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GSM Signal Strength Measurement in Kwale Delta State Nigeria

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ABSTRACT

This research work was carried out by investigating signal strength along the travelling path of two GSM network service provider in Kwale, Delta State using a network monitor. This study has to do with measurement of path loss models, a vital component in planning of wireless communication, as they assist in achieving optimal signal level in deploying mobile communication base stations. The distance of the network service provides Base Station (BS) to the mobile station (MS) and the difference in signal level were investigated. The effect of the properties of signal strength in relation to that of the environment were observed. To study this effect, measurement of signal power was taken by moving away from the Base Station with the use of standard parameters and the computed values of the free-space obtained; value of the signal power received and pathloss is less than the value obtain from measurement.

Keywords:
Transmitting Base Station (BS),
Received power (PR),
Antenna Gain,
Network service Providers,
Path loss,
Mobile Station (MS).

INTRODUCTION

The use of GSM as means of communication and access to the internet across the world have made the telephone industry a lucrative business for both GSM network service operators. Observation shows that between the year 2014 and 2024 and going forward, the use of mobile phone among adults and adolescents in Nigeria continue to grow rapidly by over 85%. The statistics also shows that Nigeria top the list of Africa nation with high rate of mobile phone usage. Most adults make use of the mobile set for communication or internet purpose (NCC, 2025, Sunday Ojeme, 2025, Petroc Taylor, 2025) and Chike Onwuegbuchi, 2025).

From the above report, the increase in demand for the use of GSM by individual have led to increase in the number of subscribers against fewer numbers of GSM network service providers installed facilities in Nigeria.

This can also lead to the inability of the GSM Network service provider to provide quality network service to its customers in the area investigated necessitated this research study. The inadequate maintenance and upgrade of GSM network service facilities across the country are the reasons for the poor network service delivery nationwide. For the purpose of this work, received signal strength in three different locations within Kwale Delta State was investigated using network service provider A, and network provider B as case study. The research works show that the area experienced poor quality network service required for communication link for optimum service delivery.

The parameter used for calculating the received signal power and path losses are the free-space and Vector Parabolic Equation (VPE) model to determine the actual network performance.

Many scientific research works have been conducted on GSM received signal strength. Pathloss measurement for wireless communication in south-west Nigeria. (Ohworho *et al.,* 2023) shows that vector parabolic equation model generally gives a better prediction of pathloss in the study area. In 2010, measurement and modeling of path losses for GSM in sub-urban environment over irregular terrain in mushin town was investigated (Shalengwa *et al.,* 2010). Shows that radio path losses determine many elements of radio communication system especially the transmitter power, antenna gain height, and the general located of the transmitting base station.

Similarity, it was observed that geometric algorithm for computing receiving Signal Strength base on mobile position provides more accurate data for simulating the actual position of the mobile location than other method like the standard least square method (Peter *et al.,* 2005).

Research conducted in 2009, a mobile set with installed network monitor was used to measure received signal strength from GSM Network providers Base Station. (Shoewu *et al.*, 2014). The data Obtained from the experiment was analyzed to determine the propagation

path loss exponents which was a major contributing factor for determining Network Signal strength.
Studies from empirical models, analytical and numerical formation have also been carried out in predicting the received radio signal strength in wireless communication system. (Mike, 2010). Furthermore, an empirical formula found to be easier and more accurate to compute propagation losses of GSM signals was also developed. (Mike, 2010). In the same way, a series of monograms derived from the Theoretical model that can be used to consider the effects of building on radio propagation paths. (Ray Mark, 2002).

MATERIALS AND METHODS

In other to obtain accurate results in this research work, a retroactive approach was followed, by first taking measurement of the various distances between the mobile station (MS) and the Base station (BS), and the value of the received signal Power (Pr) of the Network Service Providers in all the areas investigated by the use of electronic devices called "monitor" installed in an android phone. The data obtained in the measurement are shown. Path losses along signal transmitting paths with all conditions are considered, associated parameters were calculated using the free-space and Vector Parabolic Equation Model (Bartoni, 2000), for all the Base Station (BS) of the Network Services Providers in the areas investigated. The value obtained are also shown.

