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Base Station Placement Challenges in Cellular Networks: The Nigerian Experience.

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***Abstract*-With the embrace of cellular telecommunication in Nigeria, the sector has experienced tremendous growth in terms of users. There have also been advances in technology from 2G to 3G and even 4G networks. Irrespective of the network in use, there is a section that is yet to have an alternative which is the base transceiver station BTS of the cellular network. This paper looks at the role of the BTS location on service delivery and hence customer's satisfaction in cellular networks. A survey is carried out in five major cities in Nigeria to have a professional insight into the challenges/difficulties faced by network providers in the placement of base stations. Results from this investigation reveal topography and land use problems as major challenges to the optimal placement of base stations, hence limiting coverage optimization efforts. This study provides necessary variables for the development of a tool for optimal placement of base station in order to achieve optimized radio coverage.**

Index Terms - Base transceiver station, optimization, network, planning, coverage

I. INTRODUCTION

Radio communication has witnessed great patronage in Nigerian since the commencement of the Global System for Mobile Communications (GSM) service in Nigeria around August 2001. Nigeria has been ranked the largest and fastest growing telecom market in Africa and among the ten fastest telecom growth markets in the world[1]. With the embrace of cellular telecommunication in Nigeria, the sector has experienced tremendous growth in terms of users.

Research findings indicate that the quality of service of the GSM system in the country is unreliable, with its accessibility and retainability unsatisfactory. Operators are yet to meet customer's satisfaction as subscribers still have to own several phones/network at the same time in the event of an operator's network failure [2]. Efficient placement of radio facilities with emphasis on the base station has therefore been a concern area of research in the bid to providing better services.

In cellular telecommunication provision, cell planning is done to ensure coverage and avoid interference in a network. Deciding where to place the base station of a cellular network is a very important issue that is usually decided during the process of cell planning. Research has shown that 98% of Global System for Mobile (GSM) base stations (cell sites) in Nigeria is sited within 20 meters from residences, offices, schools, business buildings, petrol stations and public arenas [3]. The placement of base station in places of worship, schools and inside residential homes necessitated the need to investigate the reason for the indiscriminate placement of these base stations without taking environmental and best international practices into consideration.

In the course of carrying out this project, we intend to review the present challenges negating against the optimal placement of BTS by the radio engineers and network planners through the observations, questioners, oral and written interviews. The survey was carried out in some urban centers, while respondents were the radio planning engineers of all the GSM operators in the country.
Results from the questionnaires were analyzed professionally with the aim of identifying and
extracting key issues and challenges facing the optimal placement of base stations in Nigeria.

II. RESEARCH METHOD

This paper used written questioners, oral-interviews and excursions in order to review the present challenges negating against the optimal placement of BTS. Questioners are prepared for the radio engineer and network planners of the licensed GSM operator in Nigeria. Key issues addressed by the questioners were aimed at identifying key challenges to BTS location and getting opinions for what they envisage as possible solutions.

III. EXPECTED OUTCOME

Results from this investigation will be used to provide the needed parameters for a computer based automated

network planning tool that could be used for the optimal base station placement.

This tool is expected to take into cognizance, the peculiar challenges and features of Nigeria as identified in the field work that will provide better coverage as well as meet international best practices.

IV. THE BASE TRANSCEIVER STATION (BTS)

The Base Station System (BSS) of the GSM network is the equipment located at a cell site. It comprises a combination of digital and RF equipment. The major hardware components of the BSS are the Base Transceiver Station (BTS) and the Base System Controller (BSC). The BTS handles the ground coverage while the BSC supervises its activities, one BSC may control several BTSs. Its functions include traffic switching and signalling to/from BTS and mobile Switching Centre (MSC) and control of handovers handled by BTS's under its control. A cell site may house both BSC and BTS as there are many more BTSs than BSCs in a network.

The BTS is part of the base station subsystem (BSS) which is the unit responsible for managing the radio network. Its main function is to provide control and radio coverage functions for one or more cells and their associated mobile subscribers (MS). The BTS is responsible for maintaining connections to the MS within its cell. The BTS contains several transceivers (TRXs) each assigned one pair of frequency for transmitting and receiving information [4, 9]. The antennas for receiving information from/to one or more transceiver are connected to the BTS. The BTS for a given geographical area have to be well positioned for maximum coverage and minimal interference which are the indexes for measuring the quality of any mobile service [5].

V. NETWORK PLANNING

Network planning is of paramount importance to the operator. Good planning will result in less project infrastructural expenses, ensure more customer's satisfactions and less need for new sites [8]. Planning is always carried out before full implementation of any network. This is to determine the dimensioning and mode of network construction to guide the engineers based on objects and requirements. Network planning is made up of three parts:

- radio network planning,
- transport network planning and
- core network planning.

