Physical Science International Journal

22(2): 1-8, 2019; Article no.PSIJ.49183
ISSN: 2348-0130

Impact of Base Station Site, Antenna Configuration and Power Control in LTE Network

Alhassan Shilo Shekwonya[1*] and Lebe Nnanna[1]

[1]Department of Physics, College of Physical and Applied Sciences, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author ASS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author LN supervised the entire work. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/PSIJ/2019/v22i230128
Editor(s):
(1) Dr. Shi-Hai Dong, Professor, Department of Physics School of Physics and Mathematics, National Polytechnic Institute, Mexico.
(2) Dr. Christian Brosseau, Distinguished Professor, Department of Physics, Université de Bretagne Occidentale, France.
Reviewers:
(1) Muhib Ur Rahman, Dongguk University Seoul, South Korea.
(2) Jurandyr Santos Nogueira, Federal University of Bahia, Brazil.
(3) Aliyu Bhar Kisabo, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/49183

Original Research Article

Received 10 March 2019
Accepted 23 May 2019
Published 01 June 2019

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 (Nigeria), 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.

**Corresponding author: E-mail: sashilo2004@yahoo.com;*

Keywords: 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].

1.1 Gsm Network Structure

A GSM network is composed of several functional entities, whose functions and interfaces are specified [4,5]. 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 (Fig. 1) 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 [6].

1.1.1 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) [6,7].

1.2 Basic Antenna Theory

An antenna is a device to transmit and / or receive electromagnetic waves Restricted Space [8]. 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 [9].

Fig. 1. A cell tower
(www.whatsag.com)

1.2.1 Antenna basic concepts

The wireless communication is done in the form of waves. Hence, we need to have a look at the properties of waves in the communications [10,11] VSWR and Reflected Power, Radiation Intensity, Wavelength, Impedance Matching, Bandwidth, Decibels, Directivity and Gain, Radiation Patterns.

1.2.1.1 VSWR and reflected power

Voltage Standing Wave Ratio (VSWR) is an indication of the quality of the impedance match. VSWR is often abbreviated as SWR. A high VSWR [10,12] is an indication the signal is reflected prior to being radiated by the antenna. Bandwidth can be defined in terms of radiation patterns or VSWR/reflected power.

1.3 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 [13,14,15,16]. The cellular systems using orthogonal multiple access techniques (Fig. 2) are termed as orthogonal systems and those using non orthogonal multiple access schemes are known as non-orthogonal systems [17].

1.4 Capacity and Performance

LTE provides downlink peak rates of at least 300 Mbps and uplink peak rates of 50 Mbps 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 [18]. 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 [18].

2. MATERIALS AND METHODS

The LINK Planner to predict the Receive Power and Max Usable Mode, the planner must enter the variables that affect link performance [19]. 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. GPS allow reception and transmission in different frequency bands [20,21,22].The GPS coordinates where obtained using GPS MAP 76cx Garmin device.

2.1 Simulation Mode

The Access Points (Base stations) [23] 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 5.8 GHz with 30 MHz bandwidth. The Access Points and subscribers heights are assumed to be between 20 M to 35 M. 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.

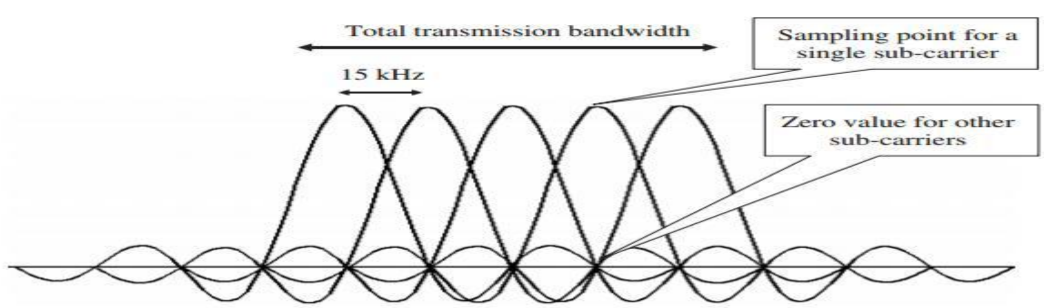

Fig. 2. Orthogonal layout of subcarriers, frequency domain
(https://pdfs.semanticscholar.org)

Table 1. Access points/ subscribers

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 (Fig. 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 Fig. 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.

If a significant portion of the Fresnel zone is obstructed the receive-signal-strength at the receiving antenna can be greatly attenuated (Fig. 3). A rule of thumb is that you need at least 60% (on like Fig. 5 that is 60% blocked) 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.

