International Journal of Electrical and Telecommunication System Research Volume 10 Number10, September, 2018

FOURTH GENERATION LONG TERM EVOLUTION (4G LTE) KEY PERFORMANCE INDICATOR ANALYSIS AND PERFORMANCE EVALUATION OF SPECTRANET

[1]Ogbuokebe S.K [2]Idigo V.E. [3] Umar A. S. [4]Alumona T.L

[1]PhD. Scholar, Dept. of Electronic & Computer Engineering, Nnamdi Azikiwe University, Awka
[2,4]Dept. of Electronic & Computer Engineering, Nnamdi Azikiwe University, Awka
[3]Satellite Systems Dept. National Space Research and Dev. Agency (NASRDA), Abuja

Corresponding Author eMail: ogbuokebekc@googlemail.com

ABSTRACT

Long Term Evolution (LTE) is necessitated by the unceasing increase in demand for high speed connection on wireless mobile networks, notwithstanding the mammoth amount of investment into communication systems by Nigerian government through Nigeria Telecommunication (NITEL), Mobile Telecommunication (MTEL), there is still need for improved Quality of Service (QOS) to enable efficient day to day businesses in the country. Proper cellular planning, adequate capacity provision and ability to sustain quality of service at all time, through means of generating and analysing key performance index of deployed radio cells at different locations, in order to detect, resolve and restore poor performing cells in shortest possible time, hence reducing downtime and enhancing Quality of Service (QoS). This paper analysed and evaluated the Key Performance Indicators (KPI) and empirical data of SPECTRANET LTD, Abuja, acquired through Huawei Imanager 2000 software tool, drive test and open Signal software. Analysing the obtained data, presented an accurate performance of the network and the performance of each cell sector. It was observed that less than or equal to 20% of online subscribers consumes about 80% of the provisioned radio resources per cell. From results obtained, it was discovered that cells with very poor throughput performance (≤0.8Mbps) as well as low number users (≤15) have island coverage, a footprint out of designed area. However, 70% the cells with average users >40 tends to have low throughput performance below < 1.5 Mbps, as well as poor Reference Signal Received Power (RSRP) of -95dBm, and Signal to Noise Ratio (SNR) of -10dB due to contention ratio amongst users. However, in contrast to conventional system of breakdown approach, this paper presented an evaluation technique based on preventive approach that reduces Mean Time to Repair (MTTR) and improves Mean Time before Failure (MTBF) by 50%, which are core maintenance metrics that drives network efficiency, reliability and availability.

Key Words: 4G LTE, KPI, MTBF, MTTR, PRB.

1.0 INTRODUCTION

Fourth Generation (4G) Long Term Evolution network, just like every other cellular network requires minute by minute monitoring of all deployed cells in the city in order to achieve 99% service availability and to guarantee Service Level Agreement (SLA) on quality of service. Hence, the need for remote information gathering based on performance conditions of Network Elements (NE). Huawei Imanager 2000 software tool is used in the case of SPECTRANET Ltd, Abuja for Key Performance Indicators (KPI) of the network element, as well as the Google Earth Pro. The Essence of KPI data is to detect the cells in a particular region that are performing well or underperforming at every given time. The software tool captures all the cell locations and cell performance metrics. The KPI also shows the amount of the network Physical Resource Block (PRB) used per cell for a given period. It helps to observe when and where congestion triggers in the network etc. In-depth analysis of KPI data generated through Huawei Imanager 2000, drive test and Google Earth Pro gives operators due advantage to detect, resolve and restore poor performing cells within shortest possible time (Mean Time to Repair). Consequently, there are improved network availability, accessibility and reliability.

2.0 REVIEW OF RELATED RESEARCH WORKS

4G LTE is standardized by third generation partnership project 3GPP with major aim of providing high data rate for mobile device and data terminal, many authors have been working on implementable methods of achieving 99.9 % LTE networks availability and network accessibility while guaranteeing Quality of service. The authors examined different efficient techniques of generating and analyzing key performance metrics determining quality service delivery of 4G networks

Kamran [3], worked on LTE System Level Performance in the Presence of Channel Quality Indicator (CQI) Feedback for Uplink Delay and Mobility [3], the research presented the impact of CQI in uplink feedback delay on the overall network performance under different scheduling algorithms and mobility patterns. Researcher also investigated average user equipment (UE) throughput, the average throughput of UEs at cell-edge and the average cell throughput under UE mobility. The results concluded that for an efficient LTE-Advanced system on network reliability and accessibility, the scheduling algorithm is a solution to UE speed and CQI feedback delays. In the case of SPECTRNANET, an intelligent scheduling algorithm that will do more of load balancing is required as well as efficient method of KPI data evaluation.

E.T Tchao [1] adopted simulation (Genex UNET) and field measurement to aid research evaluation on 4G network coverage and throughput performance of 2X2, 4X4 and 8X8 MIMO configurations of the deployed networks. The results showed that average simulated throughput (Mbps) per sector of 4X4 MIMO system configuration was better than 2X2 MIMO system configuration. Conversely, the percentage coverage for users under the 2x2 MIMO system simulation proved better than adaptive 4x4 MIMO System Configuration. This means that 2x2 MIMO system provides LTE network with more users (UE) accessibility. However, the author did not address the real circumstance or means that can improves the performances of Network elements of deployed 2x2, 4x4 or 8x8 MIMO system when system fall short of desired performances.

[5] Presented an overview on 4G LTE system on its architecture, technologies and features. The paper reviewed the QoS concepts in LTE system, QoS parameters and QoS provisioning mechanism in LTE networks. The author stated that the reliability and effectiveness of Quality of service are dependent on network bearers of UEs. In LTE network, QoS bearer mechanism is provided through scheduling scheme which in turn helps in mitigating inter cell interference and uplifting cell throughput performance and ensuring network accessibility for numerous users. The author did not state the scheduling schemes that best suits network peculiarities, as observed in the case of SPECTRANET where less than or equal to 20% of online subscribers (UEs) consumes about 80% of the provisioned radio resources per cell.

T. Dikamba [9], did research on downlink scheduling in 3GPP Long Term Evolution (LTE). He proposed a scheduling strategy that assigns resource blocks to the users with unsurpassed radio link environment using advanced CQI values to accurately detect channel condition. This method improves throughput of users with good radio conditions but the number of users accessing the network and getting bearers are limited. SPECTRANET eNodeBs in most locations has a coverage radius above 400Meters and requires good number of UEs requesting radio access.

3.0 LTE ARCHITECTURE AND KEY FEATURES

LTE is enhanced radio and core technology from 3G, 4G simplified its architecture while most of the advanced changes occurred in three aspects of the architecture thus; the Mobile stations/user equipment (UE), the Evolved Universal Terrestrial Area Network (E-UTRAN) and the Evolve packet core (EPC) however, the radio interface of LTE employed Orthogonal Frequency Division Multiplexing (OFDM) for downlink while Single Carrier Frequency Division Multiple Access (SC-FDMA) is built for uplink channel. Figure 1 presents 4G LTE network Architecture.

