# Optimization and analysis of the packet switched network with focus on the 3G network



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**Abstract**.
A class of computer communications network that groups and passes data in the form of s mall packets is referred to as the PSN.. This research aimed at analyzing the Network output on 3 G Network, which is using Packet Switching. The Performance indices observed include the Received Signal Code Power (RSCP), the Energy per Chip to Spectral Noise density ratio, Handover Success Rate, and the Throughput. These indices were used to define the Coverage, accessibility, and data throughput of the Network.

**Keywords:** Mobile Network Operator (MNO); 3G Network; WCDMA; KPI; RSCP; Ec/No; Throughput

## 1. Introduction

Communication is an integral part of life [1]. Human being has been known to communicate and send information from one end to the other by means of signaling through color, smoke, fire, sounds, among other methods. These means have been modernized gradually to this present day. The advancement has brought about sending Short Message Service (SMS), Multimedia Message Service (MMS), Circuit Switched Voice Calls, Packet Switched Voice Calls, as well as video calls. This technology did influence not only communication between people but also improved the means through which information is sent to people and increased the ease of access to the information.

There has been a consistent race by Engineers and telecommunication experts to make the communication links better and faster. The current efforts all over the world are the race to achieve 5G and get it deployed in most parts of the world [2]. This technological advancement will give birth to and help facilitate other technologies. One of such technological advancement is the Internet of Things in which every devices, gadgets, and tool that can function on its own will have a dedicated address for which it can communicate on the web.

A communication link is a connection through which information is sent from one point to the other. A medium through which information is sent needs to have some basic characteristics for effective processing. These characteristics include Reliability, Availability, and Integrity, among others. These characteristics are explained as follows.

### *1.1 Research Motivation*

In a research carried out in [3], there were some recommendations pointed out that can be worked on in future [3]. This paper is aimed at working on the area that was pointed out. The research included works on the 3G technology for the University of Ilorin community. It was carried out as a drive test and was focused on the quality of voice calls.

This paper on the other hand is focused on Data connectivity and speed of communication over the 3G technology data network.

### *1.2 Third Generation (3G) network*

Third generation (3G) systems promise faster communications services, including voice, fax and Internet, anytime and anywhere with seamless global roaming. There have been several competing proposals for a global 3G Standard, of these, the WCDMA is chosen as the best for the following reason

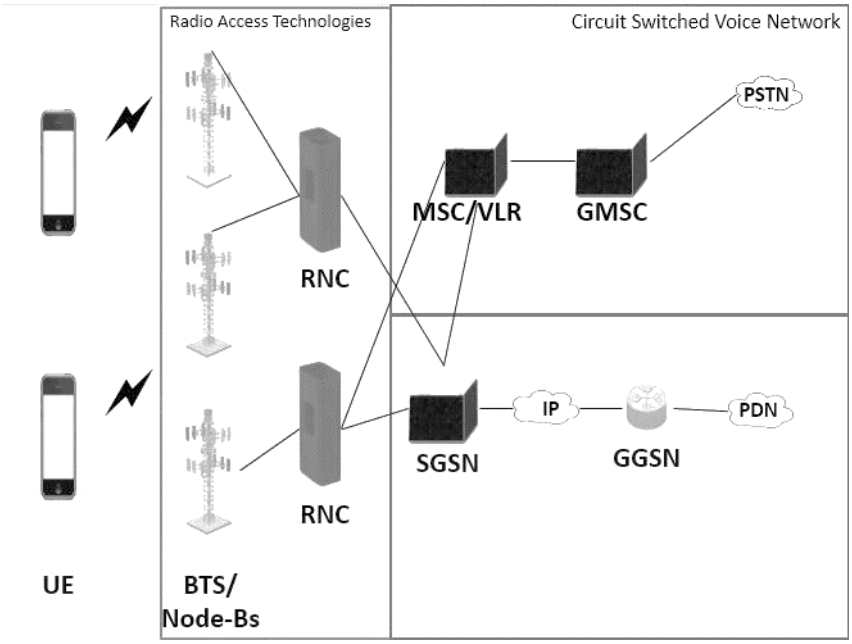


Figure 1: 3G Architectural Model [4]

WCDMA: In IMT-2000 family, the bandwidth of a WCDMA system is 5 MHz or more, and this 5 MHz is also the nominal bandwidth of all 3G WCDMA proposals. This bandwidth was chosen because:

• It is enough to provide data rates of 144 and 384 Kbps [5] (these were 3G targets), and even 2 Mbps in good conditions.

• Bandwidth is always scarce, and the smallest possible allocation should be used, especially if the system must use frequency bands already occupied by existing 2G systems.

• This bandwidth can resolve more multipaths than narrower bandwidths, thus improving performance [5].

## 2. Network and services providers

### *2.1 Key Performance Indicator Optimization*

Key Performance Indicators (KPI) are not specific to telecommunications. They have different applications and are used as a measure of performance of various systems to make them more effective. In telecommunications, these Indicators are managed and defined by the Communication regulating body or Commission of a country. They set a minimum threshold that the values must conform with.

