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Analysis of Signal Strength Variations for an Urban Public University Campus in Bangladesh

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***Abstract*:- The factors that affect mobile signals are distance and direction of the nearest mobile phone tower, transmission power, network congestion, the efficiency of an antenna, obstructions such as cloud cover, dense trees, buildings etc. Most mobile devices use a set of bars of increasing height to display the approximate strength of received signal to the mobile phone user. When signal strength is measured vertically in the ground floor, there exists many obstacles which causes the value of signal strength to be less. While moving vertically to upper line, signal strength continuously decrease due to the lack of obstacle. In this paper, GSM signal strength data is recorded at different time of the day to observe the variation of the signal strength. Also, the identical measurement grid is used in different levels of the building and different heights above floor, in order to characterize the change of the signal strength with different height and level with dry weather, and has found maximum signal strength.**

Keywords: Received Signal Strength Indicator (RSSI), GSM, Line of Sight, Radio Waves.

1. INTRODUCTION

Most mobile radio systems operates in areas where there is no direct line-of-sight path between the transmitter and the receiver antennas. Due to multiple reflections from various objects, the electromagnetic waves travel along different paths of varying lengths to the receiver simultaneously [1]. The interaction between these waves therefore causes multipath fading, resulting in increased path loss as the distance between the transmitter and receiver increases. Three radio channel features namely, the time series, auto-correlation function, and level crossing rate are extracted from unique signature of the RSSI in relation to the corresponding subject. The extracted features were then used together with four different classification learners, namely decision tree, support vector machine, k- nearest neighbors, and artificial neural network. The developed RSSI-based gait authentication approach can be complemented high-level authentication methods for increased privacy and security, without additional hardware [2]. In order to distinguish between the vertical and horizontal components of the incoming signal, the measurements are performed for horizontally and vertically positioned mobile terminal. In winter, receiver receives better signals because tree leaves falls off in the surrounding signal area. Tree leaves contain a lot of water and causes moisture, and thus they might block radio waves. In rain, better or worst signal can be received, because it washes away pollutants in the air. On the other hand, the worst signal is received due to humidity, most of signal gets absorbed by water [3].

2. LITERATURE REVIEW

In cellular mobile telephone system, it is considered most useful for vehicle location the reason is that high-quality radio channel should be assigned to moving vehicle [4]. Access point (AP) is part of a wireless local access network (WLAN) with its communications using Wi-Fi, where AP is used to transmit and receive data to users/clients. The ability of AP to serve users/clients depends on many factors. Based on service coverage area, the area which is far away from the AP then the quality of service becomes bad because the transmitted signal is weakening caused by the distance and the loss of the wall [5]. Wireless sensor network (WSN) is widely used in the fields such as environmental monitoring, industrial site acquisition, intelligent home automation and medical application. Some kinds of commercial devices are designed to support these applications. Received signal strength indicator (RSSI) is regularly used for localization, but the environment factors have much large effects on the RSSI than distance. As a result, the RSSI is too unpredictable for range estimation. So in a real application of RSSI, calibration should be adopted to reduce the influence of environment [6]. The received signal strength (RSS) plays a very crucial role in determining the nature and characteristics of location fingerprints stored in a radio-map. The received signal strength is a function of distance between the transmitter and receiving device, which varies due to various in-path interferences [7]. The measurements are performed for horizontally and vertically positioned mobile terminal at different time, in order to distinguish between the vertical and horizontal components of the receive signal. Although the received signal increases for higher levels, its strength is not uniformly increasing above floor [9].

3. METHODOLOGY

Data has been collected from a survey at the Jahangirnagar University, a public university in Bangladesh which is 45km far from the capital city of Dhaka. The campus is famous for its beautiful buildings, green trees and natural atmosphere. Social sciences building and IT building are used as sample cases. Signal from different mobile operator such as Teletalk, Grameenphone (GP), Banglalink (BL), Robi/Airtrel are used. Many factors that influence signal strength and quality are included as follows but not limited to - Tower load, Proximity to the cellular tower, Signal going through a cellular repeater, Competing signals, Physical barriers (mountains, buildings, trains, etc.). Considered signal strength for different weather such

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Vol. 9 Issue 07, July-2020

as values for sunny, rainy and foggy weather. Also considered signal strength with distance and time for morning and evening. Values with obstacles and without obstacles between BTS and MS for building, trees and hills, different levels and height also been taken into account.