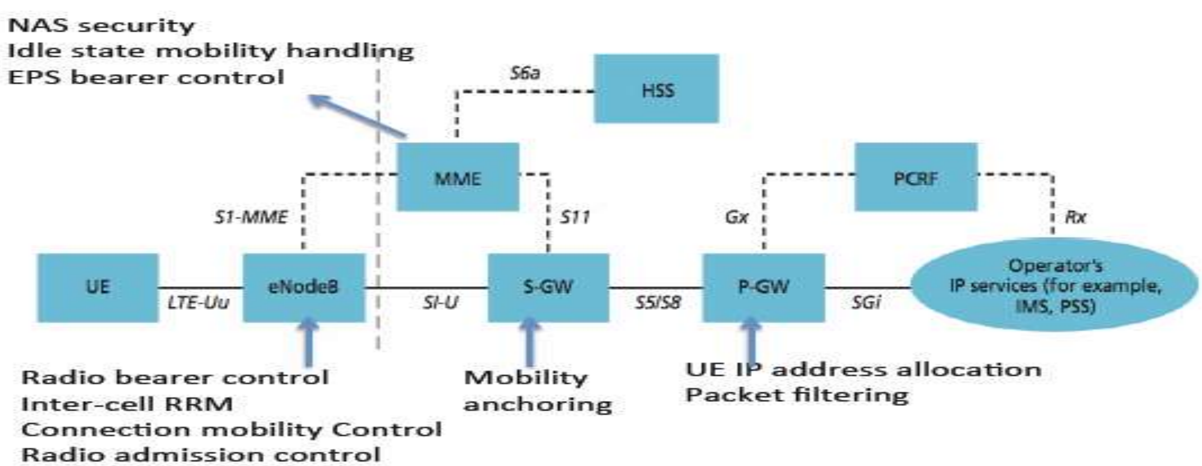

Figure 1: Long Term Evolution Network Architecture [8]

One of the key elements of the architecture is the eNodeB which is in charge of Radio bearer control and procedures of scheduling, eNodeB handles Inter-cell radio resource management, and it also controls UE connection mobility as well as radio admission control. Mobility Management Entity (MME) handles Non Stratum Access (NAS) connection security, manages UE's idle state mobility, also oversees Evolved packet System (EPS) bearer control while Serving Gateway (SGW) anchors mobility and finally, Packet Gateway (P-GW) handles UE IP address allocation and packet filtering.

4.0 KEY PERFORMANCE INDICATOR (KPI) METRICS

The following KPI metrics were generated on daily basis using Huawei Imanger 2000 for the purposes of identifying, resolving and timely optimization of cells with poor Quality of Service.

i. Average and maximum throughput (Mbps) in downlink (DL).
ii. Average and maximum throughput (Mbps) in uplink (UL).
iii. Average and maximum number of active user on the network and per cell.
iv. Average Number of Physical Resource Block (PRB) used Rate (%)
v. Congestion traffic rate
vi. Bit error rate (BER)
vii. Signal to Noise Ratio (SNR)
viii. Reference Signal Received Quality (RSRQ)
ix. Reference Signal Received Power (RSRP)
x. Number and height of antennas (Backhaul receiver and transmitter)
xi. Downlink and downlink Transport Block for QPSK, 16QAM, and 64 QAM
xii. Average Downlink and uplink MCS
xiii. Average downlink and uplink Packet loss rate
xiv. Average DL and UL Transmission Block Retransmission Rate
xv. Average Intra-eNB Handover Out Success Rate
xvi. Average Downlink CQI

Average of the data is determined before employing it over various analysis in the study:

$$Average(\bar{x}) = \frac{\sum x}{n} \qquad (1)$$

Where $x =$ collected data of various parameters, $n =$ Number of collected data

Date Rate (bps) = [1-Bler] * TBS (bits)/TTI (secs). (2)

Where Bler = Block Error rate, TBS = Transport Block Size (bits), Transmission Ttime Interval (TTI).

The throughput performance (P) of the network is calculated as [1]

$$P_T = \frac{T_e}{T_{QCI}} \qquad (3)$$

Where: T_e = Experimental throughput, T_{QCI} = Expected throughput by QCI standard

However, Spectral efficiency (ε_s) of the network is determined using modified Alpha-Shannon Formula and is given as:

$$\varepsilon_s = \alpha log_2(1 + 10^{\frac{SNR}{10G_f}}) \qquad (4)$$

Where: $\alpha =$ Bandwidth efficiency factor, $G_f =$ Geometry distribution factor in (dB)

The average signal-to-noise ratio (SNR) in decibel is the measure of the ratio of average of received signal power and average of noise power [3].

$$SNR = \frac{P_s}{P_n} \qquad (5)$$

Where: $P_s =$ Received Signal Power (dB), Pn = Noise power (dB)

Mean Time to Repair (MTTR) [6] = Total maintenance time/ total No of Repairs (6)

Mean Time before Failure (MTBF) = Total Operational Time / total No of failure (7)

5.0 DATA COLLECTION APPROACH

The filed measurements were carried out in Federal Capital Territory (FCT), Abuja in the central Northern Nigeria. It is the administrative hub of Nigeria. For the purpose of this research, collection of data lasted from November, 2018 through February, 2019 and April to June, 2019.In order to cover the extreme weathers of Abuja City. KPI data were permitted by the Network operators to be collected five times (days) in a week (Monday – Friday) for a period of seven Months. All the 403 cells of SPECTRANET were monitored and studied on daily basis. The average performances of each cell for the period under study were computed, combined, and evaluated. Figure 2 presents an overview of SPECTRANET eNodeB Sites in Abuja Metropolis.

