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## *Abstract*

This work presents a report on the quality of services provided by GSM network operators within the University of Nigeria Nsukka campus. This is expressed in terms of the ability to establish and maintain call connections; intra and inter network calls for outgoing calls in University of Nigeria Nsukka campus in Enugu State of Nigeria. The campus was divided into eight locations; these locations were used as Test points. In each of these locations, series of measurements were made. Three GSM operators represented as operator N, P and K were investigated for a period of eight weeks. The accessibility levels and call failure rate expressed in percentages show that for intra and inter - network calls, operator N network had better call quality of service assessment of 89.8% and 86.3% respectively; and lowest call failure rate within the University of Nigeria Nsukka campus for the period investigated.

## *1.0 Introduction*

G.S.M is the most popular standard of mobile phone in the world and is currently used by over 3 billion people across more than 212 countries and territories [1]. Its ubiquity makes international roaming very common between mobile phone operators enabling subscribers to use their phones in many parts of the world.

All through the day and night availability and complete coverage, coupled with acceptable quality at appropriate terms are important factors that are used to characterize different service providers. GSM Operators are not simply desirous of meeting these needs; user requirement must be met if the aim of customer satisfaction is not to be jeopardized. Further growth is completely dependent on this. The volume and coverage required must be provided, yet special attention must also be paid to quality.

This research presents an assessment carried out on the call quality of service provided by operators N, P and K for outgoing calls; intra and inter network. Emphasis is laid on the call quality, number of calls attempted and signal power received.

In the field of telephony, quality of service is defined in the ITU standard X.902 as "a

set of quality requirements on the collective behavior of one or more objects". Quality of Service comprises requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, cross-talk, echo, interrupts, frequency response, loudness levels, and so on. A subset of telephony QoS is Grade of Service (GOS) requirements, which comprises aspects of a connection relating to capacity and coverage of a network, for example guaranteed maximum blocking probability and outage probability [3].

In the field of computer networking and other packet-switched telecommunication networks, the traffic engineering term quality of service (QoS) refers to resource reservation control mechanisms rather than the achieved service quality. Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. For example, a required bit rate, delay, jitter, packet dropping probability and/or bit error rate may be guaranteed. Quality of service guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over internet protocol (IP), online games etc, since these

often require fixed bit rate and are delay sensitive, and in networks where the capacity is a limited resource, for example in cellular data communication [3].

Generally, Nigerians are not satisfied with the quality of service provided by the GSM operators in the country. This problem results basically from incompatibility of the computer-base radio propagation prediction tools with our environment. The quality of the service provided is poorer in the mountainous terrain experiencing 'shadowing effects' created by the presence of obstacles including tall buildings, trees, hills and rocks between the Base Transceiver Station and the Mobile Station.

University of Nigeria Nsukka Campus is one of these mountainous terrains full of tall buildings and trees. In an attempt to evaluate the quality of service (QoS) of GSM network providers in the said University we embarked on this research work.

The aim of this research is to evaluate the quality of service of GSM network providers within the university of Nigeria Nsukka campus and to make suggestions on how the providers can improve on it.

## 2.0 Literature Review

In September and October 2009 the Autoridade Nacional de Comunicações (ANACOM) carried out an assessment of the quality of mobile services. These services include: voice, video-telephony, GSM, Wideband Code Division Multiple Access (WCDMA) and Universal Mobile Telecommunications System (UMTS) network coverage. These services are provided by operators OPTIMUS, TMN and VODAFONE in the main urban agglomerations and major roads of Mainland Portugal. They analyzed technical parameters that translate the quality perception from the consumer's standpoint. Their data collection took place on working days and during normal working hours, from September 14 to October 20, 2009. They made 23,971 test

calls and took 4,731,307 radio signal level measurements, amounting to approximately 218 hours of measurements over 9,916 kilometers. The results of the quality of service indicators analyzed in this study showed that GSM mobile communication systems have good coverage levels and a good performance for the voice service, both in urban agglomerations and on major roads [4]. Adeseko Ayeni in his PhD research work on "Quality of Service Profile of the Nigerian GSM Network," finds out that relatively low call failure rates were recorded on intra and international routes as against the inter and Public switched telephone network (PSTN) routes. He also observed that definite call failure patterns could not be observed when viewed over the hours of the day, as is expected in normal traffic studies. He therefore concluded that factors like infrastructural deficiencies other than trunk dimensioning, contributed to the excessive call failure rate on the network [2].