Radio network planning is about reaching a balance between capacity, coverage and quality this is done in other to achieve an optimized design and meet the requirements of operators.

Radio network planning is very crucial as investment on radio access network accounts for more than 70% of the total investment on the entire mobile communication network [6]. In determining the choice of facility locations in a network, three key issues are taken into consideration;

- Return on investment (ROI) which takes target population into consideration with respect to commercial viability of the investment,
- Legal laws guiding installation of radio equipment and restrictions,
- Engineering/technical requirements.

Typically, the process of cell planning is conducted in an ad-hoc fashion after manually inspecting maps depicting the propagation properties of the service area. A more efficient method is to utilize the data concerning the radio propagation characteristics of the area in a GIS map depicting potential cell sites. Manual investigations and tests have to be carried out to ascertain if the potential sites meet legal, civil and environmental requirements. Fig. 1 is a chart showing the typical cell planning process [3].

The outcome of radio planning is to achieve the locations of the BTS in a manner such that radio coverage is maximized while equipment and maintenance cost are minimized. The challenges faced in obtaining the optimal position for the placement of base station affect both the operators and the customers.

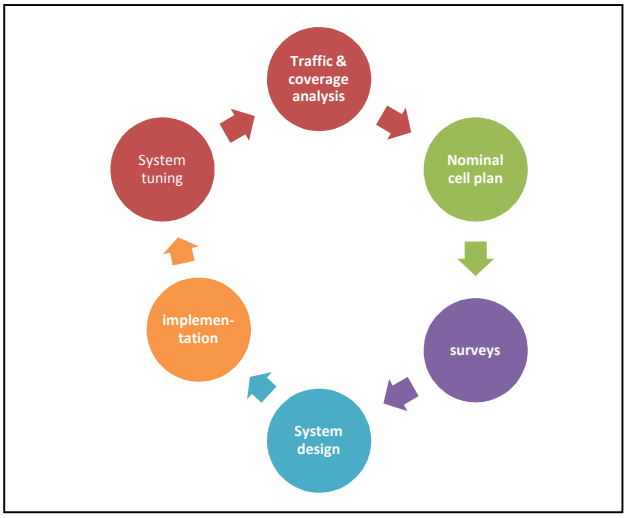


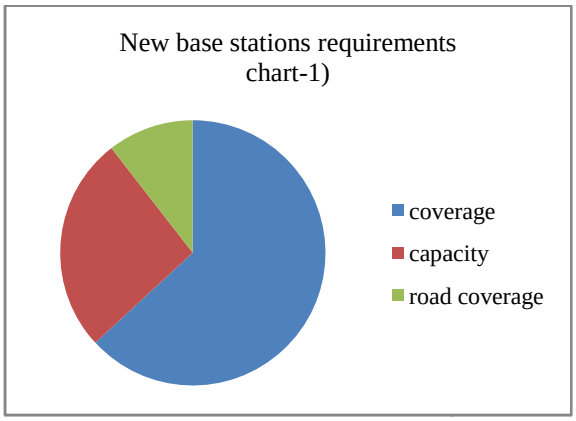
Fig 1: Traditional cell planning Process

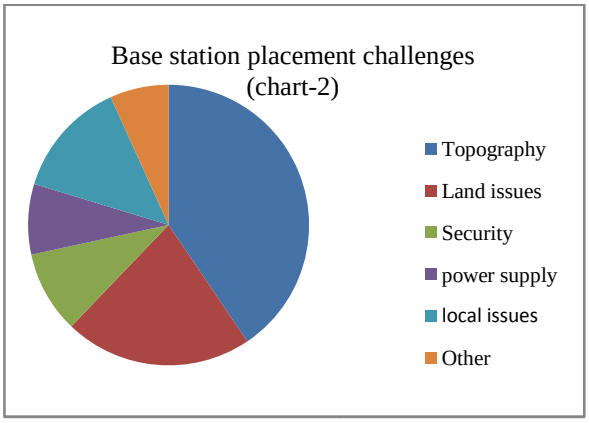
VI. DATA COLLECTION AND PRESENTATION

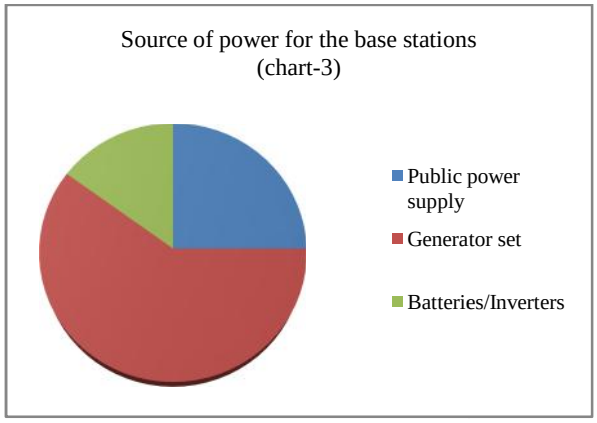
Questioners were distributed to network planners and radio engineers who have been in the field. Details and understanding were drawn from interviews and site visits