4. SIGNAL STRENGTH AND MEASUREMENT

In telecommunication, signal strength refers to the transmitting power output as received by a reference antenna at a cell phone and/or cell data device, is a radio. Radio's operate on signal strength and signal quality, these are both measured in decibels (dBm). Decibels are expressed as a negative number, like -70 dBm. The closer the number is to 0, the stronger the signal. For example, -70 dBm is a stronger signal than -90 dBm [9]. A front panel LED on the CDI device are used to flash a number of times corresponding to indicate the signal strength as per the table below:

Table 1: Signal strength measurement scale

RSSI	Signal strength	Description
>= -70 dBm	Excellent	Strong signal with maximum data speeds
-70 dBm to - 85 dBm	Good	Strong signal with good speeds
-86 dBm to - 100 dBm	Fair	Fair but useful, fast and reliable data speeds may be attained, but marginal data with drop-outs is possible
< -100 dBm	Poor	Performance will drop drastically
-110 dBm	No signal	Disconnection

4.1 Signal Quality

A signal is a function that conveys information about a phenomenon. In electronics and telecommunications, it refers to any time varying voltage, current or electromagnetic wave that carries information. A signal may also be defined as an observable change in a quality and quantity. Any quality, such as physical quantity that exhibits variation in space or time can be used as a signal to share messages between observers [10]. Following table represents the quality of signal:

Table 2: Represents the quality of signal

EC/IO	Signal quality	Description
0 to -6	Excellent	Strong signal with maximum data speeds.
-7 to -10	Good	Strong signal with good data speeds.
-11 to -20	Fair to poor	Reliable data speeds may be attained, but marginal data with drop-outs is possible. When this value gets close to -20, performance will drop drastically.

4.2 Signal Strength Calculation

A. For case of cell phones

To measure the power of the signal received by the antenna, the numbers are usually reported in dBm. Since this is coming from a controlled impedance antenna and transmission line, need to use of RMS voltage or current. For example, let's say we measure the RMS voltage to be 2mV, and we have a 50 ohm antenna system. Then:

$$P = E2RMS/R$$
$$= (0.002V)2/50\Omega$$
$$= 8{\cdot}10{-}8W$$

Typically this is converted to decibels relative to 1mW, dBm:

$$LdBm = 10log10(P0.001W)$$
$$= 10log10(8{\cdot}10{-}8W0.001W)$$
$$= 10log10(8{\cdot}10{-}5)$$
$$= -40.97$$

Therefore, our signal strength is about -41dBm.

The trouble with this method is that it is actually not measuring the signal, but all electromagnetic energy received by the antenna. That is, it also includes noise. The signal might be "strong", but the noise might also be strong, so the signal quality will be poor. Another way to calculate "signal strength" is bit error rate or BER. It is the percentage of bits that were in correctly received [11].

B. Path loss for free space

Free Space Loss is the power loss of a radio signal as it travels through free space. Free space loss depends on frequency and distance. The loss increases with increase in frequency and obviously with increase in distance [12].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 07, July-2020

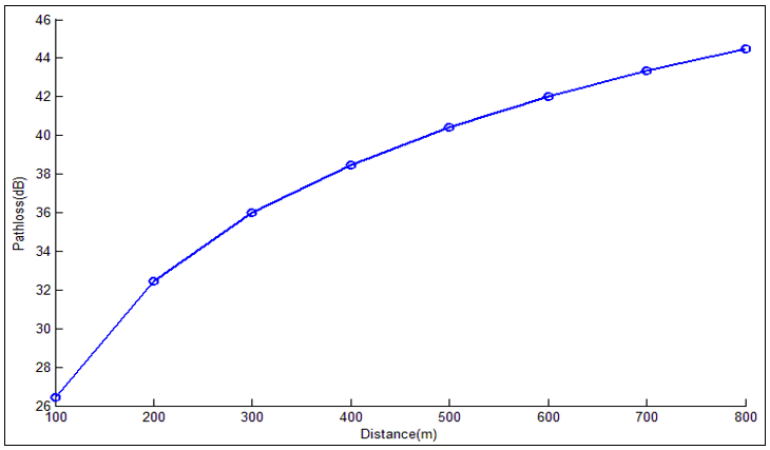


Fig 4.7: Free space path loss

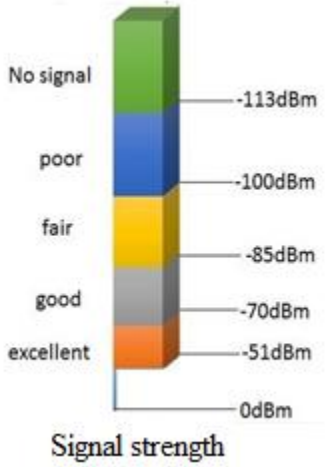
Following is the formula for Free Space loss