## 3.0 Test Area and Methodology

It is desirable to collect data from all strategic locations within the premises of University of Nigeria Nsukka main campus with the available network providers. The University campus was divided into eight locations.

Measurements were conducted within the University campus. Two groups, each made of three people, were equipped with Nokia 6630 handsets. Mobile subscribers with mobile phones were positioned at these test locations, then calls were made to other mobile users of the same network (intra) and other networks (inter) within and outside the campus. At any location a sample number of three trials of calls were made. The data gathered from this assessment included the number of calls attempted and numbers of call hold success rate for a period of two minutes. The data recorded were averaged daily and then weekly for both intra and inter network connections using Microsoft

Excel software package. If a call was initiated for three consecutive trials and such call could not be established, no routes was recorded for such event as the maximum number of trials set out for such calls has been exceeded.

#### 4.0 Data Collection and Evaluation

Data were collected throughout the campus from first week of March, 2010 to last week of April, 2010. During the period of investigation, a total of six thousand nine hundred and twelve (6,912) calls were made round the campus of which four thousand six hundred and eight (4,608) were for inter network connection and seven hundred and sixty eight (768) from each network for intra network calls. As long as the location system is providing totally consistent results from call to call resulting in large variance, the numbers of calls made were adequate (ATIS standard, 2004).

Four tables below show four out of ninety six tables which represent calls from inter and intra networks from different subscriber at specific location and at a particular time within UNN main campus. Letters "A" on the table indicates intra and inter calls results that were initiated and letter "B" indicates intra and inter calls results that were sustained for more than two minutes. Number "1" on the table signifies successful calls and number "0" signifies calls that are not successful. The data were collected for three network providers denoted as N, P, and K.

|   | LOCATION <sub>1</sub> |    |    | LOCATION <sub>2</sub> |    |    | LOCATION <sub>3</sub> |    |    | LOCATION <sub>4</sub> |    |    |
|---|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|
|   | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  |
|   | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB |
| N | 11                    | 11 | 11 | 11                    | 11 | 00 | 10                    | 10 | 00 | 11                    | 00 | 10 |
| P | 00                    | 10 | 11 | 11                    | 10 | 11 | 11                    | 11 | 11 | 11                    | 11 | 11 |
| K | 10                    | 11 | 10 | 11                    | 10 | 11 | 10                    | 11 | 11 | 00                    | 01 | 11 |

Table 1B: Data for Week 1, Day 1

|   | LOCATION <sub>1</sub> |    |    | LOCATION <sub>2</sub> |    |    | LOCATION <sub>3</sub> |    |    | LOCATION <sub>4</sub> |    |    |
|---|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|
|   | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  |
|   | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB |
| N | 11                    | 11 | 11 | 11                    | 11 | 11 | 10                    | 00 | 11 | 11                    | 00 | 00 |
| P | 11                    | 11 | 10 | 00                    | 11 | 11 | 11                    | 11 | 11 | 11                    | 11 | 11 |
| K | 11                    | 11 | 11 | 11                    | 00 | 11 | 11                    | 00 | 11 | 00                    | 11 | 11 |

Table 2A: Data for Week 1, Day 2

|   | LOCATION <sub>5</sub> |    |    | LOCATION <sub>6</sub> |    |    | LOCATION <sub>7</sub> |    |    | LOCATION <sub>8</sub> |    |    |
|---|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|
|   | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  |
|   | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB |
| N | 11                    | 11 | 10 | 11                    | 11 | 00 | 11                    | 11 | 10 | 11                    | 11 | 00 |
| P | 00                    | 11 | 11 | 00                    | 10 | 10 | 00                    | 11 | 00 | 10                    | 11 | 11 |
| K | 11                    | 10 | 11 | 11                    | 10 | 11 | 11                    | 11 | 11 | 11                    | 00 | 11 |

