INTERFERENCE MITIGATION IN MICROWAVE PROPAGATION

Didigwu Fidelis Uchenna and J. J. Biebuma

Department of Electrical and Electronics Engineering, University of Port Harcourt

Port Harcourt

E-mail: didigwufidelis@gmail.com +2348036804487

Abstract

Wireless communication is observing a fast development in today's communication era. In mobile communication the Base Transceiver Station (BTS) to Base Station Controller (BSC) or Mobile Switching Centre (MSC) link is based on microwave link. Therefore, analysis and planning of a microwave link is very much important. The microwave equipment can be installed after a careful planning and detailed analysis of a microwave radio system. A poorly designed path can result in periodic system outages, resulting in increased system latency, decreased throughput, or worst case, a complete failure of the system. In this thesis a two ray model is used to analyse the effect of obstruction height on a propagating signal from PAR003 base station to PAR007 base station which causes signal fading. Using repeater decision approach; this means that a repeater position determines where a free space will be achieved in order to avert obstacle in microwave planning.

Keywords: Base Station Controller (BSC), microwave link, two ray model, fading and repeater

Introduction

In wireless technologies information is sent by electromagnetic waves. During Propagation an interaction between waves and environment attenuates the signal level. It causes path loss and limits coverage area. The accurate path loss prediction is a crucial element in the first step of network planning. The capability of determining optimum base station locations, obtaining suitable data rates and estimating coverage is of high importance in communication. To ensure reliability in our network, we continuously must guarantee controlled and coordinated interference environments, even in the face of ever-increasing interference (Boston, 1987).

The channel between the transmitter and receiver could be as simple as line of sight (LOS), but more likely the presence of objects such as buildings, mountains, and trees will create obstruction and provide multiple paths (multipath) for the waves to reach the receiver. Multipath and fading are major players in the way channels affect the transmitted signal as it propagates through the media to the receiver. The electromagnetic wave propagation for wireless radio systems depends on three phenomena: reflection, diffraction, and scattering.

Reflection happens when the signal encounter a flat object with size much larger than the wavelength of the signal. Diffraction happens when the signal encounters a discontinuity, such as an object with an irregular surface and sharp edges. Scattering occurs when the signal encounters an object much smaller than the wavelength of the signal, such as rain drops (Rappaport, 2006).

Background studies

In wireless communication, microwave propagation is a means of transmitting radio signals from one point (transmitter) to another (receiver). For successful transmission of radio signals the transmitter and receiver must be in line of sight (Bruce, 1989). In other words, both the transmitter and receiver must be seeing each other on the radio horizon. This therefore means that there will be no obstruction in the transmission link. This is therefore is the aim of this thesis to analyse signal obstruction using a two ray model and apply repeater decision approach to overcome the obstruction.

Methodology

- Using Global Positioning System (GPS) to obtain the Base Station coordinates.
- Using Path loss software to obtain path profile of the terrain.
- Using mathematical equations to analyze the effect of obstruction height on signal strength.
- Using repeater to overcome obstruction where it exists

Data collection

The data in the table below are the coordinates of different sites obtained using Global Positioning System (GPS) in different cities/villages in Rivers state. Also, in the table is cordinates(longitude and latitude) of the locations.

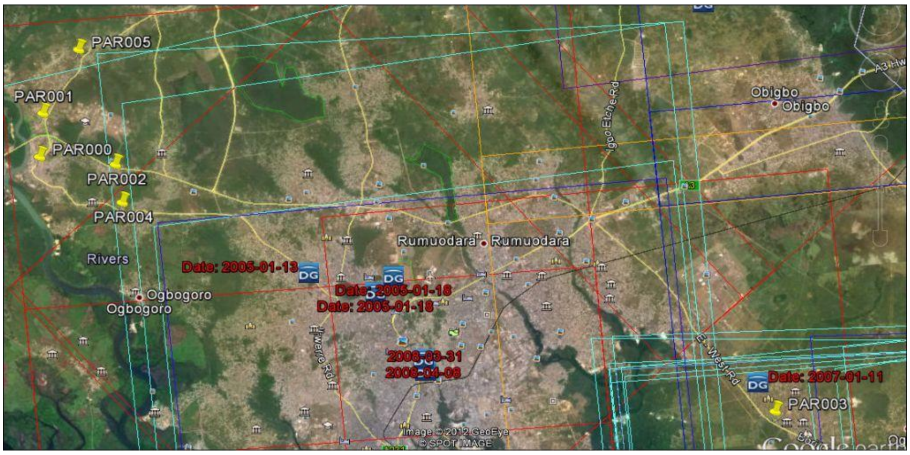

Figure 1: Google earth showing all the base stations in different villages in Rivers State Nigeria