Calculation of Path loss using free Space model

Received Power, $P_r = 20\log(A) + P_t + G_t + G_r$
Where P_t=Transmitting Power, G_t= Transmitting Antenna Gain, Gr = Receiving Antenna Gain, and wavelength (λ) = $^{c}/_{f}$ where c = speed of light, Fc = cut off frequency = distance measured from the Base Station. f = 1200MHz

For service provider A, Base Station (BS)

P_t = 56db, G_t = 24db G_r = 2.3db, C = 3 x 10^8 m/s
And $\lambda_1 = \frac{1}{3m}$for fe = F_1: and $\frac{1}{6m}$ for fe =f_2

$P_r = 20\text{Log}\left[\frac{\lambda}{4rd}\right] + 54 + 24 + 2.3$

For Service Provider B, Base Station (BS)

P_t = 54dbm, G_t= 26.1, G_r = 2.4, C.3 x 10mls, F_1 = 600MHz, F_2= 1200MHz and $\lambda_1 = \frac{1}{3\text{m}}$ for $F_c = F_1$ and $\lambda_2 = \frac{\lambda}{6\text{m}}$ for $Fc = F_2$

$P_r = 20\log\left[\frac{\lambda}{4rd}\right] + 54 + 26.1 - 2.4$

Calculation of Pathloss (PL) using VPE

For Service Provider A

The wave equation is given in terms of the reduced function thus

$$\frac{d^2u}{dx^2} + \frac{2ikdu}{dx} + \frac{d^2U}{dy^2} + \frac{d^2U}{dy^2} = 0$$

The electric field component is
$F(x, y, z) = u\ (x, y, z)\ \exp\ (1kx)$
Where $\exp\ (1kx)$ is the time-harmonic dependent, K is the free space wave number and $U(x, y, z)$ is a slow-varying function along x – coordinate
The parabolic wave equation is given as (Pennock, 2014).

$$\frac{du}{dx} + ik\left(1 - \sqrt{a + x}\right)u$$

With solution $u\ (x + \Delta x, y, Z = \exp\ (-ik\Delta x \exp\ (ik\Delta x = Qu\ (x, y, z)$
This is the standard parabolic equation, it is a narrow angle approximation.
For service provider A is 15^1 of the direction of x-axis
For service provider B is 18^1 of the direction of x-axis

RESULTS AND DISCUSSION

Average value of the data obtained from the measurement of Received signal strength and computed path-loss both of GSM network service providers A and B where done with the aid of electronics device called MONITOR.
Similarly, average computed values of the received signal power (Pr) and path losses of the network of the network service providers, using the free, space and VPE mode are presented.

Table 1: Average measured received Power (Pr) and computed path loss for service provider A, Umusadege

Distance(m)	Received Signal Power(dbm)	Computed Path loss [dbm]	Free Space(dbm)
100.00	-86.00	152.0	66.00
200.00	-94.23	160.2	65.97
300.00	-98.60	173.4	74.8
400.00	-102.70	181.5	78.8
500.00	-112.40	198.6	86.2

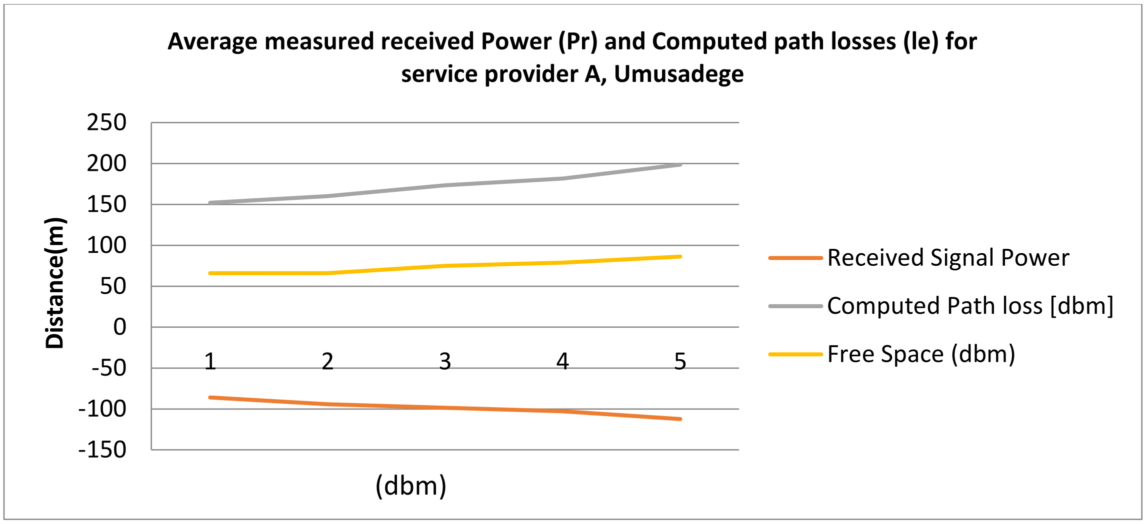

Figure 1: Service provider A, Umusadege

Table 2: Average measured Received signal power (Pr) and computed path loss for service provider (B) Umusadege

