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GSM Network Optimization And Planning For Nelson Mandela African Institute Of Science And Technology

Anselemi Babilas Lukonge[1], Jan Kaaya[1], Dr. Michael Kisangiri PhD[2]
[1]Msc Student, [2]Senior Lecturer at Nelson Mandela African Institute of Science and Technology, Arusha- Tanzania.

***Abstract*— GSM network planning and optimization processes take in consideration a number of network parameters. In order to improve the network Key Performance Indicators (KPIs) are used as a guiding points. This paper has taken Nelson Mandela African Institute of Science and Technology as case study for network optimization.**

***Index terms*—** MS- Mobile Station, TRX- Transmitter Receiver Unit, BTS- Base Transceiver System, BSC-Base Station Controller, KPI- Key Performance Indicators, QoS- Quality of Service, GFA- Ground Floor Wing A, FFA- First Floor Wing A,

I. INTRODUCTION

GSM stands for Global System for Mobile Communication. GSM network is comprised of a mobile Station (MS) which is connected to the Base Transceiver Station (BTS) via air interface. In addition to other hardware, BTS contains the equipment called Transceiver (TRX), which is responsible for the transmission and reception of several radio frequency (RF) signals to/from the end user [1].

BTS is then connected to the base station controller (BSC) via abis interface. BSC usually handles radio resource management and handovers of the calls from one BTS (or cell/sector) to the other BTS (or cell/sector) equipped in it. BSC is then connected to Mobile Switching Centre (MSC).

Nelson Mandela African Institute of Science and Technology(NM-AIST) is situated at latitude 3°24′22″South, longitude 36°50′01″South with altitude about 1113.4 metres from sea level. The area is served by two sites which are Tengeru site situated about 3.09 Kilometre from NM-AIST and Kiliflora which is about 2.24 kilometres from NM-AIST. Mobile communication users at NM-AIST are facing poor received signal level; in campus buildings. This paper considers the solution of received signal level and also gives the procedures undertaken to during optimization of GSM networks.

For outdoor coverage optimization proposed solution was to dedicate one sector from the existing sites at Tengeru and Kiliflora to serve NM-AIST community.

For Indoor coverage optimization, proposed solution was to establish an indoor site at NM-AIST.

To achieve this Line of Site path profile was established between NM-AIST and Tengeru site together with NM-AIST and Kiliflora Site using Google earth software. Only link from NM-AIST to Kiliflora was viable since the path profile from NM-AIST to Tengeru site was found to have obstruction.

Kiliflora site was observed to have Line of Site to NM-AIST as in the path profile below:

Kiliflora Side NM-AIST Side

Path loss between Kiliflora Site and NM-AIST proposed site can be calculated by using Friis equation:

$$Pr = PtGtGr(\frac{\lambda}{4\Pi R})^2$$

Where:
Pr -Received signal Power
Pt- Transmitted Power
Gt -Gain of Transmitting Antenna
Gr -Gain of Receiving Antenna
λ -Wavelength
R -Distance between the two sites

According to microwave frequency band plan assigned frequencies for Microwave link ranges in 7 GHz range. Selection of frequency pair to be used depends on avoidance of interference to other nearby Microwave Links.

Other parameters considered in Microwave link planning include:

- Bit error rate
- Fade Margin
- Cable loss
- Connectors loss
- Modulation Scheme
- Polarization discrimination
- Receiver filtering

To avoid over reach interference between the proposed link and other existing links techniques to deploy include

- Stagger the positions of the repeater stations so that they are no longer in a straight line
- Use alternate polarizations
- Use different frequencies
- Use antennas which are more directional
- Use antennas with better back-to-front rations

Traffic Estimation:
NM-AIST society is comprised of about 500 people, who can be potential subscribers. The number of subscriber is expected to grow to 1000 within a year.
Channel estimation is calculated by the formula

