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KPI measurement on the 4G network within the University of Ilorin

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Abstract. The present work seeks to address the following question which serves a key motivation behind this research: 'What if there is a guide on the University of Ilorin website or in the weekly published magazine within the school, guiding the student on which MNO is best for internet connectivity based on the location which they are at any point in time?". This research is key to answering the question. Data was gathered through a walk test using TEMS Investigation 16.3.4 and analyzed using TEMS Discovery Device 10. The test was based on internet access on the 4G Network by users who are subscribed to the various MNOs that are serving within the school premises.

Keywords: Mobile Network Operator (MNO); Walk Test; 4G Network

1. Introduction

Communication between two or more people creates a link through which information transverses the communication link and media to get them to the intended delivery point. The advent of smartphones, various social media applications, and platforms led to a high rise in the demand for Internet connectivity, thereby increasing the internet penetration of the world. This continuous increase has led to the technological advancements and the drive for better and high speed of transmitting information from one end to the other. This has brought about a paradigm shift from the Circuit-switched communication system to Packet-switched communication. The communication network has undergone revolution through the years since its inception. This revolution has been categorized into various Generations, from 1st to 5th [1-12]. The mobile network communication technologies have evolved, and the populace has as well changed in their preferred choice of communication model as the majority have shifted from cellular calls to Video and data calls. Smartphones are the order of the day now, and anyone seen with a non-smartphone is referred to as living primitive or utilizing it for calls only. In this view, it is of the essence to make people aware of their immediate environment and which data network suits them best, be it on the third-generation band or of the fourth generation. Fifth-generation Network (5G) has not been implemented in Nigeria and as such test on 5G is yet to be possible.

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2. The 4G Network and the Key Performance Indicators

The 4G Network was borne out of the need for higher data throughput in transmitting information from one point to the other on the Network. This generation of mobile communication technology was intended to replace the 3G communication technology such that it provides all its services over a data network without having to use a circuit-switched system of communication. The Network is designed such that it uses Internet Protocol (IP).

The 4G Network utilizes 20MHz bandwidth for communication, which can work on all the frequency bands the 2G and 3G, as well as CDMA communication technologies use. It is designed to provide an optimum data throughput of 100Mbps to 1Gbps. The Multiple access technique it makes use of is the Orthogonal Frequency Division Multiple Access (OFDMA). See Figure 1 for details.

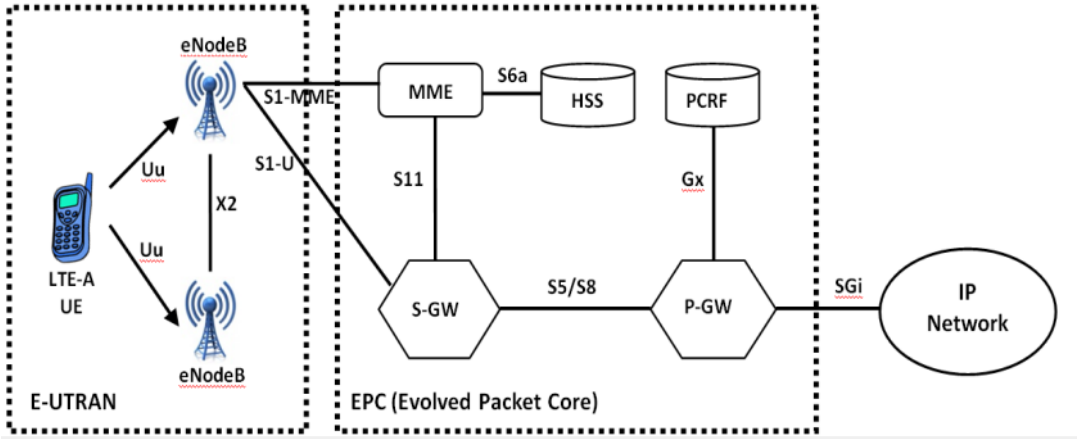

Figure 1: 4G Architecture [2]

The Radio Access Network is specified as the EUTRAN (Evolved Universal Mobile Telecommunication System Terrestrial Radio Access Network). It consists of LTE compatible Mobile Terminals (these are called User Equipment in 3G and Mobile Station in 2G), Radio Interface (known as the Air Interface in 3G), an eNode-B meaning E-UTRAN Node-B (this performs the function of Node-Bs in 3G network and BTS in 2G Network).

