# UNIVERSITY OF GHANA

# DEPARTMENT OF COMPUTER SCIENCE

**A Study on The Variation of Telecommunication Network Signal Strength on The Campus of The University of Ghana**

**DECLARATION**

I hereby declare that, except for specific references which have been duly acknowledged, it is work is the result of my own field research and it has not been submitted either in part or whole for any other degree elsewhere.

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## ABSTRACT

The main focus of this project is to analyze the signal strength quality of telecommunication networks on the University of Ghana campus. In this project, the authors are investigating the issues of cell phone signal strength by collecting and analyzing data from a sample area on the campus around the hostels that are the student populated areas at different times of the day and weather conditions. This was to ascertain the various variations in signal strength of selected student populated areas at different points in time and under different weather conditions. After which the authors will create a web application to be a resource provider for students on where to get good network signals, for network service providers to get to know areas on campus with poor signals that need improvement, and provide data for further studies.

## DEDICATION

This work is dedicated to the almighty God for his grace and blessings which have propelled us this far.

# ACKNOWLEDGEMENT

We would like to express our gratitude to our primary supervisor, Prof. Apietu Ferdinand Katsriku, who guided us throughout this project. We would also like to thank our friends and family who supported us and offered deep insight into the study.

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## ABBREVIATIONS

| | |
|---|---|
| RSSI | Received Signal Strength Indicator |
| RSRP | Reference Signals Received Power |
| RSRQ | Reference Signal Received Quality |
| RSCP | Received Signal Code Power |
| SINR | Signal-to-Interference-plus-Noise Ratio |
| EC/IO | |

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# CHAPTER ONE

## 1. INTRODUCTION

### 1.1 BACKGROUND:

Almost everything and everyone is accessible over the internet or telecom networks. A person needs good network coverage in order to make calls or access the internet within a few seconds without problems. Having good reception is such a big deal in modern-day Ghana. Students find themselves having weak signals or even no signal in some areas on campus. The cause of this problem could be vast and may take a while to eliminate. Some students may rely on the institution's Wi-Fi for accessing academic platforms and resources whereas others may rely solely on their cellular networks be it 3G (HSPA, HSPA+), LTE, or 4G supported. These are good until you find yourself in an unsupported area. The best thing one can do currently when there is poor signal strength is walking around until he/she finds a good spot.

Poor cell phone connections are a common issue on the University of Ghana campus, and students report comparable issues such as; The reasons for signal failure may be classified into two types. The geographical distance or barriers to the base station nearest to the mobile phone are a variety of localized faults caused by building materials or destructive interference.

## 1.2 OBJECTIVES:

At the end of this study students involved will be able to:

- Outline the causes of signal strength variation of mobile phone networks (MTN, Vodafone, and Airteltigo) in the University of Ghana Campus.

- Create a connectivity map that will depict the network connectivity per network provider or place on campus.This would be done by using the data collected to create a web application that will provide you with the required information by a query search.

- The outcome of this research work could be used as a reference point when deciding a venue for activities that rely heavily on strength of the signal received by one’s device.

- Outline a proper solution to the problem stated.

## 1.3 PROBLEM STATEMENT

The cellular telephone system has been the best communication device nationwide. A study on causes of signal strength variation of the three big network service providers (i.e., taking into consideration MTN, Vodafone, and AirtelTigo) to identify where there usually exist dead zones and poor quality of services on campus.

## 1.4 AIM OF THE STUDY

The purpose of this project is to investigate the causes of signal strength variation of mobile phone network providers in the student populated areas of the University of

Ghana campus (i.e mainly the residential facilities; the Diaspora halls and the Traditional halls.)

## 1.5 METHODOLOGY

• The first stage of research is browsing through and reviewing journals and required information pertaining to the topic area.

• The second stage of this research is the collection of Received Signal Strength Indicator (RSSI) along the various locations stated in the scope.

## 1.6 SCOPE OF STUDY

The focus of the project is directly on the cause of signal strength variation of mobile phone networks in the University of Ghana Campus. We are well looking at MTN, Vodafone, as well as AirtelTigo as part of the major operators.

## 1.7 SIGNIFICANCE OF THE STUDY

Campus life appears to be fashionable, and students use a variety of communication platforms. They rely on a mobile network connection when WiFi is unavailable. This desire makes it much more disturbing when the network fails to connect at all. Students have expressed severe concerns about the substandard quality of service (QoS) offered by the telecom carriers identified in this survey area. The most vexing element of this is that it affects every student or user, regardless of a moderator. Based on these customer concerns, this inquiry was launched to determine the root cause of the issue. As a result, in order to alleviate subscriber discontent, this white project evaluates the signal strength of the University of Ghana's communications networks (MTN, AIRTELTIGO, and VODAFONE). This research will assist operators in improving future coverage, quality, and capacity.

### 1.8 LIMITATIONS OF STUDY

As we all know, there is no such thing as a painless human endeavor to attain a goal. As a result, some limits have been faced throughout the project's execution, and they are as follows:

Obtaining information is difficult: It is quite difficult for us to locate helpful material connected to our task, and this course helps us to search for answers in numerous libraries and on the Internet.

Time limitations: The researcher will be involved in this study as well as other academic projects. As a result, the time spent on research will be reduced and also the area of study(i.e., A few student populated areas are sampled).

### 1.9 PROJECT ORGANISATION

The work is arranged as follows: the first chapter is an introduction to the work, the second is a literature review of the research, the third is a description of the methods used, and the fourth is a conclusion. The article covers the work's outcomes, and the fifth chapter summarizes the research findings and suggestions.

# CHAPTER TWO

## 2. LITERATURE REVIEW

### 2.1 INTRODUCTION

A mobile network signal is the signal strength that is measured in dBm which is received by a mobile phone from a cellular network or mobile network. Based on the variety of the factors that affect mobile network signal such as proximity between the phone receiving and a tower or mast, the battery of the mobile phone dying, obstruction or blockage such as buildings, trees or materials or metals that hinder mobile network signal transmission in the path of the transmitting signals will the signal strength vary. Generally, most phones use bars or circles to show or predict the approximate of the received mobile network signal to the mobile phone. Mostly a number of five or four bars or circles are used to show the received mobile network signal strength.