In Nigeria, the governing body is the Nigeria Communication Commission (NCC). The function of the commission is basically regulation of the telecommunications sector. They maintain law

and order of this sector with duties assigned to the various departments of the commission. The departments in charge of this are the Technical standards department and the Department of Compliance and Monitoring [6].
The threshold values they set stand as a guide for Mobile Network Operators (MNO) when designing and installing an infrastructure in any area. They should make sure that the service they are providing to their customers are optimum.

*2.2 Related Works*
P3 Connect, an Optimization company in the United Kingdom wrote carried out a network test to get the Network Performance [7]. The test involved the following network providers; Vodafone, Three, O2 and EE. They did a benchmarking test which results in the comparison of services offered by the Service providers. The test included Voice and Data quality and was classified by how populated and developed the areas are.
A group of researchers carried out radio frequency optimization on the Network deployed in Abeokuta and the Handover failures was highlighted and optimized. They used MapInfo for post analysis of logfiles data captured using TEMS Investigation [8].
A number of researchers in Bangkok used Agilent 5.2 drive test tool for data gathering in order to optimize the Handover success rate of users in their city. They used ACTIX for post processing of data collected [8]. A similar research was carried out here in the City of Akure, Nigeria. This research was carried out with TEMS investigation at different times of the day. They analyzed more KPIs in this case which includes Call setup success rate (CSSR), Received Signal Code Power (RSCP), Call drop rate and Soft Handover Success rate [10].
A network optimization was done on the GSM network using drive test to gather data. The researchers optimized the following KPIs; HOSR, RXLEV, RXQUAL and CSSR. The test was carried out in the northern part of Nigeria [11].

## 3. Methodology
The research requires that data be gathered from various areas within the University of Ilorin. The study is based on 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 is uploaded at the various test areas, as indicated in the scope of this project.
The test is to be carried out on the major Mobile Network Operators in Nigeria. The areas of focus include Faculty of Arts Lecture area, Walkway, Faculty of Law Lecture Areas and the Faculty of CIS lecture area.

*3.1 Data Collection*
A process referred to as walktest was used in the data collecting process. A software called TEMS Investigation will carry out Collection of Data. For the sake of this project, TEMS Investigation

16.3.4 was installed on the Laptop used for the Project. The project will be analysed with the aid of a TEMS Discovery Device 10. This will be used in conjunction with Microsoft Excel for statistical presentation of data.

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

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

In addition, it is common the use of adapters and/or hubs that allow the correct interconnection of all equipment. The diagram below describes the schematic of standard connections [12]. Quality of facilities, access to usage, performance assessment, efficient staff and so on are of considerable significance in mobile networking[13-19].

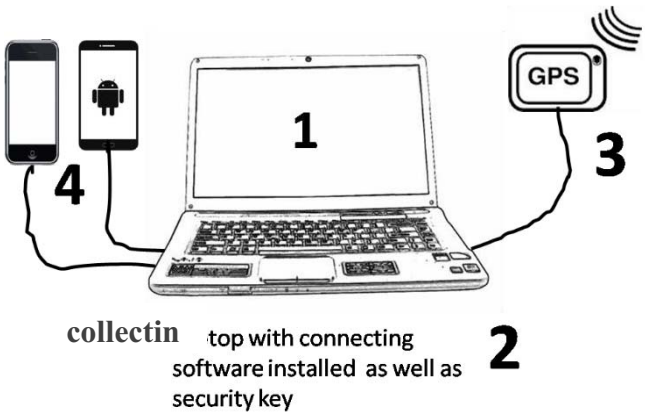


Figure 2: Schematic of Standard Connection of Devices used for the test [4]

The main goal of performing the walk test is to collect test data, which can be analyzed in real time during the test or after the test, showing the performance of the network on the field. Data from the test are collated by collecting software and stored in one or more output files called Logfiles.

## 4. Results and Discussion

The results of the Walk test are represented summarized for easy understanding with the aid of TEMS Discovery tool. The logfiles are uploaded and categorized into datasets for the different location on which the test was carried out.

The KPIs displayed here are RSCP, Ec/No and Throughput.

