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# Investigation of Call Quality in Cdma: Case Study of Two Network Operators in Epe Town, Nigeria

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**Abstract** This work presents the study of the call quality provided by the two CDMA service operators within Epe town of Lagos State, South-West Nigeria by collecting and analyzing call data from the Network Operation Centre in an attempt to evaluate the call quality parameters as provided by these operators. The result of the analysis is then compared with that those specified by the Nigerian Communication Commission NCC which is the main regulatory body for telecommunication operations in Nigeria. In this work, various call quality parameters were being evaluated for two CDMA mobile operators, that is, Operators 1 and Operator 2 with existing network infrastructures within Epe town. A total of three parameters were evaluated. These parameters are Ec/Io, Rx_Level and Tx_Power. In the course of this research, the six call quality parameters and the quality of services provided by two CDMA network operators were investigated, the research outcome shows that both operators provided a very good quality of services as specified by the Nigerian Communication Commission (NCC) during the period within which this research work was carried out.

***Keywords:*** *call quality, CDMA, Ec/Io, Rx_Level and Tx_Power*

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## 1. Introduction

The first North American digital cellular standard, based on time-division multiple-access (TDMA) technology, was adopted in 1989. Immediately thereafter, in 1990, Qualcomm, Inc. proposed a spread-spectrum digital cellular system based on code-division multiple-access (CDMA) technology, which in 1993 became the second North American digital cellular standard, known as the IS-95 system [1].

Code division multiple access (CDMA) is a channel access method utilized by various radio communication technologies. It should not be confused with the mobile phone standards called cdmaOne and CDMA2000 (which are often referred to as simply "CDMA"), which use CDMA as an underlying channel access method.

An analogy to the problem of multiple access is a room (channel) in which people wish to communicate with each other. To avoid confusion, people could take turns speaking (time division), speak at different pitches (frequency division), or speak in different languages (code division). CDMA is analogous to the last example where people speaking the same language can understand each other, but not other people. Similarly, in radio CDMA, each group of users is given a shared code. Many codes occupy the same channel, but only users associated with a particular code can understand each other.

These CDMA communications systems are spread-spectrum systems and make use of most of the modern communication and information- theoretic techniques that have so far been discovered by so many scientists and engineers.

In 1988, the Cellular Telecommunications Industry Association (CTIA) released cellular service requirements for the next-generation (second generation) digital cellular system technology, known as a users' performance requirements (UPR) document. The key requirements included a tenfold increase in call capacity over that of AMPS, a means for call privacy, and compatibility with the existing analog system. The compatibility requirement arose from the fact that the FCC did not allocate a separate band for the digital system, so the second-generation system must operate in the same band as AMPS [4].

In 1989, a committee of the Telecommunications Industry Association (TIA) formulated an interim standard for a second-generation cellular system that was published in 1992 as IS-54 [I]. In that standard, which became the first U.S. digital cellular standard, the committee adopted a time-division multiple access (TDMA) technology approach to the common air interface (CAI) for the digital radio channel transmissions [5]. The IS-54 TDMA digital cellular system employs digital voice produced at 10 kbps (8 kbps plus overhead) and transmitted with π/4 differentially encoded quadrature phase-shift keying (π/4 DQPSK) modulation [6]. The design envisioned non-coherent demodulation, such as by using a limiterdiscriminator or a class of differential phase detectors. Because the IS-54 system permits 30 kHz/10 kbps = 3 callers per 30-kHz channel spacing, the increase of capacity over AMPS is only a factor of three (180 calls per cell), and the TDMA digital cellular system so far falls short of meeting the capacity objective of the UPR. Immediately following the emergence of the IS-54 digital cellular standard, Qualcomm, Inc., in 1990 proposed a digital cellular telephone system based on CDMA technology, which in July 1993 was adopted as a second As is shown in Section 3, the actual capacity is lower than 60 calls per cell because of the allocation of some channels to signaling traffic. Using spread-spectrum signal techniques, the IS-95 system provides a very high capacity, as will be convincingly shown in this work, and is designed to provide compatibility with the existing AMPS, in compliance with the specifications of the UPR document.

## 2. Literature Review

### 2.1. Overview of CDMA

This section introduces the architecture of the CDMA network with each element of the network well explained. This is followed by explanation of the basic multiple access technologies, that is, FDMA, TDMA and CDMA, with emphasis on the Spread Spectrum Characteristics of CDMA. It explains the CDMA channels with an illustration of the Call process flow within a CDMA network. It is then ended with explanation of the Network Monitoring Centre.

