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Design and Improvement of GSM Network in a Local Area

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Abstract— **In this paper, a Global system for mobile communication (GSM) architecture for a certain area was analyzed. Then a problematic area under this GSM system in Bangladesh was detected. The cause of this problem was checked and found. The main problem was no network coverage at some points of the certain area taken under the GSM. Due to a greater no signal-coverage area, repeaters could not be used as a solution. So, a new Base Transceiver Station (BTS) had to be setup at the problematic area. For this, at first GSM plan was given and after that frequency plan for the new BTS was setup. Finally, the new BTS signal-coverage was checked and it was found that it successfully covered the whole problematic area.**

Index Terms- **GSM, TEMS,BTS, GSM Planning, MSC**

I. INTRODUCTION

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz. It is estimated that many countries outside of Europe will join the GSM partnership. [1]

II. GSM & RADIO NETWORK

GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe technologies for second generation (2G) digital cellular networks. Developed as a replacement for first generation (1G) analog cellular networks, the GSM standard originally described a digital, circuit switched network optimized for full duplex voice telephony. The standard was expanded over time to include first circuit switched data transport, then packet data transport via GPRS (General Packet Radio services). Packet data transmission speeds were later increased via EDGE (Enhanced Data rates for GSM Evolution) referred as EGPRS. In this case, the problematic area of the GSM system was Ranikhali, Sylhet. The problem was solved and new frequency plan was given for the first time in this particular area of Bangladesh.[1]

A. GSM System Architecture

A GSM system consists of many components which can be properly understood by studying its architecture.For example, Ericsson provides two systems for GSM network.● **MS** Mobile Station = phone + SIM card. ● **BTS** Base Transceiver Station (It contains the antenna system, radio frequency power amplifier & digital signal equipment). ● **BSC** Base Station Controller (control & supervises a number of RBS & radio connection in the system). ● **MSC** Mobile services Switching Centre (responsible for setting up, routing & supervising call to & from the mobile suscriber). ● **GMSC** Getway MSC (Interface between mobile network to other network such as PSTN or other mobile). ● **VLR** Visitor Location Register (temporarily store information about the MS currently visiting its service area). ● **HLR** Home Location Register (HLR database store & manage all mobile subscriptions belonging to a specify operator). ● **AUC** Authentication Centre (integrated in HLR. The AUC provides to HLR authentication parameters & ciphering keys by generating triplets). ● **EIR** Equipment Identity Register (check if any MS has been stolen or black listed). ● **NMC** Network Management Center. ● **OMC** Operation and Maintenance Center. ● **SMSC** Short Message Service "Support" Centre. ● **VMS** Voice Messaging System. ● **PrePaid Node** Hosting prepaid service system. ● **IN** Intelligent Network services. ● **PSTN** Public Switched Telephone Network. ● **PABX** Private Automatic Branch Exchange. [1]

B. Frequency Concepts

There are various kinds of frequency requirements and their related specifications in GSM. A GSM system must have uplink, downlink, wavelengths, bandwidth, duplex distance, carrier separation, radio channel, transmission rate etc.
The following table summarizes the frequency-related specifications of each of the GSM systems. The terms used in the table are not explained in the remainder of this section they are most common terms in communication, but these terms will be used in the upcoming sections frequently. [2]

Table 1: Frequency-related specifications

System	**P-GSM 900**	**E-GSM 900**
Frequencies Uplink Downlink	890-915 MHz 935-960 MHz	880-915 MHz 925-960 MHz
Wavelength	~ 33 cm	~ 33 cm
Bandwidth	25 MHz	35 MHz
Duplex Distance	45 MHz	45 MHz
Carrier Separation	200 kHz	200 kHz
Radio Channels	125	175
Transmission Rate	270 kbits/s	270 kbits/s