NB: The yellow icons on the map represent each of the Base Stations

Table1; showing the coordinates of different Base Stations

S/N	SITE ID	GPS Measurement Longitude (°)	Latitude (°)	LOCATION	Obsta-cle height
1	PAR000	6.903629	4.88898	35 Rumuchakara str, off Choba/Uniport road, Choba	10m
2	PAR001	6.905939	4.9025036	Delta Park, Uniport, Along Aluu road	9m
3	PAR002	6.926059	4.8842859	Plot 30 NYSC road, off Rumudike Alakahia PotHarcourt	9m
4	PAR003	7.115774	4.78731	Chief Saro compound, Eleme road, refinery junction	14m
5	PAR004	6.92695	4.87220	Akpor Grammer School, along NTA Rd	18m
6	PAR005	6.91870	4.92139	Beside Omega Power Ministry, along UDSS, Aluu	10m
7	PAR006	6.85932	4.87960	Beside St. Luke Anglican Church, Rumuche, Emuoha	10m
8	PAR007	6.86190	4.88478	Beside Elioma Hostel, Rumuakunde, along East-West Rd.	10m

The distance between Base Stations PAR003 and PAR007 is far (30.15km) that it could not be captured at a time in a screen shot that is why the screen shot (fig.1) of the Google map is captured.

The Google map shows that all the Base Stations are located near roads to enable the maintenance Engineers to have access to the Base Stations in time of maintenance.

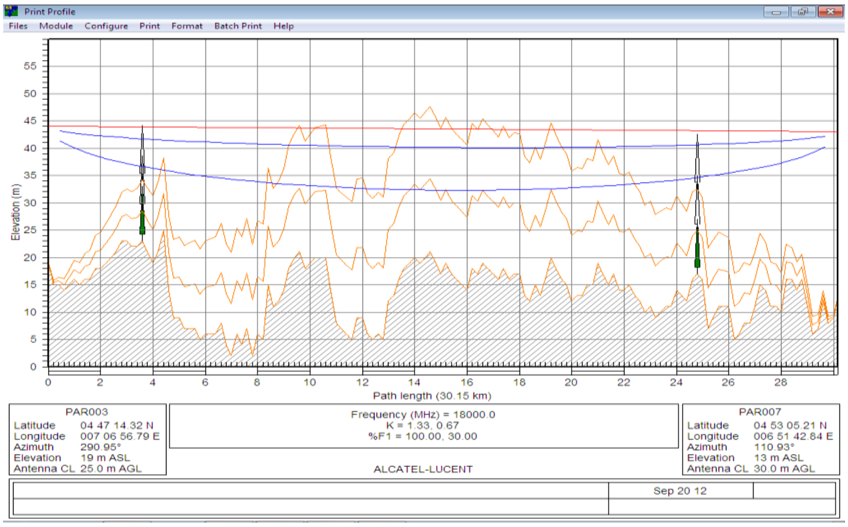

Figure 2: Path profile that links PAR003 to PAR007 with obstruction (Not line of sight).

The red line is known as line of sight line which has to be clear of any obstacle for a good communication occurs. While the blue line represents 1st (inner blue line) and 2nd (outer blue line) Fresnel zone. In microwave planning, 60% of 1st Fresnel zone must be clear of any obstruction for line of sight to be achieved. The simulation above shows that there is obstruction in line of sight propagation between PAR003 and PAR007 in the communication link. This obstruction is as a result of terrain structures due to high grounds and tall trees. This research work is to find a solution to the obstructed signal in figure 2 above.