Distance(m)	Received Signal Power (dbm)	Computed Path loss [dbm]	Free Space(dbm)
100.00	-84.00	150.0	65.5
200.00	-90.70	156.0	65.3
300.00	-96.20	161.2	65.0
400.00	-100.12	173.5	73.3
500.00	-110.00	192.8	82.8

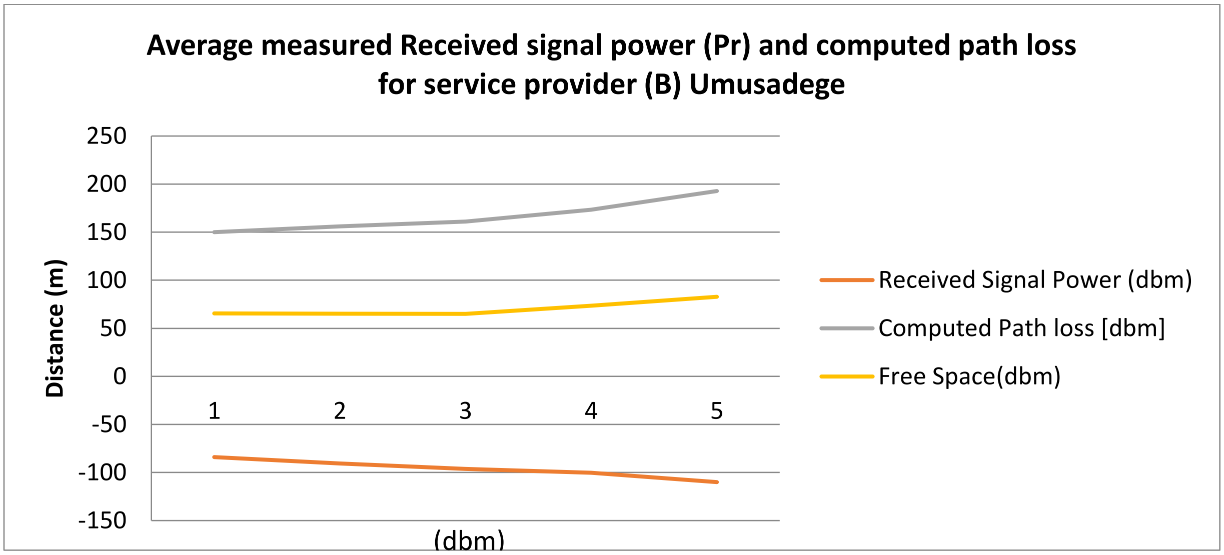

Figure 2: Service provider (B) Umusadege

Table 3: Average measured Received Signal Power (Pr) and computed path loss for the Service Provider A Umusam

Distance(m)	Received Signal Power	Computed Path loss [dbm]	Free Space(dbm)
100.00	-85.52	154.0	68.48
200.00	-92.20	150.1	67.9
300.00	-97.31	171.6	74.29
400.00	-98.50	174.0	75.5
500.00	-108.10	183.4	75.3