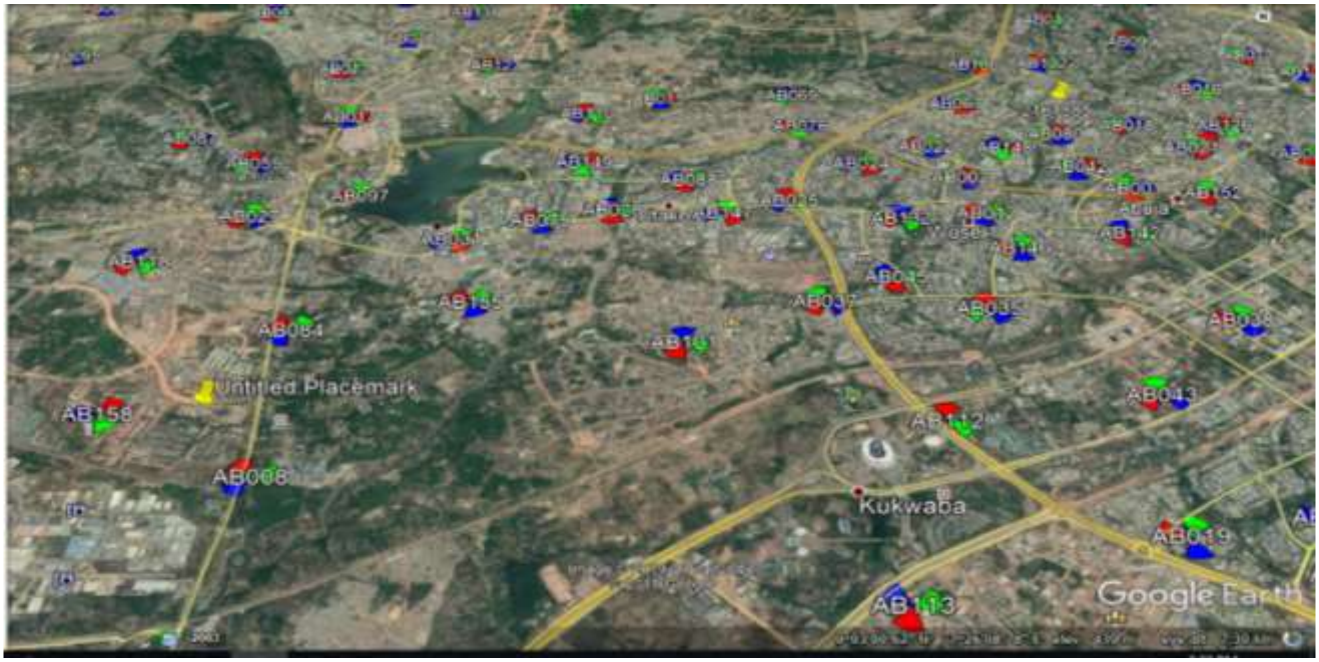

Figure 2: Overview of SPECTRANET eNodeB Sites in Abuja Metropolis

Huawei Imanager 2000 helped in generating KPI data for active cells across Abuja metropolis. Table 1 and Table 2 presents the sample of the KPI data logs as generated per day (24Hrs) and the Key performances are organized per Site, Sector (eNodeB), Busy Hour (BH), Evening Hour (EH), Congestion Hours, and Network Traffic. Table-1 depicts Abuja KPI Data Log sample for 24Hrs performance per Sector for a particular day. It shows the measured average Downlink and uplink throughput performance (Mbps), average and maximum users per cell. Other .

Measured parameters shown are the Maximum Downlink and Uplink Physical Resource Block (PRB) Used Rate (%), Downlink and Uplink PRB utilization rate above eighty percent (> 80%) etc. However, Table 2 shows sub data sheet for the measured average Downlink throughput performance (Mbps), average Throughput Uplink (Mbps), Maximum Throughput Downlink (Mbps) etc. per network site (eNodeB). Recall that a network site has more than one active cell.

Table 1: SPECTRANET Cells KPI DATA sample for 24Hrs-Sector Record

S2 fx 15

	Start Time	Cell	Avg_Th Put_DL (mb/second)	Avg_Th Put_UL (kbit/s)	Max_Th Put_DL (mb/second)	Max_Th Put_UL (mbit/s)	Max user	Average user	Max of Average User	Max of Total Thput	MAX DL PRB Used Rate(%)	MAX UL PRB Used Rate(%)	DL PRB Used Rate(Busy Hour)(%)	UL PRB Used Rate(Busy Hour)(%)	Average 24 hrs DL PRB Used Rate	Average 24 hrs UL PRB Used Rate	DL PRB>=80 Count(Busy Hour)	UL PRB>=80 Count(Busy Hour)	DL PRB>=80 Count(24 Hour)
2	10/3/2019	=2, Cell Name=AB_12001_2, eNodeB	6.60	0.80	16.01	4.75	52.00	27.32	44.522	16.70648535	96.50	81.21	70.77	49.50	47.83	44.70	13	0	15
3	10/3/2019	=1, Cell Name=AB_12001_1, eNodeB	6.61	1.31	14.23	5.77	54.00	28.58	46.548	16.12671191	97.64	82.98	88.89	61.30	55.80	57.51	28	1	35
4	10/3/2019	=0, Cell Name=AB_12001_0, eNodeB	7.33	1.04	19.10	2.64	42.00	21.28	35.533	20.25155371	94.52	73.62	62.54	42.13	43.36	40.99	7	0	11
5	10/3/2019	ell ID=2, Cell Name=AB_12022_2, eNod	2.32	0.33	13.21	2.17	36.00	8.76	24.477	14.32376172	67.62	72.22	25.63	24.43	16.33	20.23	0	0	0
6	10/3/2019	ell ID=1, Cell Name=AB_12022_1, eNod	4.53	0.57	17.25	2.54	53.00	17.07	46.819	18.49173438	98.00	86.91	46.25	36.77	29.98	29.99	10	4	13
7	10/3/2019	ell ID=0, Cell Name=AB_12022_0, eNod	6.30	1.01	22.27	4.44	101.00	31.38	85.651	24.86068848	98.18	93.02	55.05	41.58	31.14	33.32	18	4	22
8	10/3/2019	ell ID=2, Cell Name=AB_12024_2, eNod	5.69	0.60	19.98	2.52	32.00	20.35	27.27	20.72852051	96.59	63.68	35.89	31.67	33.42	33.28	0	0	7
9	10/3/2019	ell ID=1, Cell Name=AB_12024_1, eNod	5.02	0.56	22.73	2.87	40.00	22.01	32.841	24.27062598	95.75	67.56	35.91	38.39	28.24	38.06	2	0	3
10	10/3/2019	ell ID=0, Cell Name=AB_12024_0, eNod	1.78	0.41	14.28	5.25	22.00	10.19	17.31	14.60169629	73.85	69.76	24.42	28.24	16.45	27.67	0	0	0
11	10/3/2019	Cell ID=2, Cell Name=AB_12043_2, eN	3.66	0.39	25.32	1.74	36.00	21.59	30.271	26.4965791	93.65	57.40	41.97	34.16	24.28	31.99	2	0	2
12	10/3/2019	Cell ID=1, Cell Name=AB_12043_1, eN	3.03	0.35	16.95	5.58	26.00	11.99	22.243	17.58034473	54.42	82.10	23.71	31.18	13.30	25.37	0	0	0
13	10/3/2019	Cell ID=0, Cell Name=AB_12043_0, eN	8.45	0.65	20.66	3.23	69.00	26.38	60.619	23.89018652	99.41	68.62	86.82	52.54	53.47	36.14	26	0	30
14	10/3/2019	ell ID=2, Cell Name=AB_12050_2, eNod	1.00	0.17	5.85	2.09	13.00	5.27	9.051	6.070774414	46.48	56.51	13.61	24.22	8.68	21.19	0	0	0
15	10/3/2019	ell ID=1, Cell Name=AB_12050_1, eNod	9.32	1.33	18.42	4.30	51.00	35.28	42.122	19.26453223	97.40	79.11	80.76	49.49	56.82	47.75	22	0	27
16	10/3/2019	ell ID=0, Cell Name=AB_12050_0, eNod	0.38	0.05	2.29	0.78	8.00	3.10	5.919	2.445160156	13.73	32.70	5.10	17.30	2.89	15.43	0	0	0
17	10/3/2019	ell ID=2, Cell Name=AB_12054_2, eNod	1.89	0.58	9.25	2.34	14.00	7.33	10.541	10.24173438	54.03	95.02	16.25	22.22	12.19	41.33	0	0	0
18	10/3/2019	ell ID=1, Cell Name=AB_12054_1, eNod	2.09	0.17	13.65	0.70	25.00	9.90	21.256	14.35041309	68.28	45.64	23.87	28.47	14.40	22.51	0	0	0
19	10/3/2019	ell ID=0, Cell Name=AB_12054_0, eNod	1.70	0.17	8.30	0.85	20.00	6.97	15.124	8.651216797	62.65	42.84	27.11	26.49	14.34	21.80	0	0	0
20	10/3/2019	ID=2, Cell Name=AB_12057_2, eNode	4.45	0.36	16.06	1.47	35.00	18.39	29.89	17.25035059	90.06	65.28	32.68	32.28	25.07	30.72	0	0	1
21	10/3/2019	ID=1, Cell Name=AB_12057_1, eNode	3.02	0.39	12.25	2.22	22.00	15.08	19.229	13.41616895	78.09	62.69	16.96	30.98	18.42	32.00	0	0	0
22	10/3/2019	ID=0, Cell Name=AB_12057_0, eNode	4.89	0.75	31.26	2.28	35.00	21.49	26.762	32.82866016	96.74	77.04	52.77	45.48	35.98	44.96	5	0	8
23	10/3/2019	ID=2, Cell Name=AB_12066_2, eNode	4.18	0.40	20.25	1.99	39.00	20.05	34.846	21.29986426	95.97	65.47	15.81	27.87	26.31	31.55	0	0	4
24	10/3/2019	ID=1, Cell Name=AB_12066_1, eNode	4.14	0.30	15.89	1.86	31.00	12.60	24.988	17.05767773	95.34	55.72	34.14	33.79	32.04	34.31	4	0	10
25	10/3/2019	ID=0, Cell Name=AB_12066_0, eNode	1.13	0.25	15.57	2.61	14.00	5.74	10.82	15.90155566	36.60	92.57	4.34	16.36	7.85	22.25	0	0	0
26	10/3/2019	Cell ID=2, Cell Name=AB_12032_2, eNo	3.29	0.45	12.95	1.83	39.00	14.36	31.832	13.62925195	95.02	65.52	67.26	39.83	31.98	28.92	12	0	17
27	10/3/2019	Cell ID=1, Cell Name=AB_12032_1, eNo	5.14	0.54	14.09	3.65	33.00	14.55	26.04	14.6357041	93.41	67.35	44.90	38.39	23.96	29.39	1	0	2
28	10/3/2019	Cell ID=0, Cell Name=AB_12032_0, eNo	3.11	0.42	11.19	3.55	35.00	18.43	29.217	12.32299316	95.70	72.50	68.72	39.09	38.98	34.12	12	0	13
29	10/3/2019	ID=2, Cell Name=AB_12068_2, eNode	3.39	0.50	13.21	1.42	22.00	13.01	19.97	13.76717188	67.06	66.19	15.39	33.42	22.03	37.33	0	0	0
30	10/3/2019	ID=1, Cell Name=AB_12068_1, eNode	0.93	0.10	6.27	0.58	10.00	4.66	7.984	6.449657617	49.61	39.13	3.63	16.02	7.84	18.80	0	0	0