The other part of the 4G Network architecture is the Core network, which is quite different from the usual RNC or BSC, MSC, HLR, among others. It has four main parts, which are Mobility Management Entity (MME), Serving Gateway (S-GW), Home Subscriber Server (HSS), and Policy and Charging Rules Function (PCRF). The Core Network of the 4G Network is called Evolved Packet Core Network (EPC) or System Architecture Evolution (SAE).

2.1 Key Performance Indicators (4KPIs)

Key Performance Indicators are metrics put in place and are used to check and grade the quality of service delivered to subscribers on the Network. These metrics can be optimized when routine optimization is carried out on the Network to know the serving capacity of a site. They also serve as a measure of how good or bad the service received is. The efficiency of the obtained reference signal is quite close to the RSRP (reference signal received quality), and the interaction between the two is clear. This is used for handover and re-selection of cells in rankings. RSRP measured in decibel milliwatts (dBm) is the average power taken over resource items in increasing bandwidth that holds

reference signals for different cells. Each resource block has 84 resource elements, and the resource blocks have a cumulative frequency domain size of 180 kHz, and time-domain size of 0.5ms. Within the time-frequency map, every user is assigned several so-called resource points. The higher the RSRP, the higher the channel efficiency measure allocated to the customer, and the higher the network blocks that a user gets, so the higher the network element modulation, the higher the bit rate. Signal to noise plus interference ratio (SINR) is defined as the ratio of signal intensity to the amount of neighboring cells' average interruption strength, and the background noise is the calculation of the unwanted portion of the signal received. The SINR may be calculated through its Resource Block (RB) from the user's equipment.

This calculation is very critical as it is used to decide the modulation code scheme (MCS) that will be appropriate for data transmission in the RB and thereby evaluate whether or not the throughput is sufficient. A consumer with a strong SINR rating would have a better performance, because higher-order MCS will be added to this signal, resulting in more bits being sent per modulation mark. The received signal strength indicator (RSSI) is close to that of the RSRP. The distinction is that RSSI is only determined in OFDM symbols bearing reference symbols from the non-serving co-channel, and serving cells, neighboring channel disturbance, and consumer device thermal noise. If the resource block number is specified, otherwise, RSRP and RSRQ are defined. Throughput implies the rate of transmission of data over a user's allocated resource sheets. A person closest to the base station (eNodeB) would more definitely have a higher performance than those further removed from the eNodeB eating [3].

The scheduler within eNodeB employs the UE-sent Channel Quality Indicator (CQI) reports to collect the channel quality details received by the users and, on this basis, assign resources to each user.

2.2 Overview of Related Activities

A group of researchers did a performance check on the quality service the users are receiving om the 2G, 3G, and 4G networks. They used QualiPoc software to carry out this test. They tested both the voice and data performance of the Network. They observed that the more recent the technology, the better the services provided [4]. Rana, Yaser and Kara [5], differentiated the Circuit switch analysis from Packet switch. The Circuit Switch network being a call analysis, and the Packet switch being data analysis. They used Call Setup Success Rate (CSSR), Call Setup Time (CST), Dropped Call Rate (DCR), Speech Quality (PESQ), and Received Signal Level (dBm) as the Key Performance Indicators for the CS analysis. The KPIs used for PS analysis include Attach Success Rate, Attach Time Setup, Packet data Protocol Context activation Success Rate (PDP CASR), Packet Data Protocol Context Service success rate (PDP SACR), Service session success rate, File Transfer Protocol Data Throughput (FTP DL) Kbps [5].

Imoize et al. [6] performed an analysis of the performance of the fourth-generation Network in Smart cities. They examined specific KPIs related to network performance. The method of data collection adopted is a drive test with the aid of Genex Probe V16. The result was analyzed and presented using probability distribution functions. Anselemi, et al., [7], carried out tests in South Africa to check the quality of service in the Nelson Mandela African Institute of Science and Technology. The result they got was then used to plan and optimize the existing Network. They also gave a recommendation for better services [7]. Network utility needs excellent attention with reference to networking, quality of services, access to usage, performance evaluation, competent personnel, and so on [13-22].

3. Methodology

The research is a data test to get throughput among other KPIs to be measured. The walk test involves the upload of files and download of data or streaming of videos online. The data was uploaded at the various test areas, as indicated in the scope of this research. The test is to be carried out on the major Mobile Network Operators in Nigeria. The areas of focus include Lecture Theater 1, Lecture Theater 2, Lecture Theater 3, Lecture Theater 4, Faculty of Arts Lecture area, Faculty of Law Lecture Areas, and the Faculty of CIS lecture theatre.