Fig. 3. Fresnel zone and Line of Sight (LoS) blocked by terrain profile

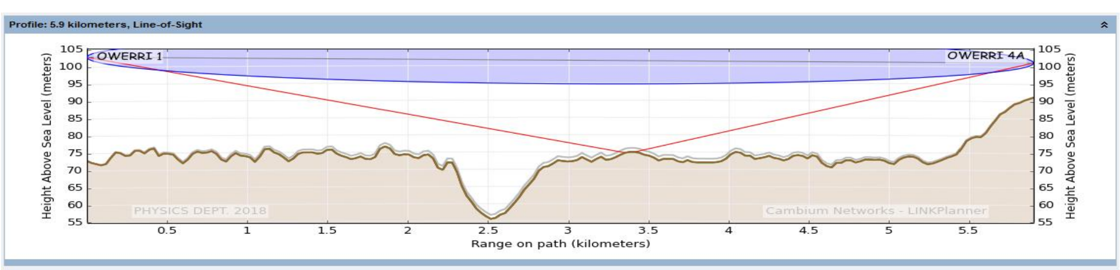

Fig. 4. Fresnel zone and line of sight free from terrain profile

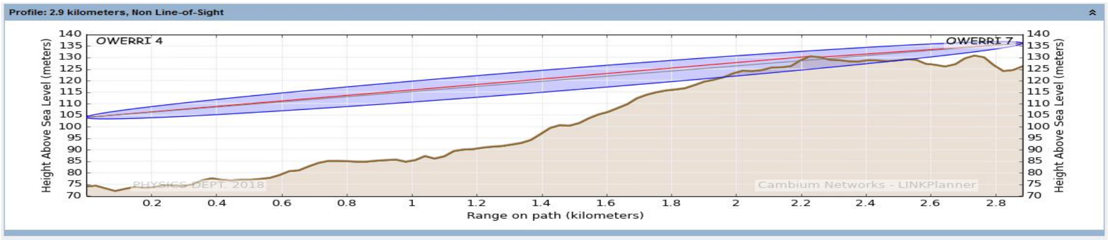

Fig. 5. Fresnel zone and line of sight partly obstructed

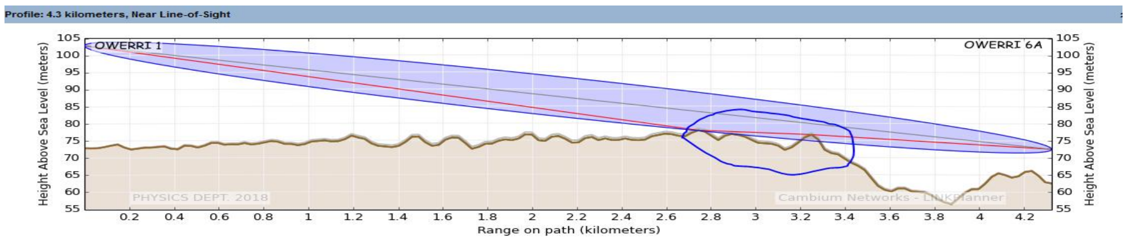

Fig. 6. Terrain profile impinging on fresnel zone

Table 2. Fresnel zone analysis

Figure	Fresnel zone	Percentages of free zone
Fig. 3	Fully blocked by the terrain	0%
Fig. 4	Free from the terrain	100%
Fig. 5	Partly blocked by the terrain	40%
Fig. 6	Partly blocked by the terrain	80%

3.1.1 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 showed that only Figs. 4 and 6 have cleared zone above 60%.

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 (Fig. 7) because they are less than required values and the excess path loss was high.

3.2.1.1 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. Due to the impact of the terrain on the LoS and the entire Fresnel zone, the variability and the capacity of Owerri 9 to Owerri 4 was null (Fig. 8). No signal was observed in the chart.

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 (Figs. 9 and 10) that the predicted values now meet the performance objective and required values and the excess path loss was zero.

3.2.2.2 Chart of performance

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 (Fig. 11). 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.

3.3 Impact of the Configuration

3.3.1 Impact of transmitter power on coverage

Table 3 shows that as the transmitter band width increases received power also increases, consider the APs Owerri1 to Owerri4A, with the profile diagram Fig. 7 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, the predicted receiver power also increased.

