Original Research Article

IMPACT OF BASE STATION SITE, ANTENNA CONFIGURATION AND POWER CONTROL IN LTE NETWORK

ABSTRACT

This study analyzed the impact of spatial distribution of APs/Base stations, antenna configuration and power control in a dense populated area like Owerri, using link planner network simulator and google-earth software. High-effective data capacity at hotspots in conjunction with bandwidth and the predicted power at the receiver for LTE network are required to capture some number of users and provide high data rates over the Wi-Fi interface. The data rates are influenced by the terrain, which loses throughput due to delays, path loss and interference. The hotspot range which determines the number of users, that can associate, is limited by the power of the client and the access point. The variables that affect link performance, such as: band, region, equipment, antenna, height, terrain and obstructions towards providing enhanced capacity and coverage are measured by the link planner. The characteristics like gain, beam, width and frequency, for evaluation of results in terms of coverage and capacity for different antenna configurations, receive-Power, terrain, bandwidth and distances are also observed respectively. The results show that pathloss increases or decreases with these factors between nodes. The strategy to place the transmitter in the highest position has also proven better performance for implementation of the LTE system and its long run operation.

***Key words**: Network performance, Access Point (AP), wifi, Terrain profile, Fresnel zone, Line of Sight (LoS).*

1. INTRODUCTION

Telecommunications has been defined as a technology concerned with communicating from a distance [1], it involves the exchange of information by electronic and electrical means over a significant distance. A complete telecommunication arrangement is made up of two or more stations equipped with transmitter and receiver devices. A single co-arrangement of transmitter and receivers, called a transmitter, may also be used in many telecommunication stations [2]. Telecommunication devices include telephone, telegraph, radio, microwave communication arrangements, fiber optics, satellites and internet [3].

1.2 GSM NETWORK STRUCTURE

A GSM network is composed of several functional entities, whose functions and interfaces are specified [4]. The GSM network can be divided into three broad parts.

i. The mobile station is carried by the subscriber

ii. The base station subsystem controls the radio link with mobile station

iii. The network subsystem which consists of the mobile services switching enter (MSC) as its main part, performs the switching of calls between the mobile phone users and then between mobile phone and fixed network users.

A wireless telephone base station communicates with a mobile or hand-held phone. Other equipment is involved depending on the system architecture. Mobile telephone provider networks, such as European GSM networks, may involve carrier, microwave radio, and switching facilities to connect the call. In the case of a portable phone such as a US cordless phone, the connection is directly connected to a wired land line [5].

1.2.1 Evolution of Wireless Access Networks

Developing mobile technologies has also changed, from being a national or regional concern, to becoming a very complex task undertaken by global standards developing organizations. The introduction, standardisation and theoretical background of LTE are managed by the Third Generation Partnership Project (3GPP) [5].

Figure 1: A cell tower.(www.whatsag.com)

1.3 BASIC ANTENNA THEORY

An antenna is a device to transmit and/or receive electromagnetic waves Restricted Space [6]. Electromagnetic waves are often referred to as radio waves. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned (matched) to the same frequency band as the radio system to which it is connected, otherwise reception and/or transmission will be impaired [7].

1.4 MULTIPLE ANTENNA TECHNIQUES

Multiple antenna techniques have been in development since 1984. Triggered with the fast evolution and growing availability of processing power, these techniques soon found their place in various radio technologies, e.g. in HSPA+, WCMDA, WLAN and WiMAX [8]. The cellular systems using orthogonal multiple access techniques are termed as orthogonal systems and those using non orthogonal multiple access schemes are known as non-orthogonal systems [9].

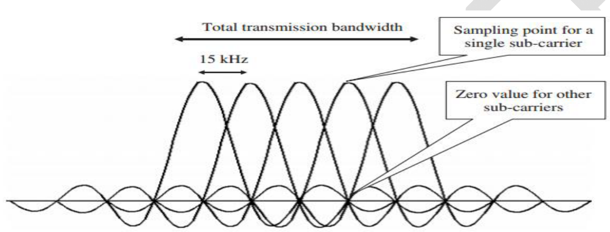

Figure 2: Orthogonal layout of subcarriers, frequency domain

1.5 CAPACITY AND PERFORMANCE

LTE provides downlink peak rates of at least 300Mbps and uplink peak rates of 50Mbps in 20 MHz channel. LTE leverages advanced antenna techniques such as MIMO, SDMA and beamforming, which provides benefits to users in both high and low signal strength areas [10]. The basic premise behind cellular systems is to exploit the power falloff with distance of signal propagation to reuse the same channel at spatially-separated locations. Specifically, the coverage area of a cellular system is divided into non-overlapping cells where some set of frequencies or channels is assigned to each cell. This same channel set is used in another cell some distance away. The reuse of channels is called frequency reuse or channel reuse [10].