Table 2B: Data for Week 1, Day 2

|   | LOCATION <sub>5</sub> |    |    | LOCATION <sub>6</sub> |    |    | LOCATION <sub>7</sub> |    |    | LOCATION <sub>8</sub> |    |    |
|---|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|-----------------------|----|----|
|   | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  | N                     | P  | K  |
|   | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB | AB                    | AB | AB |
| N | 11                    | 00 | 11 | 11                    | 11 | 11 | 10                    | 10 | 00 | 11                    | 11 | 00 |
| P | 10                    | 11 | 11 | 11                    | 10 | 11 | 11                    | 11 | 00 | 11                    | 11 | 10 |
| K | 00                    | 11 | 11 | 11                    | 10 | 11 | 00                    | 11 | 11 | 00                    | 11 | 11 |

The digits "1" and "0" representing successful and unsuccessful calls respectively were sorted out using a command in Microsoft Excel called "Sort Data by Values" for both inter and intra network.

The Parameters Used For Quality of Service Evaluation:

1. Service Accessibility
2. Call Failure Rate
3. Network Availability (Coverage)

#### 4.1 SERVICE ACCESSIBILITY (VOICE)

Service accessibility is the probability of the user having access to the service (voice or video telephony), i.e. likelihood of success when establishing a (voice or video-telephony) call. A call is considered to be "Set Up Successfully" if it reaches

the called terminal (one hears the "calling signal" on the calling terminal) [4].

$$\text{Service Accessibility (\%)} = \frac{\text{No. of successful Set Up Calls} \times 100}{\text{Total No. of Attempted Set Up calls}}$$

$$\text{Thus, } \alpha(\%) = \frac{\beta \times 100}{\mu}$$

Where,

$\alpha$  = Service Accessibility

$\beta$  = Number of Successful Set up Calls

$\mu$  = Total Number of Attempted Set up Call

Applying equation (1) on the data collected, the accessibility levels in percentage for the period for each network operator were computed as:

Table 3: Intra calls assessment for GSM network in UNN Nsukka Campus

| PERIOD  | Operator N (%) | Operator P (%) | Operator K (%) |
|---------|----------------|----------------|----------------|
| WEEK 1  | 72.2           | 76.7           | 75.7           |
| WEEK 2  | 84.4           | 87.3           | 94.4           |
| WEEK 3  | 89.2           | 83.3           | 85.1           |
| WEEK 4  | 86.5           | 83.3           | 82.6           |
| WEEK 5  | 88.5           | 76.7           | 82.3           |
| WEEK 6  | 87.8           | 92.4           | 79.9           |
| WEEK 7  | 93.4           | 96.2           | 83.3           |
| WEEK 8  | 88.5           | 85.8           | 84.7           |
| AVERAGE | 86.3           | 85.2           | 83.5           |

Table 4:

Inter calls assessment for GSM network in UNN Nsukka Campus

| PERIOD  | Operator N (%) | Operator P (%) | Operator K (%) |
|---------|----------------|----------------|----------------|
| WEEK 1  | 95.8           | 87.5           | 80.6           |
| WEEK 2  | 85.4           | 87.5           | 78.4           |
| WEEK 3  | 91.7           | 91.7           | 82.7           |
| WEEK 4  | 83.3           | 79.2           | 80.2           |
| WEEK 5  | 83.3           | 81.3           | 76.2           |
| WEEK 6  | 91.7           | 70.6           | 92.8           |
| WEEK 7  | 97.9           | 76.4           | 80.7           |
| WEEK 8  | 89.6           | 72.2           | 78.2           |
| AVERAGE | 89.8           | 80.8           | 81.2           |