3.1 Process of Network testing

A process referred to as a walk-test was used in the data collecting process. A software called TEMS Investigation was used to carry out the Collection of Data. For the sake of this research, TEMS Investigation 16.3.4 was installed on the Laptop used for the work. The data were analyzed with the aid of a TEMS Discovery Device 10. This was used in conjunction with Microsoft Excel for the statistical presentation of data.

Walk-test, as already mentioned, is the procedure to perform a test while walking. The devices required to carry out the test effectively include:

I. A Laptop - or other similar devices (1)
II. collecting Software installed & License Key (Dongle) (2),
III. at least 1 Mobile Station (3),
IV. one GPS (4).

Besides, it is common to use adapters and/or hubs that allow the correct interconnection of all equipment. The diagram below describes the schematic of standard connections. See Figure 2 for the relevant Schematic of Standard Connection.

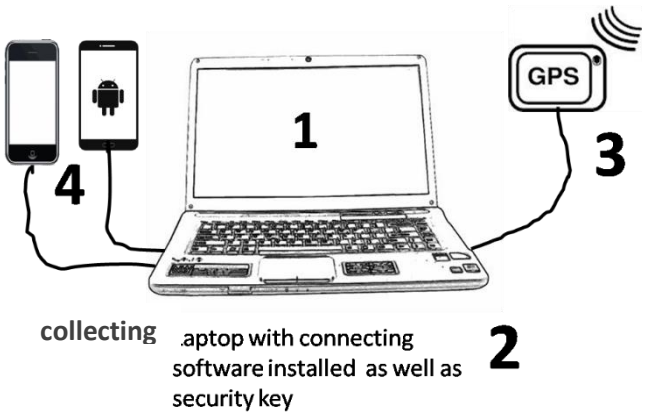

Figure 2: Schematic of Standard Connection *[8]*

4. Result Analysis

Results of the walk test were analyzed by Location and Mobile network operators. The results below will be represented with bar charts, showing the Percentage of times the services are optimum for RSRP, RSRQ, and SINR on the 4G networks. The results are shown in Figures 3-10.

4.1 4G in Faculty of Art

Here, Figures 3a-3c present the results in relation to 4G Network in the 4G in Faculty of Art.