Although the best place to receive good or best mobile network signal strength should be the urban places or the city since they are more modern developments to support the fluid supply of good reception, there are still some places in the city or urban places where you receive bad to no mobile network signal. A scenario is the Limann and Kwapong halls and their sides that face the Nougochi institute and some lecture halls, especially the Jones Quartey building. From studies, we have learned that mobile network signals are designed to be resistant to multipath distortions when they are being broadcast. Yet still the mobile network signals are blocked by building such high buildings, even trees. By contrast, the rural areas also have poor to no mobile network signal in their vicinity. Also along major highways, the signal is bad or lost. In cases where the mobile network signal is normally strong, other factors like the inside of a building with very thick walls or one of most metal construction, signal attenuation may interfere and prevent the mobile phone from being able to be used. In places such as underground areas, there will be a lack of mobile network signals unless those areas are wired for mobile cell signals. And an untying case where there may be gaps in the service contours of the individual base stations is that the cell towers of the mobile network provider do not completely cross each other.

Whereas the climate or the weather comes in place, the strength of the mobile network signal is affected. This is due to the propagation of the scattering of the clouds which may cause signal reflection hindering the broadcasted mobile network signals not to reach the mobile phones or cells. This same scenario affects the radio band and its propagation, due to this they can be charged for international usage although being in the country since the mobile network was roaming.

## 2.2 THE FACTORS THAT ACCOUNT FOR THE VARIATION OF THE MOBILE NETWORK SIGNAL

### *2.2.1 Proximity between the tower and the mobile cell or phone*

Every mobile base station or tower mast has an area they cover where they can broadcast a signal. The distance or the area of coverage is defined by the hardware the mobile network provider used on the base station, the output power and the location of the mast in the territory it finds itself, and the frequency at which is being broadcasted. One of the critical factors in defining or predicting the reach of these tower masts is the tower search window area. For the mobile networks to work efficiently, the towers supply the lots or majority of the mobile network's phone or customers within the search area with the best quality service and ignore those on the edge of the window coverage area that use valuable resources. They also hinder the reach at which a customer's mobile phone can see the tower. If you are on the outskirts of the window search area, the mobile network signals may be very poor with usually call dropouts and slower data speeds.

### *2.2.2 Physical obstructions*

Poor mobile network signals usually are the result of the obstacles in the way of the propagation of mobile network signals between the base station and the customer or the mobile phone. The location of the mobile network phone or the device in the building will also have an impact on the mobile network signal strength.

### *2.2.3 Building structures*

The coverage is impacted by the materials that are used in the construction of the building that shield the signal from entering the building such as brick, concrete and tiles, double glazed or tinted windows, metal roofs, reinforced steel concrete walls

### *2.2.4 Interference*

The base station could experience a radio-emitting device, causing the tower to lower its output power. Other objects known to cause interference are such as solar panels and large stadium viewing screens.

### *2.2.5 Weather*

Every cellular or mobile phone and its mode of work depends on weather conditions. The rains, winds, and lightning will all have an effect on the function of the mast. The call is firstly received by the mast or tower, and sends the call using a computer connection. The connection problems can slow or stop the transmission of the mobile network signals.

### *2.2.6 Tower output power*

It would be easier for a mobile phone to capture or receive signals from a tower which is much greater than that of your mobile phone. The signal output that should be received from the tower must be greater.  The range of the output of a mobile phone is usually between 0.2 watts to 0.6watts and based on the terrain or location of the mobile phone, the tower or mast can have an output signal of 3.0 watts. This scenario explains why you may see your network indicator on your phone with full bars and yet still experience call failures or bad network

### *2.2.7 Reflection and diffraction*

Reflection is a phenomenon where electromagnetic waves bounce back when it hits a smooth surface whose signal wavelengths are greater. This affects the propagation of waves and will not allow the waves to travel to the desired location. Diffraction is a phenomenon where electromagnetic waves hit a surface and then new waves are created since they are diverted. It is also known as shadowing since the diffracted waves may reach the receiving mobile phone.

### *2.2.8 Congestion on Network or on a Tower*

The number of mobile phones receiving from a particular tower can affect the mobile network signal. You usually notice that the times where the network is being used much, mobile phone users may experience lower signals than normal.

## 2.3 FACTORS AFFECTING SERVICE EFFICIENCY

### *2.3.1 Instability in power supply*

The power supply is the critical factor in the supply of good mobile network signal or reception and they rely on more power to be able to provide a strong and large reach of broadcast. They mostly rely on fuel for their generators or the main power grid. If the power supply is stable, then the supply of network signal would be stable and the reception will be better since it is broadcasting at most conditions.

### *2.3.2 Dropped calls*

It is a case whereby an established or connected call ends suddenly while a call is ongoing. This happens when the mobile phone user moves out of the coverage area and the signal cannot be sustained. This may happen when there is an imbalance of traffic between the two base stations or tower masts of coverage. It may also happen when there is a difference in configuration making one base station not expecting traffic from another.

## 2.4 HOW SIGNAL STRENGTH IS MEASURED

Signal strength levels are derived by a variety of measurements, which differ even between service modes. These measurements are as follows:

### *2.4.1 RSSI*

The Received Signal Strength Indicator (RSSI) in telecommunications is a measurement of the power contained in a received radio signal. RSSI is represented as a negative dBm number. This number represents the cellular signal strength from the tower to the modem. The greater the number, the stronger the signal. The precise figures differ depending on the cellphone provider. However, -70 dBm and greater readings typically indicate that the modem is in a good coverage region. The stronger the signal, the closer it is to 0 dBm. There comes a point where attempting to acquire more signals yields diminishing results, because the quality of the link is characterized by more than simply RSSI.

### *2.4.2 RSRP & RSRQ*

Received reference signal strength (RSRP) and received reference signal quality (RSRQ) are critical measurements of signal strength and quality in contemporary LTE networks. When a mobile device goes from cell to cell in a cellular network, performing cell select/reselect and processing, it must measure the signal strength/quality of the surrounding cells. In the transmission technique, the LTE standard provides for the usage of RSRP, RSRQ, or both.