Analysis of ground reflected signal using two ray model

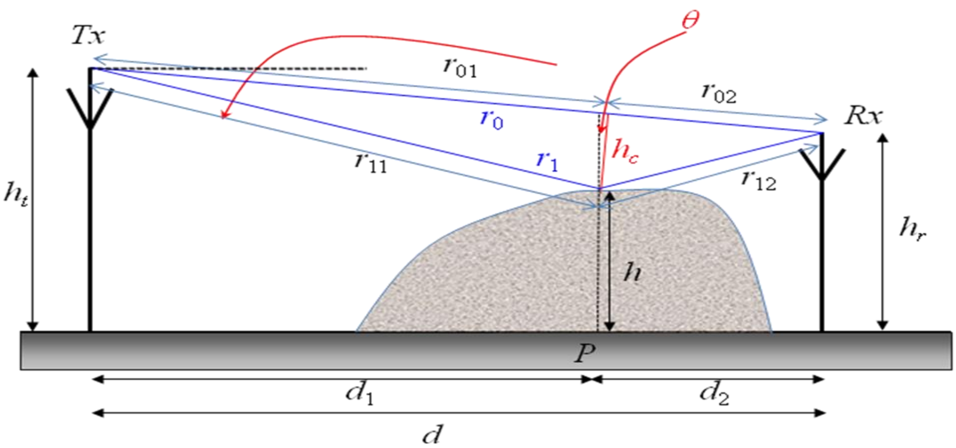

Fig.3; Analysis of ground reflected

This diagram above shows the effect of obstacle height in radio wave transmission. As can be seen, r_o represents direct wave which comprises r_{o1} and r_{o2} while r_1 represents ground reflected wave which consists of r_{11} and r_{12}, h represents the obstacle height while d_1 and d_2 represents the distance between the transmitter and receiver respectively. The equations below analyse how the obstacle height affects the radio signals when it obstructs direct line of sight as seen in MATLAB simulation in fig.4 below.

$$\Delta \quad = \quad (r_1 - r_0) = (r_{11} + r_{12} - r_{01} - r_{02})$$

$$= \left(\sqrt{r_{01}{}^2 + h^2} - r_{01}\right) + \left(\sqrt{r_{02}{}^2 + h^2} - r_{02}\right)$$

$$\Delta \quad = \quad \left(r^2{}_{01} + h^2\right)^{1/2} - r_{01} + \left(r^2{}_{02} + h^2\right)^{1/2} - r_{02}$$

Using binomial expansion of fractional index.

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$$(a + x)^n = a^n + na^{n-1}x + \frac{n}{1}\,\frac{n-1}{2}\,a^{n-2}x^2 ....$$

$$= \left(r_{01}^2\right)^{1/2} + \frac{1}{2}\left[r_{01}^2\right]^{1/2-1} x\ h^2 - r_{01} + \frac{1}{2}\left[r_{02}^2\right]^{1/2-1} x\ h^2 - r_{02}$$

$$= r_{01} + \frac{1}{2}\left[r_{01}^2\right]^{1/2-1} x\ h^2 - r_{01} + 1/2\left[r_{02}^2\right]^{-1/2} x\ h^2 - r_{02}$$

$$= \frac{1}{2}\left[r_{01}\right]^{-1} x\ h^2 + 1/2\left[r_{02}\right]^{-1} x\ h^2$$

$$= \frac{h^2}{2\ r_{01}} + \frac{h^2}{2\ r_{02}} \quad = \quad \frac{h^2}{2}\left[\frac{1}{r_{01}} + \frac{1}{r_{02}}\right]$$

$$but \quad r_{01} \approx d_1$$
$$r_{02} \approx d_2$$
$$\therefore \quad \Delta = \frac{h^2}{2}\left[\frac{1}{d_1} + \frac{1}{d_2}\right] = \frac{h^2}{2}\left[\frac{d_2 + d_1}{d_1 + d_2}\right]$$

$$but$$
$$v = \quad 2\sqrt{\frac{\Delta}{\lambda}} \quad and \quad \Delta = \frac{h^2 d}{2 d_1 d_2}$$
$$v = \quad 2\sqrt{\frac{h^2 d}{2 d_1 d_2 \ \lambda}}$$
$$= \quad h\sqrt{\frac{4d}{2 d_1 d_2 \ \lambda}}$$
$$= \quad h\sqrt{\frac{2(d_1 + d_2)}{d_1 d_2 \ \lambda}}$$

$$v = diffraction \quad loss$$
$$f = frequency \ (GH_2)$$
$$d = Pathlenghth \ (km)$$

Δ= path difference
h_c = obstacle clearance/height
d_1 = distance from transmitter to obstacle
d_2 = distance from receiver to obstacle.
r_0= direct ray
r_1 = reflected ray
V= diffraction loss parameter