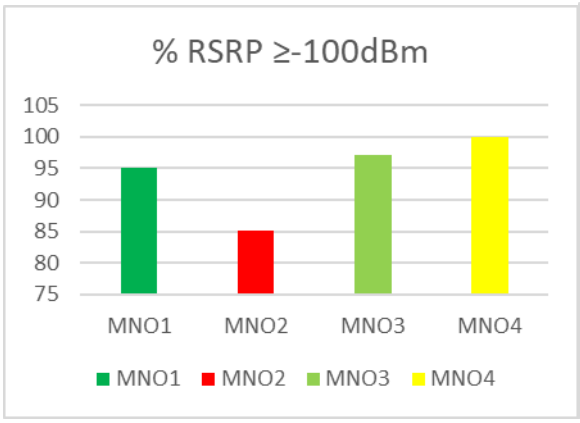

Figure 3a: 4G results in Faculty of Art

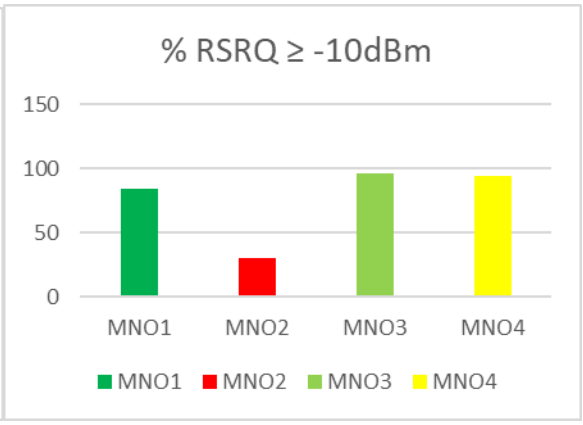

Figure 3b: 4G results in Faculty of Art

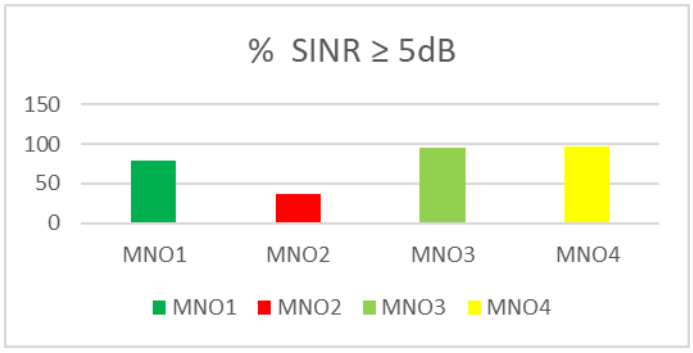

Figure 3c: 4G results in Faculty of Art

4.2 4G in the Faculty of Communication and Information Science

Here, Figures 4a-4c present the results in relation to 4G Network in the Faculty of Communication and Information Science.

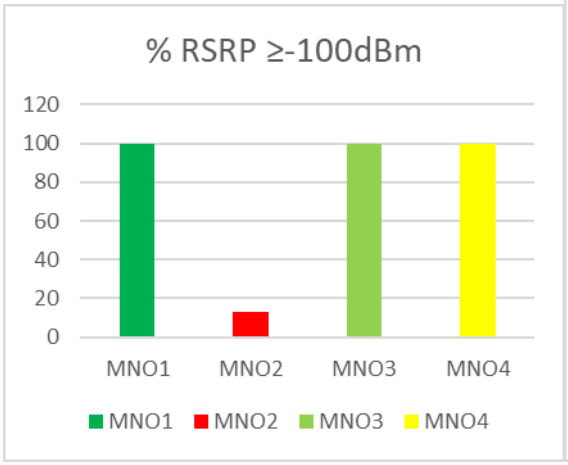

Figure 4a: 4G results in Faculty of CIS

Figure 4b: 4G results in Faculty of CIS

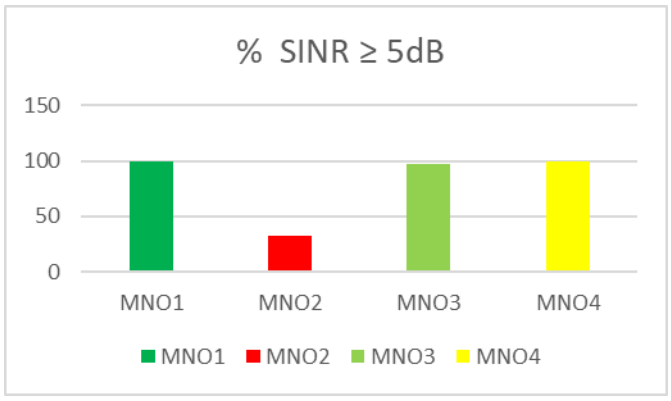

Figure 4c: 4G results in Faculty of CIS

4.3 4G in Faculty of Law

Here, Figures 5a-5c present the results in relation to 4G Network in the Faculty of Law.