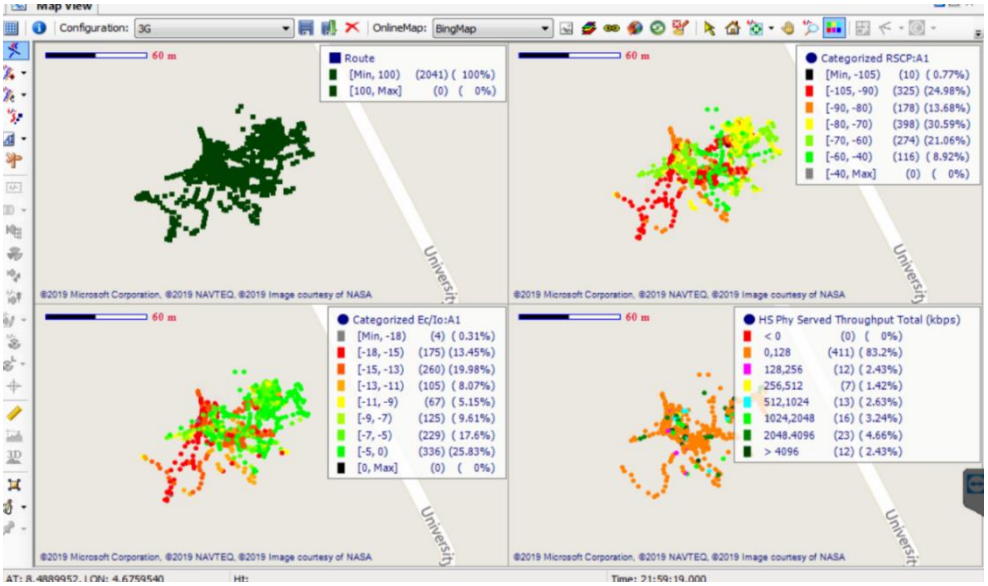


Figure 3: Screenshot showing the Service quality for all for MNOs in Faculty of CIS

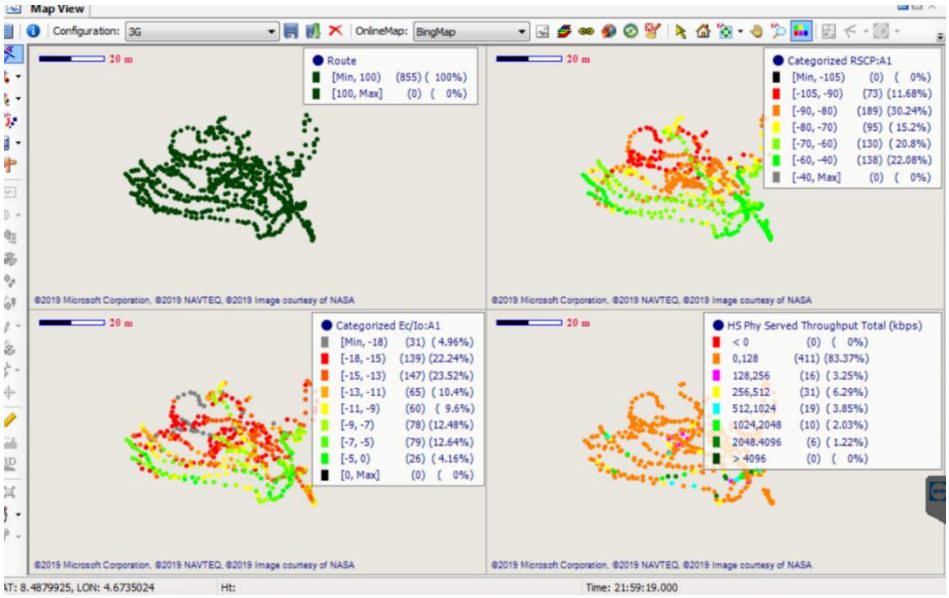


Figure 4: Screenshot showing the Service quality for all for MNOs in the Faculty of Art

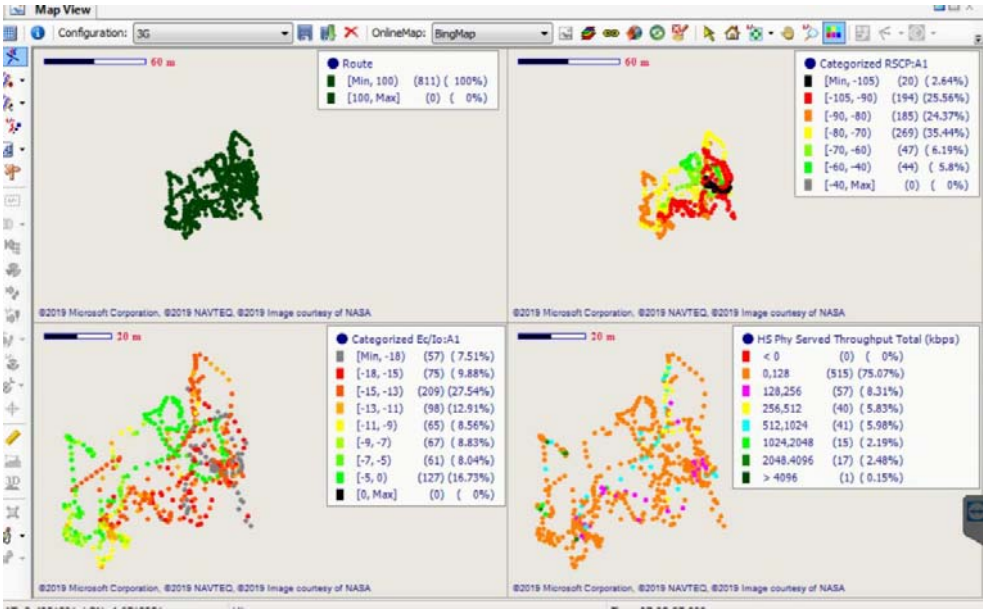


Figure 5: Screenshot showing the Service quality for all for MNOs in Faculty of Law