2. MATERIAL AND METHODS

The LINKPlanner to predict the Receive Power and Max Usable Mode, the planner must enter the variables that affect link performance [11]. The search field narrows the choice when there is large number of sites in the list. Select one or more sites from the list. Set the number of Access Points required on each hub and the azimuth of the first Access Point on the site. The separation angle defaults to 360 degrees divided by the number of Access Points, select a different angle if required. The GPS coordinates where obtained using GPS MAP 76cx Garmin device.

2.1 SIMULATION MODE

The Access Points (Base stations) Owerri 1 - 10 as shown in Table.1 as well as the users/subscribers are positioned in dense hotspot areas in the present day Owerri Imo State Capital and can be viewed using Google-Earth App. They are assumed to operate at 5.8GHz with 30MHz bandwidth. The Access Points and subscribers heights are assumed to be between 20M to 35M. The hotspots and AP are at various distances within the metropolis. The mobility issues are not considered during the simulation since a static simulator model is used but as a generic assumption,

Table 1: Access points/ subscibers

Name	Latitude	Longitude	Maximum Height (m)	Description
OWERRI 1	05:28:43.6N	007:00:13.9E	30	WORLDBANK
OWERRI 2	05:28:18.6N	007:02:07.8E	20	OP
OWERRI 3	05:28:22.4N	007:01:12.1E	30	YAR ADUA RD
OWERRI 4	05:29:32.1N	007:02:53.3E	30	ALADINMA
OWERRI 5	05:29:26.6N	007:02:18.3E	30	IKENEGBU
OWERRI 6	05:30:28.3N	007:01:23.4E	30	AMAKOHIA
OWERRI 7	05:31:03.6N	007:03:14.0E	30	ORJI
OWERRI 8	05:27:08.8N	007:15:07.8E	30	ABOH MBAISE
OWERRI 9	05:31:18.5N	007:16:05.8E	30	AHIAZU MBAISE
OWERRI 10	05:27:57.8N	007:19:36.2E	35	EZINIHITTE MBAISE

3. RESULTS AND DISCUSSION

The locations/areas of AP for the study were in and around Owerri Imo State capital.

3.1 FRESNEL ZONE OF THE AP

The concept of Fresnel zone clearance may be used to analyze interference by obstacles near the path of a radio beam. The first zone must be kept largely free from obstructions to avoid interfering with the radio reception (Figure 4). However, some obstruction of the Fresnel zones can often be tolerated. The 'rule of thumb' states, first, that the maximum obstruction allowable is 40%, secondly, that the recommended obstruction should be 20% or less (as seen in Figure 6). For establishing Fresnel zones, first determine the RF Line of Sight (RF LoS), which in simple terms is a straight line between the transmitting and receiving antennas. Now the zone surrounding the RF LoS is said to be the Fresnel zone.

