New Cellular Network Planning at 900MHz in a Rural Environment

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Summary
The desire in this work is to design a new cellular network for Gombi town Adamawa State Nigeria with better coverage, capacity and quality of the Global system for Mobile Communication (GSM) signal strength deliver to the end user of a mobile phone. This research is an extension of the research work previously carried out to determine the path loss propagation for Gombi town. In the design we were able to achieved the following parameters; For ZAIN network operator the radius of the cell (R) = 3.84km, Number of the cell (C) = 9, Traffic per Subscriber (T) = 17, Estimated number of subscribers per cell (E) =1333, shape and size of the cell Ha = 14.75km2, for MTN network operator the radius of the cell (R)= 3.76km , Number of the cell (C)= 9, Traffic per subscriber (T) = 17, Estimated number of subscribers per cell (E) = 1333, shape and size of the cell Ha = 14.14km2 and for GLO network operator the radius of the cell (R) = 30.36km2, Number of the cell (C) = 4, Traffic per subscriber (T) = 17, Estimated number of subscribers per cell (E) = 1333, shape and size of the cell Ha = 11.04km. We believe, if this research work can be implemented by the GSM network operators in Gombi it would tremendously reduce the influence of the factors affecting the GSM signal strength and the coverage, capacity and quality of the GSM signal may be improve.
Keywords:
Design, Signal Strength, Coverage, Capacity, Quality, GSM and Subscribers.

1. Introduction

GSM commence it operation in Nigeria 2001 as at then GSM service does not cover Gombi town however gradually GSM technology propagates and spread to almost all over the rural and urban areas in Nigeria. In 2004 the three (3) GSM network Operators came into operation almost at the same time in Gombi, since then as the number of subscribers increases the spectral efficiency becomes more critical because frequency allocation is limited resources [6]. The services of all GSM network operators fall below expectation and it becomes an area of great concern among the subscribers in Gombi, because of the uncertainties of the network quality. Subscribers are therefore confuse on which network to subscribe that is why GSM network operators need to improve the coverage, capacity and quality of their service, is the reason for its consideration in this work. For any GSM network operator to gain a lion share of the subscribers or to take the leadership position among the three GSM network operators in today's marketplace, network operators need to deliver outstanding levels of the network quality and performance so that the end user of the mobile phone can be satisfy. Any reliable GSM network operator is expected to serve customers without or little interference. In planning of efficient radio network the following must be put in place, step by step; the scope of the radio network, cell shape and size, elements in a radio network and channel configuration [2]. The radio network planning is the part of the network that includes the base station (BS) and mobile Station (MS) and the interface between them [2]. This is the stage where it requires detail process; the BS usually have radio connection with the MS perhaps the connection between them is geographically disperse over wide area which may not be hitch free from transmission impairments that may consequently hamper the effectiveness of the communication [4], therefore these factor need to be studied critically and understood before taking any step in designing of radio network in order to come out with an efficient radio network plan.

2. Methodology

2.1 Method of Data Collection

No data is really collected in this work but an extension of our previous work published [3]. Model Equations developed for the three GSM network Operators base on Hata Model is adapted. The model Equations are then further process with the view to address the general complains of the subscribers in Gombi town.

2.2 Theoretical and Analytical Methods

The analysis considers the model Equations for the three GSM network Operators namely ZAIN, MTN and GLO. The following are model Equations.

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$$L_{m(ZAIN)} = 67.83 + 26.16\log_{10}(f) - 13.82\log_{10}(h_B) - [0.8 + (1.1\log_{10}(f) - 0.70)h_m - 1.56\log_{10}(f)] + [44.9 - 6.55\log_{10}(h_B)]\log_{10} R \quad (1)$$

$$L_{m(MTN)} = 67.31 + 26.16\log_{10}(f) - 13.82\log_{10}(h_B) - [0.8 + (1.1\log_{10}(f) - 0.7)h_m - 1.56\log_{10}(f)] + [44.9 - 6.55\log_{10}(h_B)]\log_{10} R \quad (2)$$

$$L_{m(GLO)} = 66.41 + 26.16\log_{10}(f) - 13.82\log_{10}(h_B) - [0.8 + (1.1\log_{10}(f) - 0.7)h_m - 1.56\log_{10}(f)] + [44.9 - 6.55\log_{10}(h_B)]\log_{10} R \quad (3)$$

Where:

L_m(ZAIN) = Path Loss Model Equation for Zain measured in decibels (dB)
L_m(MTN) = Path Loss Model Equation for MTN measured in decibels (dB)
L_m(GLO) = Path loss Model Equation for GLO measured in decibels (dB)
f = Operating frequency (MHz)
h_B = Height of the Base Station(m)
h_M = Height of the mobile Station (m) and
R = Radius of the cell (km)

Table 1: Results of path loss propagation model for Gombi town Adamawa State Nigeria [3]