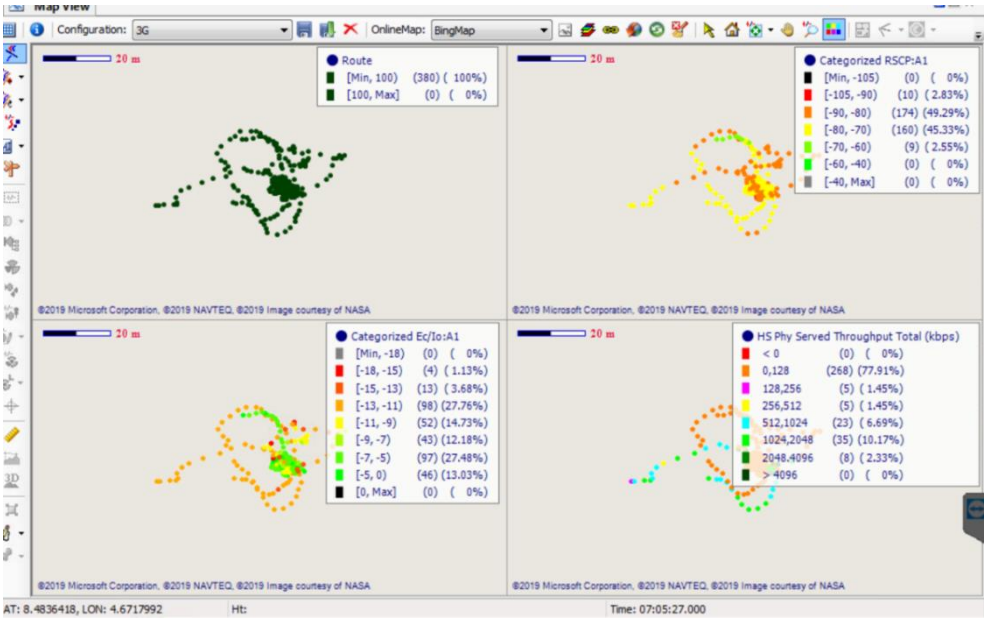


Figure 6: Screenshot showing the Service quality for all for MNOs in the first part of Walkway

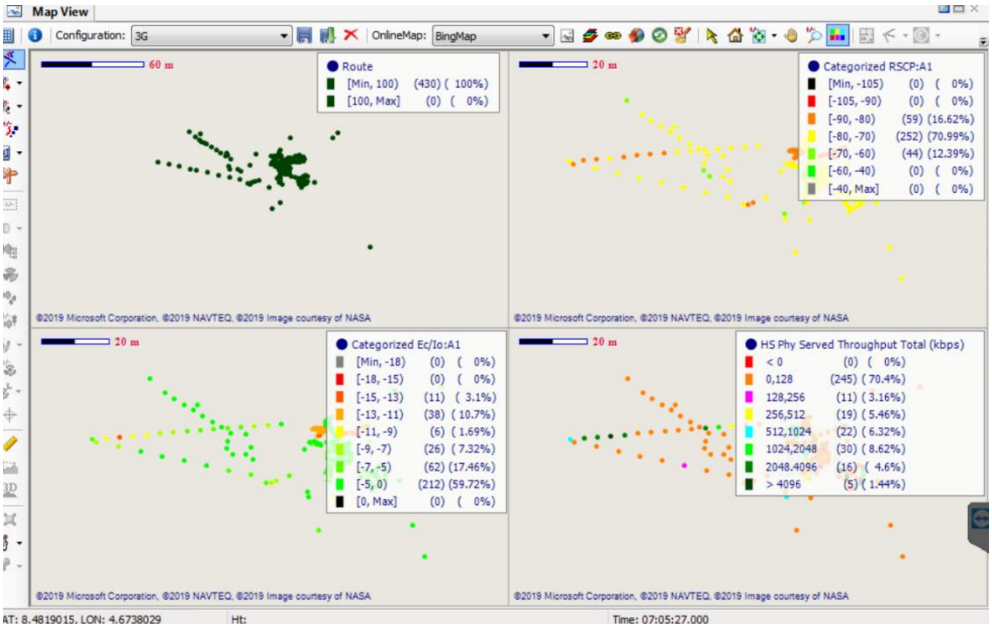


Figure 7: Screenshot showing the Service quality for all for MNOs in the second part of Walkway

