Smart Analysis of GSM Mobile Network

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Abstract

The cell sectorization techniques are widely used in cellular system to reduce co-channel interference by means of directional antennas. Cell sectorization and improvement of the chip energy/others interference ratio (E_c/I_o) are technologies to offer good quality of services (QoSs) and coverage for new and sophisticated power control to achieve high capacity. Mobile network analysis on the basis of KEE Parameter indicators(KPI) Report includes Blocked Call Troubleshooting, Drop Call – Troubleshooting, Speech Quality Parameters, Speech Quality – Troubleshooting, Handover Troubleshooting, Coverage Analysis ,Quality of SFH & Non-SFH network, Drop Call Rate, Call setup success rate, Blocked Call Rate, Hopping C/I, hand over Margin using basic Formulas.

I. INTRODUCTION

The Global System for Mobile communications (GSM) is a huge, rapidly expanding and successful technology. Less than five years ago, there were a few 10's of companies working on GSM. Each of these companies had a few GSM experts who brought knowledge back from the European Telecommunications Standards Institute (ETSI) committees designing the GSM specification. Now there are 100's of companies working on GSM and 1000's of GSM experts. GSM is no longer state-of-the-art. It is everyday-technology, as likely to be understood by the service technician as the ETSI committee member. GSM evolved as a mobile communications standard when there were too many standards floating around in Europe. Analog cellular was in use for several years in different parts of world. Even today there are few networks of Analog cellular. The experience of analog cellular helped in developing specifications for a Digital Cellular standard. The work on GSM specs took a complete decade before practical systems were implemented using these specs. GSM is quickly moving out of Europe and is becoming a world standard. In this presentation we will understand the basic GSM network elements and some of the important features. Since this is a very complex system, we have to develop the knowledge in a step by step approach.

Mobile Power Control

Mobile is commanded to change its Transmit Power, Change in Power is proportionate to the Path Loss Change is Power is done in steps of 2 dbs

Timing Advance

TDMA approach requires signals to arrive at BTS at the correct time. They must not overlap

Troubleshooting

Blocked Calls, Poor Quality and Drop calls, Abnormal Handovers, Interference, and Termination Failures**.**

II. BLOCKED CALL TROUBLESHOOTING

Blocked Calls can occur due to: Access Failures, SDCCH Congestion, SDCCH Drop, and TCH Congestion, The best way of analyzing blocked calls, to identify the cause, is from a Layer III protocol log. Paging failure. A paging message always originates from the MSC and is sent to all the BSCs in the Location Area of the MS to be paged. The BSC will then calculate the Paging group of the MS and send a Paging Command to the BTSs controlling the Location Area of the MS. On the air interface there are two cases of Paging Failure, either the Mobile receives no Paging message or it receives a Paging message, but is not able to respond (not able to send a RACH) which could be due errors in the Paging message.

Access Failure

Irrespective of the purpose, for any communication required with the network, a mobile sends a channel Request (for SDCCH) on a RACH and waits for some time for a response which should come from the BTS on an AGCH. A mobile will do several retransmissions of RACHs (pre-defined) and if it still does not get a response, it goes back to idle mode and preferably does a cell reselection. At this stage we call it an Access Failure.

SDCCH Blocked

Once a mobile has sent a Channel Request on a RACH, it expects a response from the BTS on the AGCH. This should be an Immediate Assignment Command to an SDCCH. If an Immediate Assignment Reject comes instead, then this is SDCCH blocking.

TCH Blocked

After the completion of call set-up signaling, a mobile expects an Assignment Command to a TCH so that speech can commence. If no Assignment occurs for a specific period and the Mobile has to return to idle mode, then it is due to TCH congestion.

Blocked Call

Cause troubleshooting: Access Failures, CCCH Overload at the Base Station, Uplink Interference at the Base Station, Low Rxlev at the Base Station, Base Station TRX decoder malfunctioning, Downlink Low Rxlev (Coverage Hole), Downlink Interference, Excess Cell Range

Blocked Call Analysis: SDCCH Congestion Cause, Location Updates to be analyzed with OMC statistics first. If high, determine the source to target cell ratio Drive around the suspected area in the Idle Mode Configure “Delta LAC < > Constant 0” alarms Optimize Location Updates.

Interference

Analyze OMC statistics on “Idle Channel Interference “Carry out Uplink Interference Measurements using Viper, Heavy Traffic Verify from OMC statistics SDCCH Congestion, Carry Call Time measurements Optimize set up time if high, else modify channel configuration.