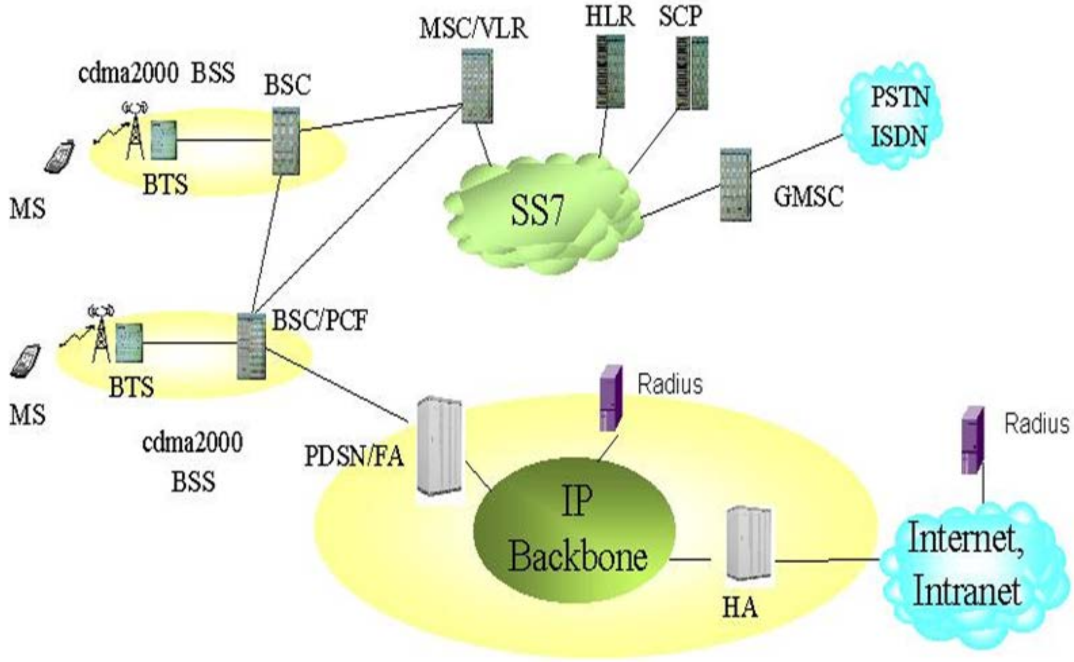


**Figure 1.** The CDMA Network Architecture [4]

#### 2.1.1. Mobile Station (MS)

The MS is the mobile subscriber equipment, which can originate and receive calls and communicate with the BTS [4].

#### 2.1.2. Base Transceiver Station (BTS)

The BTS transmits and receives radio signals, realizing communication between the radio system and the mobile station.

#### 2.1.3. Base Station Controller (BSC)

The BSC implements the following functions:

Base Transceiver Station (BTS) control and management, call connection and disconnection, mobility management, stable and reliable radio link provision for the upper-layer services by soft/hard handoff, power control, and radio resource management [4].

#### 2.1.4. Packet Control Function (PCF)

The PCF implements the R-P connection management. Because of the shortage of radio resources, some radio channels should be released when subscribers do not send or receive data, but the PPP connection is maintained continuously. The PCF can shield radio mobility for the upper-layer services via handoff.

#### 2.1.5. Packet Data Service Node (PDSN)

The PDSN implements the switching of packet data services of mobile subscribers. One PDSN can be connected to multiple PCFs. It provides the interface between the radio network and the packet data network.

#### 2.1.6. Home Agent (HA)

The home agent locates the place where the Mobile Node opens its account; receive the registration information from MN. It is similar to HLR in mobile network. Broadcast the accessible information of mobile network. Setup the tunnel between FA & HA. Transfer the data from other computer to the MN via the tunnel.

#### 2.1.7. Mobile Switching Center (MSC)

The MSC implements the service switching between the calling and called subscribers. One MSC is connected with multiple BSCs. The MSC can also be connected to the PSTN, ISDN or other MSCs. It provides the interface between the radio network and PSTN.

### 2.1.8. Visitor Location Register (VLR)

It is a dynamic database, stores the temporary information (all data necessary to set up call connections) of the roaming subscribers in the local MSC area.

VLR is used to store the subscriber information of all the MSs in its local area, which can be used to establish the incoming/outgoing call connections, to support basic services, supplementary services and mobility management.