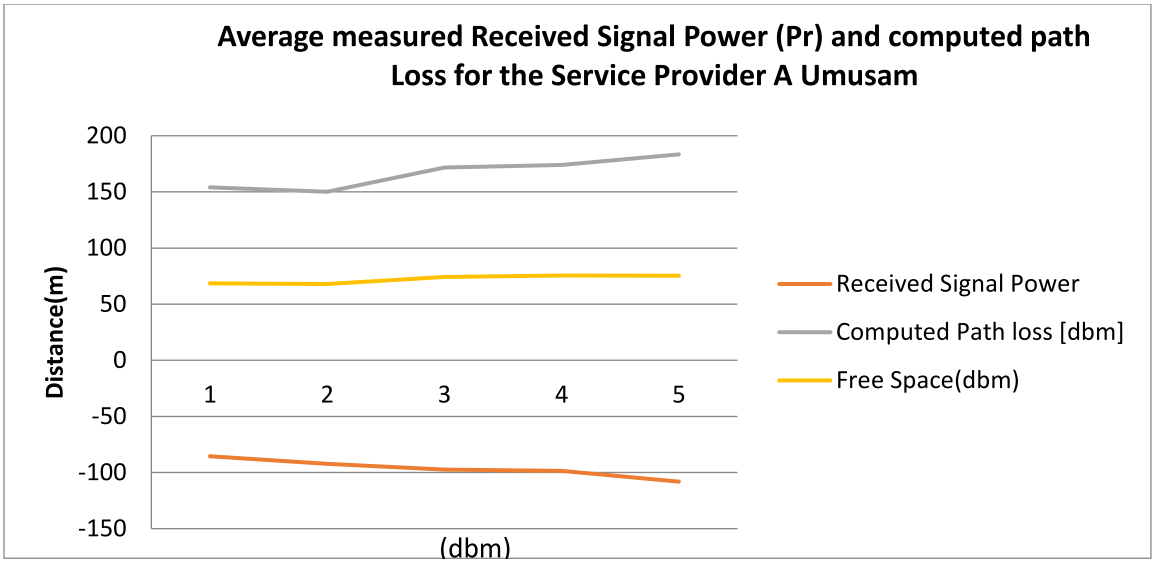

Figure 3: Service Provider A Umusam

Table 4: Average values of measured Received Signal Power (Pr) and computed path Loss for the Service Provider B Umusam

Distance(m)	Received Signal Power	Computed Path loss [dbm]	Free Space(dbm)
100.00	-86.30	150.0	63.7
200.00	-90.50	151.2	60.7
300.00	-93.00	168.3	75.3
400.00	-96.60	172.5	75.9
500.00	-105.20	184.1	78.9

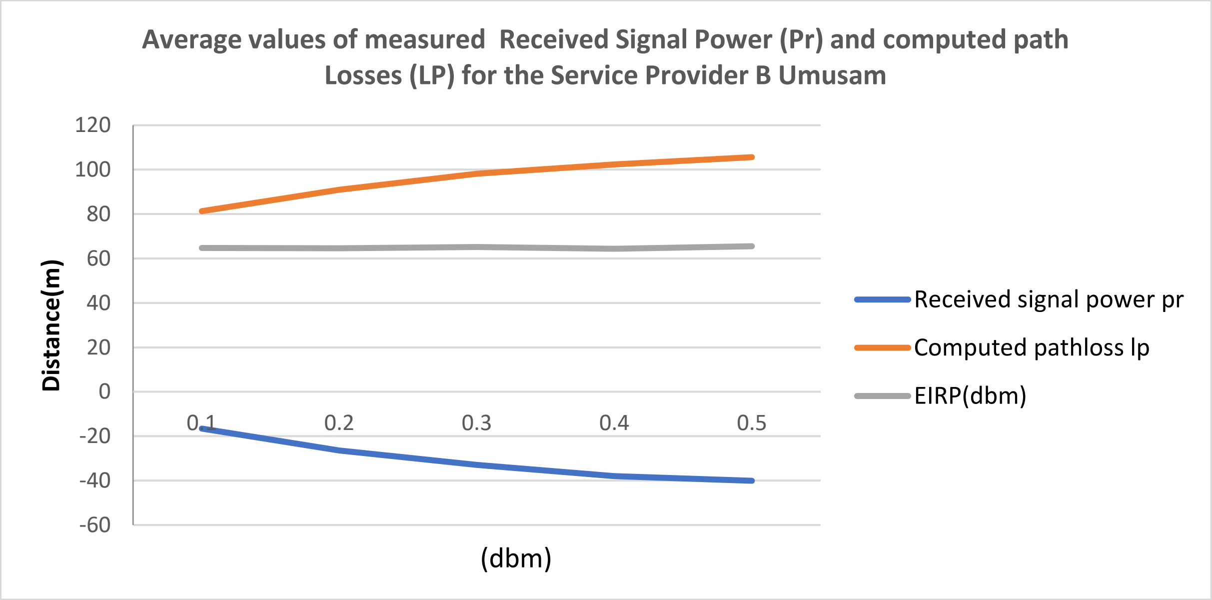

Figure 4: Service Provider B Umusam

Table 5: Average values of measured Received Signal Power (Pr) and computed path Loss for the Service Provider A Umusedeli