Blocked Call – Interference

Base Station Measures Uplink Interference on Idle Timeslots, at regular intervals, categorizes Timeslots into Interference Bands. There are Five Interference Bands. Each Interference Band has a range of interference level.

Timeslot – Testing

Activate Cell Barring from OMC, Remove this cell from the neighbor list of other cells, Get the cell configuration, ARFCN’s and Timeslots configured for TCH, For BCH carrier select the Timeslot and carry out the Testing, For TCH Carriers: Block the BCH Timeslots from OMC, Carry out Timeslot testing, If more than 1 TCH Carrier is activated, block all others.

III. DROPPED CALL TROUBLESHOOTING

Call drops are identified through SACCH message, a Radio Link Failure Counter value is broadcast on the BCH, the counter value may vary from network to network. At the establishment of a dedicated channel, the counter is set to the broadcast value (which will be the maximum allowable for the connection). The mobile decrements the counter by 1 for every FER (unrecoverable block of data) detected on the SACCH and increases the counter by 2 for every data block that is correctly received (up to the initial maximum value). If this counter reaches zero, a radio link failure is declared by the mobile and it returns back to the idle mode. If the counter reaches zero when the mobile is on a SDCCH then it is an SDCCH Drop. If it happens on a TCH, it is a TCH drop. Sometimes an attempted handover, which may in it have been an attempt to prevent a drop, can result in a dropped call. When the quality drops, a mobile is usually commanded to perform a handover. Sometimes however, when it attempts to handover, it finds that the target cell is not suitable. When this happens it jumps back to the old cell and sends a Handover Failure message to the old cell. At this stage, if the handover was attempted at the survival threshold, the call may get dropped anyway. If on the other hand the thresholds were somewhat higher, the network can attempt another handover.

We will examine the potential causes behind call drops and some solutions to combat them.

Coverage

Poor non-contiguous coverage will reduce C/N and hence will reduce the Ec/No and will result into call drops.

IV. GSM Air Interface

Bursts

Each carrier frequency used in GSM is divided into 8 independent timeslots and into each of these timeslots a burst is placed. The diagram shows the general form of a GSM burst. The receiver can only receive the burst and decode it if it is received within the timeslot designated for it. The timing, therefore, must be extremely accurate but the structure does allow for a small margin of error by incorporating a ‘guard period’. To be precise, the timeslot is 0.577ms long, whereas the burst is slightly shorter at 0.546ms. Eight bursts occupy one Time Division Multiple Access (TDMA) frame. The ‘‘flag-bits” are set when the frame has been ‘stolen’ by the Fast Associated Control Channel (FACCH). The ‘‘training sequence” is used by the receiver’s equalizer as it estimates the transfer characteristic of the physical path between the Base Station (BSS) and the mobile (MS).

V. Timing Advance and Power Control

To simplify the design of the mobile, the GSM Recommendations specify an offset of three time-slots between the BSS and MS timing thus avoiding the necessity for the mobile to transmit and receive simultaneously. The facing diagram illustrates this. However, the synchronization of a TDMA system is critical because bursts have to be transmitted and received within the “real-time” time slots allotted to them. The further the MS is from the BSS then, superimposed upon the 3 time-slot nominal offset, ‘‘Power Control” allows the operator to not only compensate for the distance from MS to BSS, but can also cause the BSS and MS to adjust their power output to take account of the path loss. The closer the MS is to the BSS, the less the power it and the BSS will be required to transmit. This feature saves radio battery power at the MS, and helps to reduce co-channel and adjacent channel interference. GSM Recommendations state that uplink power control is mandatory, whereas downlink power control is optional.

VI. Cell coverage

presents the sensitivity level for both the MS and the BTS. However, when planning a system it is not sufficient to use this sensitivity level as a planning criterion. Various margins have to be added in order to obtain the desired coverage. In this chapter these margins are discussed and the planning criteria to use in different types of environments are presented.

Cell coverage

Definitions: Required signal strength

To the sensitivity level of an MS, margins have to be added to compensate for Rayleigh fading, interference and body loss. The obtained signal strength is what is required to perform a phone call in a real-life situation and will be referred to as SSreq. SSreq is independent of the environment.