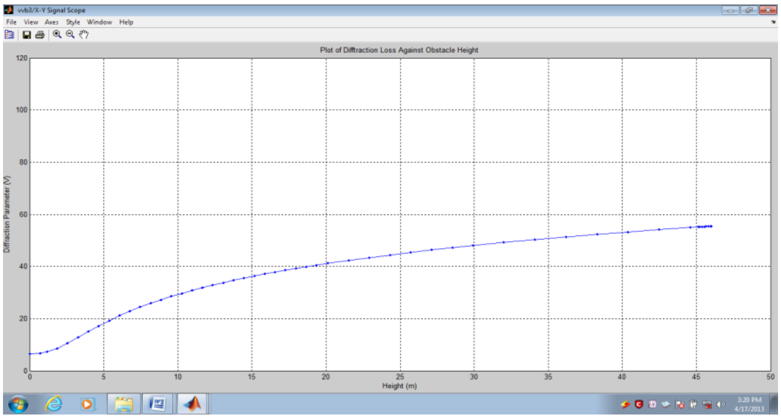

Figure 4: Simulation of diffraction loss parameter against obstacle height showing faded signal.

The simulation work above shows the diffraction loss parameter against obstacle height. Diffraction loss parameter is simply the ratio of electric field due obstacle to that of free space (E/E_o). As can be seen in the simulated work, even when the height is '0' there is a signal loss due to free space. The diffraction loss parameter tends to increase as obstacle height increases until at 43m high when the signal is completely absorbed and faded away. This effect is what we try to avoid in microwave communication.

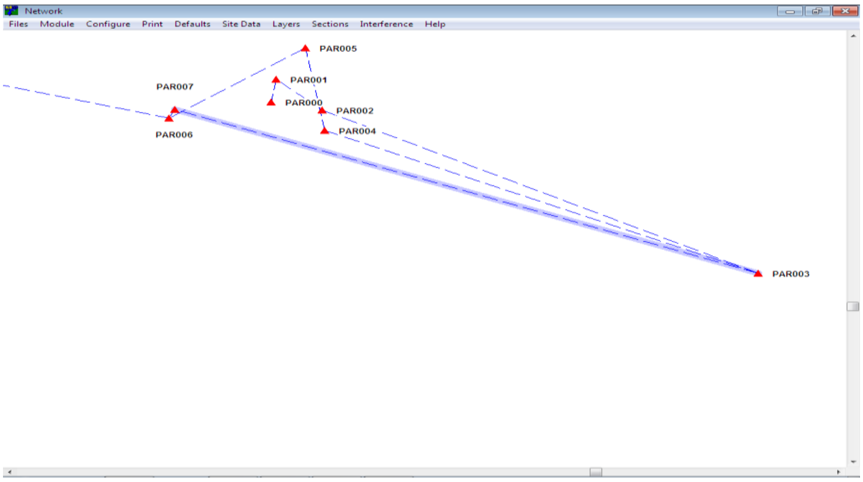

Figure 5: All the eight base stations on network module to decide repeater position.

In the figure 5 above, it shows the wide spread of all the Base Stations on network module. But in this thesis, we have obstructed signal between link PAR003 and PAR007, so using MapInfo simulation will decide the position of the repeater where the microwave signal will be transmitted without obstruction.

Figure 6 below, shows Add Item which generates the coordinate of the position of the repeater. As can be seen, longitude; 04 50 19.81 and latitude; 006 67 50.59. The simulation link in fig.7 and fig.8 shows the repeater and the two Base Stations (PAR003 and PAR007) with successful signal transmission devoid of obstruction.

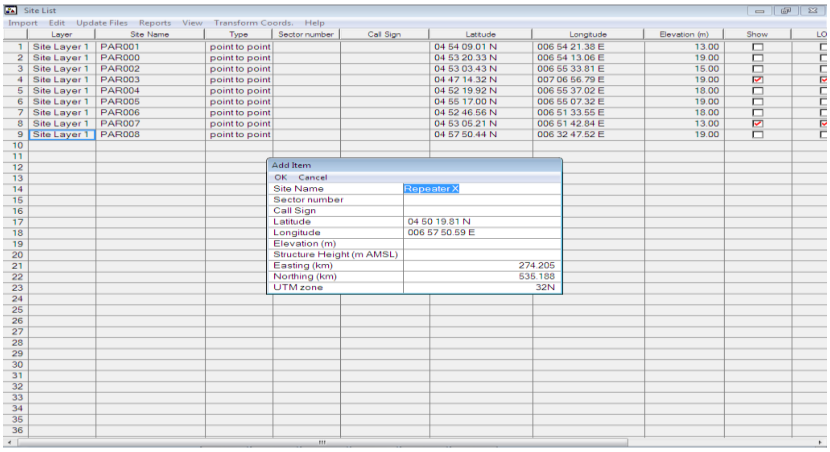

Figure 6: Add Item showing the coordinate of the repeater position

This simulation shows that there is no obstruction between repeater 'X' and the Base Station PAR003, and this is the main aim of this research work. Also, simulating repeater 'X' and PAR007 below shows no obstruction in signal propagation since both 1st and 2nd Fresnel zones are clear of obstruction.