### 2.1.9. Home Location Register (HLR)

It is a database for mobile subscriber management, the HLR (Home Location Register) is responsible for storing subscription information (telecom service subscription information and subscriber status), MS location information, MDN, IMSI (MIN), etc. The AC (Authentication Center) is physically combined with the HLR. It is a functional entity of the HLR, specially dedicated to the security management of the CDMA system. It stores the authentication information. It also prevents unauthorized subscribers from accessing the system and prevents the radio interface data from being stolen [4].

## 3. Materials and Methods

So many methods have been used by researchers and the industries experts to collect call data within a Public Line Mobile Network. Call data can be obtained from mere initiating calls from the mobile stations. It can also be obtained from analysis of drive test data. The most commonly used method is by obtaining these parameters from a central monitoring centre called the Operation and Maintenance Centre (OMC), Network Operation Centre (NOC) or the Network Management Centre (NMC).This has since been proved to be the most reliable method of call data collection. This is because the NOC connects directly to the BSC and MSC which are the most sensitive equipments within the GSM infrastructures.

Different classes of data are obtained from the NOC including traffic and signaling messages. Reports are then generated from these data via enterprise software applications referred to as Element Management Software EMS. This software provides platforms for reports generation in various file formats with the Microsoft Excel format being the most common. Reports are collected on a daily, weekly, monthly and even yearly basis.The essence of this work is to investigate the call quality provided by the two CDMA service operators withinEpe town of Lagos State, South-West Nigeria by collecting and analyzing call data from the Network Operation Centre. The result of the analysis is then compared with that those specified by the Nigerian Communication Commission NCC.

### 3.1. Data Collection

In this work, data collection was obtained from the Network Operation Centre for the two CDMA services operators (Operator 1and Operator 2) providing services to Epe town. The data for a total of seventeen months within the periods of January 2008 and May 2009 were obtained showing a detailed research operation. Parameters for analysis here are Mean Ec/Io (dBm), Receive Power (dBm) andTransmit Power (%)

The following table shows the data obtained for each of the parameters as above stated.

**Table 1. Data For Monthly Ec/Io Distribution**

| | Ec/Io_Total (dB) | |
|---|---|---|
| | **Network A** | **Network B** |
| January,2008 | -7.16 | -5.84 |
| February,2008 | -5.29 | -3.59 |
| March,2008 | -4.06 | -9.15 |
| April,2008 | -2.16 | -8.96 |
| May,2008 | -3.93 | -7.58 |
| June,2008 | -5.22 | -6.09 |
| July,2008 | -4.25 | -5.99 |
| August,2008 | -3.17 | -5.33 |
| September,2008 | -7.23 | -6.14 |
| October,2008 | -6.45 | -7.01 |
| November,2008 | -8.35 | -9.85 |
| December,2008 | -9.17 | -10.18 |
| January,2009 | -7.21 | -7.50 |
| February,2009 | -4.65 | -5.81 |
| March,2009 | -4.41 | -3.42 |
| April,2009 | -5.78 | -4.43 |
| May,2009 | -4.94 | -6.33 |

**Table 2. Receive-Power Distribution**

| | Rx_Level (dBm) | |
|---|---|---|
| | **Network A** | **Network B** |
| January,2008 | -62.89 | -73.27 |
| February,2008 | -75.10 | -69.84 |
| March,2008 | -62.70 | -64.63 |
| April,2008 | -74.95 | -72.90 |
| May,2008 | -81.17 | -68.54 |
| June,2008 | -67.35 | -84.45 |
| July,2008 | -69.29 | -82.51 |
| August,2008 | -61.84 | -89.04 |
| September,2008 | -67.51 | -93.49 |
| October,2008 | -77.01 | -70.12 |
| November,2008 | -72.31 | -67.03 |
| December,2008 | -85.23 | -61.34 |
| January,2009 | -90.29 | -69.23 |
| February,2009 | -80.03 | -80.12 |
| March,2009 | -83.84 | -70.85 |
| April,2009 | -75.71 | -75.03 |
| May,2009 | -67.29 | -66.83 |

**Table 3. Data For Transmit Power (DBM)**

| | Tx_Level > = -5 dBm and < = -20 dBm | |
|---|---|---|
| | **Network A** | **Network B** |
| January,2008 | -9.23 | -8.65 |
| February,2008 | -10.82 | -14.73 |
| March,2008 | -12.65 | -11.25 |
| April,2008 | -8.09 | -8.73 |
| May,2008 | -19.87 | -12.51 |
| June,2008 | -7.54 | -15.79 |
| July,2008 | -8.97 | -8.64 |
| August,2008 | -9.21 | -8.72 |
| September,2008 | -16.35 | -13.29 |
| October,2008 | -8.79 | -6.09 |
| November,2008 | -17.89 | -17.56 |
| December,2008 | -10.08 | -7.92 |
| January,2009 | -23.34 | -9.03 |
| February,2009 | -12.69 | -16.78 |
| March,2009 | -16.04 | -11.34 |
| April,2009 | -7.26 | -16.34 |
| May,2009 | -6.71 | -20.23 |

## 4. Results and Discussion

It is pertinent to note here that each of those parameters under analysis represents the mean values of the set of data over a range of time. Any of these parameters can be obtained at any time. For instance, a monthly value of say -6 dB for Ec/Io represents the mean values of Ec/Io over a month period.