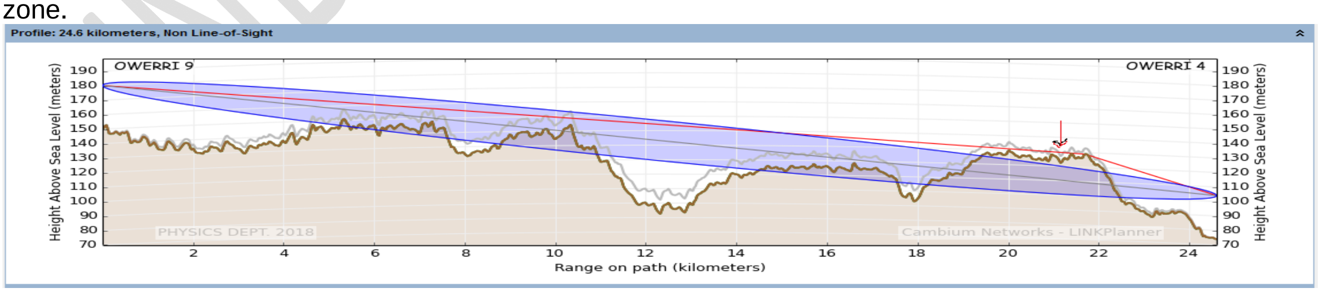

Figure 3: Fresnel zone and Line of Sight (LoS) blocked by terrain profile

If a significant portion of the Fresnel zone is obstructed the receive-signal-strength at the receiving antenna can be greatly attenuated (Figure 3). A rule of thumb is that you need at least 60% of the first Fresnel zone clear of any obstructions in order for the radio wave propagation to behave as if it is in "free space". "60% of the first Fresnel zone" means a narrower ellipsoid with a radius that is 60% of the radius of this first Fresnel zone.

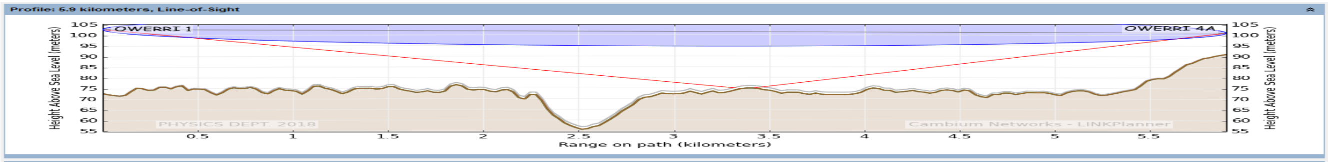

Figure 4: Fresnel zone and Line of Sight free from terrain profile

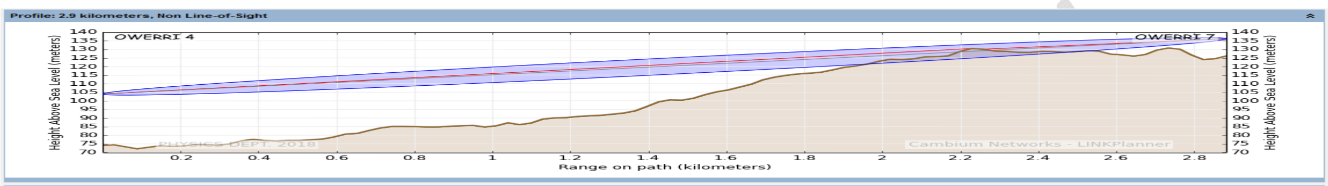

Figure 5: Fresnel zone and Line of Sight partly obstructed

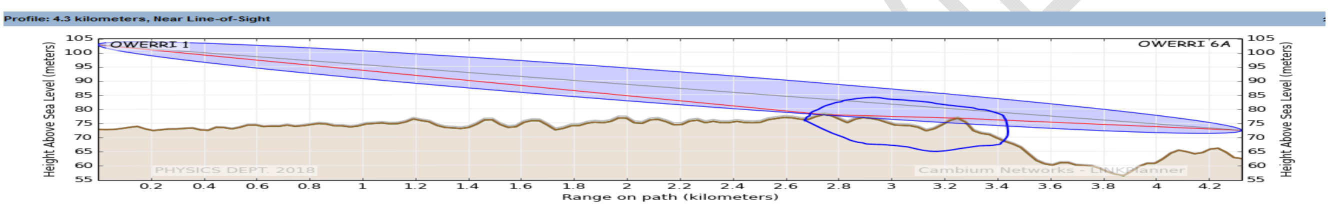

Figure 6: Terrain profile impinging on Fresnel zone

Fresnel Zone Analysis

If you have 60% of the first Fresnel zone cleared of any obstructions then the RF propagation in your link will be similar to free space

Table 2: Fresnel zone analysis

FIGURE	FRESNEL ZONE	PERCENTAGES OF FREE ZONE
Figure 3	Fully blocked by the terrain	0%
Figure 4	Free from the terrain	100%
Figure 5	Partly blocked by the terrain	40%
Figure 6	Partly blocked by the terrain	80%

3.2 ANTENNA CONFIGURATION AND POWER CONTROL

3.2.1 Configuration and Requirements at Owerri 9 to Owerri 4

Antennas were adjusted at both ends of the link and confirm that the selected equipment meets the performance requirements: It was observed that the predicted values are now red because they are less than required values and the excess path loss was high