C. Transmission Problems and Solution

Many problems may occur during the transmission of a radio signal. Some of the most common problems are path loss, penetration loss, shadowing, multipath fading, Rayleigh fading, time dispersion and carrier to interference. This section describes some solutions to the problems. Although many of these do not entirely solve all problems on the radio transmission path, they do play an important part in maintaining call quality for as long as possible. [2]

Cell Planning means building a network able to provide service to the customer wherever they are. The cell planning is used to reduce problems with path loss, shadowing, co-channel interference and adjacent channel interference. [2]

In digital transmission, the quality of the transmitted signal is often expressed in terms of how many of the received bits are incorrect. This is called Bit Error Rate (BER). BER defines the percentage of the total number of received bits which are incorrectly detected. This percentage should be as low as possible. It is not possible to reduce the percentage to zero because the transmission path is constantly changing. This means that there must be an allowance for a certain amount of errors and at the same time an ability to restore the information, or at least detect errors so the incorrect information bits are not interpreted as correct. This is especially important during transmission of data, as opposed to speech, for which a higher BER is acceptable. Channel coding is used to detect and correct errors in a received bit stream. It adds bits to a message. These bits enable a channel decoder to determine whether the message has faulty bits, and to potentially correct the faulty bits. [2]

As mentioned previously, Rayleigh fading is frequency dependent. This means that the fading dips occur at different places for different frequencies. To benefit from this fact, it is possible for the BTS and MS to hop from frequency to frequency. [2]

Timing advance is a solution specifically designed to counteract the problem of time alignment. It works by instructing the miss-aligned MS to transmit its burst earlier or later than it normally would. In GSM, the timing advance information relates to bit times. Thus, an MS may be instructed to commence its transmission a certain number of bit times earlier or later, related to previous position, to reach its timeslot at the BTS in right time. Maximum 63 bit times can be used in standard GSM systems. This limits GSM normal cell size to 35km radius. However with extended range equipment, distances up to 70km or even 121km can be handled, using 2 timeslots and both speech and single slot GPRS are supported. Because 2 timeslots are required this results in a drop in the number of available channels in the cell by 50%. [2]

D. Different Site Solutions

1. Roof top [RT] Site: Usually in urban area
2. Green Field [GF] Site: Usually in Rural area

These two above type of sites may have the following solutions

a) 900MHz Site: for coverage, capacity and quality requirement
b) Collocation with1800MHz BTS: for capacity and quality requirement
c) 3rd cabinet with 1800Mhz BTS: for capacity requirement

Some other special case solutions in dense urban area:
a) IBS [In Building Solution]: For better coverage, capacity and quality.
b) MC [Micro cell]: To improve quality as well as capacity in the hot spot like traffic junction and road.
c) Repeater site: For better coverage and quality. Repeater cannot ensure capacity. [2]

III. BASE TRANSCEIVER STATION (BTS)

A Base Transceiver Station includes all radio and transmission interface equipment needed on site to provide radio transmission for one or several cells.

A. Ericsson BTS

Ericsson: one of Sweden's largest companies is a provider of telecommunication and data communication systems, and related services, covering a range of technologies, including especially mobile networks. Ericsson is currently the world's largest mobile telecommunications equipment vendor. [2]

B. Huawei BTS

Huawei (officially Huawei Technologies Co. Ltd.) is a Chinese multinational networking and telecommunications equipment and services company headquartered in Shenzhen, Guangdong, China. It is the largest China-based networking and telecommunications equipment supplier and the second-largest supplier of mobile telecommunications infrastructure equipment in the world (after Ericsson). [6]

Table 2: Huawei BTS

Indoor Macro	Outdoor Macro	Micro BTS	Pico Cell
BTS3012 BTS3900 BTS3900L DBS3900	BTS3900A	BTS3900E	BTS3900B BTS3900C

IV. RADIO TOOLS (SOFTWARE):

To GSM network planning, optimization and frequency spectrum management solutions Mentum planet, TEMS Investigation, Fallows etc. are used. [4]