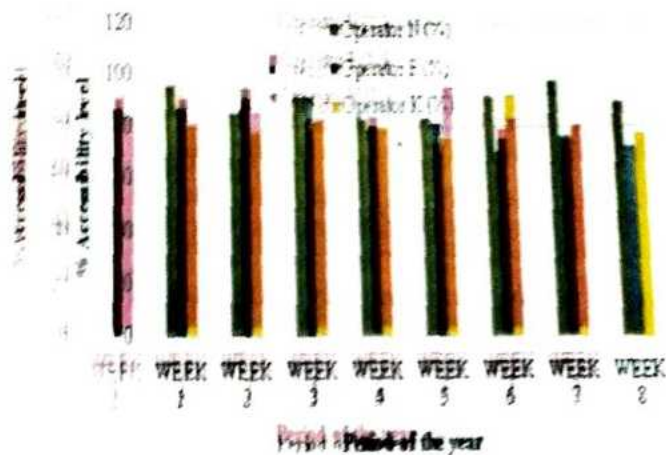


Fig. 1: A bar chart of Accessibility level against period of the year for intra network calls (March – April, 2010).

Figure 1 above is a bar chart of accessibility level against period of the year for intra network calls. The green colour bars represent accessibility level of Operator 'N' in percentages. The black colour bars represent accessibility level of Operator 'P' in percentages and the red colour bars represent accessibility level of Operator 'K' in percentages. Its illustrate the performance of outgoing calls (intra) for GSM network providers at University of Nigeria Nsukka campus for the period investigated.

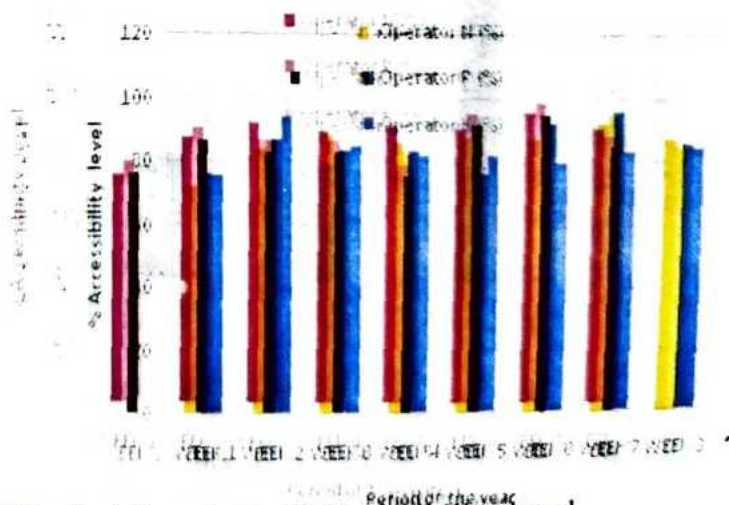


Fig. 2: A bar chart of Accessibility level against period of the year for inter network calls (March – April, 2010).

Figure 2 above is a bar chart of accessibility level against period of the year for inter network calls. The red colour bars represent accessibility level of Operator 'N' in percentages. The black colour bars represent accessibility level of Operator 'P' in percentages and the blue colour bars represent accessibility level of Operator 'K' in percentages. Performance of outgoing calls (inter) for GSM network providers at University of Nigeria Nsukka campus for the period investigated is illustrated by the chart.

Quality of service (QOS) profile describes the performance evaluation of a system from the consumer perspective, using specific parameters. In telephony, parameters used include service accessibility, call failure rate, call drop, voice quality, etc. All of these are affected by system configuration or dimensioning. Figure 3 below shows the quality of outgoing calls (Intra) for GSM network providers at the University of Nigeria Nsukka campus, for the period of investigation.