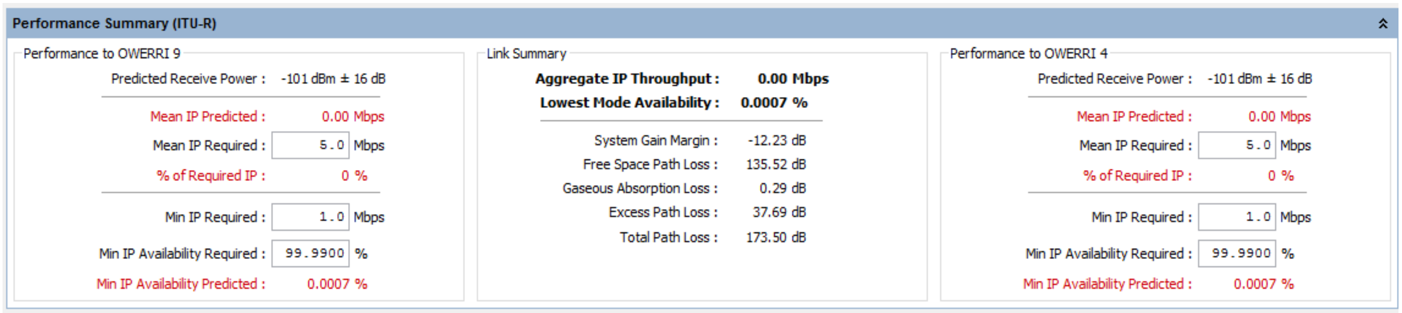

Figure 7: configuration performance at this height.

Charts

The following charts show the variability in percentage of time availability with capacity, for each direction in the link. Availability (given as a percentage) and unavailability (given as a unit of time).The throughput given is the maximum throughput at that availability.

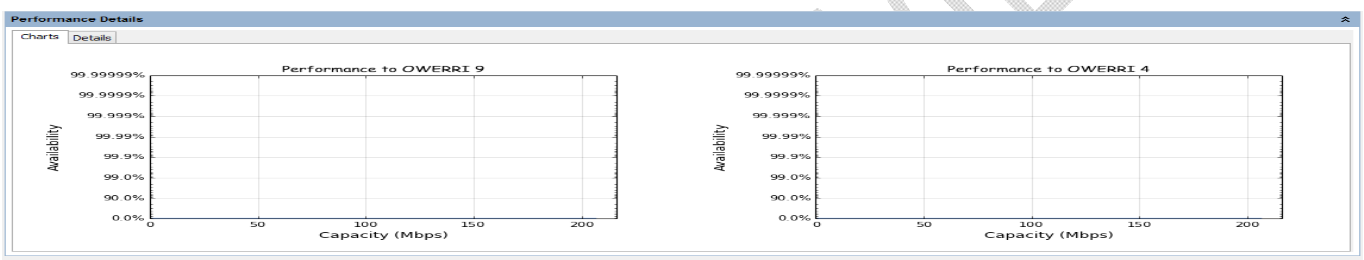

Figure 8: Capacity and the availability base on the performance in Figure 7 above.

The chart revile that all signals were cancelled out and lost.

3.2.2 Configuration and Requirements at Owerri 4 to Owerri 1

3.2.2.1 Path Loss

It was observed that the predicted values now meet the performance objective and required values and the excess path loss was zero.

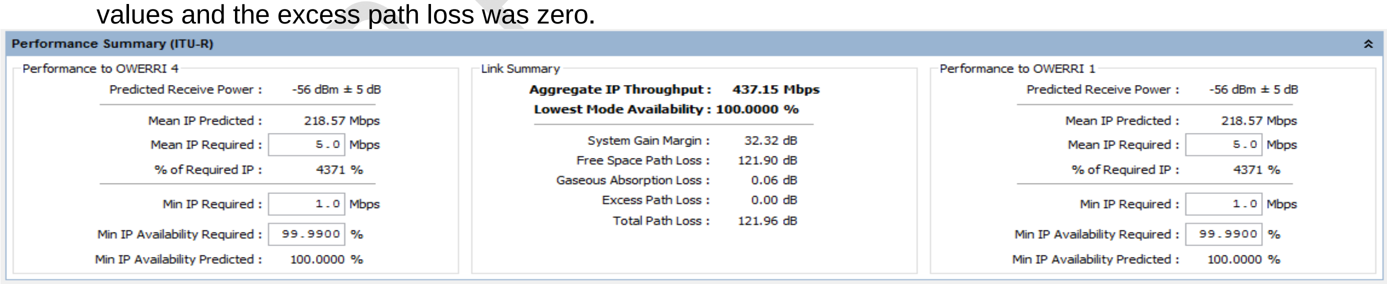

Figure 9: configuration performances at this height.