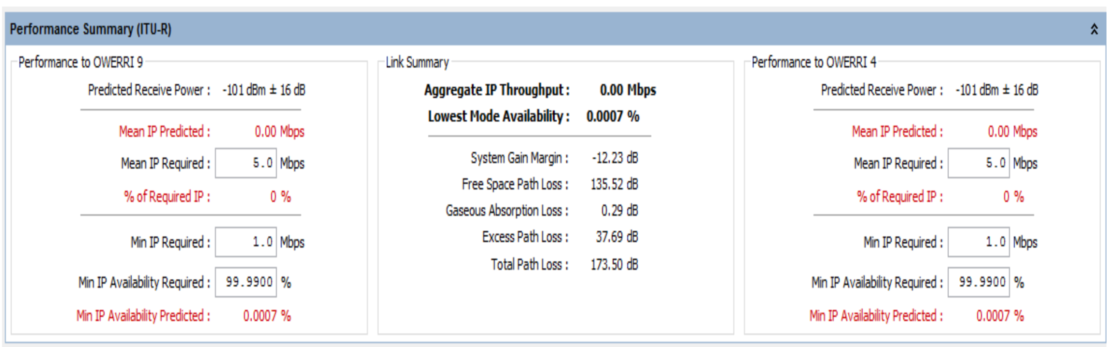

Fig. 7. Configuration performance at this height

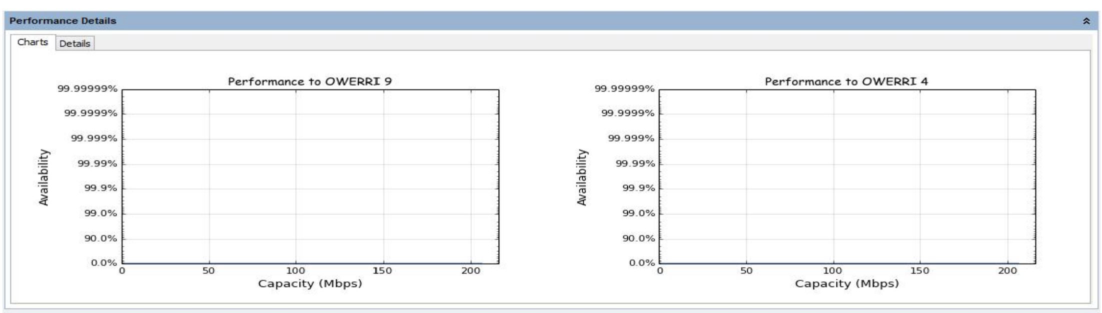

Fig. 8. Capacity and the availability base on the performance in Fig. 7 above

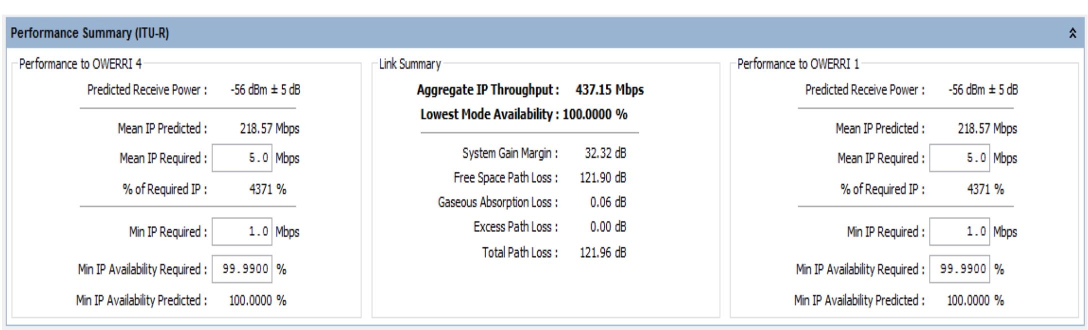

Fig 9. Configuration performances at this height

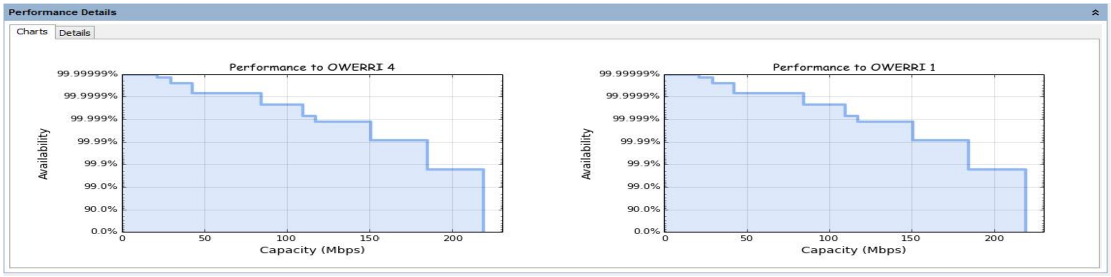

Fig. 10. Performance graph

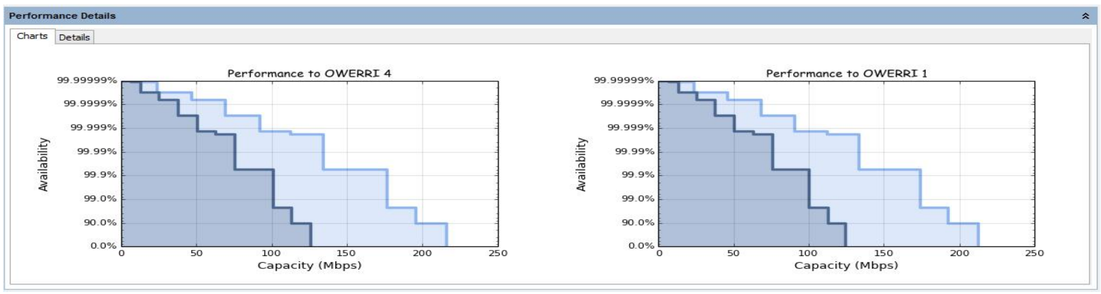

Fig. 11. Adaptive symmetry

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Omogunloye, et al. Analysis of mast management distribution and telecommunication service using geospatial technique; 2013. Available:http://www.iosrjournals.org/iosr-jestft/papers/vol3-issue3/I0335875.pdf IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). *2013;3(3):58-75.* e-ISSN: 2319-2402 p-ISSN: 2319-2399. *Available:www.Iosrjournals.org* www.iosrjournals.org 58 |

2. Barkotel Communication; 2014. Available:http://www.barkotel.com/service/telecommunicationsystems
3. Telecommunication; 2018. Available:https://www.techopedia.com/definition/5570/telecommunications
4. John Scourias. Overview of the global system for mobile communications; 2018. Available:https://www.cs.sfu.ca/mmbook/furtherv2/gsmreport.html
5. Network Security. Wireless Base Stations; 2018. Available:https://www.networxsecurity.org/members-area/glossary/b/base-stations.html
6. Walt Fair Jr. W5ALT restricted space antennas; 2018. Available:http://www.comportco.com/~w5alt/antennas/notes/ant-notes.php?pg=3
7. Ryszard Struzak; 2007. Available:https://www.academia.edu/38567047/Basic_Antenna_Theory_Ryszard_Struzak
8. Antenna basic concept; 2018. Available:https://www.pulseelectronics.com/antenna_basic_concepts/
9. Flores A, Knightly E. Dual Wi-Fi: Dual channel Wi-Fi for congested WLANs with asymmetric traffic loads; 2013. IEEE 802.11-13/1409r0
10. Mateo Šoša. The challenges of LTE technologies. Student Id, Jmbag: 0246024264, Final thesis no.: 1517 Zagreb. Polytechnic of zagreb professional study in electrical engineering; 2013.