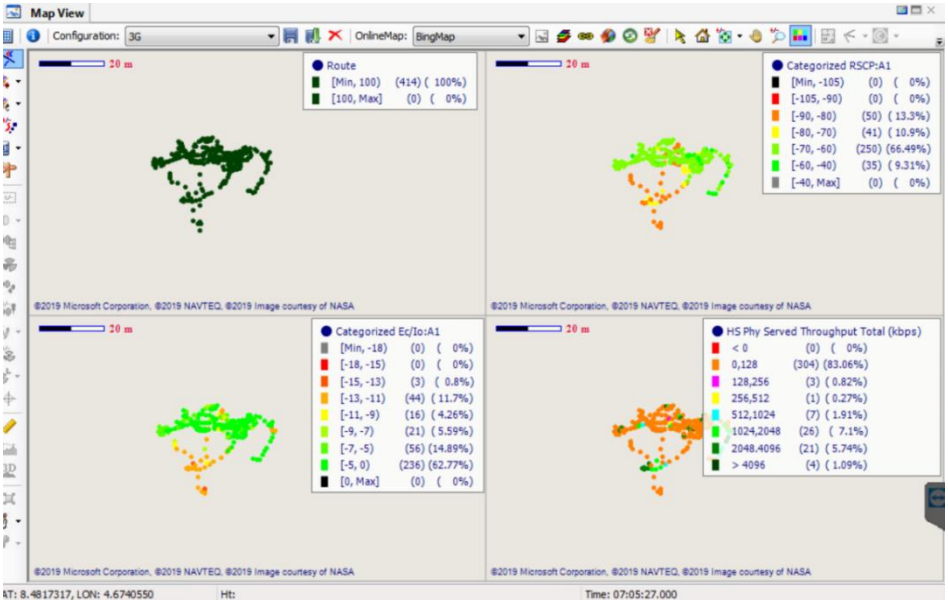


Figure 8: Screenshot showing the Service quality for all for MNOs in the third part of Walkway

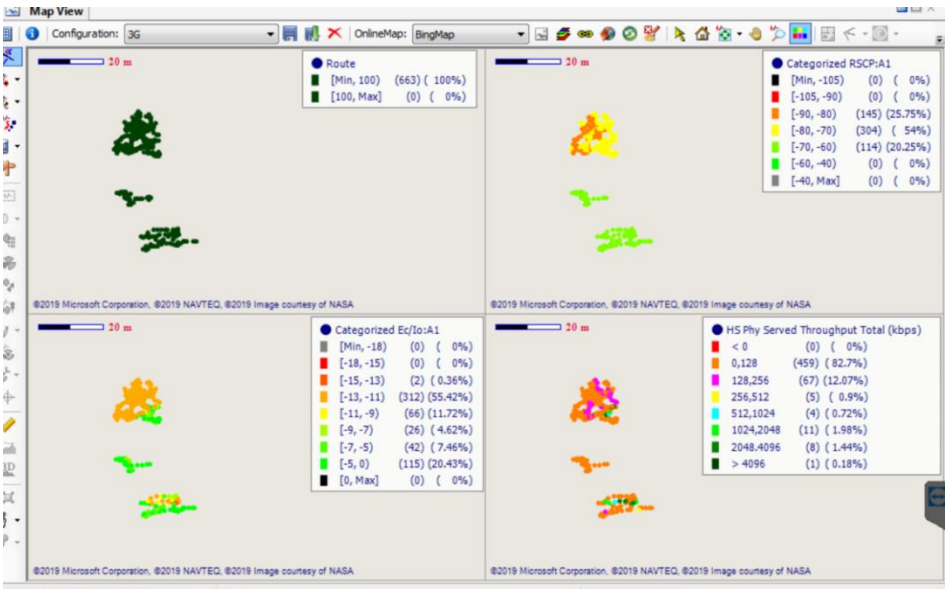


Figure 9: Screenshot showing the Service quality for all for MNOs in the fourth part of Walkway

*4.1 Result analysis*

The Packet-switched Data section of this report is based on UE data collected. Packet service accessibility is assessed by means of Radio Access Server (RAS) dialup statistics, and

retainability statistics are obtained for each supported service through an analysis of PS data sessions.

*4.1.1 Distribution of Radio Access Technology Usage*

Since the Radio Access Network (RAN) Tuning tool handles inter-RAT traffic cases, GSM data may occur, and the following chart is drawn to show the distribution of time spent on the different cellular technologies during active data sessions. The graph shows that when the Mobile is inactive, it switches between Radio Access Technologies to connect to the best at the time.

Table 1: Hint for figure 10

| **Range** | **Value** |
|---|---|
| GSM | 1.94 |
| LTE | 13.87 |
| WCDMA | 84.19 |