3.2.2.2. Chart of performance

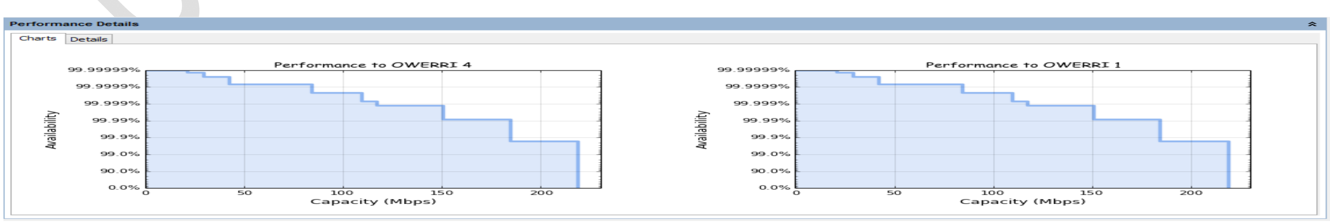

Figure 10: performance graph

At high path-loss, however, the transmission power is considerably lower than that set by the full path-loss compensation scheme, which leads to a lower number of assigned resource blocks by Adaptive Transmission Bandwidth and consequently to lower throughput for users at the cell border. But the performance reverses when the path loss reduces.

3.2.2.3. Performance Charts for Adaptive Symmetry.

When traffic is only being sent in one direction the other direction has no load on it and a peak throughput can be achieved in a single direction at a given time. When one direction of the link is saturated the maximum throughput in the other direction balances that load and provides a symmetrical throughput in each direction, for identical link conditions.

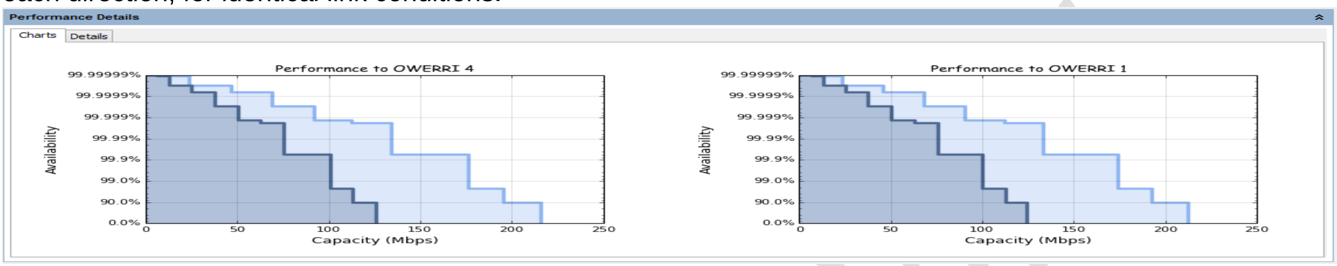

Figure 11:Adaptive Symmetry

3.3 IMPACT OF THE CONFIGURATION

Impact of Transmitter Power on Coverage

As the transmitter bandwidth increases received power also increases, consider the APs Owerri1 to Owerri4A, with the profile diagram Figure7 above. The Impact on received signal level (coverage area) by varying the transmitted bandwidth from 5 MHz to 45 MHz is shown in table 3 below, the predicted receiver power also increased

Table 3: Bandwidth and the predicted power at the receiver (Owerri1 to Owerri4A).

Bandwidth (MHz)	Predicted Receiver Power (Mbps)
5	15.70
10	32.26
15	41.41
20	49.92
30	61.05
40	72.79
45	75.90

The propagation distance and other parameters had impact on the power at the receiver as well as the antenna heights.

4. CONCLUSION

The key to practical aspects for capacity and coverage planning of a commercial LTE (long term evolution) network as the link planner provides for different LTE channels is related to radio planning in LTE. By adding more antennas access point, significant gains can be achieved in several key areas. LTE will only utilize the larger number of receive antennas when it is worthwhile. The benefits, in terms of increased system capacity, maximum data rates and network stability are likely to significantly affect the perceived user experience positively. It's designed to handle Wi-Fi bandwidth efficiently, hence is capable of delivering better data rates to multiple connected clients simultaneously.

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