11. Muhib Ur Rahman. CPW fed miniaturized UWB tri-notch antenna with bandwidth enhancement. Department of Electrical Engineering, College of Signals, National University of Sciences and Technology, Islamabad, Pakistan. Advances in Electrical Engineering. 2016;7. Article ID 7279056 Available:http://dx.doi.org/10.1155/2016/7279056
12. Bilal Muhammad. Closed loop power control for LTE uplink. Master of science in electrical engineering with emphasis on Telecommunications Blekinge Institute of Technology School of Engineering; 2008. Available:https://www.diva-portal.org/smash/get/diva2:831452/FULLTEXT01.pdf
13. Cambium Networks; (LINK Planner 2018). Available:www.cambiumnetwork.com/linkplanner 2018
14. Copyright. Antenna Theory. (2009-2016) Available:http://www.antenna-theory.com/basics/gain.php
15. 3rd generation partnership project [3GPP]. The Mobile Broadband; 2018. Available:http://www.3gpp.org/
16. Antenna power control. Available:www.sharetechnote.com
17. Antenna basic concept; 2018. Available:https://www.pulseelectronics.com/antenna_basic_concepts/
18. Agnew DC, Larson KM. Finding the repeat times of the GPS constellation. GPS Solutions (Springer). 2007;11(1):71–76. Doi: 10.1007/s10291-006-0038-4
19. Antonelli C. The diffusion of advanced telecommunications in developing countries, paris; 1991.
20. Azar, 'LTE Power control' (case of uplink channel: PUSCH. Pg. 10 2017). Available:www.techtrained.com
21. The broadband standard; 2018. 3GPP TS 23.402. Architecture enhancements for non-3GPP accesses. Available:www.3gpp.org
22. The broadband standard; 2018. 3GPP TR 37.834. Study on Wireless Local Area Network (WLAN) - 3GPP radio interworking. Available:www.3gpp.org
23. 3rd generation partnership project [3GPP]. The Mobile Broadband; 2018. Available:http://www.3gpp.org/

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/49183