FSPL (*dB*) = 20*log*10(4*πc*) + 20*log*10(*d*) + 20*log*10(*f*) Where,
f is the signal frequency (in hertz),
d is the distance from the transmitter (in meters),
c is the speed of light or
Free Space Loss (dB) = 36.6 + 20 x Log (Frequency (MHz) x Distance (Miles))

It is shown that path loss depends on frequency and distance, as the distance is increase the path losses also increase.

C. Signal strength measurement scale

Values closer to 0 are stronger signals. Signal Strength can run from -51dBm to -113dBm. Values closer to -51dBm are stronger. A signal beyond -98dBm is not considered strong enough to work properly [13].



5. RESULT & DISCUSSION

5.1 For Grameephone (GP)

According to measurement scale 3rd floor and 2nd floor, for are received excellent signal strength in sunny day and rainy day respectively. Figure 5.1 shows signal variation for GP in different weather.

Table 3: Data variants in different weather (for GP)

Weather	1st Floor	2nd Floor	3rd Floor	4th Floor
Sunny day	63	73	51	85
Rainy day	53	51	63	79
Cloudy day	90	85	70	95
Foggy day	95	80	75	65

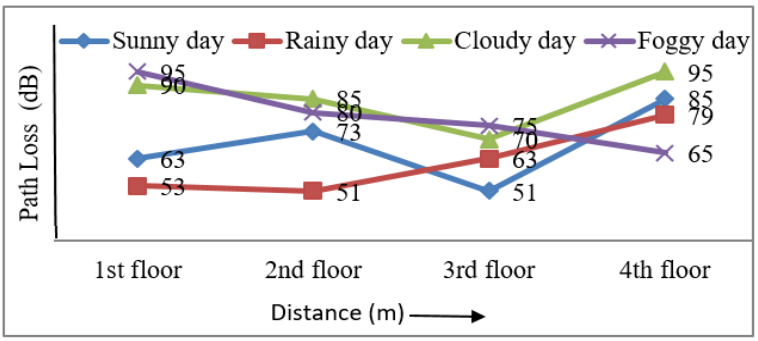


Fig 5.1: Data variants in different weather (for GP)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 07, July-2020

5.2 For Banglalink (BL)

According to measurement scale 2nd floor is received good signal strength and 1st floor is relatively excellent for all weather, as shown in figure 5.2.

Table 4: Data variants in different weather (for BL)

Weather	1st Floor	2nd Floor	3rd Floor	4th Floor
Sunny day	51	65	76	95
Rainy day	45	56	81	85
Cloudy day	59	70	69	75
Foggy day	65	75	65	69

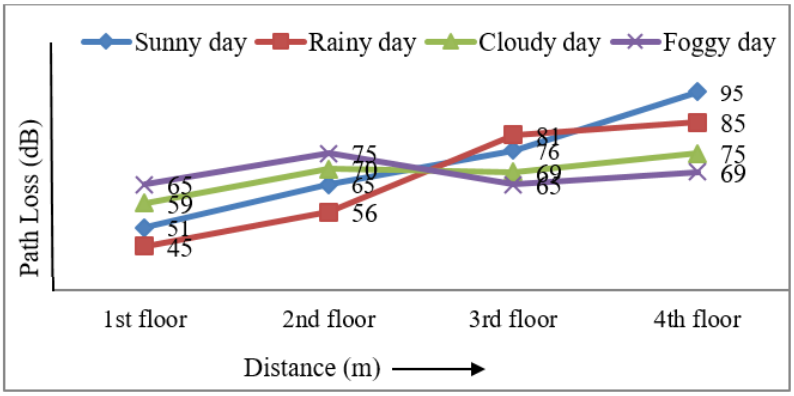


Fig 5.2: Data variants in different weather (for BL)

5.3 For Robi/Airtel

According to measurement scale 2nd floor is received good signal strength and 3rd floor is fairly good for sunny and foggy days, as shown in figure 5.3.