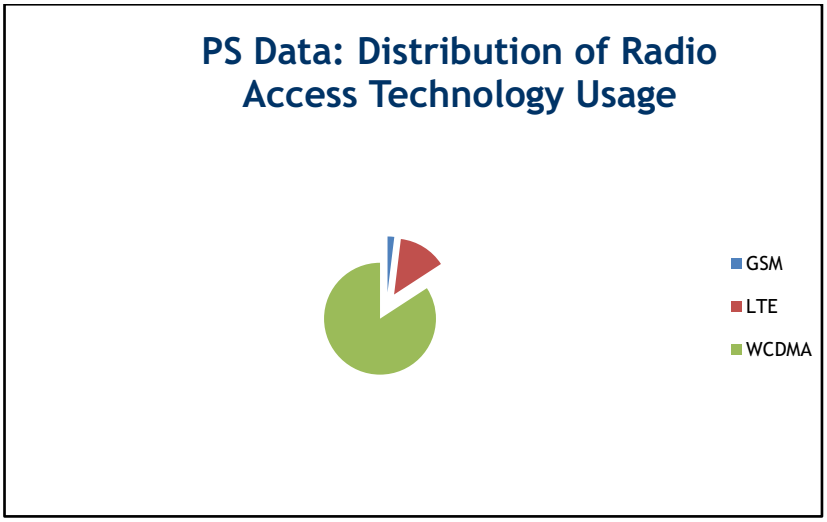


Figure 10: Percentage of Radio Access technology used

*4.1.2 Coverage*

The graph below shows the Received Signal Code Power and the Ec/No. These two KPIs are used to determine if the network is of good quality. RSCP is used to denote Signal Power while Ec/No is used to determine the Signal Quality. The two KPIs when combined gives the RSSI which dictates the quality of the network. As you can see from the tables that follow the graph. Table 1 through Table 14, showed that the coverage was best for 55% of the total time the test was carried out, and Figure 1-16 contained the associated links.

Table 2: Hint for Figure 11

| Range | RSCPPDF % |
|---|---|
| [Min, -105) | 0.69 |
| [-105, -90] | 13.9 |
| [-90, -80] | 22.62 |
| [-80, -70] | 35.06 |
| [-70, -60] | 20.04 |
| [-60, -40] | 7.69 |
| [-40, 0] | 0.00 |

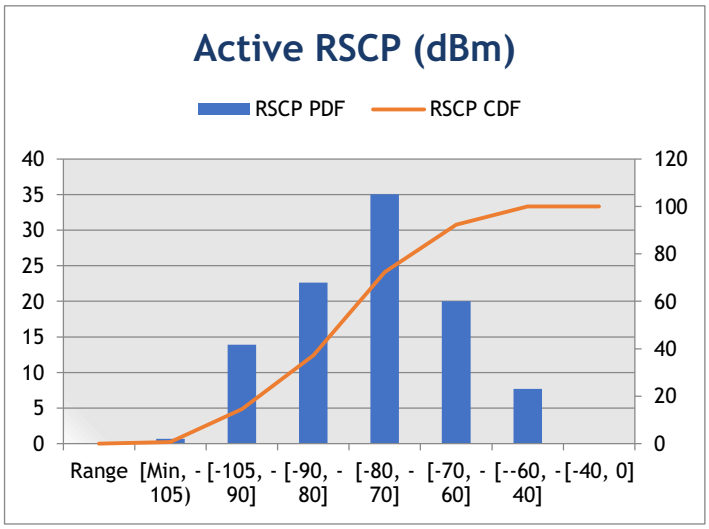


*Figure 11:* RSCP Ranges (85.41% above -90dBm)

Table 3a: Hint for Figure 12

| | Ec/Io PDF |
|---|---|
| Range | PDF % |
| [Min, -18) | 2.12 |
| [-18, -15) | 9.07 |
| [-15, -13) | 14.9 |
| [-13, -11) | 17.54 |
| [-11, -9) | 7.66 |
| [-9, -7) | 8.91 |

| | |
|---|---|
| [-7, -5) | 14.45 |
| [-5, 0) | 25.35 |
| [0, Max] | 0 |

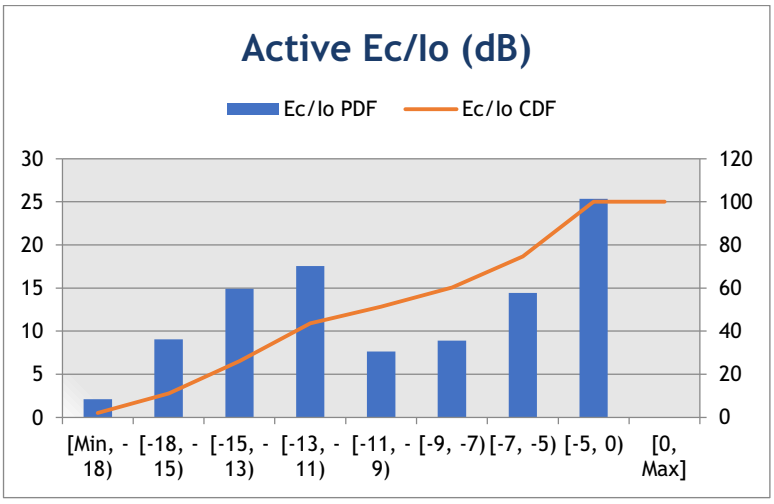


Figure 12: Ec/Io Ranges (56.37% above -11dB)

Table 3b: shows the percentage distribution of the cell measurements across RSCP and Ec/No value ranges, as well as across coverage classes (defined by RSCP and Ec/No)

| **Pilot Coverage Class** | **RSCP >=-92** | **-92 > RSCP >= -95** | **-95 > RSCP >= -107** | **RSCP <-107** | **Any RSCP** |
|---|---|---|---|---|---|
| Ec/No >=-9.7 | 2317 | 1 | 0 | 0 | 2318 |
| -9.7 > Ec/No >= -12 | 490 | 5 | 3 | 0 | 498 |
| -12 > Ec/No >= -16 | 971 | 99 | 145 | 0 | 1215 |
| Ec/No < -16 | 113 | 22 | 30 | 7 | 172 |
| Any Ec/No | 3891 | 127 | 178 | 7 | 4203 |