24 / BH / EH / 24-sector data / congestion BH / Network Traffic

Table 3: Abuja Coverage KPI DATA LOG sample for 24Hrs –Site Record

F14 fx 5.3922509765625

	Start Time	NE Name	Avg_ThPut_DL (mb/second)	Avg_ThPut_UL (Mbit	Max_ThPut_DL (mb/second)	Max_ThPut_UL (Mbit/s)	Max user	Average user	Max of Average User	Max of Total Thput	Total Max Th_
3	10/3/2019 0:00	AB001	20.54	3.15	38.36	7.68	144.00	77.17	122.024	42.2171416	46.04
4	10/3/2019 0:00	AB022_Wuse_II	13.15	1.91	47.04	7.26	180.00	57.22	148.616	53.73093359	54.30
5	10/3/2019 0:00	AB024_Wuse_I	12.40	1.56	39.28	5.78	81.00	52.06	65.244	41.7415752	45.06
6	10/3/2019 0:00	AB043_FCT_Abuja	15.14	1.39	42.22	6.30	128.00	59.96	109.813	45.1199062	48.52
7	10/3/2019 0:00	AB050_Garki_1	10.69	1.56	22.67	4.31	67.00	43.66	53.61	24.24053027	26.98
8	10/3/2019 0:00	AB054_Garki_2	5.68	0.92	23.73	2.94	55.00	24.19	45.578	24.98330664	26.66
9	10/3/2019 0:00	AB057_Apo	12.36	1.50	34.13	3.92	90.00	54.95	69.724	36.55739648	38.05
10	10/3/2019 0:00	AB066_Apo	9.45	0.95	27.85	4.04	74.00	38.39	63.154	29.46752832	31.89
11	10/3/2019 0:00	AB032_Wuse_IV	11.65	1.42	29.46	5.05	96.00	47.33	80.666	30.92139258	34.50
12	10/3/2019 0:00	AB068_Apo	10.35	1.31	21.02	3.52	74.00	42.37	66.594	22.38131836	24.54
13	10/3/2019 0:00	AB059_Kaura	12.15	1.14	43.86	3.47	85.00	45.80	68.324	45.75735547	47.33
14	10/3/2019 0:00	AB062_Gudu	18.01	2.09	36.77	5.39	108.00	63.99	91.93	38.17700098	41.16
15	10/3/2019 0:00	AB025_Utako	21.38	2.33	41.16	4.95	171.00	103.79	146.018	44.17648582	46.11
16	10/3/2019 0:00	AB030	12.87	1.33	34.20	4.41	93.00	42.85	78.369	36.60420898	38.50
17	10/3/2019 0:00	AB037_Wuse_7	17.36	1.72	42.66	4.18	80.00	51.69	54.804	44.16624316	46.84
18	10/3/2019 0:00	AB031_Jabi	16.17	1.89	38.93	5.00	108.00	74.50	88.895	42.27327539	43.92
19	10/3/2019 0:00	AB027_Gwarimpa	25.40	2.41	49.85	7.18	142.00	91.22	118.946	53.51638281	57.01
20	10/3/2019 0:00	AB066_Lugbe	12.95	1.72	30.17	6.07	93.00	56.32	78.353	31.86330078	36.24
21	10/3/2019 0:00	AB070_Lugbe	11.23	1.34	31.32	4.72	68.00	41.81	56.802	32.93080859	36.04
22	10/3/2019 0:00	AB038_Phase_2	11.78	1.44	31.50	4.15	133.00	46.35	115.8	35.0188125	35.65
23	10/3/2019 0:00	AB046_Garki_7	12.23	1.15	25.09	3.97	70.00	33.11	49.092	27.73869152	29.06
24	10/3/2019 0:00	AB048_Garki_2	13.33	0.96	29.76	3.36	67.00	35.88	54.144	31.46614258	33.11
25	10/3/2019 0:00	AB041_Garki_2	16.44	1.85	33.31	4.62	123.00	56.91	105.424	36.63857617	37.93
26	10/3/2019 0:00	AB029_Three_Arms	10.05	1.16	27.31	3.32	81.00	39.67	66.319	30.24656348	30.54
27	10/3/2019 0:00	AB079_Childrens_Park	12.63	2.08	26.71	8.13	87.00	50.27	65.465	27.99063867	34.84
28	10/3/2019 0:00	AB047_Asokoro	20.12	1.97	53.27	5.10	117.00	83.79	97.915	56.39827246	58.37
29	10/3/2019 0:00	AB044_Asokoro	18.22	2.51	36.19	5.96	133.00	83.33	104.86	38.98350977	42.15
30	10/3/2019 0:00	AB072_Landmark	27.65	1.52	44.30	7.37	146.00	97.88	118.284	49.56572949	52.27