RSSRP is a subset of the RSSI measure. It refers to the intensity of the LTE reference signals dispersed throughout the whole bandwidth as well as the narrowband. A minimum of 20 dB SINR (from the SSynch channel) is required for RSRP/RSRQ detection.

RSRQ: RSSI and the amount of resource blocks consumed are used to determine quality (N) On the same bandwidth, RSRQ = (N * RSRP) / RSSI. RSRQ is a C/I measurement that represents the quality of the reference signal received. When RSRP alone is insufficient to make a correct cell transfer or reselect decision, the RSRQ measure comes in handy.

### *2.4.3 RSCP*

In the UMTS mobile communication system, Received Signal Code Power (RSCP) is the power measured by the receiver across a given physical communication channel. It is used as a signal strength indicator, a handover criteria, to monitor downlink power, and to calculate route loss. In a CDMA system, a physical channel corresponds to a certain spreading code, thus the name (Code Power of the received signal). RSCP is an abbreviation for Receiver Side Call Power.

RSCP may be used in any CDMA system, although it is most often employed in UMTS. Furthermore, while RSCP may potentially be monitored on both the downlink and the uplink, it is specified for the downlink only and is thus expected to be measured and reported by the UE (User Equipment) for Node B.

### *2.4.4 SINR*

In information theory and telecommunications engineering, the signal-to-noise-to-noise ratio (SINR) is a measure used to indicate the theoretical upper limit of channel capacity (or information transfer rate). In the system of communication Network comparable to Wireless Network SINR, like SNR, is defined as the power of a signal of special interest divided by the total interfering power (of all other interfering signals) and the intensity of specific background sounds in cable communication systems. When the power of the noise term is zero, the SINR equals the signal/noise ratio (SIR). The lack of noise, on the other hand, decreases the SINR to a signal-to-noise ratio (SN). When there is no interference, the SINR is reduced to a signal-to-noise ratio (SNR), which is less often employed in creating mathematical models of wireless networks such as cellular networks.

### *2.4.5 EC/IO*

The EC/IO represents the signal-to-noise ratio (the ratio of received/good energy to interference/bad energy) and is a measure of the quality/cleanliness of the signal from the tower to the modem. It is expressed in decibels (dB). In an ideal environment with no real interference, the interference level equals the noise level, resulting in EC/IO = 0 dB. When the EC/IO exceeds -7.0 dB, your connection will degrade.A greater EC/IO value can be caused by a variety of reasons, including fluorescent lights, electric motors, equipment, power supplies, bad/poor cabling, trees, hills, buildings, walls, shorted connections, improper antenna alignment, incorrect antenna polarization, tower congestion, and so on.

## 2.5 REVIEW OF RELATED WORK

This part of this project summarizes and explains previous works or research which were conducted in our field of study in mobile network signal strength variation.

Brett Glidden's (2018) 3D signal strength Mapping of 2.4GHz Wifi Networks gives and lays out the designing and prototyping of a system to achieve 2.4GHz WiFi signal quality measurements in a three-dimensional reference plane. This system or instruments monitors its location and the 2.4GHz WiFi network's received signal strength. The user generates a 3D model of the 2.4GHz WiFi network coverage using the collected signal metrics.

Basiran and M. M. Mesbahuddin's (2020) analysis of signal strength variations for an urban public university campus in Bangladesh measures and collects the GSM signal strength data at different times of the day to observe the variation. It again measures the signals at different heights of the building to attain the maximum signal strength.

Benjamin j. Ritter (2011) SU Wireless Signal Strength provides outlines of problems and solutions for the Shippensburg University architecture. Although Shippensburg University has installed wireless access points and routers around campus, areas still remain that have weak or no signals, referred to as "dead spots". I have personally found some of these "dead spots" only after finding a nice place to do work, setting up my laptop, and then failing to connect to the SU network, which can be frustrating. The university has a list of areas on campus that should be in wireless range, but we believe a detailed map that allows students to visualize wireless signal coverage and wireless signal strength would be much more helpful. As the use of "smartphones" increases, providing wireless access throughout the entire campus (not just near buildings) has become even more vital. Students also get discouraged when lab spaces and resources are limited. In order to help expand this space and further student potential, maintaining a wide wireless signal is critical. As the university continues to transform itself, with the redesigning of the Ceddia Union Building (CUB) and the future revamping of the on-campus student living quarters, determining the geospatial distribution of wireless signal availability and strength will help me to determine which areas need more signal strength and which areas are receiving more signal than needed. Mapping out the results of the analysis so that students and faculty can utilize them as aids were the main objective of this research project.

Adewumi et al.[2015] studied the influence of atmospheric parameters on UHF Radio Propagation in South Western Nigeria. The received signal level rose with increasing temperature, but relative humidity increased with signal route loss. According to the findings, air temperature and relative humidity have a substantial impact on UHF signal propagation in the troposphere of southwest Nigeria.

Context Awareness through GSM Signal Strength Fluctuation, Ian Anderson [2007] He shows how, by monitoring the fluctuation of GSM signal strength levels and surrounding cell information, a mobile phone may deduce contextual information such as mode of travel. He demonstrates that these signals are stable enough to discriminate between distinct states of movement such as walking, driving, and standing motionless. We report early findings for an urban setting.

Usman, Abraham U. [2015] Variation of GSM Signal Strength with Weather and Environmental Factors Variations in atmospheric conditions, as well as other environmental variables, cause spatial and temporal alterations in transmitted radio waves. This study examines and establishes several meteorological and environmental factors that have a dominant influence on temporal signal intensity fluctuations that occur even at a fixed site.The average refractivity gradient dN/dh derived from hourly measurements collected at a fixed site for seven days was -61.3 N/km, indicating that the average propagation circumstances correspond to the normal mode, however super refraction was to be expected between 10 a.m. and 8 p.m. Overall, because the correlation between the variables is as low as 0.091, the fluctuation in dN/dh does not explain the temporal variations in the received signal Pr. Among the environmental elements studied for their impact on signal intensity variations, receiver location has the most influence.