### 4.1. Ec/Io Analysis and Result Interpretation

Ec/Io is the measurement mobiles use to gauge strengths of the various nearby sectors they encounter. Ec means the energy per chip of the pilot of the observed sector and Io means the total power currently being picked up by the mobile. It is a notation used to represent a dimensionless ratio of the average power of a channel, typically the pilot channel, to the total signal power.

Mobiles measure the pilot strength of a sector, determining its strength as a percentage of total received power.

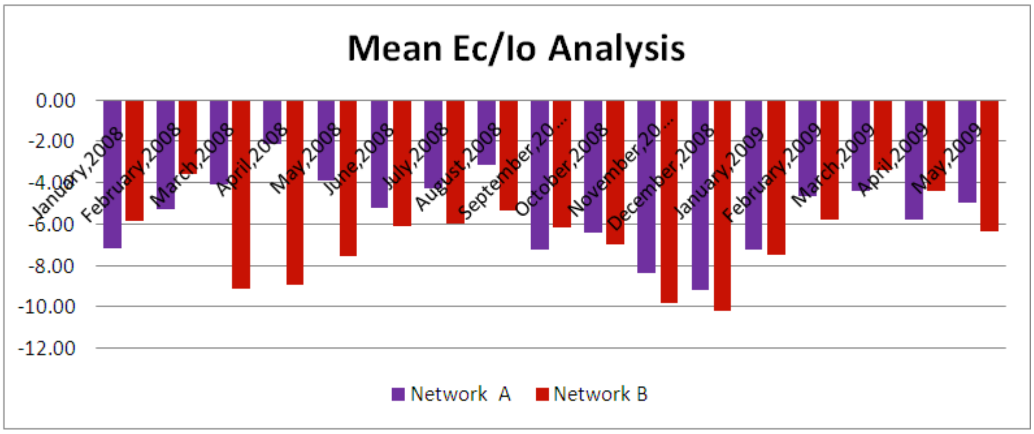


**Figure 2.** Graph of monthly EC/IO distribution

The Nigeria Communication Commission (NCC), recommends that the Mean Ec/Io value should not go below -9 dB within a CDMA network.

The result of this research shows that Network A has a good value for Ec/Io for the period of this research except in December 2008 when it dropped slightly below -9 Bb. For Network B; the Ec/Io values were also acceptable except for March, November and December, 2008.

Taking an overall average, Network A delivered an average Mean Ec/Io value of -5.50 dB while it is -6.66 dB for Network B.

### 4.2. Receive Power Analysis and Result Interpretation

The receive signal level is the receive power at a receiver input and is usually expressed in dB (decibel) with respect to 1 mw, i.e., 0 dBm. The Nigeria Communication Commission, (NCC) recommends that the Mean Receive Power value should not go below -90 dBm within a CDMA network.