$$A = \frac{n * t}{3600}[E]$$

Where A = traffic from one subscriber

n = number of call per hour per subscriber

t = average call duration

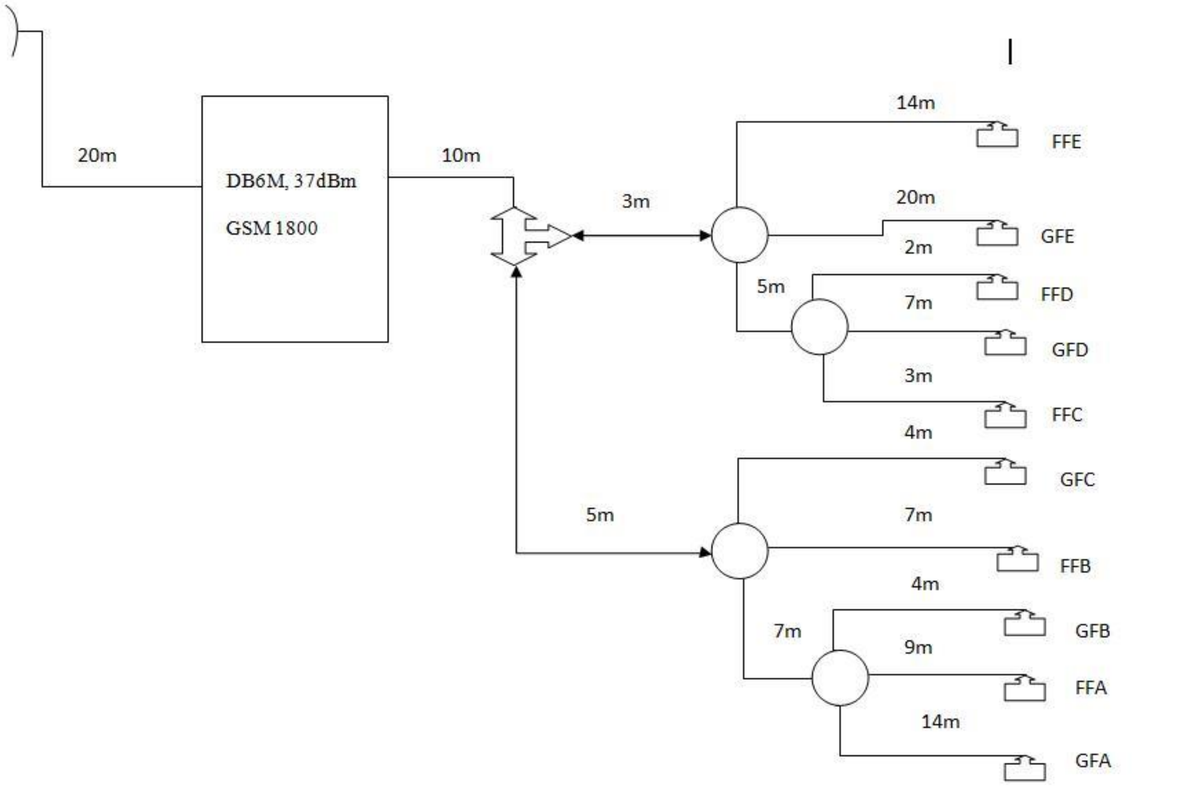
Typical values considered for estimation are: n=1 and t= 120

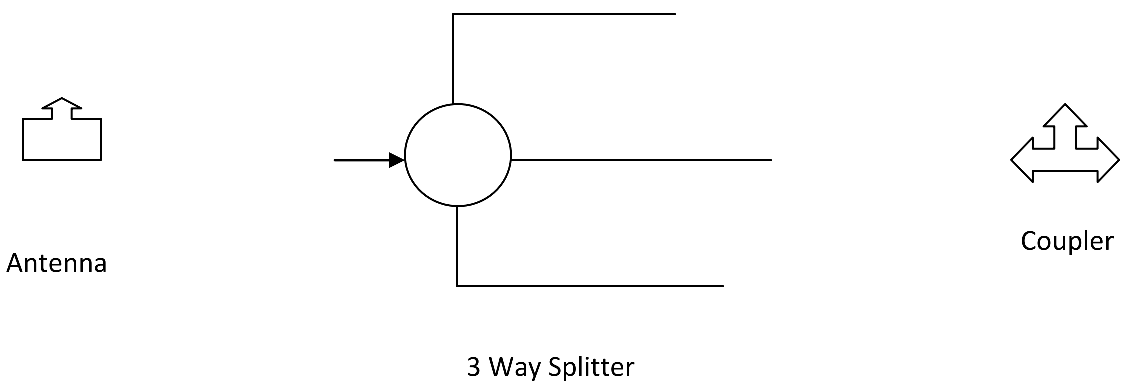
From 500 subscribers the generated traffic will be:

$$A_{TOTAL} = \frac{500 * 1 * 120}{3600} = 16.67E$$

Using Erlang B table with Grade of service of 2% these erlangs will correspond to 25 channels. One Radio Transceiver Unit has 8 channels hence for this number of channels, 4 Radio Transceiver Unit will be installed. The proposed site has to be placed in Administration block near conference hall. Distance to other building wings A, B, C, D and E was approximated to be 50 metres.