24 / BH / EH / 24-sector data / congestion BH / Network Traffic

Table 1 and 2 shows each eNodeB Function name: AB001, Cell name (e.g: AB_12001_2), Local Cell ID = 2, EnodeB ID = 12001 as well as Cell FDD TDD indication: Cell_ TDD. Another important column in the log is the PRBs for Uplink and downlink, it presents them in percentage when the PRBs are almost consumed (> 80% usage) for each cell. Once it gets to 90%, there will be congestion and packet data will start to drop after number of HARQ sequence. This causes increase in delay of delivering packets successfully.

SPECTRANET operates 20MHz bandwidth, thus 100 PRBs and one PRB has 12 sub-carriers, and each sub-carrier corresponds to one User (UE- user equipment) allotment. Theoretically, the maximum number of user each cell can have or contain at every given point in time is 1200 subscribers.

Other Sub sheets or Tab shows the average performances at EH (Evening hours (6PM to 9PM)) and BH (Busy Hours) (9AM to 12PM) in each site. The Congestion Tab shows the performance as at the set Busy Hour. Good to monitor and observe changes during this period.

6.0 DRIVE TEST

Drive test helps identify cell's Physical Cell Identifier (PCI) number, RSRP performance of each cell which gives the detail of the total received power towards a particular area, RSRQ which gives details of quality of received signal at every given location and SINR value which presents the ratio of signal strength against noise at every given location. Figure 4 depicts drive test kits configuration.

Figure 3: Drive Test kits and illustration [4]

Figure 3 presents tools used for single and cluster cells experiment (Drive-Test). HP Laptop, GPS device, SPECTRANET Modem, Car, Google Earth, MA-INFO, Transmission Evaluation and Monitoring System (TEMS) 15.3.4, Power Inverter etc. Figure 4 presents a screen grab of sectors routes driven.

.

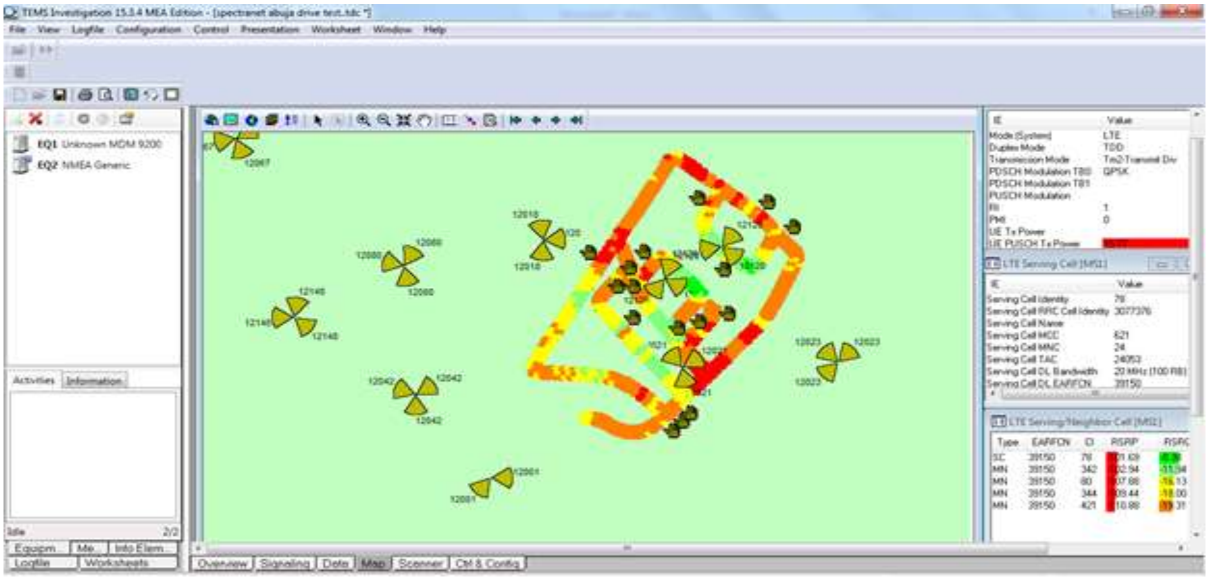

Figure 4: Drive Test for Optimization over MAITAMA District eNodeB Sites, Abuja

Figure 4 is a screen shot of events during drive test using TEMS Investigation 15.3.4 at Maitama District Abuja. All serving sectors (Cells) and sites in the route are monitored; PCI numbers of serving are displayed. The Signal Quality indication is identified by colours (Red= Poor, Yellow= Good, Green = Excellent), observe some sites are two sectored sites but Majorly 98% of the sites in Maitama district are three sectored site, the handover symbols with the hand sign, frequent and successive handover within a short distance is a sign of degraded service or wrong configuration. The monitoring cells to each serving cell are listed on the right hand side of the tab. The monitoring cells observes the connectivity and performance of each cell and UE and ever ready to accept UEs with poor RSRP or that those UEs making request for handover etc. The generated data log was further analysed using MapInfo software. Summary of empirical data from Drive test is given in table 3.

Table 3: SPECTRANET LTE Empirical Values

S/N	Performance Remark	SINR (dB)	RSRQ (dB)	RSRP (dBm)
1	Excellent	20 – 50	-10 – 0	-70 – 0
2	Very Good	10 – 20	-12 – (-10)	-80 – (-70)
3	Good	5 – 10	-14 – (-12)	-90 – (-80)
4	Bad	(-5) – (5)	-16 – (-14)	-110 – (-90)
5	Very Bad	(-20) – (-5)	-20 – (-16)	-150 – (-110)

7.0 RESULT AND DATA ANALYSIS

From 403 deployed active cells in the network of SPECTRANET LTD, Abuja, empirical data were obtained through different means and for different purposes. Key Performance Indicator (KPI), Drive test, Google Earth Professional, and OpenSignal are some of means for data collection. Figures (6 – 9) present sample cells performance analysis. Figure 6 presents the corresponding average throughput (Mbps) performance for various Cells (AB0012 to AB0017) during the period of investigation.