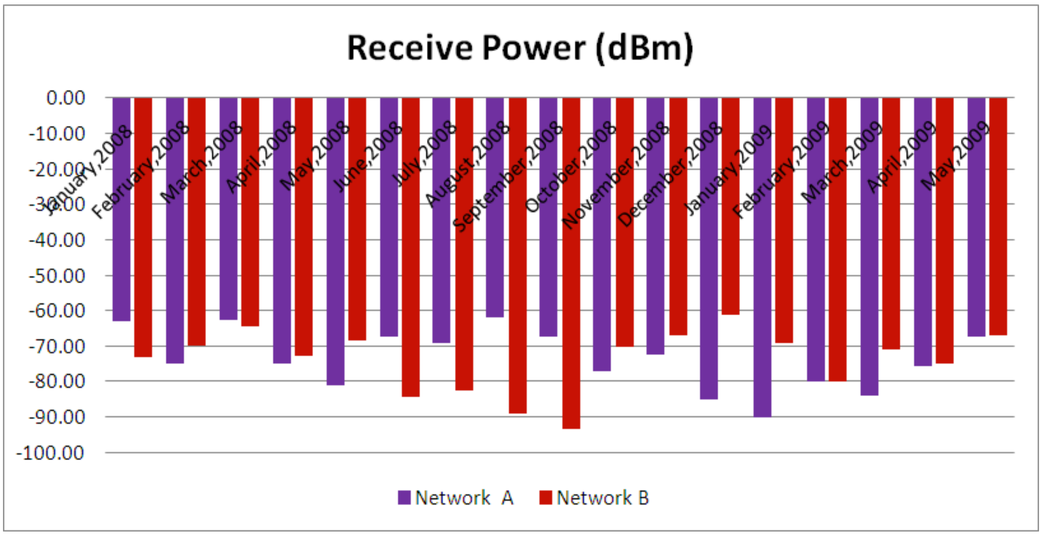


**Figure 3.** Graph of monthly receive power (DBM) distribution

Network A shows an excellent receive signal power values for the period of research. On the other hand, Network B had its receive power going below -90 dBm for September 2008. In the overall, Network A produced a perfect mean receive power of -73.79 dBm while Network B produced -74.07 dBm.

### 4.3. Transmit Power Analysis and Result Interpretation

The transmit power refers to the power in dBm that the mobile station use to access to network resources. These transmit power at all time should be small at all time.

When the receive level to a CDMA mobile station reduces, the mobile station has a feature of raising its transmit power to cushion the effect of the reduced power. This is referred to as the power control feature of the CDMA technology.

The Nigerian Communication Commission (NCC) recommends that the Transmit Power value should not go below -20 dBm within a CDMA network under normal circumstances.

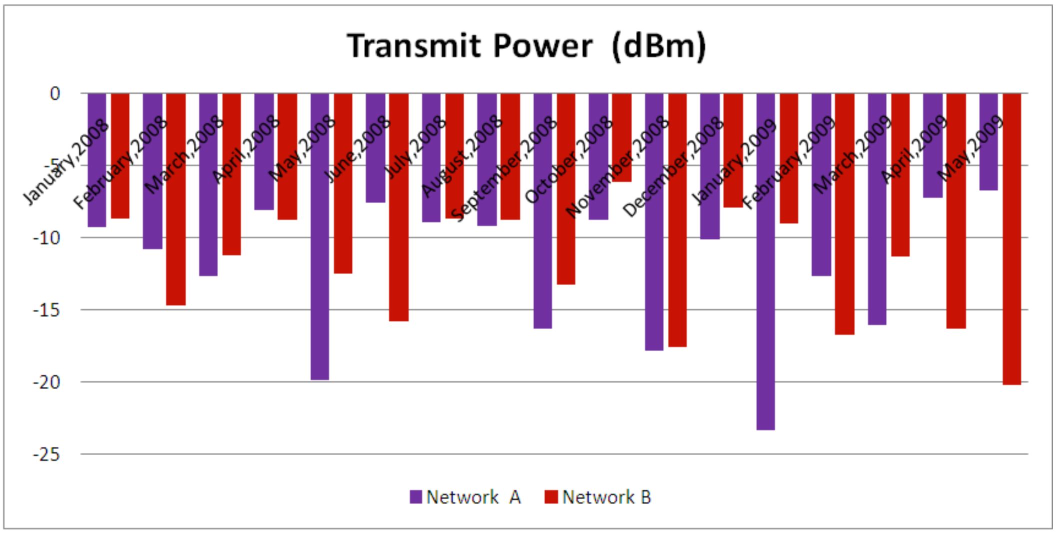


**Figure 4.** Graph of Transmit Power (DBM)

From the result of this research, Network A shows good Transmit Power for the period of research except for January 2009 where the value went down to -23.34 dBm. For Network B, the transmit power was good as well except for May 2009. In the overall, Network A shows a mean Transmit power of -12.09 dBm while Network B shows -12.21 dBm.

## 5. Conclusion

Following the implementation of an eighteen month research on the three call quality parameters (Ec/Io, Rx_Level and Tx_Level) and the quality of services provided by two CDMA network operators and considering their respective facilities in Epe town of Lagos State, Western Nigeria, it can be concluded that both operators provided a very good quality of services as specified by the Nigerian Communication Commission (NCC) during the period within which this research work was carried out.

## Recommendations

The following are recommended from this research:

1. There should be a well established monitoring scheme to evaluate all necessary data and information through which this scheme can be used.
2. Personnel should be encouraged to co-operate with data centers in order to arrive at a valid data for proper comparison.
3. There should be more co-operations between network providers and the academia to help improve the quality of services provided.

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