pilot Alert	
09:55:10.063	10/1/2016	6.4819868	7.4865621										Poor Active Set Pilot Quality		Weak Pilot Alert	
09:55:10.715	10/1/2016	6.4819794	7.4865782										Poor Active Set Pilot Quality	Strong DL Interference Alert	Weak Pilot Alert	

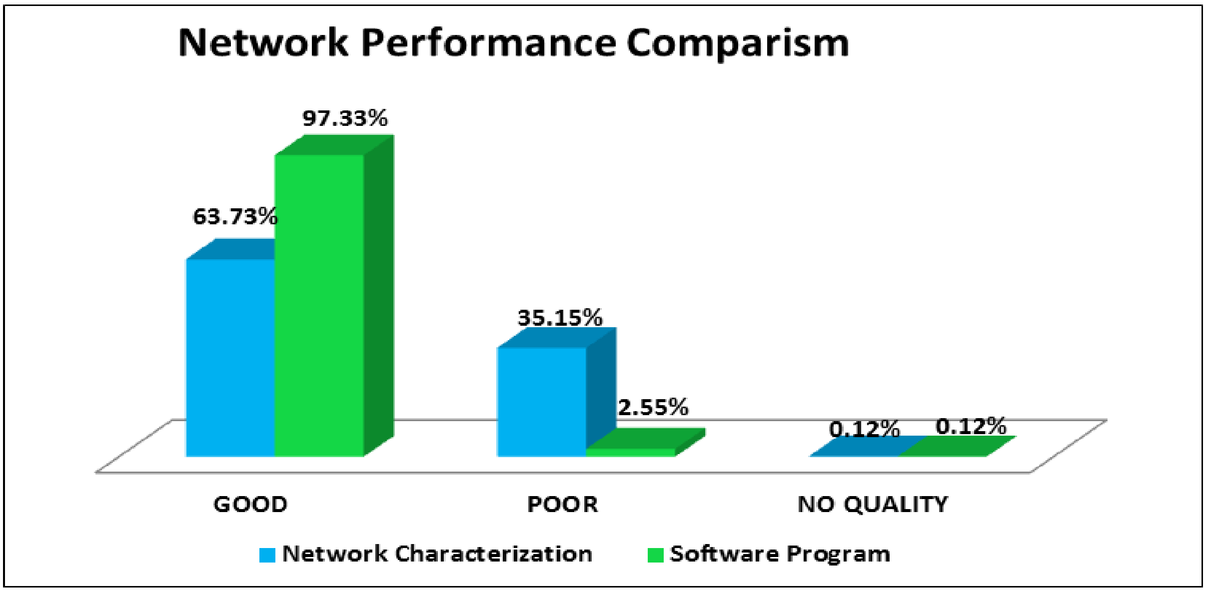

Fig-6: Network Performance Comparison

CONCLUSION

The overall performance of a telecommunications operator is measured on her ability to strike a good balance between depth of signal coverage and quality as both parameters cannot be measured in isolation of the other.

The method of using a system program to improve the signal quality in a WCDMA network improved the signal quality in Enugu metropolis by 33.60% leaving the affected areas to cover 2.67% of the test route. The areas that are still affected cannot be resolved by the system program as they require physical optimization.

Availability of Data and Materials

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

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