Table 3: Network Design Steps

#	**Network design steps**
1.	Site planning, Radio optimization
2.	Frequency planning, BSIC planning
3.	WR generation to other stake holder
4.	Used network performance data retrieval
5.	Capacity optimization for data & voice
6.	Real time voice and data quality check

V. GSM NETWORK DESIGN, IMPLEMENTATION & IMPROVEMENT

A. Statement of the problem:

As mobile subscribers complain we found a problematic area Ranikhali, Sylhet. [3]

Fig 1.0: Geographical view of Ranikhali

The summaries of Ranikhali area & radio network status were as follows:

Table 4: Information of Ranikhali area

Information Element	**Number**
Shops at bazaar	250
Population of Ranikhali village	5000

B. Network Status checking:

The coverage status is taken from the Idle Mood and the quality status is taken from the Dedicated Mood Drive test data. We have set acceptable threshold value for Rxlev Sub is -90dBm (In Car) and threshold value for Rxqual Sub is 5 (In Car).Throughout the drive test, we have found some problematic spots. Received signal's quality, coverage & event level in the following table. [9]

Table 5: Radio network Status at Ranikhali.

Information	**Category**	**Value Range**	**Pre**
RxQual Sub	**Good**	0 to 5	75.70%
	Bad	6 or above	24.30%
RxLev Sub (dBm)	**Good**	0 to -90	77.70%
	Bad	-91 or below	22.3 %

Table 6: Count of Events occurred (Active mode)

Event (Active Mode)	**Pre (# of event)**
Call Attempt	10
Call Attempt Retry	2
Dropped Call	**5**
Handover	22
Handover Failure	14
Intra-cell Handover	3
Intra-cell Handover Failure	0

Table 7: Count of Events occurred (Idle mode)

Event (Idle Mode)	**Pre (# of event)**
Call Reselection	28
Location Area Update	1
Location Area Update Failure	0

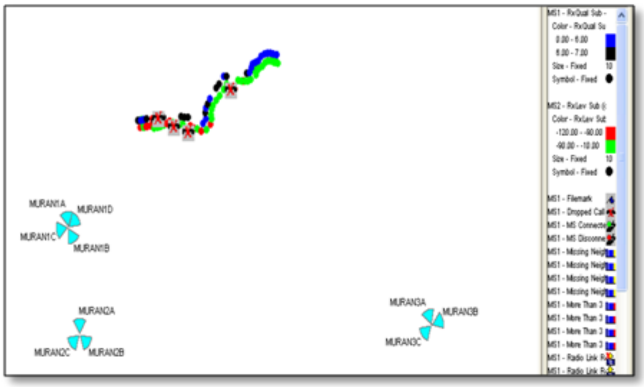

Fig 2.0: RxQual & RxLev Plot in TEMS Map

C. New Site Justification:

Site or GSM Antenna maximum height: MURAN1 24 meter, MURAN2 42 meter, MURAN3 42 meters. We also found some time out of coverage signal level also very poor. In this situation we need new site for better radio solution. [3]

Table 8: New Site Criterion Summary.

New Site Criterion Summary MURAN4 (Ranikhali)	
Site to Site Distance	9.3 Km (Avg.)
Coverage Plot	Poor Coverage
Customer Complaints	Y
Total no of Bazaar in New Site Serving Area	1 (Very Big)
Affected Subscriber	3000
Clutter Type	Populated

D. GSM Planning:

For GSM Planning we use Mentum Planet Radio Network Tools. We plan a Green Field site of 42 meter height tower MURAN4 (Ranikhali).

Limitation:

- Every mobile operator has limited frequency. And BTS also support limited TRX or frequency
- Bangladesh Telecommunication Regulatory Commission (BTRC) controls every new BTS, GSM coverage & call setup access etc.