Table 5: Data variants in different weather (for Robi/Airtel)

Weather	1st Floor	2nd Floor	3rd Floor	4th Floor
Sunny day	67	74	65	93
Rainy day	80	74	90	85
Cloudy day	56	67	75	80
Foggy day	60	59	55	72

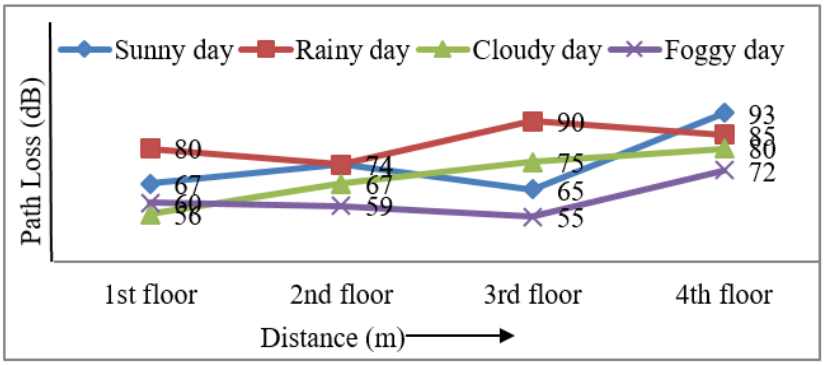


Fig 5:3: Data variation in different weather (for Robi/Airtel)

5.4 For Teletalk

According to measurement scale 2nd floor is received good signal strength, as shown in figure 5.4.

International Journal of Engineering Research & Technology (IJERT)
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Vol. 9 Issue 07, July-2020

Table 6: Data variants in different weather (for Teletalk)

Weather	1st Floor	2nd Floor	3rd Floor	4th Floor
Sunny day	99	55	65	70
Rainy day	80	85	84	76
Cloudy day	75	77	80	88
Foggy day	87	67	77	95

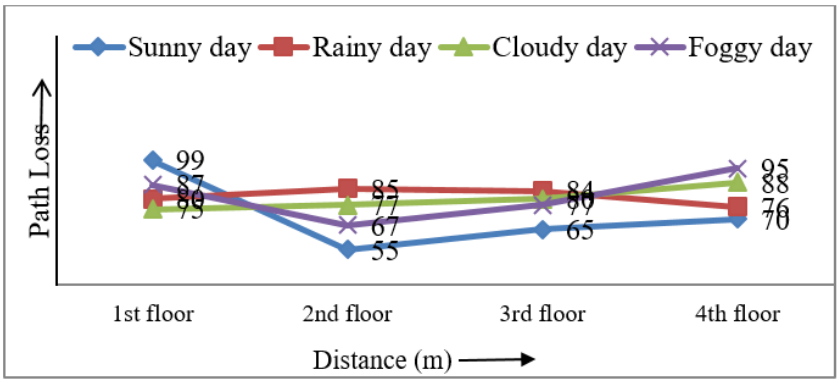

Fig 5.4: Data variants in different weather (for Teletalk)

5.5 Different Operators (only Rainy Day)

Different operator receive different signal strength. Below bar chart shows received signal variation different operator in different floor in rainy day. According to measurement scale 2nd floor is nearly appropriate for these operators where BL receive signal strength is excellent than other operators (Fig. 5.5).

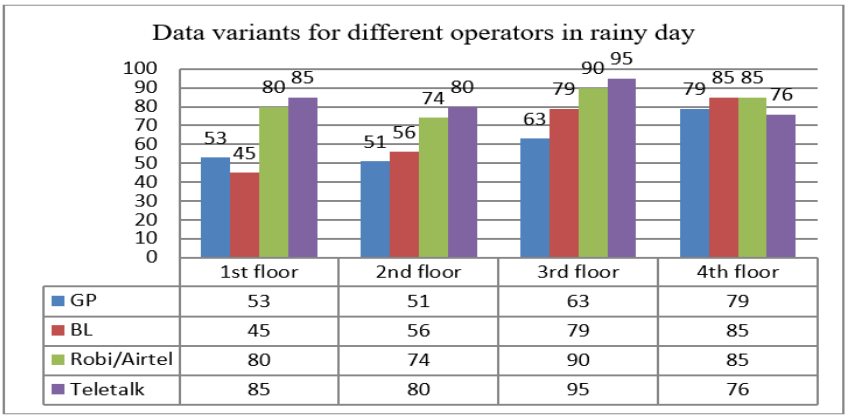

Fig 5.5: Signal variation for different operator in sunny day

5.6 Different Operators (only Sunny Day)

According to measurement scale 3rd floor is nearly appropriate for these operators where GP receive signal strength is excellent than other operators (Fig. 5.6).