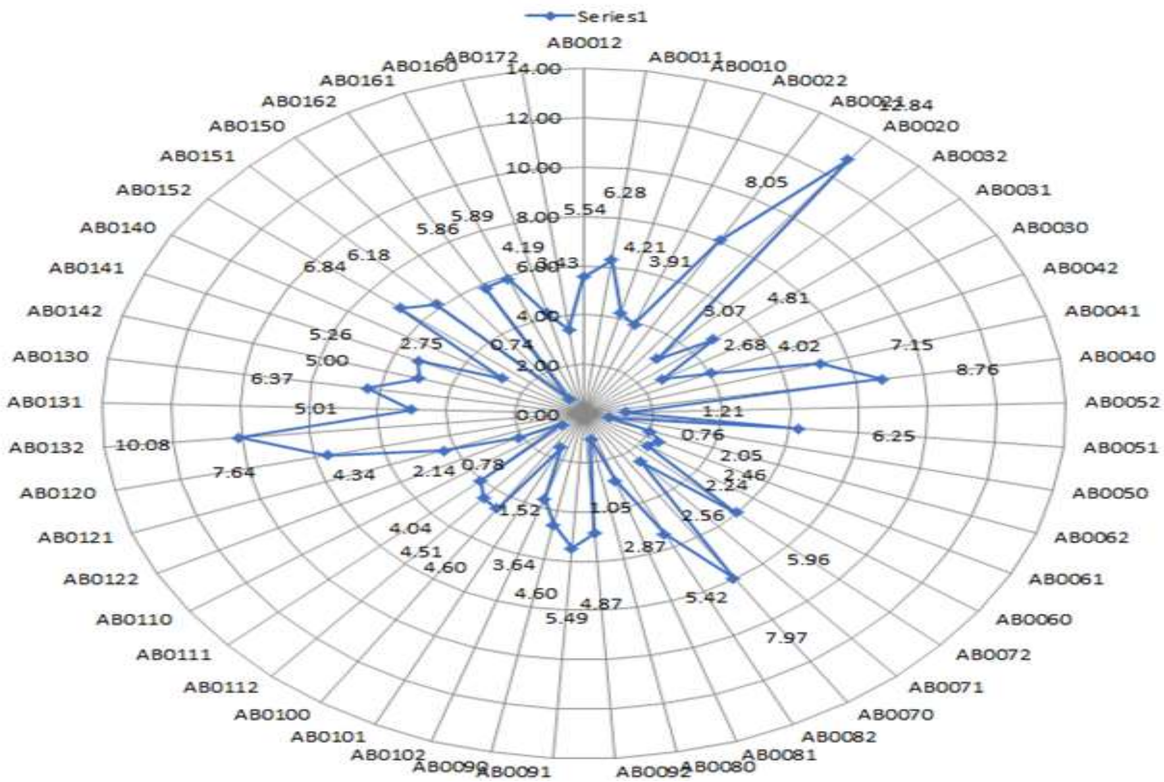

Figure 5: Average Throughput (Mbps) Performance per Active Cell (AB0012 – AB0171)

Figure 5 presented the corresponding average throughput performance for each Cell under study. They are part of the actively deployed cells around Abuja metropolis. The cells are serialized in order of deployment, just like the PCI numbers are given in order of commissioning of sectors. Cells with average throughput of ≤ 0.8 Mbps are considered to be underperforming while cells with throughput ≥0.8 Mbps are in the cadre of good performance.

The underperforming sectors (Mbps) are: AB0121 (0.78), AB0050 (0.76), AB0150 (0.74)

Sector with great performance (Mbps): AB0020 (12.84), AB0132 (10.08), AB0070 (7.97)

Percentage of good performing to underperforming: > 80% Great

Possible causes and actions for improvement: Number of users and contention ratio, and lack of dominant cell.

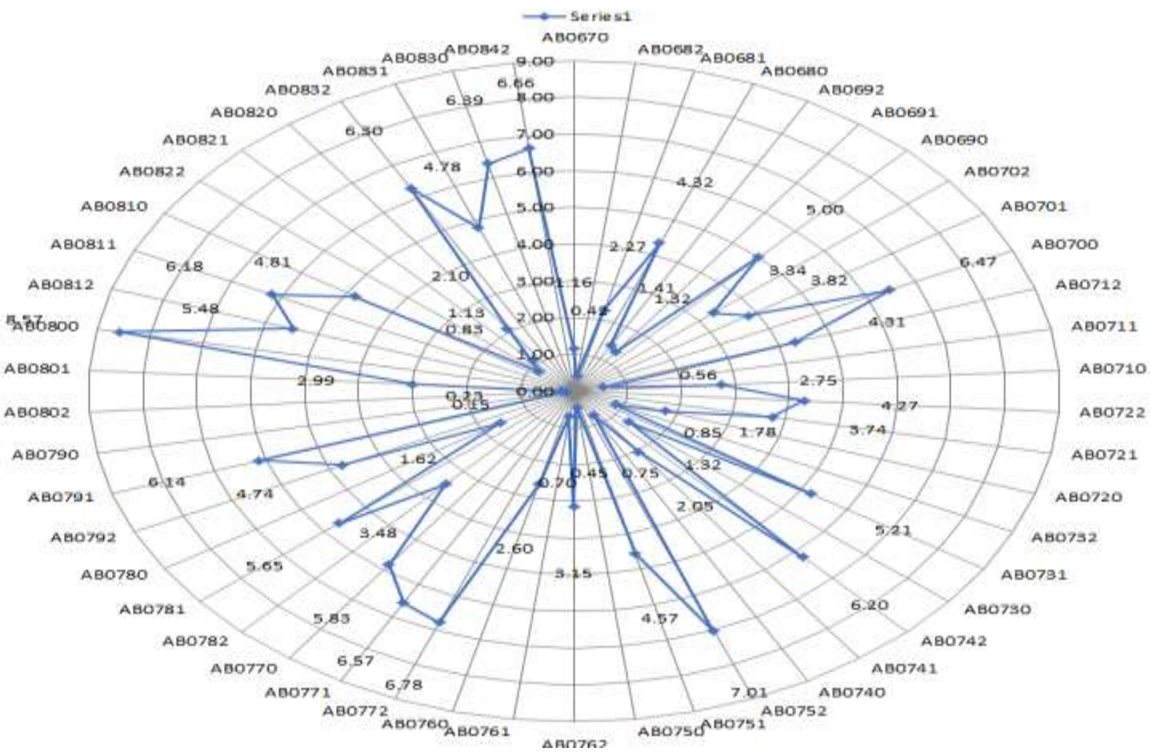

Figure 6: Average Throughput (Mbps) Performance per Cell for (AB0670 – AB0842)

Figure 6 presents the corresponding average throughput performance per Cell under study. This helps in identifying cells that are underperforming (Mbps). From figure 6, sectors such as AB0790 (0.15), AB0802 (0.23), AB0750 (0.45) etc. are found to be underperforming.

Sector with good and great performance: AB0752 (7.01), AB0800 (8.57), AB0700 (6.47)

Percentage of good performing to underperforming: > 80% Great

Causes and Actions for improvement: Number of users and contention ratio, Monitoring cells, weak coverage and lack of dominant cell.