Table 9: New site GSM Plan

Site Name	**MURAN4**		
Site Area	Ranikhali, Sylhet		
Cell Name	**A**	**B**	**C**
Cell ID	19011	19012	19013
Cell Type	UL1	UL1	UL1
Ant Model	739686	739686	739686
Ant Band	900	900	900
Dir (deg)	70	150	250
Polarization	Cross	Cross	Cross
Height(m)	40	35	40
Length(m)	2.25	2.25	2.25
Ant. M.Tilting (deg)	0	0	0
Ant. E.Tilting (deg)	2	2	2
TRU Config.	3	2	4
LAT	24 42 48		
LON	9135 16		
BTS Type	BTS3900		

Now that plan uploaded for other stake holder to build the site. [5]

E. Frequency planning:

We use 89 to 124 Frequencies for 900 Band.

- BCCH Frequency: 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117
- TCH Frequency: 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116 & 118 to 124

F. Cell planning by Fallows:

After complete the site we plan the cell frequency or parameter. We use Huawei BTS3900 with 6 MRFU. And one MRFU contain maximum 80w power & 6 TRx. For example we plan 4 TRx at C cell of MURAN4 site. So every TRx contain 80/4= 20w power (80w/4)

Table 10: Neighbor Relation

Serving cell	**NBR cell**	**Both Way**
MURAN4A	MURAN4B	Yes
	MURAN4C	Yes
	MURAN1A	Yes
	MURAN1D	Yes
	MURAN2A	Yes
	MURAN3A	Yes
MURAN4B	MURAN4A	Yes
	MURAN4C	Yes
	MURAN1A	Yes
	MURAN1B	Yes
	MURAN1D	Yes
	MURAN2A	Yes
	MURAN2B	Yes
	MURAN3A	Yes
	MURAN3B	Yes
	MURAN3C	Yes
MURAN4C	MURAN4A	Yes
	MURAN4B	Yes
	MURAN1A	Yes
	MURAN1B	Yes
	MURAN1C	Yes
	MURAN1D	Yes
	MURAN2A	Yes
	MURAN2B	Yes
	MURAN2C	Yes
	MURAN3A	Yes
	MURAN3C	Yes

Table 11: Cell Parameter

Site name	MURAN4		
Cell name	A	B	C
Band	900	900	900
BCCH	97	109	117
Cell Frequency	97,112, 122	109,94	117,120, 90,110
NCC	2	2	2
BCC	2	3	4
CI	19011	19012	19013
SDCCH8	3	3	3
SDCCH Dynamic Allocation	Yes	Yes	Yes
SDCCH+CBCH	YES	YES	YES
Frequency Hopping	BB	BB	BB
HSN (900)	1	1	1
BSC	MU2012	MU2012	MU2012
TRX	3	2	4
MRFU Slot	0	2	4
Power Level	0	0	0
Power Type	20W	20W	20W
Power Fine tune	0	0	0
FR Uplink DTX	Shall Use	Shall Use	Shall Use
HR Uplink DTX	Shall Use	Shall Use	Shall Use
FR Use Downlink DTX	Yes	Yes	Yes
HR Use Downlink DTX	Yes	Yes	Yes

Other stack holder built the site (Tower, BTS room, Power etc.). Now they declare the site is on air. Throughout the drive test, we have found good result. [4]

G. Comparison between Pre & Post Network Status:

Over all received signal's quality, coverage & event level status comparison of pre & post DT.

Table 12: Ccomparison of receive signal

Information	**Category**	**Value Range**	**Pre**	**Post**
RxQual Sub	**Good**	0 to 5	**75.70%**	**99.60%**
	Bad	6 or above	24.30%	0.40%
RxLev Sub (dBm)	**Good**	0 to -90	**77.70%**	**93.70%**
	Bad	-91 or below	22.3 %	6.30%

Table 13: Count of Events occurred (Active mode)

Event (Active Mode)	**Pre (# of event)**	**Post (# of event)**
Call Attempt	10	1
Call Attempt Retry	2	0
Dropped Call	**5**	**0**
Handover	22	5
Handover Failure	14	0
Intra-cell Handover	3	0
Intra-cell Handover Failure	0	0

Table 14: Count of Events occurred (Idle mode)

Event (Idle Mode)	**Pre (# of event)**	**Post (# of event)**
Call Reselection	28	8
Location Area Update	1	0
Location Area Update Failure	0	0

Table 15: Legend for RxQual & RxLev

Legend	**Element**	**Good**	**Bad**
	RxQual		
	RxLev	0 to -90	91to -120

The improvement of quality & coverage spots is shown in the following picture.