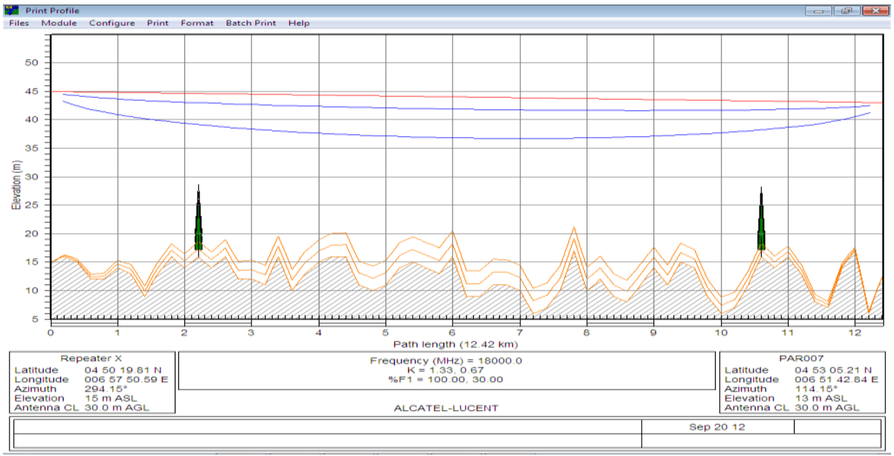

Figure 7: simulation link showing propagation with a clear line of sight between Repeater 'X' and PAR003

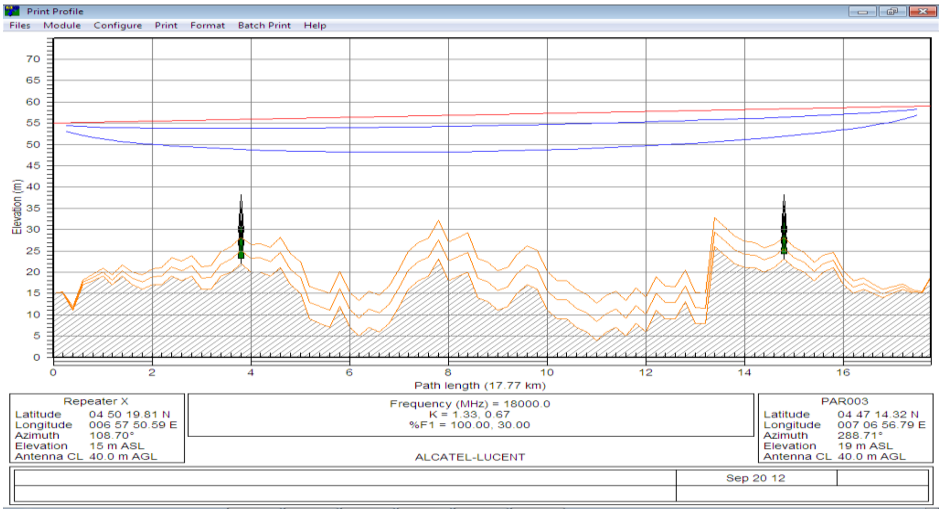

Figure 8: simulation showing clear line of sight between repeater 'X' and PAR007

Conclusion

Microwave communication is playing the role of a key factor in the current time of wireless communication. The performance and quality of service of all the Mobile Communication Service Providers broadly depends on the quality and availability of their Microwave Link. It requires a series of works to establish a microwave link between two long distance and short distance points. All the steps are performed by engineer as to establish a Microwave link. For establishing a microwave link analyzing factors, first factor is terrestrial factors that are Site Survey, condition of terrain (flat / hilly /desert), and presence of water body like big river/lake/sea, presence of forest or big trees.

A microwave link free of obstruction is only affected by free space loss which is the acceptable loss in microwave planning. In this thesis, it is seen that obstructions are averted and line of sight is attained. This therefore ensures good quality of service in radio link.

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