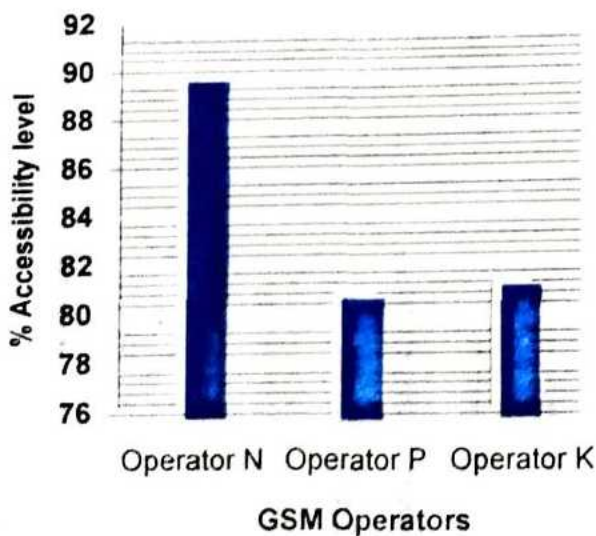


Fig. 3: A bar chart of accessibility level against GSM operators for intra network calls, (March – April, 2010)

Figure 4 below illustrate the quality of outgoing calls (Inter) for GSM network providers at the University of Nigeria

Nsukka campus, for the period of investigation.

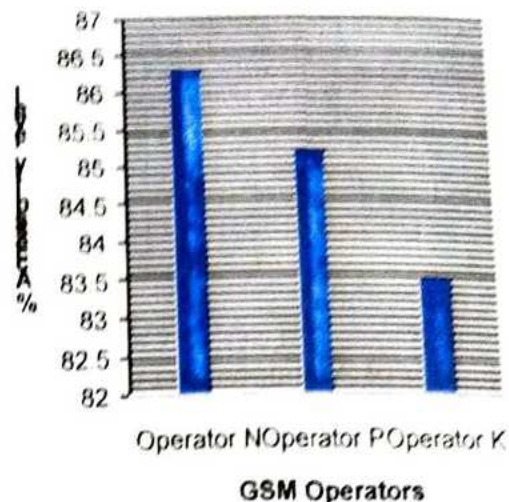


Fig. 4: A bar chart of accessibility level against GSM operators for inter network calls, (March – April, 2010)

## 4.2 CALL FAILURE RATE

Call failure rate is another parameter also used to evaluate the quality of service of GSM network providers at University of Nigeria Nsukka:

$$\text{Call Failure Rate (\%)} = \frac{\text{Number of Unsuccessful calls} \times 100}{\text{Total Number of Calls}} \dots\dots\dots (2)$$

Table 5: Intra Network Calls measurement on call failure rate – Operator N

| Period | Number of Calls | Number Successful | Number Unsuccessful | Failure Rate (%) |
|--------|-----------------|-------------------|---------------------|------------------|
| Week 1 | 96              | 89                | 7                   | 7.29             |
| Week 2 | 96              | 90                | 6                   | 6.25             |
| Week 3 | 96              | 86                | 10                  | 10.42            |
| Week 4 | 96              | 92                | 4                   | 4.17             |
| Week 5 | 96              | 84                | 12                  | 12.50            |
| Week 6 | 96              | 87                | 9                   | 9.38             |
| Week 7 | 96              | 86                | 10                  | 10.42            |
| Week 8 | 96              | 87                | 9                   | 9.38             |

Table 6: Intra Network Calls measurement on call failure rate – Operator P

| Period | Number of Calls | Number Successful | Number Unsuccessful | Failure Rate (%) |
|--------|-----------------|-------------------|---------------------|------------------|
| Week 1 | 96              | 83                | 13                  | 13.54            |
| Week 2 | 96              | 88                | 8                   | 8.33             |
| Week 3 | 96              | 86                | 10                  | 10.42            |
| Week 4 | 96              | 88                | 8                   | 8.33             |
| Week 5 | 96              | 82                | 14                  | 14.58            |
| Week 6 | 96              | 81                | 15                  | 15.63            |
| Week 7 | 96              | 79                | 17                  | 17.71            |
| Week 8 | 96              | 81                | 15                  | 15.63            |