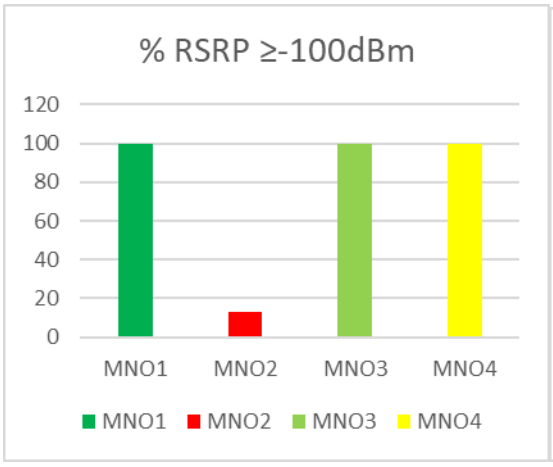

Figure 5a: 4G results in Faculty of Law

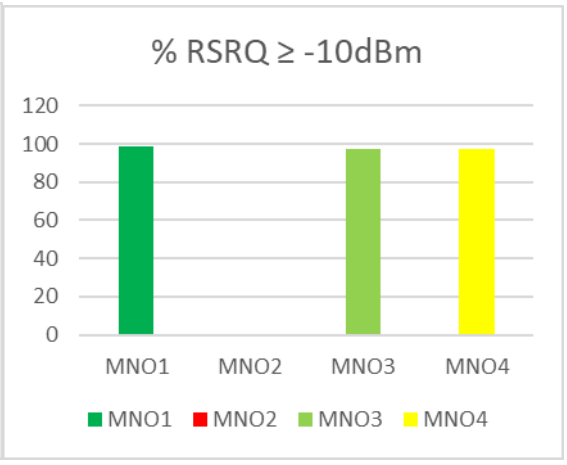

Figure 5b: 4G results in Faculty of Law

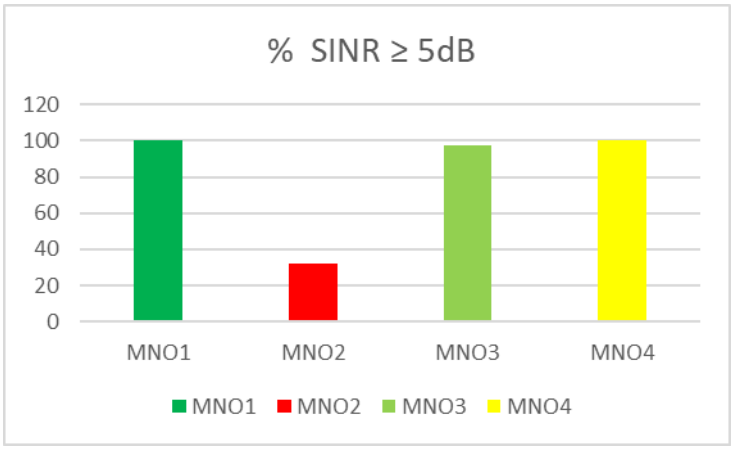

Figure 5c: 4G results in Faculty of Law

4.4 G in Lecture Theatre 1

Here, Figures 6a-6c present the results in relation to 4G Network in the Lecture Theatre 1.

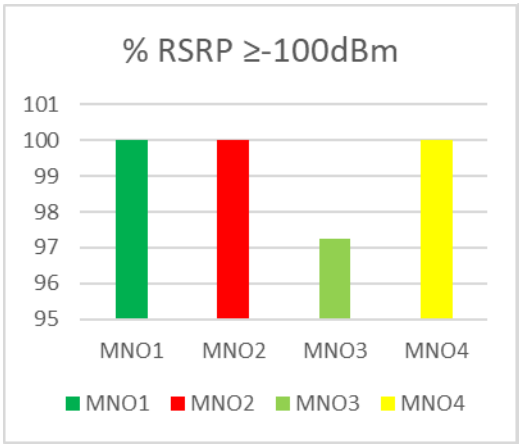

Figure 6a: 4G results in Lecture theater 1

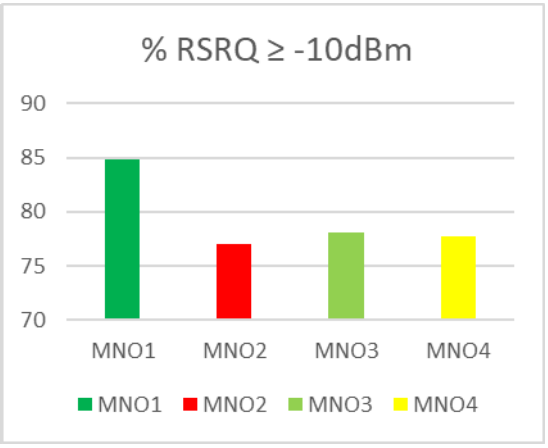

Figure 6b: 4G results in Lecture theater 1

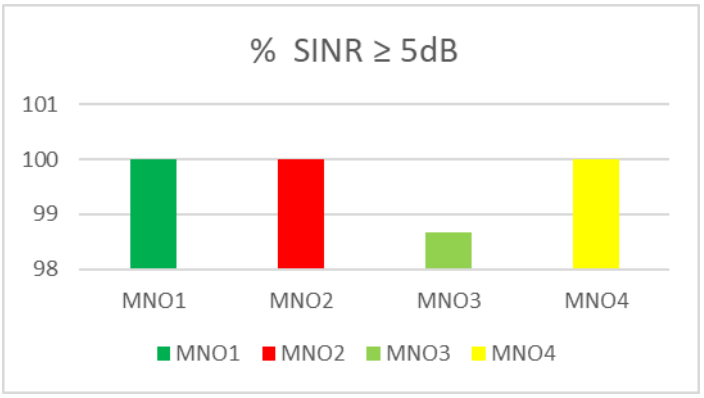

Figure 6c: 4G results in Lecture theater 1

4.5 4G in Lecture Theatre 2

Here, Figures 7a-7c present the results in relation to 4G Network in the Lecture Theatre 2.