Distance(m)	Received Signal Power	Computed Path loss [dbm]	Free Space (dbm)
100.00	-88.52	156.0	67.48
200.00	-95.88	152.4	56.52
300.00	-106.75	170.3	63.55
400.00	-112.55	176.5	63.95
500.00	-118.67	180.4	61.73

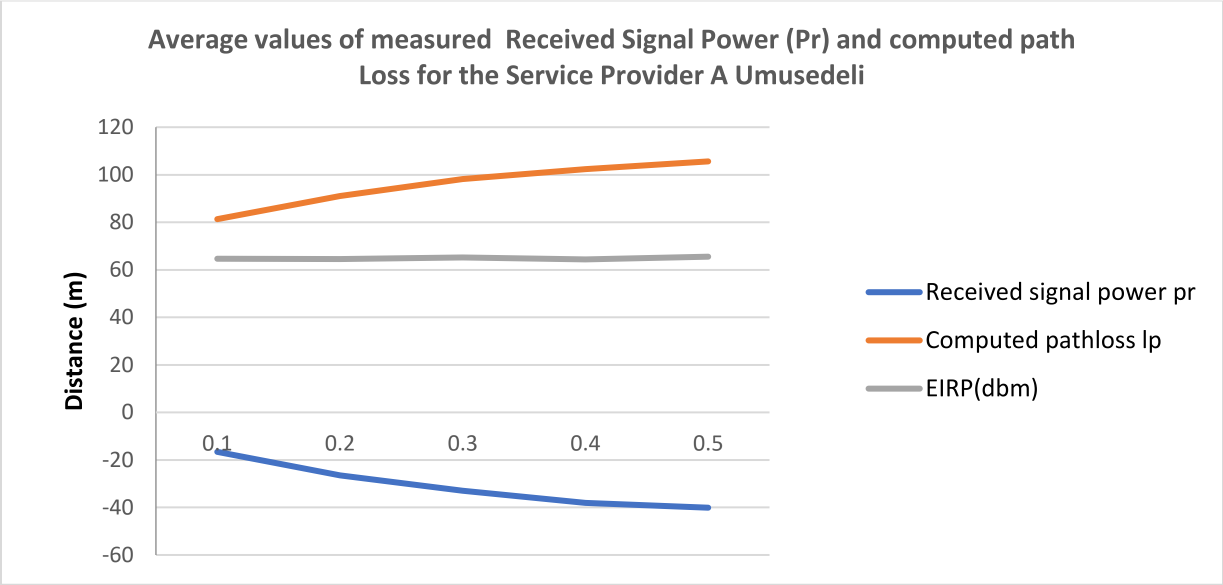

Figure 5: Service Provider A Umusedeli

Table 6: Average values of measured Received Signal Power (Pr) and computed path loss for Service Provider around Umusedeli

Distance(m)	Received Signal Power	Computed Path loss [dbm]	Free Space(dbm)
100.00	-87.92	158.60	70.6
200.00	-95.66	140.16	44.5
300.00	-102.60	169.10	66.5
400.00	-112.70	152.20	39.5
500.00	-120.60	184.00	63.4