Table 4: Pilot Coverage Class Distribution, Overall (selected cells only)

| **Coverage Class** | **Percentage** |
|---|---|
| Level 1 | 55.13% |
| Level 2 | 11.80% |
| Level 3 | 28.98% |
| Level 4 | 4.09% |

*4.1.3 Accessibility*

Accessibility in the packet-switched case is determined by the success rate of RAS dialups, PS attaches, PDP context activations and Handover during the test. Accessibility statistics for the test area are given in Table 3 for each pilot coverage class and overall. The tables and graphs show how accessible the network is. It also showed the time in seconds the network takes to establish connection for a Packet switched call. The handover statistics showed that Handover was successful more than 94% of the times. Figure 11 shows the high rate of failure to maintain the RRC connection.

Table 5: PS Data: Setup Time Statistics:

| Procedure | Min | Average | Max |
|---|---|---|---|
| PS Attach | 643 | 1278.33 | 1682 |
| PDP Context Activation | 1291 | 2303 | 4101 |
| PS Access | 829 | 6137.23 | 21280 |

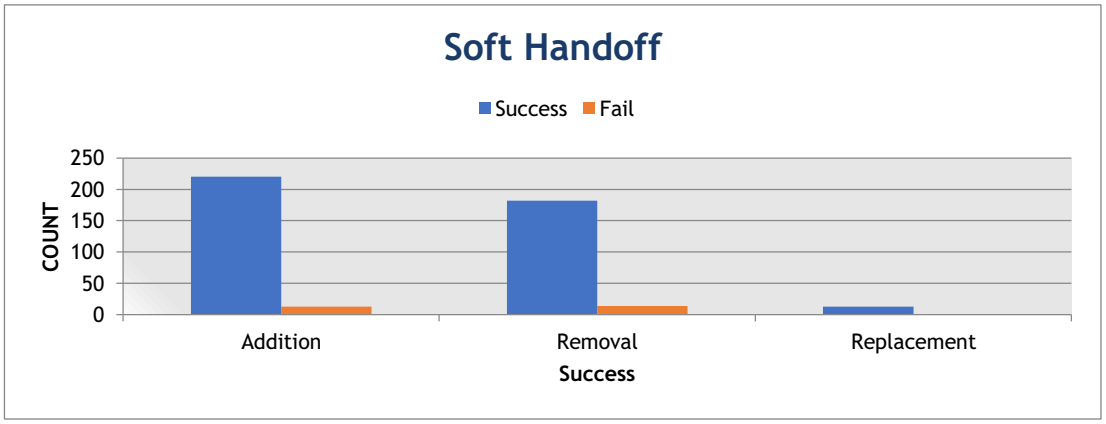


Figure 13: Handover success rate

*4.1.4 Data Throughput Best Server Throughput*

Table 6: PS Data: Binned RLC/Transport Channel Throughput Statistics

| Statistic | Min (kbit/s) | Average (kbit/s) | Max (kbit/s |
|---|---|---|---|
| Average RLC DL throughput | 0 | 241.87 | 6423.1 |
| Average RLC UL throughput | 0 | 1107.77 | 5571.22 |

Table 7: PS Data: RLC DL Throughput vs. CPICH Ec/No

| **Statistic** | **Median RLC DL Throughput <= 64 kbit/s** | **64 kbit/s < Median RLC DL Throughput <= 128 kbit/s** | **128 kbit/s < Median RLC DL Throughput** | **Any Median RLC DL Throughput** |
|---|---|---|---|---|
| Ec/No >=-9.7 | 1198 | 44 | 387 | 1629 |
| -9.7 > Ec/No >= -12 | 218 | 116 | 89 | 423 |
| -12 > Ec/No >= -16 | 595 | 164 | 281 | 1040 |
| Ec/No < -16 | 135 | 5 | 19 | 159 |
| Any Ec/No | 2146 | 329 | 776 | |

Table 8: Hint for Figure 14

| Range | |
|---|---|
| | CDF % |
| [Min, 0] | 0 |
| [0, 200] | 80.1 |
| [200, 400] | 4.55 |
| [400, 600] | 3.32 |
| [600, 800] | 2.4 |
| [800, 1000] | 1.41 |
| [1000, 1200] | 1.6 |
| [1200, Max] | 6.61 |