SSreq = MSsens + RFmarg + IFmarg + BL (1)

Where

MSsens = MS sensitivity

RFmarg = Rayleigh fading margin

IFmarg = Interference margin

BL = Body loss

Design level

Extra margins have to be added to SSreq to handle the log-normal fading as well as different types of penetration losses. These margins depend on the environment and on the desired area coverage. The obtained signal strength is what should be used when planning the system and it will be referred to as the design level, SS design. This signal strength is the value that should be obtained on the cell border when planning with prediction tools like EET/TCP.

The design level can be calculated from:

SSdesign = SSreq + LNFmarg(o) MS outdoor (2)

SSdesign = SSreq + LNFmarg(o) + CPL MS in-car (3)

SSdesign = SSreq + LNFmarg (o+i) + BPLmean MS indoor (4)

Where

LNFmarg (o) = Outdoor log-normal fading margin

LNFmarg (o+i) = Outdoor + indoor log-normal fading margin

CPL = Car penetration loss

BPL mean = Mean building penetration loss

VII. Margins

Rayleigh fading

Rayleigh fading is due to multipath interference and occurs especially in urban environments where there is high probability of blocked sight between transmitter and receiver. The distance between two adjacent fading dips is approximately $\lambda/2$. The required sensitivity performance of GSM in terms of FER, BER or RBER is specified for each type of channel and at different fading models (called channel models). The channel models reflect different types of propagation environment and different MS speeds. The sensitivity is measured under simulated Rayleigh fading conditions for all the different channel models and the sensitivity is defined as the level where the required quality performance is achieved. In a noise limited environment the sensitivity is the one listed .This would mean that Rayleigh fading is already taken into consideration in the sensitivity definition. However, the GSM specification allows worse quality for slow MSs (3 km/h) than for fast moving MSs. The sensitivity performance at fading conditions corresponding to an MS speed of 50 km/h in an urban environment (called TU502), is in accordance with good speech quality, while the sensitivity performance for slow MSs at TU32 does not correspond to acceptable speech quality. In order to obtain good speech quality even for slow mobiles, an extra margin, RFmarg, is recommended when planning. From experience, 3 dB margin seems adequate. In a frequency hopping system the Rayleigh fading dips are leveled out and there should be no need for a Rayleigh fading margin. But since a Broadcast Control Channel (BCCH) never hops, the Rayleigh fading margin is recommended in cell coverage estimations, regardless of using frequency hopping or not. Also antenna diversity reduces the effect of Rayleigh fading but in a different way than frequency hopping. Therefore, diversity gain is still relevant in frequency hopping systems. (For simplicity the diversity gain figure is considered independent of frequency hopping and MS speed distribution).

Rayleigh fading margin (RFmarg) = 3 dB

Log-normal fading

The signal strength value computed by wave propagation algorithms can be considered as a mean value of the signal strength in a small area with a size determined by the resolution and accuracy of the model. Assumed that the fast fading is removed, the local mean value of the signal strength fluctuates in away not considered in the prediction algorithm. This deviation of the local mean in dB compared to the predicted mean has nearly a normal distribution. Therefore this variation is called log-normal fading.

The received signal strength is a random process and it is only possible to estimate the probability that the received signal strength exceeds a certain threshold. In the result from a prediction in for example EET or TCP, 50% of the locations (for example at the cell borders) can be considered to have a signal strength that exceeds the predicted value. In order to plan for more than 50% probability of signal strength above the threshold, a log-normal fading margin, LNFmarg, is added to the threshold during the design process.

Jakes' formulas

A common way to calculate LNFmarg is to use Jakes' formulas, ref. 21. In Jakes' formulas simple radial path loss dependence (1/rn) is assumed in order to calculate the **percentage of area** within an Omni-cell with signal strength exceeding a certain threshold. The threshold is related to the **percentage of locations at the cell border** that have a signal that exceeds the same threshold. The border coverage corresponding to desired area coverage is given when the threshold referred to is the required signal strength in the MS. The margin in dB (LNFmarg) to go from the original 50% coverage at the cell border to the given border percentage is **x*Standard deviation**. x is the variable in the cumulative normal function F(x) when F(x) has the value of the border percentage given by Jakes formulas.