# CHAPTER THREE

# 3. METHODOLOGY

## 3.1 INTRODUCTION

This chapter goes into great detail on the methodologies employed, the particular activities taken, and the instruments used to gather and evaluate the data required to answer the research topic. He is particularly interested in research design, population, sample size, sampling methodologies, data sources, and data processing procedures.

The theory of how to carry out or conduct research is known as methodology. This comprises the theoretical and philosophical assumptions that underpin the study, as well as the consequences of these assumptions for the method(s) used. It is the investigation of the research method(s) that identifies relevant facts that can lead to the solution of the research problem (Encarta Dictionary). Methods are the techniques and procedures used to gather and evaluate data.

## 3.2 SIGNAL STRENGTH

The transmitting power output as received by a reference antenna at a mobile phone and/or cellular data equipment is referred to as signal strength in telecommunication. The unit of measurement for signal strength is decibel-milliwatts (dBm), which is a unit of electrical power in milliwatts (mW) expressed on a decibel (dB) scale. Decibels are written as a negative number, such as -70 dBm. The closer the value is to zero, the stronger the signal (for example, -70 dBm is stronger than -90 dBm), and the closer it is to -120 dBm, the weaker the signal. The table below shows how the categorization of cell network RSSI strengths is arranged from excellent to no-signal:

| RSSI (dBm) | Signal Strength |
|---|---|
| >-70 | Excellent |
| -71dBm to -85dBm | Good |
| -86dBm to -100dBm | Fair |
| -100dBm to -110dBm | Poor |
| <-110 | No Signal |

*Table 1: Signal Strength Categorization*

### 3.3 What device or app did we use?

We used Network Cell Info Lite, an android application used for capturing the RSSI at every cell phone. Since the application is only available for the android version, we used an android device. The application is capable of identifying bands, has an automated visual logger, advanced LTE, 4G, 3G, and CDMA data analyzer, and many other settings customizable for a unique user experience. It enables you to also know your dB level and the nearest cell tower. But the interest in the research was in its ability to capture RSSI for 3G networks and this was used as a base for cell phone network mode.

### 3.4 RSS DATA COLLECTION

A site survey is a technique for measuring cell signal strength location by location within a service region. This approach is used by the writers to begin measuring in this chapter. The information was gathered from student-populated locations on the University of Ghana's Main Campus (i.e. the traditional halls and the diaspora hall). Many factors impact signal strength and quality, including but not limited to tower load, proximity to the cellular tower, and signal quality. Signal propagation over a cellular repeater, competing signals, and physical obstacles (mountains, buildings, trains, etc.). Signal strength was considered at different times of day (morning, afternoon, and evening), as well as signal strength with a distance of different mobile carriers (i.e. MTN, Vodafone, and AirtelTigo ).

### 3.5 Data collection process.

In order to do so, we had to move about campus and check the signal strength from selected points. We used Network Cell Info Lite to pick the RSSI from the capture devices (Cell phones) for the service providers that have been sampled, at strategic places. We went around campus to the various hostels, i.e. Diaspora halls and the traditional halls. For each checkpoint, we repeated the process three times for the three main telecoms service providers (ie MTN, Vodafone, AirtelTigo). The captured RSSI information was then used to populate a google form, where we use scripts to add the Geodata (i.e geolocation and address) of the area we took the signal data from.

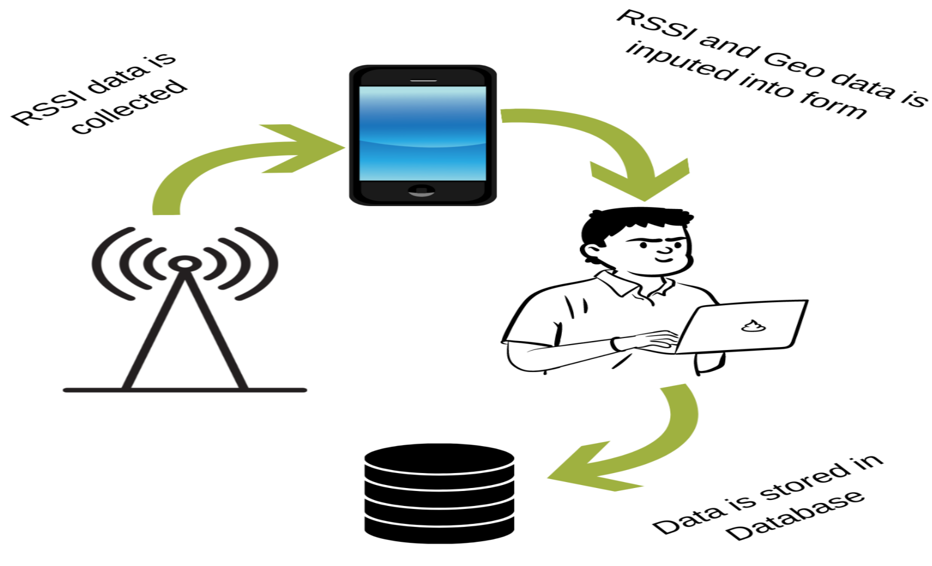


*Figure 1: Data Collection Process*

**3.6 Duration of data collection**

The measurement lasted for a week to complete. In this period, we conducted the test each day from Monday to Friday. In each location, three measurements were taken per day (i.e. morning, afternoon, and evening) under various conditions. In each of the halls, measurements were taken from both inside and outside, this is to ascertain accurate measurement of the signal from both ends.

**3.7 CONCLUSION**

The research methodology used in this project has been outlined and justified in this chapter. Due to the nature of the research, the authors chose a qualitative strategy that was constrained by an interpretive approach. The primary research tools were cell phones, RSSI monitoring apps, and Google forms. The focal regions were carefully chosen, and RSSI data for those sites was gathered through a site survey. Due to the tiny size of the focal region, the findings were manually evaluated. The next chapter discusses the project's key outcomes and findings.

# CHAPTER FOUR

## 4. RESULTS AND DISCUSSION

### 4.1 INTRODUCTION

The data gathered from the site survey is presented in this chapter. Graphs and tables were used to represent the data. The data was also presented in relation to the literature review and compared to the data gathered in the field. For the purposes of this study, the mobile signal strength of the top three (3) network providers, namely MTN, VODAFONE, and AIRTELTIGO, was assessed. The signal readings were done at selected halls of residence on the main campus of University of Ghana(Akuafo, Mensah Sarbah, Legon to Commonwealth, Jubilee, and the Diaspora halls).