7.1 Average Throughput Performance against Average number of UEs

This analysis shows the impact of average number of users on throughput performance; average number of users on each cell is calculated and plotted against average throughput performance. Theoretically, stable network should be able to admit high number of users and still have average throughput above 3Mbps, while the underperforming cells have low number of users as well as low throughput performance, figure 7 and 8 presented cells of SPECTRANET network performances with respect to average number of user.

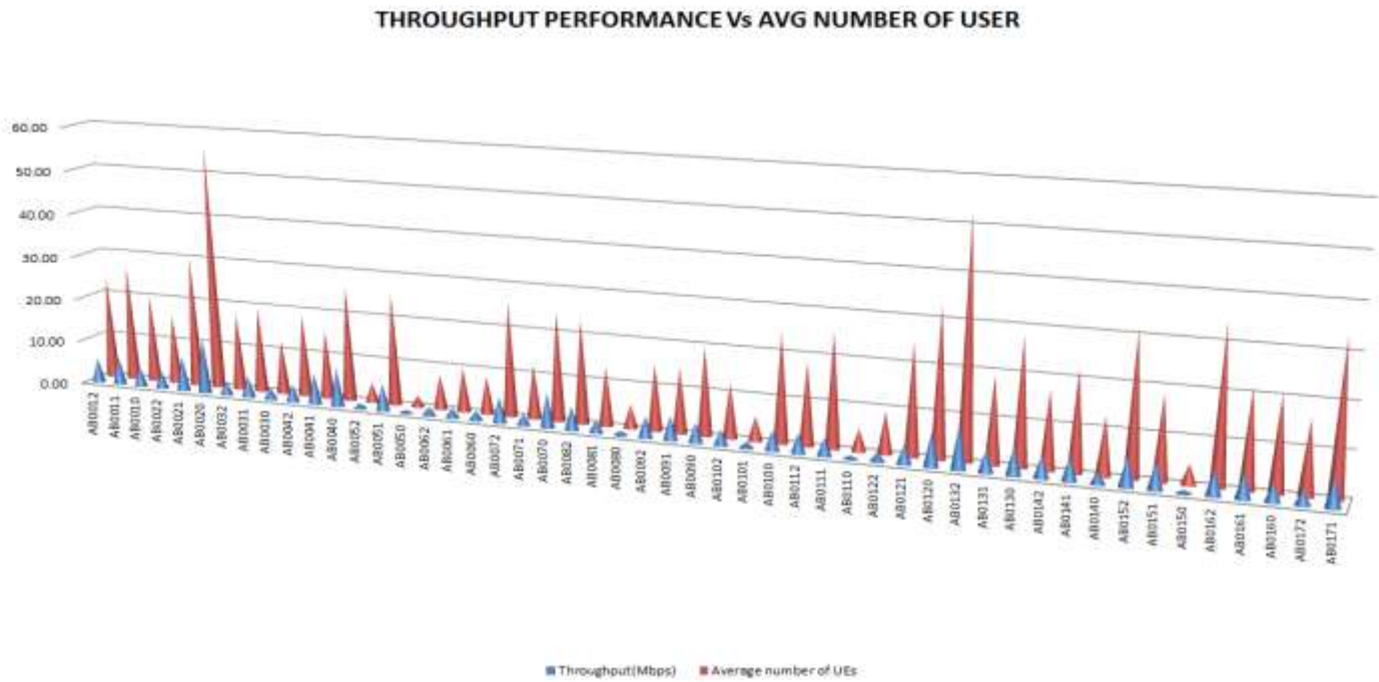

Figure 7: Average Throughput (Mbps) Performance against Average number of UEs sample 50 sectors (AB0012 –AB0171)

Figure 7 shows Stable and good performing Cells: AB0021, AB0020, AB0120, AB0132, AB0162, and AB0171. They all have an average number of users >25 and average throughput >3Mbps.

The Underperforming cells: AB0052, AB0050, AB0080, AB0110, AB0150. They all have an average users < 10 and average throughput less than 0.8 Mbps

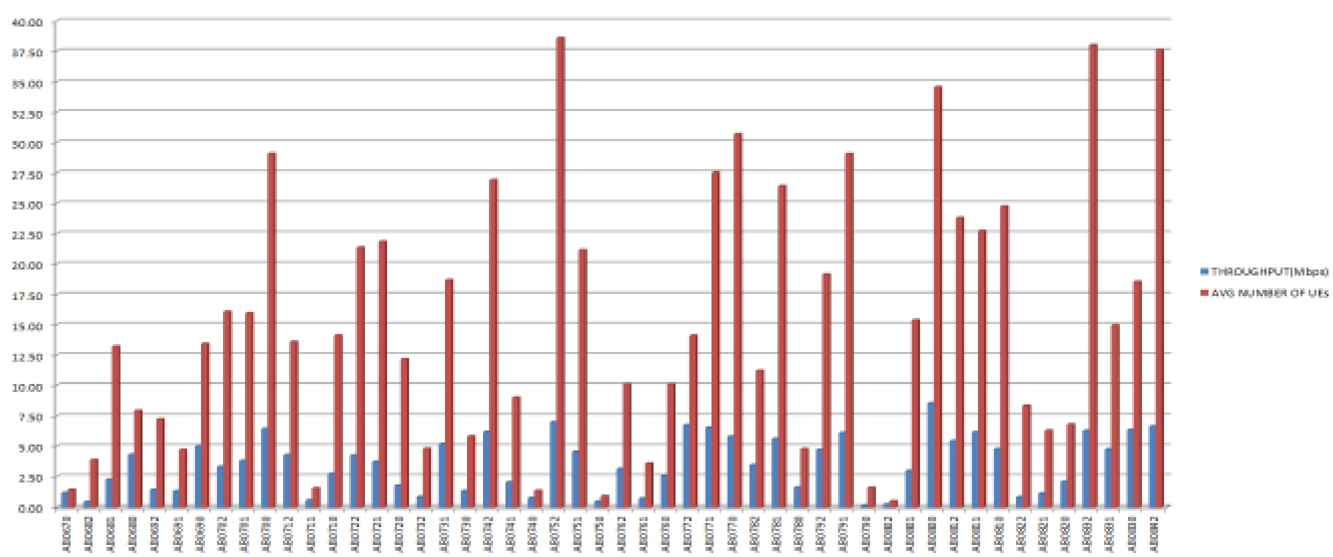

Figure 8: Average Throughput (Mbps) Performance Vs Average number of UEs sampled 50 sectors (AB0670 –AB0812)

Figure 8 presents Stable and good performing cells: AB0700, AB0742, AB0752, AB0771, AB0770, AB0800 etc. The listed cells have an average user above 30 and throughput > 3Mbps

Underperforming cells: AB0711, AB0790, AB0802, AB0750, AB0740 etc. they are have very low average number of user < 10 and poor throughput < 0.8mbps.

7.2 Relationship Effect between Average Number of Users and PRB Utilization

The sampled cells in figure 9 showed the number of times the cell's PRB utilization went above over 80% and its corresponding average number of users. Theoretically, the higher the number of UEs that latch into an eNodeB, there will be high utilization of the Physical Resource Blocks (PRB). From the graph in figure 9, observe that most of the times when a cell's number of users is high, the PRB utilization count for 80% utilization and above is also high.