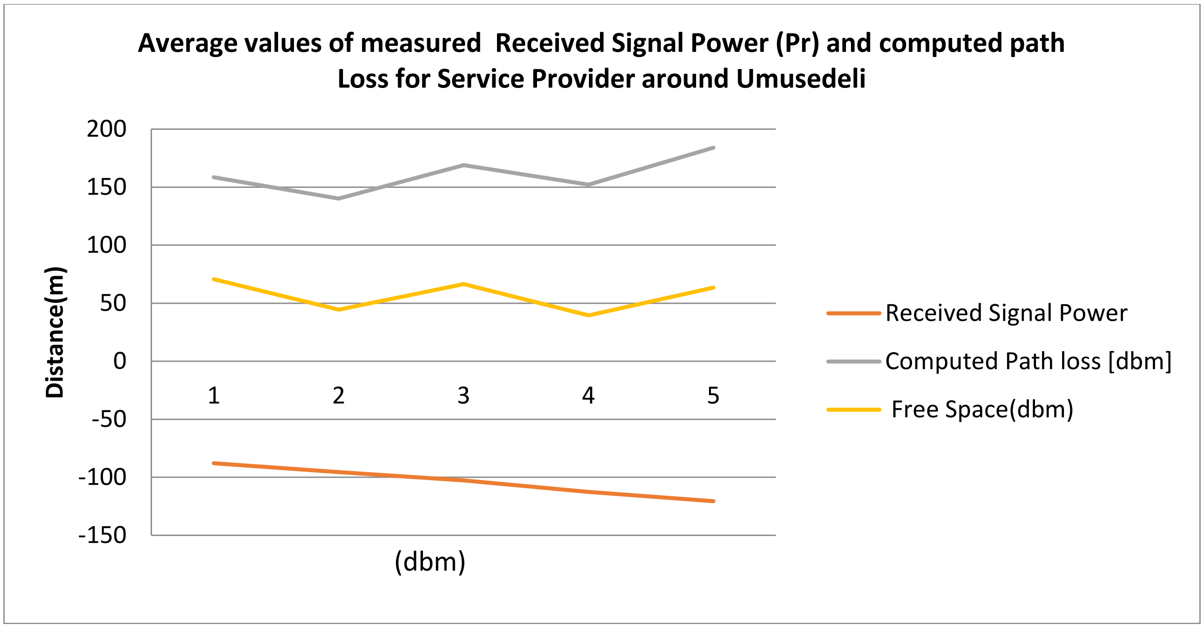

Figure 6: Service Provider around Umusedeli

Table 7: Average values of measured Received Signal Power (Pr) and computed path loss for the Service Provider B Umusam

Distance(m)	Receive Signal power	Computed Path loss [dbm]	Free Space(dbm)
100	-19.80	101.60	81.80
200	-25.92	108.81	82.80
300	-29.40	116.40	87.00
400	-31.60	103.72	72.12
500	-33.80	109.63	75.83

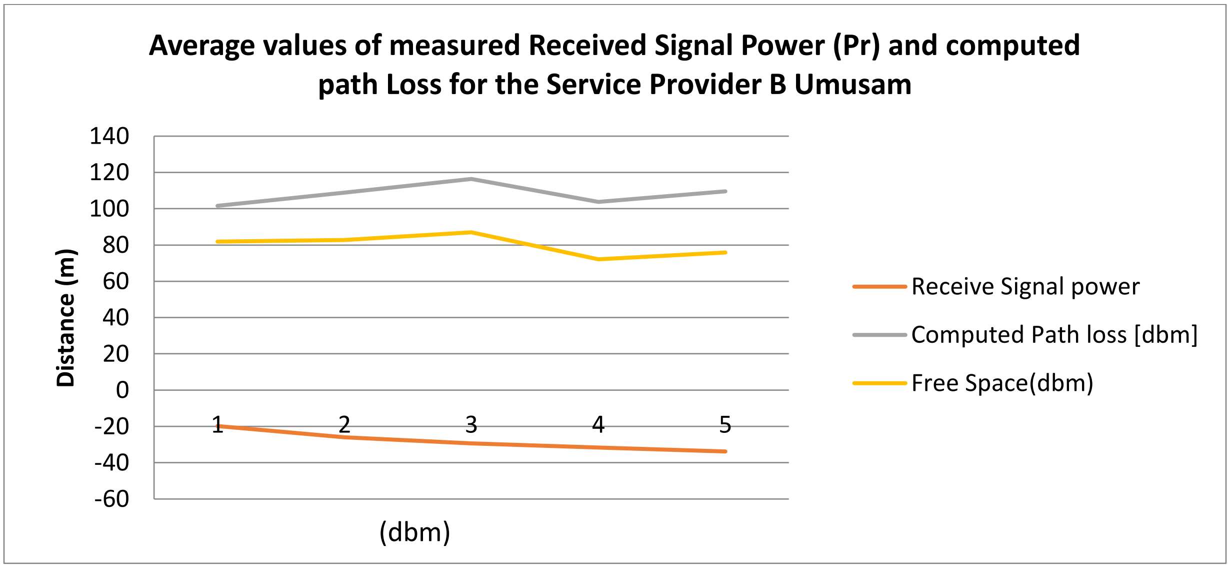

Figure 7: Service Provider B Umusam

Table 8: Average values of measured Received Signal Power (Pr) and computed path loss for the Service Provider B Umusam

Distance(m)	Received Signal Power	Computed Path loss [dbm]	Free Space(dbm)
100	-19.62	102.30	82.68
200	-25.70	110.42	84.72
300	-28.98	114.93	86.00
400	-30.94	103.60	72.66
500	-33.86	106.82	72.96