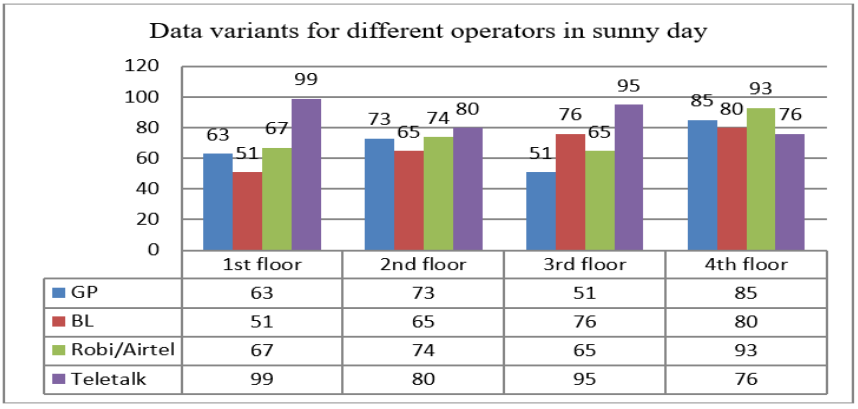

Fig 5.6: Signal variation for different operator in sunny day

International Journal of Engineering Research & Technology (IJERT)
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Vol. 9 Issue 07, July-2020

5.7 Signal variation in Social Science Building

According to fig 5.7, 2nd floor is appropriate for operator in receiving signal strength good or excellent. Between IT building and Social Science building, it seems that received signal is good for Banglalink at Jahangirnagar University (Fig.5.7).

Table 7: Data variants in Social Science Building for different operators

Operators	1st Floor	2nd Floor	3rd Floor	4th Floor	5th Floor
GP	51	65	76	87	95
BL	47	56	85	82	86
Teletalk	71	80	95	76	65
Robi	67	74	65	72	90

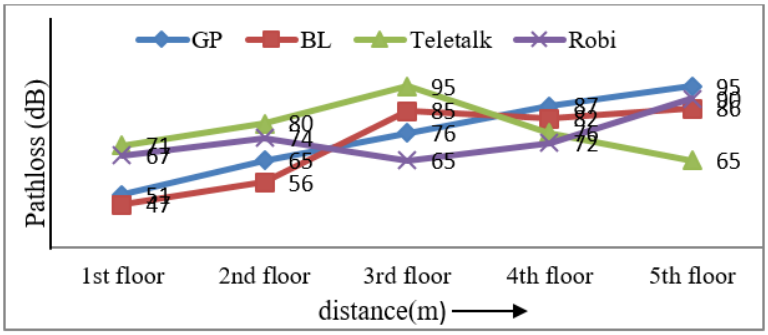

Fig 5.7: Signal variation in Social Science Building for different operators

6. LIMITATION & FURTHER DEVELOPMENT

There are a lot of limitations with the mobile signal being changed, such as the network issues will start to show up as soon as there is a bit of change in the weather. The weather has an impact on taking values [14]. The signal varies with different factors like weather, time, distance, and so on, there would still be some limitations as the signal in dry weather is different from foggy or rainy weather. And if everything goes correct with the weather, another limitation of the signal can be the variation of the signal as the signal varies randomly, so at a time, may be in daylight, there will be less signal compared to the one in the evening, thus it may create a problem to take a fixed value of that day. In some places, the signal strength may be lower and higher for other reasons too. The base station of the signal network provides a cell phone network with the average which can be used for transmission of voice, data, and others. Every base station covers a fixed coverage area. That's why signal strength is different in different areas [15]. Environmental and atmospheric effects affect pollution and also disasters which may cause the limitation for measure signal. More natural things than disasters which are trees, buildings, hills, they are the obstacle for the network to pass, so a slower network may spread as the signal needs to go very far. These are the main limitations of the network to be controlled at certain times.

7. CONCLUSION

Signal strength also varies with the environmental factors such as location, weather, time of day etc. that have a dominating impact on the received signal strength. As the signal strength depends on the frequency, when signal strength is measured horizontally, it decreases with the increase of distance. Similarly, when measured vertically, in the ground floor, as there are many obstacles, the value of signal strength causes less. When move vertically to upper line, signal strength continuously will increases due to the lack of obstacle. However, neither signal strength variation with the weather and environmental factors have been unimproved nor calculation of signal strength for fixed coverage area for a better service to the customers.

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Vol. 9 Issue 07, July-2020

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