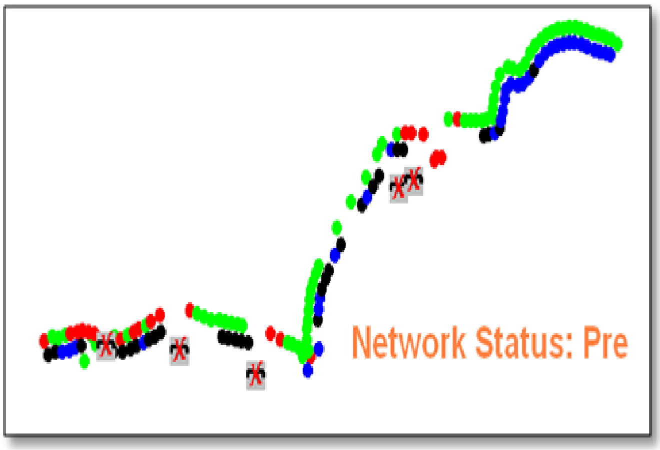

Fig 3.0: Pre Network Status

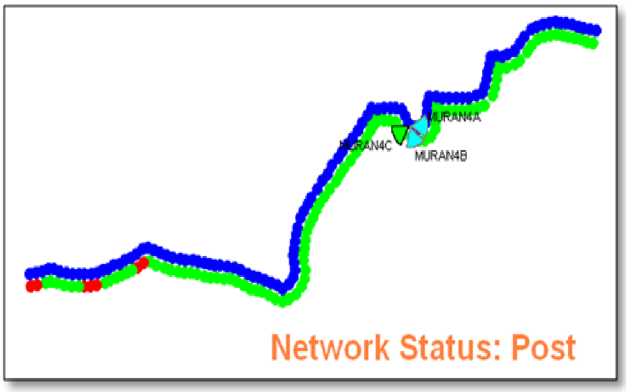

Fig 4.0: Post Network Status

VI. CONCLUSION:

Form the report; we see that the overall Radio network status at Ranikhali is excellent. We have achieved 93.7% good coverage area (where at pre DT we found some out of coverage area) and 99.6 % good quality samples in the village. [3]

Radio Coverage (RxLev Sub) Improvement is 16% (with 100% coverage), Radio Quality (RxQual) Improvement is 23.9% and for more improvement we need to do optimization & retuning.

REFERENCES:

[1] Ericsson, GSM System Survey: EN/LZT 123 3321, Revision 5B, Ericsson Radio Systems AB, 2004

[2] George Kennedy and Bernard Davis, Electronic Communication System, Fourth edition, McGraw-Hill, New Delhi, 1999

[3] Grameenphone Ltd, Radio Planning, Technology Division, GPHouse, Baridhara, Dhaka-1229., Bangladesh

[4] TEMS for Wireless Network Testing and Measurement http://www.ascom.com/en/index/group/divisions/network-testing-home.htm

[5] Mentum–Innovative wireless network planning, management and optimization solutions for broadband networks http://www.mentum.com/

[6] David M. Balston. The pan-European cellular technology. In R.C.V. Macario, editor, Personal and Mobile Radio Systems. Peter Peregrinus, London, 1991.

[7] Michel Mouly and Marie-Bernadette Pautet, The GSM System for Mobile Communications. Published by the authors, 1992.

[8] Ericsson - A world of communication http://www.ericsson.com/

[9] Radio Planning, Technology Division, Grameenphone Ltd. Bangladesh.