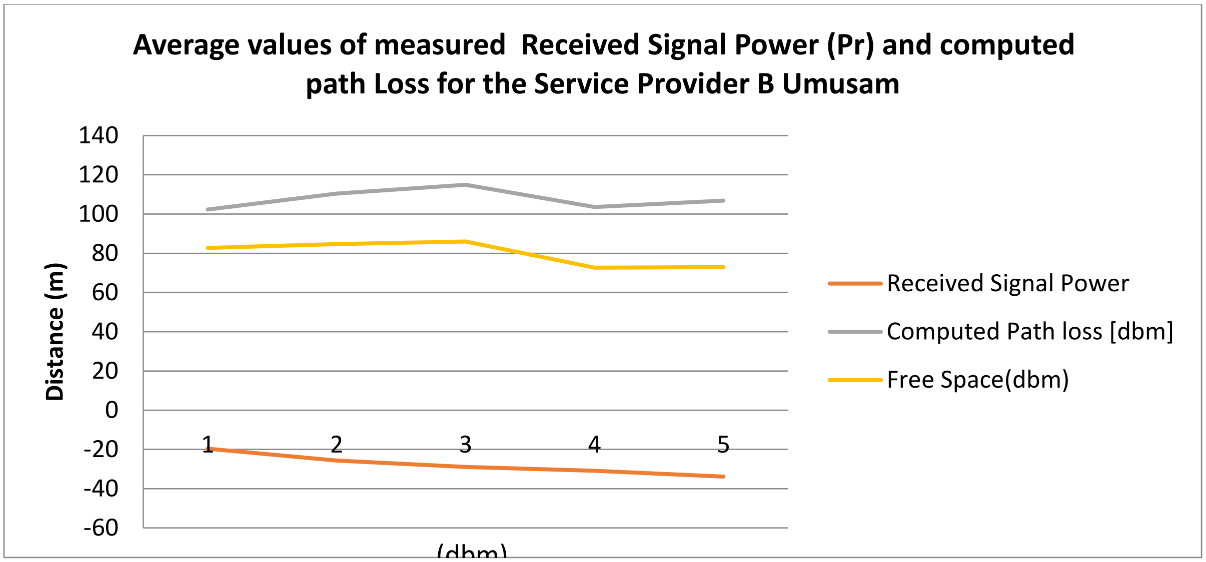

Figure 8: Service Provider B Umusam

Table 9: VPE (Vector Parabolic Equation) model computed received signal power and path loss for service provider A. open/rural environment

Distance(m)	Received signal power	Computed path loss [dbm]	VPE (dbm)
100	-16.60	81.32	64.72
200	-27.92	92.41	64.49
300	-33.65	97.23	63.58
400	-37.60	101.44	63.84
500	-41.00	105.21	64.21