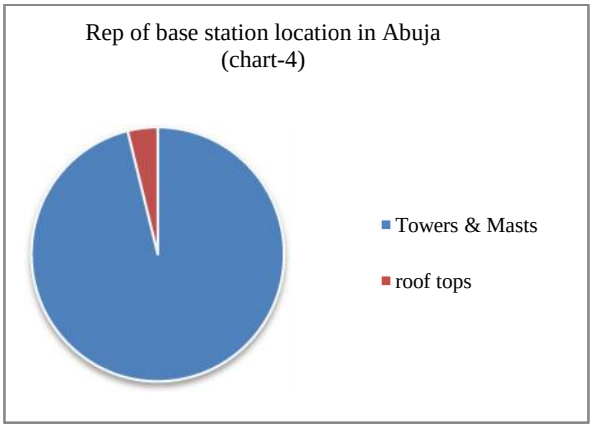
to some base stations in the GSM sector. The GSM sector was chosen for its wide spread and huge customer base. They provide over 94% of communication services in Nigeria, with a total customer base of over 90 million subscribers as at Dec 2011[7]

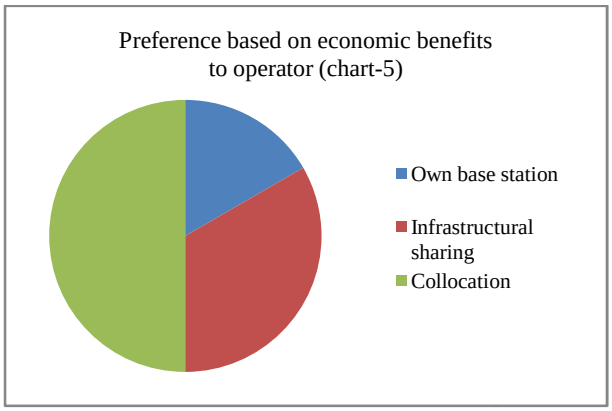
Data presented in charts-1 through chart-6 are graphical representation of results obtained from the five GSM operators in Nigeria, namely; MTN Nigeria Communications, Globacom Limited, Celtel Nigeria Limited (Airtel), MTEL Limited and EMTS Limited (Etisalat). The cities considered were Minna, Kaduna, Cross river, Lagos and the Federal capital territory Abuja.

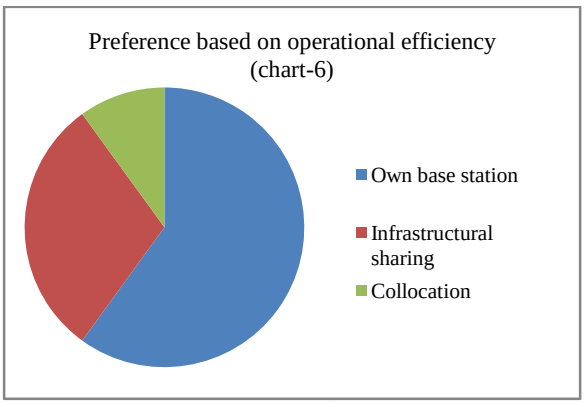












VII.

VIII. DATA ANALYSIS

- *New base station requirement (chart-1):*

  Results in of fig. 2 chart-1 indicated that more BTS's are needed to be installed to meet an acceptable teledensity average for the nation. 60% of this requirement is required to meet coverage needs mostly in the rural centers, while 30% is required for capacity purposes in urban centres, 10% of this requirement is for road coverage. The operators presently in the country are yet to attain full coverage, as there is a very huge market in Nigeria with target subscriber base of over 100 million.

- *BTS placement challenges (chart-2):*

  Several issues were raised as placement challenges as depicted in chart-2 prominent amongst them is the space acquisition challenge. The land use act presently used in the country can be described as outdated and outmoded, as it is based on the act promulgated in 1978 [10]. Only recently, this has been addressed by relevant agencies but no change has yet been implemented. This deficiency has adverse effect on the location of base stations as some prospective sites have been abandoned following issues of no clear certificates of ownership, family tussle and land disputes.

  Radio engineers in the delta regions identified terrain accessibility represented in chart-2 as topography as their major challenge to optimal placement. This is understandable considering the riverine nature of the Delta region. In Kaduna and Niger states, placement challenges were in getting stakeholders to agree to incentives and allow placement. Lagos had better community awareness but tenancy renewal and multiple taxes and state laws stand as major challenges.