### 4.2 RESULTS AND DISCUSSION

As a result of the analysis, different results were found for MTN, VODAFONE and AIRTELTIGO at various survey sites and at different times of the day.

#### 4.2.1 Signal Quality at Akuafo Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 5 | 6 | 8 | 13 | 12 | 14 | 6 | 6 | 5 |
| GOOD | 17 | 14 | 14 | 12 | 12 | 11 | 17 | 11 | 12 |
| FAIR | 7 | 10 | 7 | 5 | 6 | 5 | 6 | 11 | 12 |
| POOR | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 1 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 2: Signal Quality at Akuafo Hall*


*Figure 2: Signal Quality at Akuafo Hall  Representation*

At Akuafo, Vodafone recorded the most amount of data that fell within the excellent category in the mornings and also recorded a good amount of good signals throughout the afternoon. AirtelTigo and MTN barely recorded excellent signal quality in the morning, afternoon and evening as compared to Vodafone. Based on the data presented for this area, MTN was mostly good throughout the entire day followed by AitelTigo which saw the most fair and poor RSSI.  On the average, all 3 networks saw a good network.

### 4.2.2 Signal Quality at Jubilee Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 2 | 4 | 3 | 3 | 1 | 4 | 4 | 3 | 2 |
| GOOD | 11 | 9 | 11 | 10 | 11 | 8 | 8 | 11 | 10 |
| FAIR | 11 | 12 | 13 | 15 | 15 | 14 | 13 | 11 | 13 |
| POOR | 4 | 3 | 1 | 0 | 1 | 2 | 3 | 3 | 3 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 3: Signal Quality at Jubilee Hall*

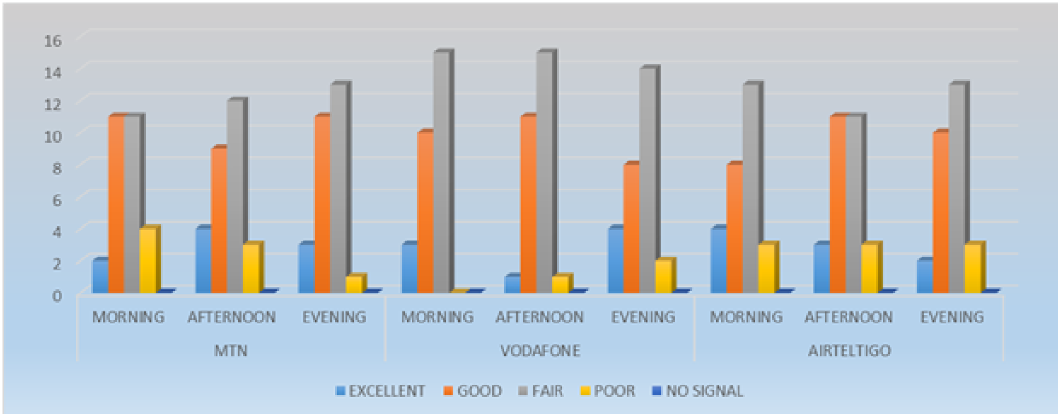


*Figure 3: Signal Quality at Jubilee Hall Representation*

MTN and AirtelTigo saw the most amount of excellent signals throughout the day whereas Vodafone saw the most. All three networks recurrently experienced fair signal quality at all times of the day and short-term poor signals.

### 4.2.3 Signal Quality at Mensah Sarbah Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 33 | 33 | 31 | 21 | 20 | 23 | 15 | 15 | 18 |
| GOOD | 4 | 4 | 7 | 17 | 18 | 15 | 16 | 18 | 15 |
| FAIR | 2 | 2 | 1 | 1 | 1 | 1 | 8 | 6 | 6 |
| POOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 4: Signal Quality at Mensah Sarbah Hall*

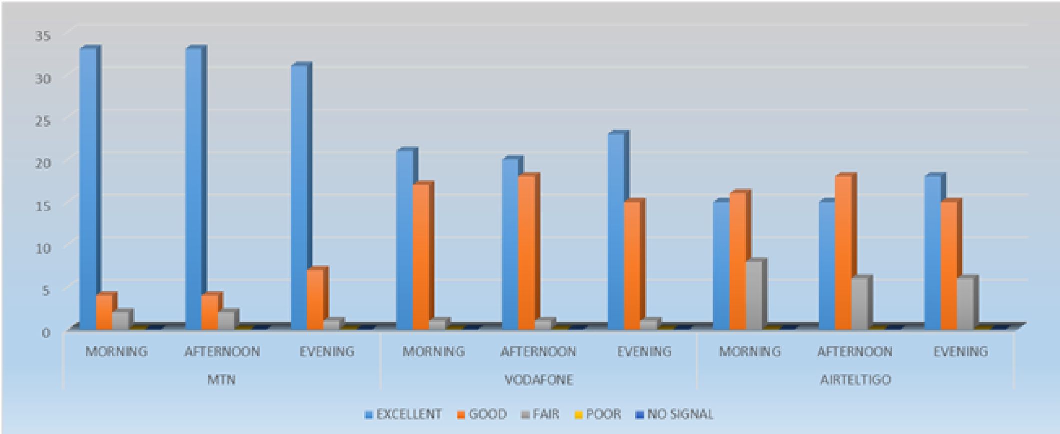


*Figure 4: Signal Quality at Mensah Sarbah Hall Representation*

In this area, MTN performed best in the morning, afternoon and evening as it repeatedly recorded excellent signal quality followed by Vodafone. Although AirtelTigo recorded some excellent and good signals, it also recorded the poorest signal in the area after noon compared to MTN and Vodafone. All networks stayed above the poor signal ranges.