Table 7: Intra Network Calls measurement on call failure rate – Operator K

| Period | Number of Calls | Number Successful | Number Unsuccessful | Failure Rate (%) |
|--------|-----------------|-------------------|---------------------|------------------|
| Week 1 | 96              | 84                | 12                  | 12.50            |
| Week 2 | 96              | 87                | 9                   | 9.38             |
| Week 3 | 96              | 88                | 8                   | 8.33             |
| Week 4 | 96              | 90                | 6                   | 6.25             |
| Week 5 | 96              | 84                | 12                  | 12.50            |
| Week 6 | 96              | 84                | 12                  | 12.50            |
| Week 7 | 96              | 80                | 16                  | 16.67            |
| Week 8 | 96              | 83                | 13                  | 13.54            |

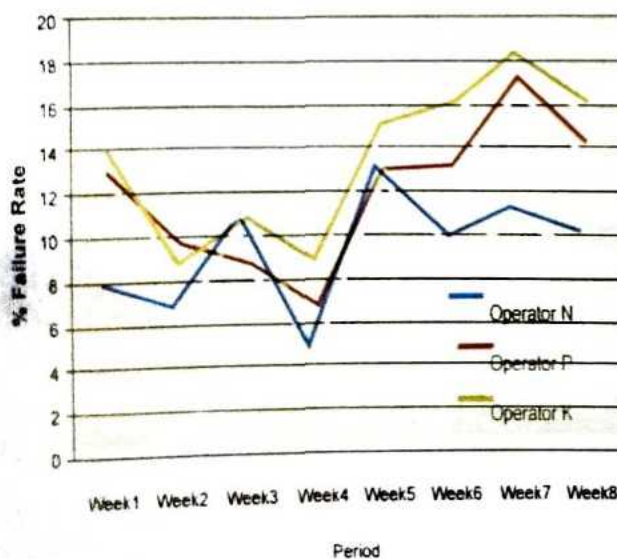


Fig. 5: Graph showing failure Rate against period of calls

### 4.3 Discussion of Results

The average accessibility level charts for intra and inter network calls obtained using equation (1) are presented in tables (3) and (4). The generated charts contain information about percentage accessibility level averaged for each week

for the respective GSM network providers.

The results are also presented in graphical form as shown in figures 1 to 4.

From this report, the quality of services provided for the outgoing calls in the University of Nigeria Nsukka campus both for inter and intra network connection is discussed. Tables 3 and 4 presented the average accessibility level as a function of successful calls both for inter and intra network connections for the investigated period.

Within the period, intra network calls quality seems to fall from 97.9% in week 7 to 83.3% in weeks 4 and 5 for Operator N network, from 91.7% in week 3 to 70.6% in week 6 for Operator P network and from 92.8% in week 6 to 76.2% in week 5 for Operator K network. While for the inter network calls, the fall was from 93.4% in week 7 to 72.2% in week 1 for Operator N network, from 96.2% in week 7 to 76.7% in week 1 for Operator P network and from 94.4% in week 2 to 75.7% in week 1 for Operator K network, were observed.

The overall average assessment was such that Operator N network had the best performance for the outgoing calls as compared with Operator P and Operator K with 89.8% for intra network calls connection and 86.3% for inter network calls.

Call failure rate is another parameter that was also used to evaluate the quality of service of GSM network providers in University of Nigeria Nsukka. Operator N network had its highest failure value as 16.28% for intra calls in week 6, Operator P network had its highest failure value as 16.54 for intra calls in week 7 and Operator K network had its highest failure

value as 18.75% for intra calls in week 7 for the period of investigation.

The overall assessment was such that Operator K network had the highest calls failure rate followed by Operator P network and Operator N had the least for the period of investigation.

### **5.0 Conclusion**

The call quality for the outgoing calls was generally good for the eight weeks of this investigation.

However, from this study there is need for system optimization (i.e. increase in the number of base stations and signal amplifiers to facilitate signal transmission and reception and minimize attenuation respectively); in order to improve GSM services in the University of Nigeria Nsukka campus.

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