- *Sources of power for base station (chart-3):*

  This represents the source of electric power supply for the base station equipment. Results in chart-3 show clearly that with the present state of the power supply in the country, over 70% of the energy required by BTS's are provided by diesel generators while the other 30% is provided by public source and inverters. Many of the BTS mostly in rural areas are not connected to the public supply and where they are, the supply is epileptic.

- *Collocation and Infrastructure sharing (charts 4,5&6):*

  Collocation involves the placement of facilities by operators in a premises managed by a facility provider, while Infrastructure sharing involves a mutual agreement between two or more operator to jointly use their network facilities [6]. Both collocation and Infrastructure sharing have laid down guidelines provided by the Nigeria Communication commission (NCC) which is the regulatory body for all operators. The Commission encourages the sharing of infrastructures such as; Rights of way, Masts, Poles, Antenna mast and tower structures, Ducts, Trenches, Space in buildings and Electric power (public or private source). The commission however does not encourage the sharing of infrastructures such as: Complete network structures, Switching centers, Radio network controllers and Base stations. Results indicated that operators viewed collocation to be of more economic benefit to them (Chart-5). However there are draw backs attributed to the present inefficiency of facility managers in sharing infrastructure with other operators which is still less expensive when compared to managing their own base station. Therefore, as operator installing and maintaining his own base station was judged as the most preferred when the issue of operational benefits is considered and keeping up with competition in business (chart-6).

IX. DISCUSSION

Findings from this survey reveal several challenges identified by the field engineers as hindering the optimal placement of radio facilities. Having exhaustively considered the various aspects of base station placement in Nigeria, one can summarily state that the sector still faces quiet a number of challenges with several variables open for optimization. These can be grouped into technical and social variables.

The technical optimization variables include the following;

- High cost of powering the base station; the percentage that use utility power supply can be optimized through building close to source of power, consideration of renewable and green power to curb noise and pollution.
- Use of roof tops; survey reveals that the use of roof tops for dense urban areas with high rise building to be more beneficial, these options could be exploited through better holistic planning and better public enlightenment.
- Collocation agreement; the laws governing collocation need to be improved for better service delivery.

- Intelligent planning; survey reveal the need for a more Intelligent planning tool which should take topographic details of terrain, interference of other service providers etc as variables requiring minimal drive test and manual inspection of sites.

The social variables that require optimization include;

- Need for an improved tenement agreements/renewal of lease agreement
- town planning to include allowance for communications facilities
- Legislative backing and removal of multiple taxation
- Land use act; review and update.
- Terrain accessibility and infrastructural development.
- Public enlightenment/education.

X. CONCLUSIONS

The provision of good communication network coverage for the teaming customers in Nigeria require proper planning, most especially with the market acclaimed to be the fastest growing telecommunication market in Africa [2] .

The radio network-planning engineer considers the base station the most important element in the network as it provides the physical connection to the mobile, and should be optimally placed. Research efforts have been ongoing in using several algorithms in determining the optimal placement of base station with particular interest is the use of genetic algorithm. This survey has brought out some salient issues which have to be addressed in the design of an intelligent network planning tool.

REFERENCES

[1] Dr. Eugene Juwah, "Telecommunications business in Nigeria: how far?" being a speech by the executive vice chairman of the Nigerian communications commission, at the international communications lecture organized by the Nigeria-Swedish chamber of commerce, He-commerce house, Victoria island, Lagos April 8, 2011,.

[2] J. J. Popoola, I. O. Megbowon, V. S. A. Adeloye, "Performance evaluation and improvement on quality of service of global system for mobile communications in Nigeria" Journal of information technology impact Vol. 9, No. 2, pp. 91-106, 2009.

[3] Okonigene, R.E., "Sitting of gsm base station antenna and its health consequences" IEEE Seventh International Conference on Information Technology: New Generations (ITNG) pgs 613 - 618, 2010.

[4] Motorolla Cellular Infrastructure Group "CP02 introduction to GSM cellular" training manual 1999 – 2002

[5] Hanif D. S, Chandra M. P, and Theodore S. R., "Optimal location of transmitters for micro-cellular radio communication system design ieee Journal on selected areas in communications, vol. 14, no 4, pp 662-673, 1996.

[6] Ericson "Cell planning principles" student text En/lzt 123 3314r3a , pgs 1-10, 1997

[7] Nigerian communications commission "Guidelines on collocation and infrastructure sharing" www.ncc.org accessed on 22nd February 2012.

[8] Jyri Hamalainen, Lecture notes on "Cellular network planning and optimization" communications and networking department, Helsinki University of Technology, part 1pags 5-6, 2007.

[9] Ajay Mishra, "Fundamentals of Cellular network planning and optimisation" John Wiley & Sons Ltd, England, pgs 21-31, 2004.

[10] Afolabi Aribigbola "Improving urban land use planning and management in Nigeria: the case of Akure" Theoretical and empirical researches in urban management, year 3, number 9, 2008.