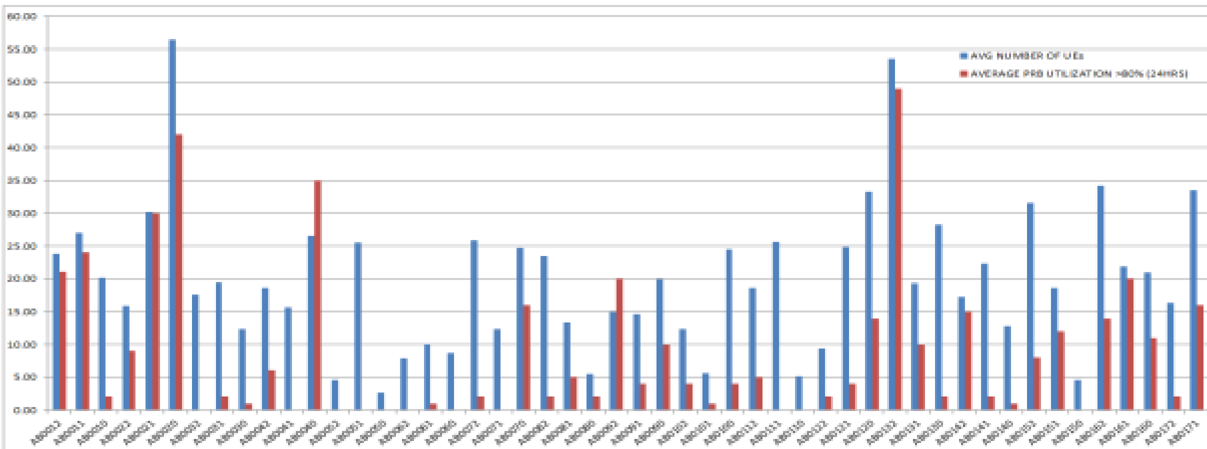

Figure 9: Average Number of UEs Vs Average PRB UTILIZATION >80% Count (24Hrs) Sampled sectors [AB0012-AB0171]

The graph figure 9 shows the sampled 50 sectors (AB0012 – AB0171) performance as regards PRB utilization greater than 80% count (Number of times) and its corresponding average number of users. Cell AB0020 and AB0132 proved to be have most robust service, they both recorded over the period of research an average of 57 users with an average of 42 times reaching the PRB utilization above 80%. They also have shown at the previous analysis to have average throughput of 10Mbps. However, AB0032, AB0052, AB0051, AB0062, AB0060, AB0111, AB0110, AB0150 sectors showed to have at an average, very little number of times utilizing their PRBs above 80%. The cells whose average number of times the PRB utilization went above 80% is greater than its average number of users are likely to have low average throughput performance, as can be observed for AB0140 with an average of 17 times hitting PRB utilization above 80% but have an average number of user set at 12, going back to earlier analysis, cell AB0140 recorded an average throughput of 2Mbps, usually in this case, RF engineers suspects high data rate users occupying the cell and pulling down the throughput performance. Finally, cells with very low number of users are always a concern, especially if the cells are located in populated area of the town.

Over time, such cells will tend to be underperforming just in the cases of AB0050 and AB0150 with 2.5 and 4.5 average number of users respectively. Notice also from the earlier analysis that their average throughput performance are below 0.7 Mbps.

8.0 CONCLUSION

4G LTE network performance is efficient in delivering high speed data rate to subscriber, however. daily monitoring and analysis of all cell performances is a definitive and first method of enhancing sustainable Quality of services (QOS) to subscribers. Nonetheless, when compared to normal system of breakdown approach, this technique reduces MTTR and improves MTBF by 50% [6], which are core maintenance metrics that drives network efficiency, reliability and availability. Preventive maintenance is assured by obtaining and analyzing with right and accurate network performance data. This gives due advantage against breakdown maintenance. This paper presented steps of empirical data and remote data acquisition of key performance indicators using Huawei Imanager tool and drive test. Analysis of obtained data proved to be able to detect the underperforming cells and the root causes of poor service delivery. First, it was observed that small percentage ≤20% of subscribers consumes about 80% of the provisioned radio resources per cell. Secondly, it was discovered that cells with very poor throughput performance as well as low number users have island coverage, a footprint out of target area. Thirdly, it was disclosed that 70% cells with users >40 tend to have low throughput performance due to contention ratio amongst users. Finally it was observed that cells configured with more neighbouring cells achieved better average throughput performance of 5Mbps while cells deployed in less populated area and fewer neighboring cells achieved average throughput of 1Mbps.

9.0 RECOMMENDATION

The following recommendations are made;

1. Network operator to deploy more robust system of essential and accurate cell performance data gathering, by incorporating a threshold alert system to improve MTTR
2. SPECTRANET to deploy more radio cell in the areas with fewer neighbouring cells.
3. Need to develop resource scheduler algorithm to differentiate Quality of service of high data rate UEs (20%) in order keep balance and fairness to all subscribers.

10.0 REFERENCES

[1] E.T Chao, J.D Gadze, O. A. Jonathan, “Performance Evaluation of a Deployed 4G LTE Network”. *International Journal of Advanced Computer Science and Applications*. Vol. 9, page No. 3. (2018).

[2] Huawei Technologies CO. LTD (2015). NodeB V200R013 Technical Description. China.

[3] A. Kamran, “LTE System Level Performance in the Presence of CQI Feedback Uplink Delay and Mobility” Mobile and Wireless Communications Research Laboratory. University of Greenwich, United Kingdom. (2016). Available: https://core.ac.uk/download/pdf/42391008.pdf

[4] U.Maria, T. U Chairunisa. Performance Analysis 4G LTE Network Operator X and Y in the District of North Balikpapan. Department of Electronics Enginering, Politeknik Negeri Balikpapan, Indonesia. (2019).

[5] A. Navita, “A Survey on Quality of Service in LTE Networks”. *International Journal of Science and Research (IJSR).* Vol. 3, pp 6 -12, 2014.

[6] O. Oskar. (2019, September). “KPI’s in plant maintenance and preventive maintenance, Mean Time between Failures in Plant Maintenance”. Available: www.worldclassmanufacturing.com

[7] Saransh M., Sangmi M., Bora K., Cheolhong K., Daejin K. and Intae H. (2014). Novel MCS Based Relay Protocols for Throughput Optimization using AMC in LTE-Advanced System” 47th Hawaii International Conference on System Science.

[8] Swift Networks Limited. “In-house Training on LTE Networks and systems” Lagos, Nigeria 2017.

[9] T. Dikamba. Downlink Scheduling in 3GPP Long Term Evolution (LTE). Wireless and Mobile Communication (WMC) Group. Masters Theisis, Dept. of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology. 2012

[10] Third (3rd) Generation Partnership Project. (2012). Technical Specification Group on Radio Access Network Evolved Universal Terrestrial Radio Access (E-UTRA). User Equipment (UE) radio transmission and reception (Release 10) TS. 36.