Parameters	ZAIN	MTN	GLO
L_m(dB)	143.76	144.12	147.76
f (MHz)	900.00	900.00	900.00
h_B (m)	35.00	30.00	35.00
h_M (m)	1.50	1.50	1.50

Using the parameters in Table 1, the radius of the cells for each of the GSM network Operator may be derived from Eqs. (1 – 3). The values of the radius of each of the GSM network Operators may be deduce as follows

$$R = \log_{10}^{-1}(L_{m(ZAIN)} - [67.83 + 26.16\log_{10}(f) - 13.82\log_{10}(h_B) - [0.8 + (1.1\log_{10}(f) - 0.70)h_m - 1.56\log_{10}(f)]]) / [44.9 - 6.55\log_{10}(h_B)] \quad (4)$$

$$R = \log_{10}^{-1}(L_{m(MTN)} - [67.31 + 26.16\log_{10}(f) - 13.82\log_{10}(h_B) - [0.8 + (1.1\log_{10}(f) - 0.7)h_m - 1.56\log_{10}(f)]]) / [44.9 - 6.55\log_{10}(h_B)] \quad (5)$$

$$R = \log_{10}^{-1}(L_{m(GLO)} - [66.41 + 26.16\log_{10}(f) - 13.82\log_{10}(h_B) - [0.8 + (1.1\log_{10}(f) - 0.7)h_m - 1.56\log_{10}(f)]]) / [44.9 - 6.55\log_{10}(h_B)] \quad (6)$$

Then the number of the cell for each GSM network Operator may be obtain using Eq. (7) as

$$C = \frac{2A}{(3\sqrt{3})R^2} \quad (7)$$

Where:

C = the number of cells per model equation of each GSM network Operator
A = the market area

Having known the number of the cells required for each model Equation, we can as well obtain the number of subscribers per cell and the traffic channel that will be available for the subscribers. Eq. (8) helps us to determine the number of traffic per cell given by

$$T = \frac{nt_a}{3600}(Erlangs) \quad (8)$$

Where:

T= offered traffic from one or more users in the system.
t_a = average call time in seconds n=number of calls per hour

Assuming that the average holding time is 60s, traffic of 21mElangs per subscriber and 28 number of available traffic channels while the estimated number of subscribers per cell may be obtain from Eq. (9) as

$$E = \frac{T_c}{T} \quad (9)$$

Where:

E=the estimated number of subscribers per cell T_c=the total traffic per cell. Hence the size of the cell may be computed using Eq. (10), assume the cell shape is Hexagonal

$$H_a = \frac{A_c}{C} \quad (10) \text{ or}$$

$$H_a = R^2 \quad (11)$$

Where:

H_a=Hexagonal area A_c=Total coverage area [1 & 5].

3. Results of the Analysis

Table2 present the results of the analysis from the various Eqs.(4 – 10).

Parameters	ZAIN	MTN	GLO
R(km)	3.84	3.76	5.51
C	9	9	4
T	17	17	17
E	1333	1333	1333
H_a (km^2)	14.75	14.14	30.36

4. Discussion

This work aim at designing a new radio network for Gombi town with the view to address the public complains posed on the status of the current coverage, capacity and the quality of the GSM signal strength delivered to the end user of the mobile phone. This work utilized the result of the previous research work conducted to determine the path loss in Gombi town [3], it emphase on the theoretical analysis of the parameters like the cell radius, number of cell assign to a particular BS/number of cells required for the entire Gombi town, traffic per subscriber, estimated number of subscribers per cell and shape/size of the cell. To obtain the values of all parameters mention above, first the Gombi model Equations of propagation path loss for each of the GSM network operators were adapted, from the model Equations. The radius of the cell was determined and also its further enable us to compute the number of cells required for each GSM network subscriber in Gombi town and consequently the other elements of radio network were obtained. In the design we obtained 9 cells each with a size of 14.75km^2, which cover a radius of approximately 3.84km and 1333 subscribers/cell that is 11,995 subscribers/9 cells for ZAIN network operator. For MTN network operator 9 cells were also obtained with a size of 14.14km^2 each, which cover radius of 3.76km and 1333 subscribers/cell that is 11,995 subscribers/9 cells while for GLO network operator we obtained 4 cells with size of 30.36km^2 each, which cover 5.51km and 1913 subscribers/cell that is 7,652 subscribers/4 cells. The results in Table 2 are adequate to under take future design of the three GSM network operators in Gombi town that may last for the next 25 years and it may also give room or direction for future planning when network service is incapacitated. We strongly believed that if this design can be adapted and implemented by our GSM network operators in Gombi town it would definitely reduce the problems associated with the quality of the GSM signal strength.

5. Conclusion

This paper highlighted on the design of a new radio network planning for Gombi town. The design of the relevant parameters such as size of the cell, estimated number of subscriber per cell and cell structure were obtained successfully with a reasonable precision, the radio network plan is adequate to the best of knowledge. If this can be put in practice it would surely reduce or address the problems associated with the quality of the GSM network.

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