### 4.2.4 Signal Quality at Legon Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 22 | 19 | 20 | 19 | 17 | 18 | 25 | 20 | 18 |
| GOOD | 11 | 16 | 14 | 24 | 25 | 27 | 11 | 16 | 17 |
| FAIR | 13 | 9 | 10 | 3 | 4 | 1 | 9 | 9 | 11 |
| POOR | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 5: Signal Quality at Legon Hall*

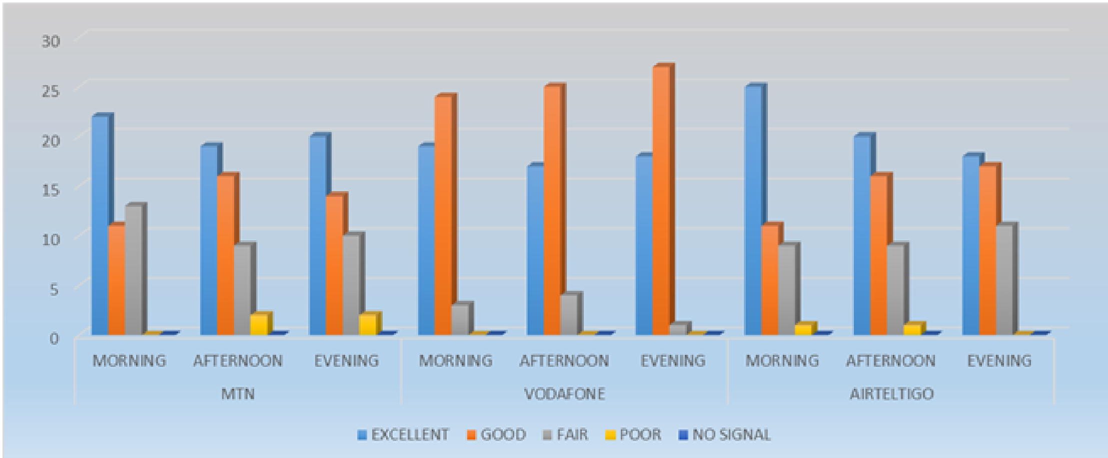


*Figure 5: Signal Quality at Legon Hall Representation*

AirtelTigo received the most amount of excellent signal readings in the mornings followed by MTN and then Vodafone. MTN recorded a few poor signals in the afternoon and evening. AirtelTigo also saw a few poor signals in the mornings and afternoons. The network that saw the greatest amount of good signals, least fair signals and no poor signal throughout the day is Vodafone.

**4.2.5 Signal Quality at Volta Hall**

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 32 | 32 | 33 | 28 | 25 | 24 | 23 | 23 | 19 |
| GOOD | 6 | 6 | 6 | 7 | 8 | 9 | 15 | 16 | 20 |
| FAIR | 1 | 1 | 0 | 4 | 6 | 6 | 1 | 0 | 0 |
| POOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 6: Signal Quality at Volta Hall*

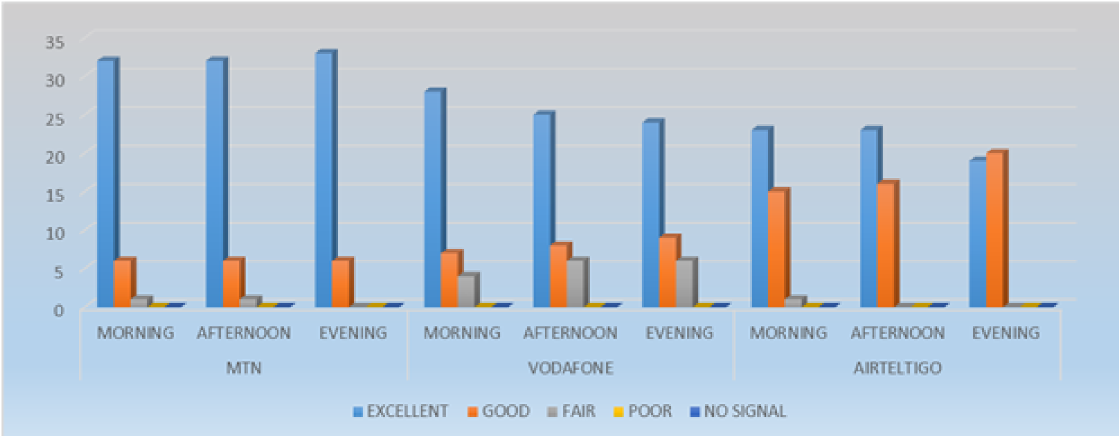


*Figure 6: Signal Quality at Volta Hall Representation*

According to the data collected and presented, all three networks experienced excellent signal quality and good signal with minimal exposure to fair signal throughout the day. MTN had the best performance and also recorded the best signal in the area at different times of the day. Again, all networks stayed above the fair and poor signal range although Vodafone gave the poorest signal amongst all three networks.

### 4.2.6 Signal Quality at Commonwealth Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 9 | 13 | 9 | 15 | 14 | 14 | 6 | 8 | 9 |
| GOOD | 22 | 18 | 21 | 10 | 13 | 13 | 25 | 22 | 19 |
| FAIR | 0 | 0 | 1 | 6 | 4 | 4 | 0 | 1 | 3 |
| POOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 7: Signal Quality at Commonwealth Hall*

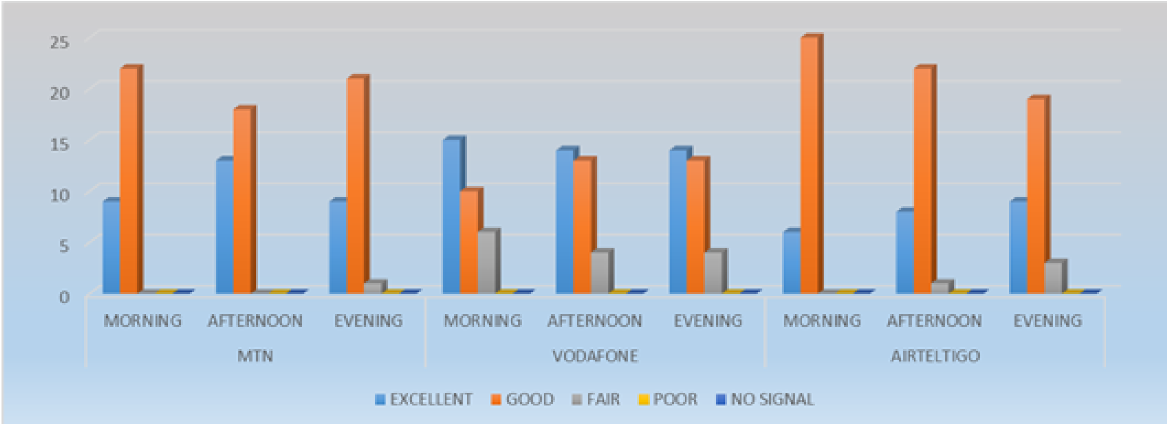


*Figure 7: Signal Quality at Commonwealth Hall Representation*

Vodafone recorded the best signal in this area but also recorded the most fair signals. A great percentage of the data collected at any time of the day fell within the good signal range. AirtelTigo had the greatest amount of good signals recorded in the morning.