Network Layout Diagram designed was as follow:





Link budget for NM-AIST site was as in the table below:

		LINK BUDGET CALCULATOR									
Ground Floor and First Floor	Loss/ Gain (dB)	Antennas									
		GFA	FFA	GFB	FFB	GFC	FFC	GFD	FFD	GFE	FFE
DB6M	37	37	37	37	37	37	37	37	37	37	37
Feeder Cable 1/2"	-0.11	-3.96	-3.14	-2.86	-2.42	-2.09	-2.31	-2.75	-2.2	-3.63	-2.97
Connector 1/2"	-0.12	-0.96	-0.96	-0.96	-0.72	-0.72	-0.96	-0.96	-0.96	-0.72	-0.72
Coupler	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Splitter 3 Way	-5.5	-11	-11	-11	-5.5	-5.5	-11	-11	-11	-5.5	-5.5
Total loss		-25.13	-25.10	-24.82	-18.64	-18.31	-24.27	-24.71	-24.16	-19.85	-19.19
Antenna Gain dBi	2	2	2	2	2	2	2	2	2	2	2
Carrier loss	8	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6
EIRP of antenna in dBm		7.87	7.90	8.18	14.36	14.69	8.73	8.29	8.84	13.15	13.81
Additional losses in dB		-10	-10	-10	-10	-10	-10	-10	-10	-10	-10

From the Link Budget the received power at the Mobile subscriber receiver within the specified range of 20metres from the antenna is within the threshold limit of -89dbm. After planning phase construction and commissioning of site follow. During commissioning tested parameters include latitudes and longitudes of the site, tower height, antenna type and tilt, proper cable layout, signal level, signal quality, speech quality, path balance, path loss, call connectivity.

II. KPI ASSESSMENT & QOS ESTIMATION

In order to understand how the behaviour of traffic channels (TCH) and control channels (SDCCH) affects the network's performance; one has to analyze TCH and SDCCH blocking when congestion in the network increases [5]. As discussed above, five major KPIs are frequently used in performance evaluation and QoS estimation of the network.

1.1 Call Set-Up Success Rate (CSSR):

Call set up success rate is the Rate of call attempts until TCH successful assignment. This can be calculated as:

$$\frac{\text{Number of successful seizure of SDCCH}}{\text{Total number of request for seizure of SD channel}}$$

A number of issues are related to degradation of CSSR such as:

i. Due to radio interface congestion.
ii. Due to lack of radio resources allocation (for instance: SDCCH).
iii. Increase in radio traffic in inbound network.

iv. Faulty BSS Hardware.
v. Access network Transmission limitations (For instance: abis expansion restrictions)

Analysis & Findings:
Following methods are used to diagnose CSSR degradations as well as improvements:

i. Radio link Congestion statistics obtained from Network statistics.
ii. Drive Test Reports.
iii. Customer complaints related to block calls have been reviewed.

Improvement Methodologies:
Following measures significantly improve the CSSR in live network:

i. Radio Resources enhancement (Parameter modification/changes in BSS/OMCR) such as half rate, traffic load sharing and direct retry parameters implementation.
ii. Transmission media Expansion to enhance hardware additions (such as TRX).
iii. Faulty Hardware Replacement (such as TRX) in order to ensure the resources availability in live network.

1.2 Call Drop Rate

This refers to rate of calls not completed successfully.

$$\frac{\textit{Number of TCH drops after assignment}}{\textit{Total number of TCH assignment}}$$

A number of issues are associated to its degradation as demonstrated below.

i. Interference being observed over air interface.
ii. Hardware faults (such as BTS transceiver) can also be incorporated in an increasing CDR, which is a part of BSS failures.
iii. Missing adjacencies (definition in BSS/OMCR) is also an important factor in CDR values increment.

Analysis & Findings:
Following methods are used to diagnose the rise in CDR values:

i. Radio uplink statistics monitored using radio counter measurement in order to confirm any uplink interference.
ii. Customer complaints related to block calls would have been reviewed.
iii. Interference band / Spectrum scanners are also useful in finding and tracing the contaminated frequency carriers resulting in increasing CDR.
iv. Drive Test Reports.

Improvement Methodologies:
Following are some methods in order to improve the CDR value up to certain pre-Defined baseline:

i. Faulty Hardware Replacement in order to ensure the resources availability in live network.
ii. Frequency re-plans and model tuning in order to ensure the clean band carriers for serving cells.
iii. New site integration is also suggested in order to improve indoor and outdoor coverage.
iv. Sometimes RF repeaters are also used in order to amplify the radio signal to extend coverage area.
v. Existing coverage optimization might be done using physical optimization techniques
vi. Frequency hopping technique is also incorporated to minimize the effect of interference.
vii. Change of antenna orientation (azimuth/tilt) i.e., increase the down tilt of interferer cell antenna.