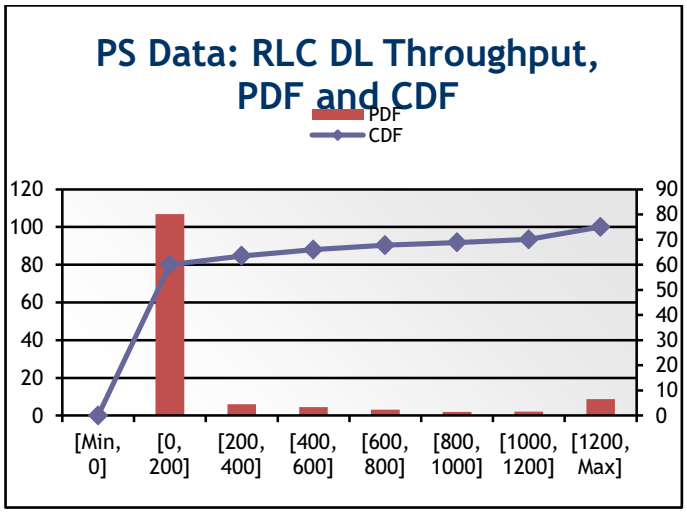


*Figure 14:* PS Data: RLC DL Throughput, PDF and CDF

Table 9: Hint for Figure 15

| Range | CDF % |
|---|---|
| [Min, 0] | 0 |
| [0, 100] | 52.73 |
| [100, 200] | 3.24 |
| [200, 300] | 1.33 |
| [300, 400] | 0.49 |
| [400, 500] | 0.96 |
| [500, Max] | 41.25 |

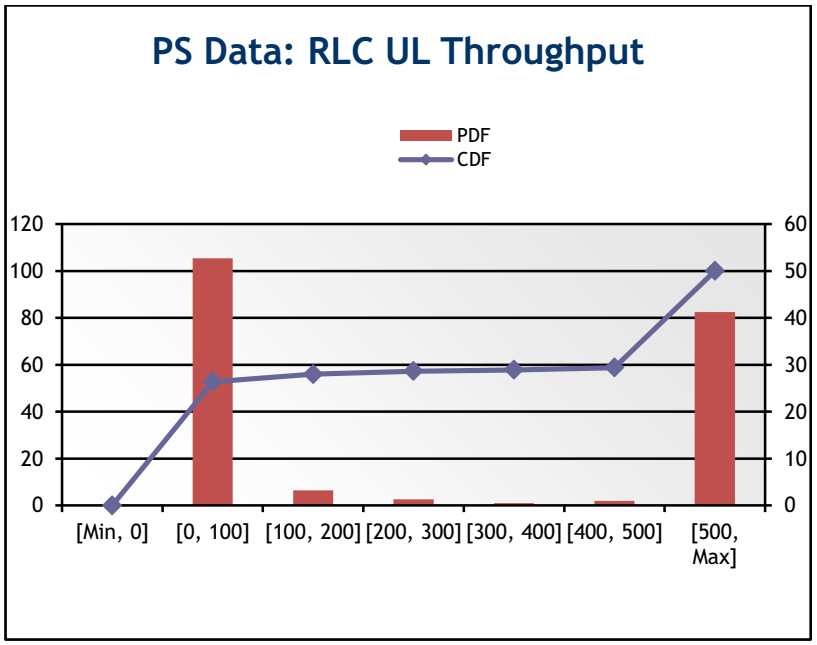


Figure 15: PS Data: RLC UL Throughput, PDF, CDF

**Downlink Throughput**

This is described as the speed of connection to the internet. The maximum speed limit for 3G network as described by the 3GPP is 2Mbps (2048kbps).

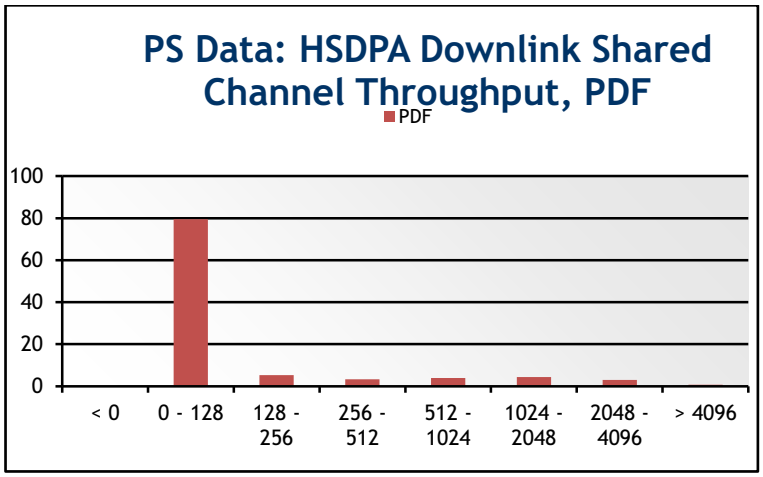


Figure 16: PS Data: HS Phy Served Throughput for HSDPA

*4.1.5 Optimization solutions*

At the initial stage, there was difficulty in getting accurate and up-to-date cell file so that the results will be exact all through. Nonetheless, one was obtained, which was used to carry out the test. In the images showing all the values for Route of the test for the area, RSCP, Ec/No and Throughput of the test (figure 3 to 9). This shows a color summary of the quality of service and at a glance, one can see which are is properly server and which part needs to be worked on.

## 5. Conclusion

The result as discussed above shows that the school network generally requires optimization as there is low percentage all through of data throughput reaching 1Mbps. The location with highest percentage of throughput reaching 1Mbps is the Walkway environment. This shows that this area is best served when compared with other areas in the school. Furthermore, very high percentage of the data connectivity throughput is below 256kbps. It is also important to note that the UL throughput is rather absurdly higher than the DL throughput.

## Acknowledgment

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