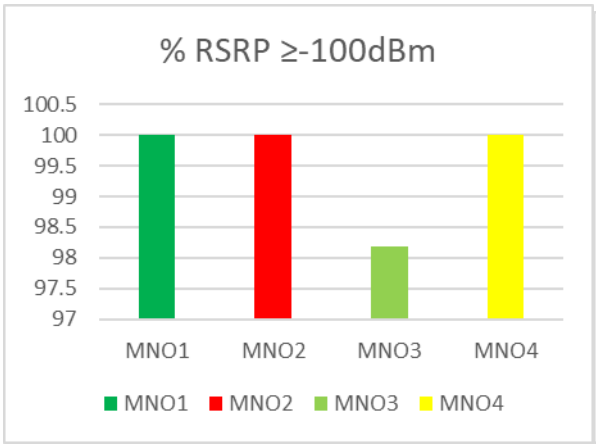

Figure 7a: 4G results in Lecture theater 2 RSRP

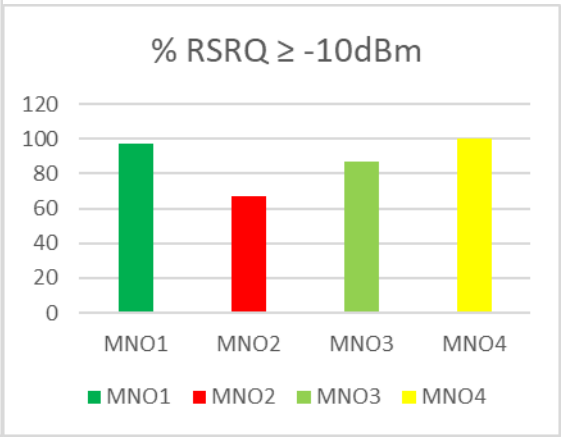

Figure 7b: 4G results in Lecture theater 2 RSRQ

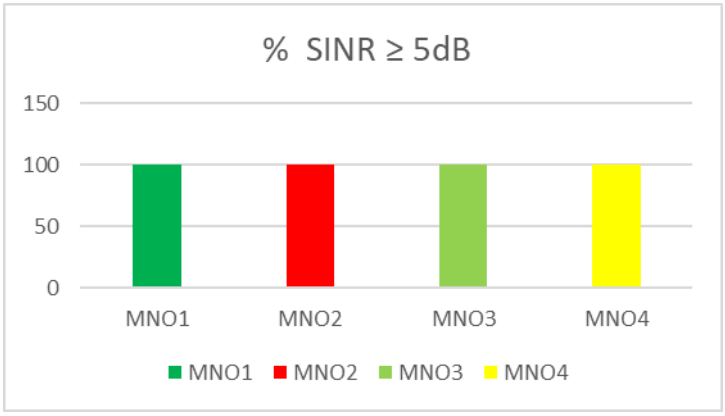

Figure 7c: 4G results in Lecture theater 2 SINR

4.6 4G in Lecture Theatre 3

Here, Figures 8a-8c present the results in relation to 4G Network in the Lecture Theatre 3.

