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Research Paper

DESIGN AND IMPLEMENTATION OF GSM NETWORK FOR AN URBAN AREA

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The importance of communication in an urban city is so obvious. This is because of the inter-relationship between the development of city's economic and effective telecommunication services-like GSM. This research work looked at means of providing an urban city, Abuja as a case study, an improved 2.5G GSM network that will provide good speech quality, spectral efficiency, support ranges of many features, low terminal and service cost. The work was done asof 2004/2005 year with a lot of planning, design calculation of all the transmission planning using a mathematical model and analysis for the link budget. With the analysis of the estimated result carried out, it was concluded that total call check was 100% with 90% and 10% of prepaid and postpaid subscribers respectively. The capacity requirement for the number of subscriber was 10,500 and traffic analysis done showed that traffic per cell for the network will be 22 traffic control channel with a 2% grade of services. Base on this traffic evaluation, 14.9 Erlang gave an equivalent of 596 subscribers (i.e., 7 sites). Due to the topography of the link between site A to site H, design of a repeater station to amplify the radio signal across each others was considered and adding the design.

Keywords: GSM network, Coverage, Capacity, GSMK modulation, Transmission planning

INTRODUCTION

Abuja city, a densely populated urban area does not enjoy communication as of the time of this research work. Thus a good quality of GSM network coverage capacity needs to be developed and deployed there.

GSM network can be implemented with different technologies such as 2 G, 2.5 G, 3 G or 4 G but this research work was focused only on the 2.5 G implementation with phase 2 plus. This work was designed and implemented for Abuja urban city in Nigeria. It deals with the transmission planning that comprises microwave/RF planning then, BTS and switching capacity analysis.

RELATED WORK

Wentzell (2000) designed a 2 G network for O'TelcomCompany in China using 1800 MHZ frequency band with Gaussian-filtered Minimum Shift Keying modulation (GMSK).

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The method used had drawback of poor quality of service and coverage because 1800 MHZ frequency band cannot travel far distance.

According to Nielsen and Wigard (2000) frequency hopping which was introduced in their design work improved the spectrum efficiency on the radio interface.

Fraser (2001) designed and implemented a 2.5 G network in south Africa. In the design work where the author combined 1800 MHZ and 900 MHZ frequency band with frequency hopping technique, a good quality of service and coverage were achieved. There were also much reduction of co-channel interference.

Architectural works of GSM network which many authors like John Scourias wrote in the book entitled "A brief overview of GSM" were reviewed. This architecture consists of the following structural node that the network is divided into namely:

- Mobile station
- Base station system
- Switching and service network system
- Operation and maintenance center.

METHODOLOGY AND DESIGN

The design of this work was carried out by using access, modulation and frequency hopping methods. An improved modulation technique Gaussian-filtered minimum shift key was used to enable the transmission of 270 kbits per second data within a 200 kHz channel. With this modulation, the phase changes which represented the change from a digital of "1" and "0" occur over a period of time.

The nominal cell plan, survey and microwave design analysis was carried out. This analysis has to do with the selection of the sites for the radio equipment, the type of radio equipment to be used and its configuration. Some radio measurement was taken using radio planning equipment like Telescope, GPS, TEMS, Spectrum Analyzer, Compass, ASSET, Calcucell, etc., to locate clutter (i.e., concentration of people in towns) and some radio parameters. The coordinate of base station was collected using the tools and acquire the property (LAND) about 100m or thereabout. Using the phenomena of the radio propagation and empirical models called OKUMURA HATA to calculate the microwave link planning for the transmission respect. The sampling data collected with planning tool were used to calculate and analyze the capacity of the Base Transceiver Station (BTS). Thus, Base Substation System (BSS) and Mobile Switching Centre (MSC) with power supply equipment rackswere also dimensioned. Allocation of capacity based on the number of expects user were done.

Design Parameter

In order to see that the design was carried out successful, some parameters like multiple access method, up and downlink frequency, channel spacing, modulation power control, portable maximum transmission power, speech coding per RF channel, channel rate, frame duration and channel coding were considered and determined.

Microwave Link Planning

The microwave like was designed with proper fade margin in order to reduce terrain effects on transmission quality by means of adequate antenna heights. The planning involves.