1.3 *Handover Success Rate*

This can be defined as the rate of successful handovers (intracell + intracell).

$$\frac{\textit{Number of successful(intercell + intracell) Handover Attempts}}{\textit{Number of handover requests}}$$

A number of issues are related for handover success rate degradation as illustrated below:

i. Interference being observed over air interface, which might affect ongoing call switching in case of handover.
ii. Missing adjacencies can also result in HSR degradation.
iii. Hardware faults (such as BTS transceiver) can also be incorporated as a decreasing HSR, which is a part of BSS failures.
iv. Location area code (LAC) boundaries wrongly planned and/or defined (where Location area represents a cluster of cells).
v. Coverage limitation is also one of the factors, which decrease HSR values.

Analysis & Findings:
Following methods are used to diagnose HSR degradations as well as improvements:

i. Radio Congestion statistics in order to confirm congestion occurrence in a particular cell or area.
ii. Neighbouring plans reviewed and adjacencies audits being done.
iii. Drive Test reports reviewed.

Improvement Methodologies:
Following methods are employed in order to improve the HSR in live network:

i. Interference free band i.e., Spectrum analysis might be done to ensure it.
ii. Adjacencies audits must be done in order to improve HSR.
iii. Coverage improvement is also a vital factor of HSR enhancement.
iv. BSS Resources upgrade
v. Parameter modification in OMCR such as Handover margin, traffic handover, power budget parameters to assist better cell handovers.

1.4 Traffic Channel Congestion Rate

Traffic channel Congestion (TCH) rate is one of the major KPI, which should be optimized to improve QoS:

This can be defined as Rate of blocked calls due to resource unavailability

$$\frac{\textit{Number of calls Blocked unavailability}}{\textit{Total number of call requests}}$$

TCH (traffic channel) congestion might arise due to following issues:

i. Hardware faults can also be incorporated as an increasing factor in TCH congestion.
ii. Increasing number of subscribers and/or traffic in a certain area also causes congestion.
iii. Lesser capacity sites (mainly due to the media issue or hardware resource unavailability) also cause congestion problems.

Analysis & Findings:
Following methods are used to diagnose TCH congestion as well as improvements:

i. Radio Congestion statistics monitored using radio counter measurement in order to confirm congestion occurrence in a particular cell or area.
ii. Customer complaints can also reveal the issue.
iii. Drive Test reports reviewed.
iv. CSSR (Call Set up Success Rate) KPIs also depict the TCH congestion problem.

v. Future subscriber density and growth is also a factor for the judgment of upcoming congestion.

Improvement Methodologies:
Following measures are used to minimize the TCH congestion in live network:

i. BSS Resources addition and expansion (including transceivers and transmission media) are important factors for TCH congestion improvement.
ii. Faulty hardware maintenance or replacement can also minimize TCH congestion.
iii. Deployment of moving/portable BTS in case of foreseeable special events such as sports events, important meetings, festivals and exhibitions etc.
iv. Parameter modification in OMCR such as half rate and traffic handover implementation.

1.5 Network Availability

Network availability gives an indication about the downtime of the MSC/BS but excludes all planned service downtime for any maintenance or software upgrade work. Recommended standard is above 99%

III. CONCLUSION

The paper describes procedure which can be used by cellular network operators to optimize the network coverage and capacity at Nelson Mandela African Institute of Science and Technology (NM-AIST). It has been shown that optimization process require Network Engineer to analyse the situation of the network by using different methodologies and fine tuning parameter to offer remarkable Quality of Service to the Network subscribers. Moreover, the issues discussed here are quite helpful for the analysis and performance evaluation of cellular networks in other areas too.

By using this report Network planning Engineers will enhance coverage, improve quality and increase capacity of Networks. Likewise A mobile operator can also set its own QoS targets based on the KPIs in order to ensure end user satisfaction.

Another issue highlighted by this paper is the need for Benchmarking between different Network operators.

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AUTHORS

Anselemi Babilas Lukonge, Msc Student at Nelson Mandela African Institute of Science and Technology, Arusha- Tanzania

Email;- lukongea@nm-aist.ac.tz

Jan Kaaya, Msc Student at Nelson Mandela African Institute of Science and Technology, Arusha- Tanzania kaayaj@nm-aist.ac.tz

Dr. Michael Kisangiri Ph.D, Senior Lecturer at Nelson Mandela African Institute of Science and Technology, Arusha- Tanzania kisangiri.michael@nm-aist.ac.tz