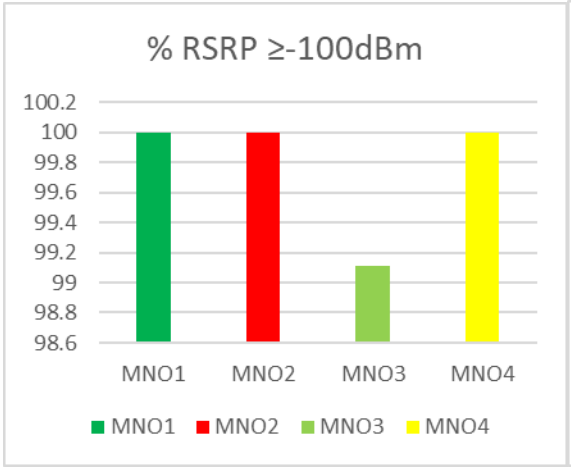

Figure 8a: 4G results in Lecture theater 3 RSCP

Figure 8b: 4G results in Lecture theater 3 RSRQ

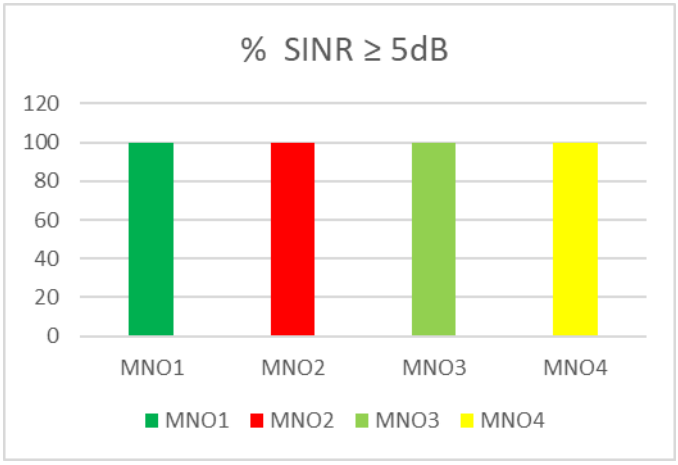

Figure 8c: 4G results in Lecture theater 3 SINR

4.7 4G in Lecture Theatre 4

Here, Figures 9a-9c present the results in relation to 4G Network in the Lecture Theatre 4.

Figure 9a: 4G results in Lecture theater 4 RSCP

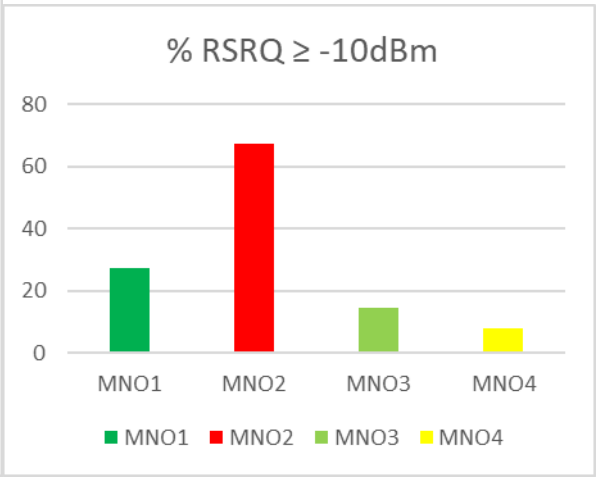

Figure 9b: 4G results in Lecture theater 4 RSRQ

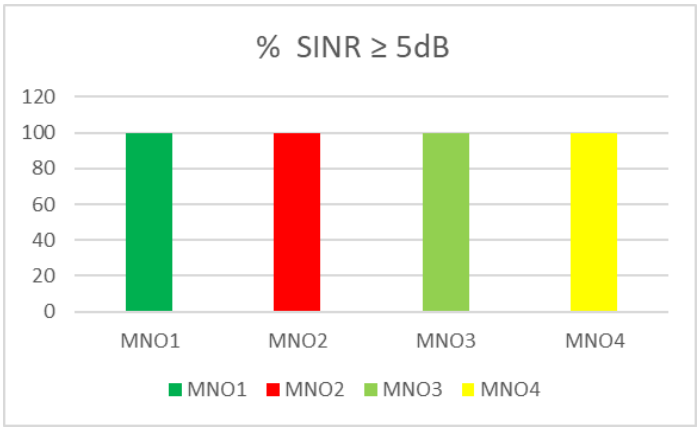

Figure 9c: 4G results in Lecture theater 4 SINR

5. Result Discussion and Concluding remarks

MNO1 is next in the level of how poor the service provided is. The service provided by this MNO is not entirely poor as it provides the little it can in all test locations. MNO2 is next in the Hierarchical level of Performance while MNO4 tops overall in the quality power and even throughput. The 4G test had no exceptional result in the areas in which the test was conducted. Respondents from students when having one on one discussions shows that there are specific locations within the school where students can enjoy optimum 4G speed. A student even pointed to the fact that he has recorded speed of up to 10Mbps within the school.

The 4G Network within the University of Ilorin requires optimization to accommodate the population growth of students within the school. Some areas witness better Networks than the others. There were cases of Overshooting and congestion; the MNOs need to optimize the Network to give better services to their subscribers. This research has a limitation of funding as it was self-funded. Some areas in the school, such as school hostel, faculty of Vet Medicine, Faculty of Pharmacy, and Staff quarters, were

not covered. Future tests in the area should include the hotel areas of the school. This will ensure that more locations are covered in the report.

Acknowledgment

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