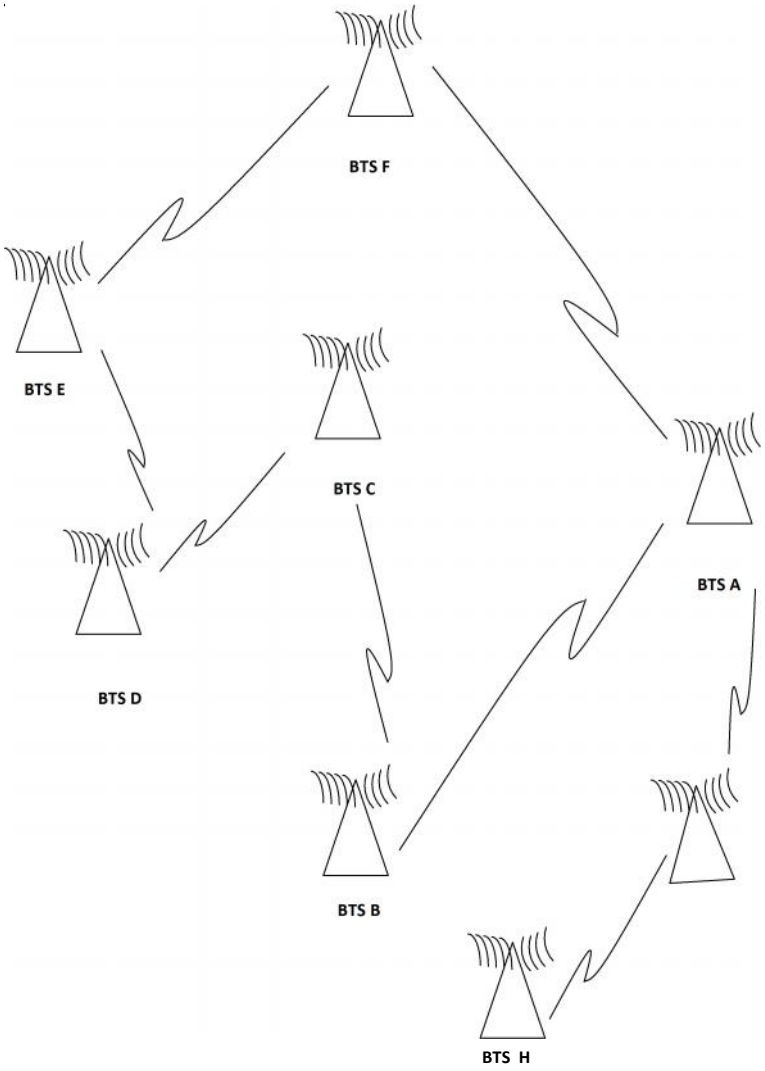
- Line of sight (LOS) line engineering strategies
- LOS clearance requirement
- LOS link distance consideration

The types of calculation done during these link clearances and hop distance consideration were LOSclearance, path, performance and interference calculations.

Power Supply of the Network

Before the network can be fully implemented, the equipment power supply was estimated. Dimension space for the radio equipment, their power supply, battery backup and the protection of the power equipments for both DC and AC sources were considered. The power rack for each base station, which involves the rectifiers, inverters, DC/AC converters, and battery bank for backup and hosts of other were designed. There was also a solar panel which was used to power the repeater station due to unavailability of power source in the hill.

Figure 1: Network Design Layout



MATHEMATICAL MODEL USED FOR LINK BUDGET ANALYSIS

Link budget isa rough calculation of all known elements of the link to determine if the signal will have the proper strength when it reaches the other end of the link. The mathematical analysis carried out in the research work helped to predict the system range based on the power output, receiver sensitivity, antenna gains, path loss and fading margin. The hop loss without fading was calculated with this expression.

$$L_{h0} = L_0 – G_{a1} – G_{a2} + L_{ex} \quad \ldots(1)$$

G_{a1} and G_{a2} and Antenna gains at mobile station and base station

L_0 = free space loss

L_{ex} = the sum of other extra attenuation that includes the external feeder losses (line losses), additional attenuation due to insufficient clearance, branching losses at transmitter and receiver, field margin, attenuation of radomes.

The output free space loss was gotten from this equate

$$Lo = 92.5 + 20 \log d \times 20 \log f + Lat \quad \ldots(2)$$

Lat = atmospheric attenuation (dB) and it is also expressed as

$Lat = g_{ot} * d$

g_{ot} = combined specific attenuation.

also

$G_a = 20 \log (D_a) + 20 \log (f) + 17.5$

$D_a$is the antenna diameter and f is the frequency

ANALYSIS OF THE MATHEMATICAL MODEL OF THE NETWORK

From the mathematical model, the transmission path data calculation was conducted among various BTS using system of 15 GHz digital microwave radio frequency. The losses and gains between sites during path clearance results of their BTS received signal level, and clearance sheets for the various sites at different spot were analyzed. The number and layout of the BTS, the number of subscribers and Grade of Service (GoS) were determined from the analysis done.

With the approximated population of 12,000 people in the urban area with 500 as estimated visitors to the city, the design work was projected towards 12,500 people.

RESULT ESTIMATION

Based on the analysis, Grade of Service (GoS) the subscriber will encounter in the network was estimated to be 2% with 24 channel allocation. 22 out of the 24 channels will be used for voice and data, 1 channel for signaling link/control channel used in synchronization and the last channel will be used as redundancy (Standby).

Using the Calcucell tool with the estimated traffic of 12,500 subscribers 25 m Erlang per subscriber was used.

Considering all there analysis done, the storage capacity of 22,500 capacity based on 12,500 subscribers plus 10,000 additional subscribers capacity after a projection of 2 years were estimated. Thus a typical switch that has a subscriber storage capacity of

25,000 subscriber of Home Location Register (HLR) will be used.

CONCLUSION

After implementing the design of the network, drive testing was conducted with continuous upgrading of the software till a proper measurement and a better quality of service were obtained.

From the results obtained conclusion was made that the GSM network designed for the Abuja urban area will have 100% capacity requirement which consists of 90% and 10% for prepaid and postpaid subscribers respectively. The network has a very good performance in quality of service delivered to the customers. The objectives of this research for spectral efficiency and better coverage were achieved especially with the good techniques adopted.

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