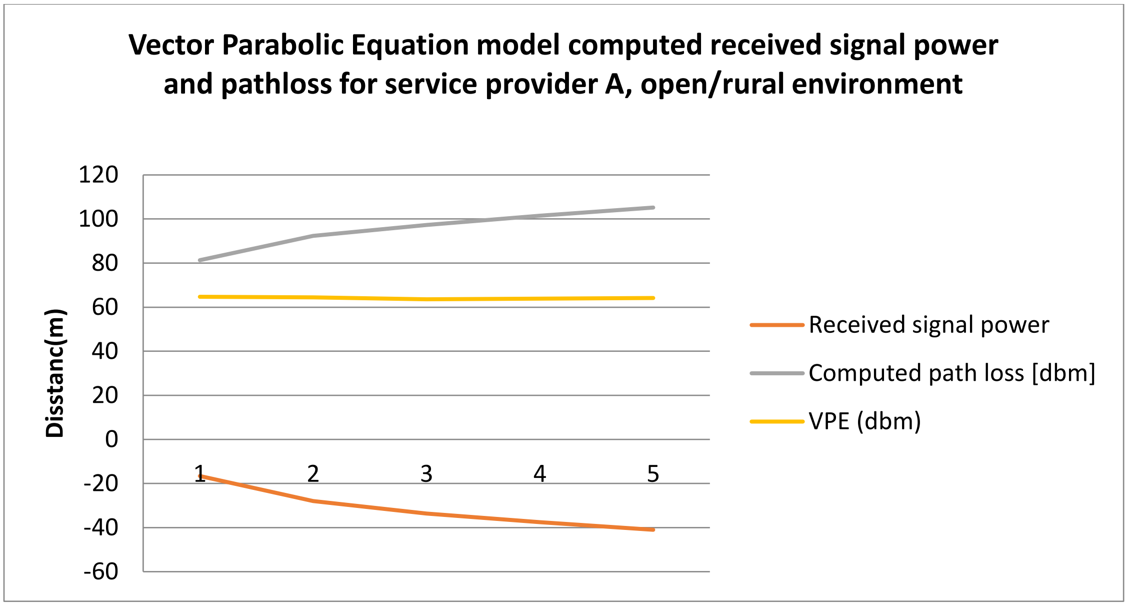

Figure 9: Service provider A, open/rural environment

Table 10: VPE (Vector Parabolic Equation) model computed received signal power and path loss for service provider B, rural/Open environment

Distance(m)	Received signal power	Computed path loss [dbm]	VPE (dbm)
100	-16.60	81.32	64.72
200	-26.46	91.04	64.58
300	-33.00	98.23	65.23
400	-38.02	102.40	64.38
500	-40.10	105.62	65.52

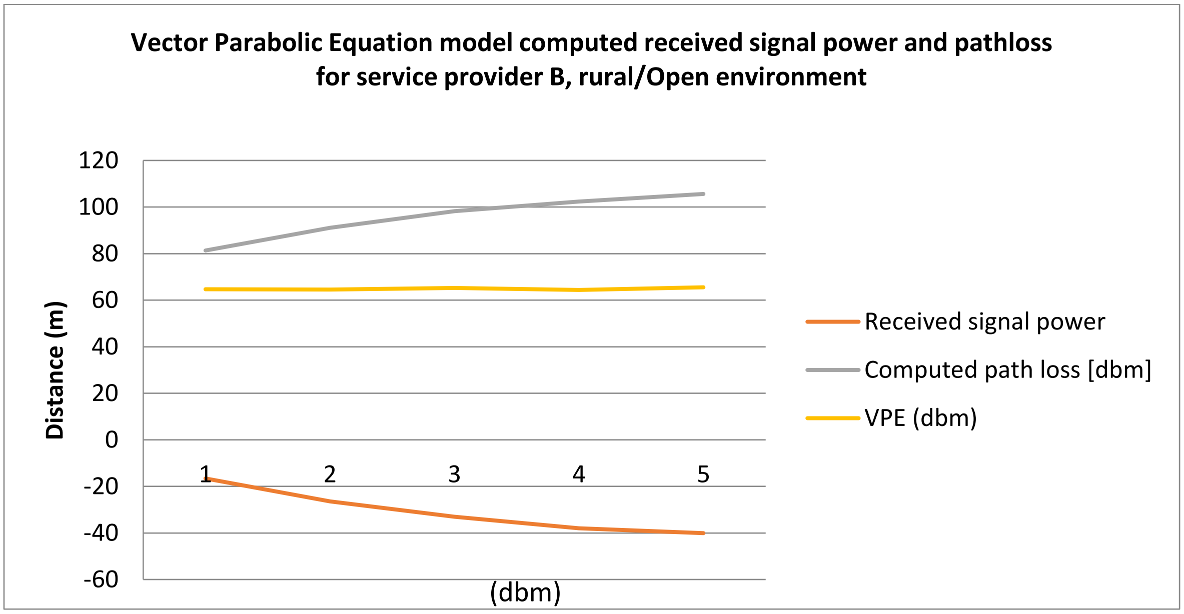

Figure 10: Service provider B, rural/Open environment

Analysis

This reseach work was analyzed using the graph in all the base stations, it is observed from the graph that the received signal power line is moving toward nagative indicating that the signal power is fading as it is moving away from the base station compare with that of VPE and free space model. The analysis show that the strenght of the signal is reduced as it is moving away from the source. From the result, it is observed that the measured received signal power obtained in the area investigated is low clearly indicated that the value obtains for the received signal power as shown in the tableis below the calculated value of the free space model and VPE. It is also discovered that network service provider A is lower than the measured received signal power in the case of service provider B, the measured received signal power is low. This is clearly demonstrated from all the value from received signal power that the value generally falls below the calculated standard value of free-space and VPE demanded for quality service performance. This research work is important for evaluating received signal strength and propagation pathloss and their effect on network service performance.

CONCLUSION

In this research, it is discovered that the network performance service Provider A is low as subscribes in this area and beyond from the Base station will experience loss of signal. Hence, the management of network service provider A and B should deploy more base station. This is important in order to increase signal power of the area.

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