### 4.2.7 Signal Quality at Dr. Hilla Limann Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 0 | 0 | 0 | 3 | 1 | 4 | 0 | 0 | 0 |
| GOOD | 15 | 15 | 16 | 11 | 18 | 13 | 7 | 6 | 4 |
| FAIR | 11 | 11 | 10 | 12 | 7 | 9 | 16 | 15 | 17 |
| POOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 5 |

*Table 8: Signal Quality at Dr. Hilla Limann Hall*

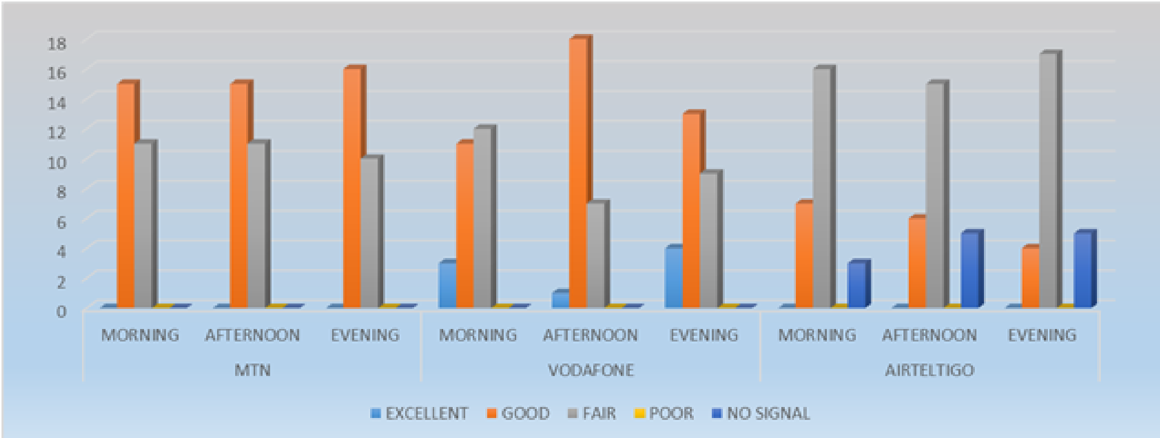


*Figure 8: Signal Quality at Dr. Hilla Limann Hall Representation*

According to the data presented, MTN and AirtelTigo did not give off a single excellent signal. MTN ranged between good and fair signal strengths. Also, AirtelTigo experienced its service being cut-off at parts of the area of survey a few times, barely recovered and saw the most fair signal strengths recorded. Vodafone saw few excellent signals throughout the day.

### 4.2.8 Signal Quality at Alexander Kwapong Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 3 | 3 | 3 | 4 | 3 | 2 | 1 | 1 | 2 |
| GOOD | 15 | 13 | 11 | 19 | 20 | 16 | 9 | 9 | 8 |
| FAIR | 11 | 13 | 15 | 6 | 6 | 11 | 18 | 17 | 18 |
| POOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

*Table 9: Signal Quality at Alexander Kwapong Hall*

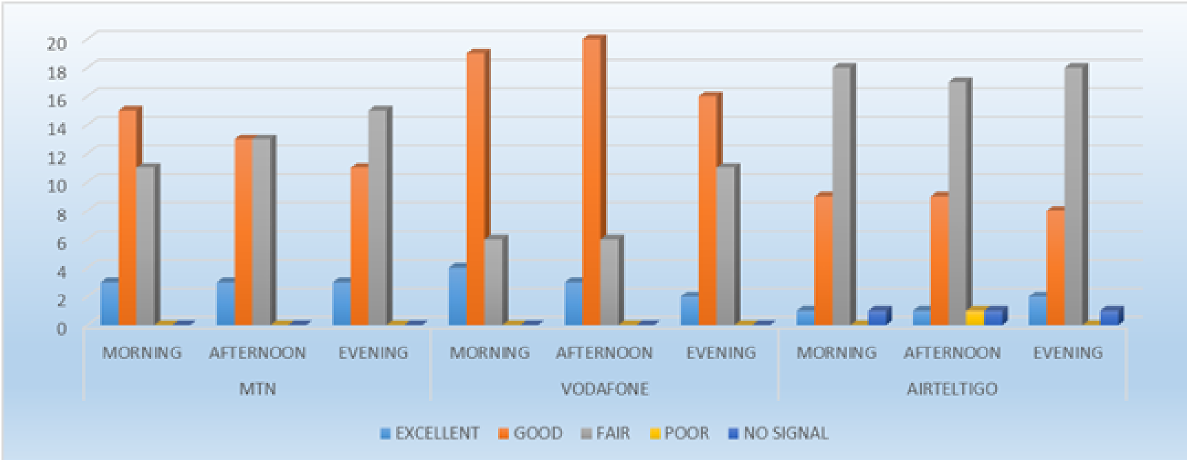


*Figure 9: Signal Quality at Alexander Kwapong Hall Representation*

Vodafone received the best signal and most of the recorded good signals in the region. AirtelTigo experienced a few downtimes during the data collected at some parts of the survey site despite receiving some excellent and good signal strengths, and also received the weakest signal in the afternoon. MTN's signal, according to the data presented, mainly ranged between good and fair signal strengths.

**4.2.9 Signal Quality at Elizabeth Sey Hall.**

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 5 | 6 | 5 | 13 | 14 | 15 | 7 | 8 | 12 |
| GOOD | 14 | 17 | 20 | 13 | 13 | 15 | 13 | 15 | 14 |
| FAIR | 24 | 20 | 18 | 15 | 15 | 13 | 22 | 20 | 17 |
| POOR | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 10: Signal Quality at Elizabeth Sey Hall*

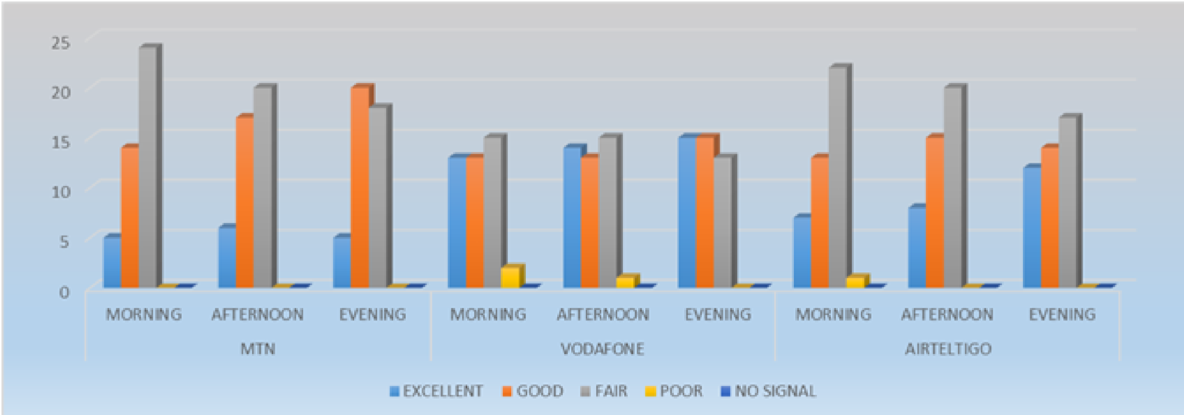


*Figure 10: Signal Quality at Elizabeth Sey Hall Representation*

Vodafone recorded the most amount of excellent signal strength and a little amount of poor signals. AirtelTigo received the weakest signal amongst all three networks. A Great percentage of signals recorded fell between good and fair ranges.

### 4.2.10 Signal Quality at Jean Nelson Hall

| | MTN | | | VODAFONE | | | AIRTELTIGO | | |
|---|---|---|---|---|---|---|---|---|---|
| | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING | MORNING | AFTERNOON | EVENING |
| EXCELLENT | 1 | 1 | 3 | 6 | 11 | 9 | 13 | 14 | 14 |
| GOOD | 14 | 16 | 18 | 21 | 16 | 18 | 16 | 15 | 14 |
| FAIR | 27 | 25 | 21 | 17 | 17 | 17 | 15 | 15 | 16 |
| POOR | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| NO SIGNAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 11: Signal Quality at  Jean Nelson Hall*


*Figure 11: Signal Quality at  Jean Nelson Hall Representation*

Vodafone received the best signals, however, AirtelTigo saw the best performance in the region having the greater amount of excellent signals and least amount of fair signal readings. MTN recorded the weakest signals but still experienced a good amount of good signal strength.

### 4.3 CONCLUSION

All three networks at the various halls focused on recorded good signal strength.  Jean Nelson hall had fairly good network signal strength followed by Elizabeth Sey hall. Hilla Limann hall and Alexander Kwapong Hall also recorded fairly good network signal strength but experienced some downtime. Amongst the traditional halls, Volta hall recorded excellent signal strength for all three networks throughout the day followed by Mensah Sarbah hall which also recorded good signal strength throughout the day as well as Legon hall and Commonwealth hall. With the above analyzed data for the various networks at each survey site, the area which/that is most suitable for academic activities such as research is Volta hall. Academic work can go on smoothly with minimum network disruptions. Other areas that offer suitable signal strength that may be used for academic purposes include Legon, Commonwealth, Jubilee and Mensah Sarbah halls. This indicates that students in the traditional halls are able to carry out academic activities smoothly as compared to students in the other halls.

# CHAPTER FIVE

## 5.1 CONCLUSION

Signal strength fluctuates depending on environmental elements such as location, weather, time of day, and others, all of which have a significant influence on the received signal intensity. Because signal intensity varies with frequency, when measured horizontally, signal strength diminishes with increasing distance. A deeper study also indicates that GSM networks record greater values of received signal strengths in the evenings, followed by those gathered in the mornings and finally those obtained in the afternoons. On the average the signal strength ranges from a min of -30dbm and -101dbm during the day outdoors. An overall average of the data collected (outdoor survey) show 29% Excellent signal strength, 46.2% Good signal strength, 24.5% Fair network signal strength, 0.3% poor network signal strength and 0% no signal coverage.

## 5.2 RECOMMENDATIONS

Deploying additional base stations in a particular service territory is one of the remedies to poor or dead zones in an area, as mentioned by N. Faruk (November, 2017). This is accomplished through the use of a Distributed Antenna System, in which extra antennas are strategically positioned to repeat the signal to a central base station. This, in turn, boosts cellular network capacity and ensures high-quality signal reception throughout the service zone.

## 5.3 FUTURE WORK

Refining research would be the focus of future development on this project. The project's future work will focus on evaluating RSS performance in a more sophisticated, accurate, easy, and systemic manner. For future works, the researchers should look to extend the focus area for this project topic. Data collection and the map should not just be limited to a portion of the institution but can also take into consideration the private hostels, the various departments and colleges, registry, and lecture halls. This will help future authors build a more advanced and detailed system. Secondly, we suggest that the author of future related work should not just extend the focus area but also collect more precise data. Measurements should be taken both indoors and outdoors of the selected area of focus as well as to measure signal strength for each network at high altitudes ensuring that RSSI data collected is a lot more precise. Last but not the least, the future authors of this topic in our opinion should also consider the use of all network providers present at the time (MTN, VODAFONE, AIRTELTIGO, and GLO) during data collection at the areas of focus. This way everyone would practically be able to access the map and make use of information beneficial to them.

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***APPENDIX***