Simulation of log-normal fading margin in a multi-cell environment:

A disadvantage with Jakes' formulas is that it does not take the effect of many servers into account. The presence of many servers at the cell borders will reduce the required log-normal margin. This is because the fading patterns of different servers are fairly independent. If the signal from one server fades down below the sensitivity level a neighbour cell can fill out the gap and rescue the connection. In order to find the log-normal fading margins in a multi-cell environment, simulations have been performed. The prerequisites for the simulations have been:

- 3 sectored sites
- correlation of log-normal fading between one MS and different BSs is 0.5
- lognormal fading correlation distance is 28.85 m
- the time to perform a handover is 0.5 s

The propagation environment is modeled with the Okumura-Hata formula as follows:

Lpath = A + 10 logd [dB], where A=15.3 and =3.76,d[m].

Five different environments (□ LNF = 6, 8, 10, 12, 14) have been studied. The used handover hysteres in the simulations is 3dB. In order to find the required value of LNFmarg:

1. Choose the curve corresponding to fading environment in question.
2. On the X-axis, find the log-normal fading margin for the desired area coverage (Y-axis).

Log-normal fading margins

Below the size of the log-normal fading margin is given for different types of fading environments and area coverage. The values originate from the simulations described above. A multi-cell environment with a handover hysteresis of 3 dB is assumed.

VIII. Flow Chart of Dropped Call Troubleshooting

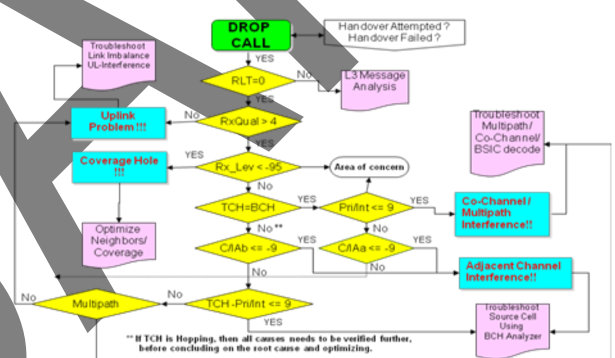

Fig1: Flow Chart of Dropped Call Troubleshooting

SDCCH Drop

Coverage, Co- Channel Interference, Adjacent Channel Interference, SDCCH Drop - Uplink

TCH Drop – Coverage, Co-Channel Interference, Adjacent Channel Interference, Uplink Problem, Handover Failure.

Poor Quality

Poor Speech Quality could be due to , Patchy Coverage (holes), No Target cell for Handover, Echo , Audio holes, Voice Clipping, Interference like as , Co-channel, Adjacent channel, External, Multipath, Noise.

IX. SPEECH QUALITY PARAMETERS

Rx- QUAL

Measured on the midamble, Indicates poor speech quality due to radio interface impairments

FER

Measured on the basis of BFI (Ping -Pong effect) Preferred under Frequency Hopping situation

Echo and Distortion

Generally caused by the Transmission and switching system.

X. SPEECH QUALITY TROUBLESHOOTING

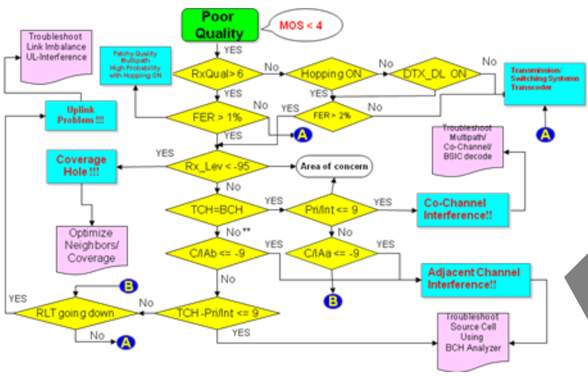

Fig 2:Flow Chart of Speech Quality Troubleshooting

If TCH is in Hopping, then all interference causes needs to be verified further, before concluding on the root cause and optimizing.

XI. HANDOVER TROUBLESHOOTING

Weak Neighbors

Total Attempted Calls, Total Dropped Calls, Total Blocked Calls, RxQUAL Full, Rx Level Full,

RLT Current Value, ARFCN, Neighbor Cell Measurements, RR Message, Phone State, Sequence number.

XII. COVERAGE ANALYSIS

The coverage test measurements include the following parameters that are collected to as certain that the network quality and performance.

Description	Measured Results	Remarks
% of sample >-65 (dBm)	56 %	Good
% of sample -65 to -75(dBm)	35 %	
% of sample -75 to -85(dBm)	11 %	
% of sample -85 to -95(dBm)	1 %	
% of sample < -95(dBm)	0 %	

Table 1: Rx Level Vs Samples

QUALITY OF SFH & NON-SFH NETWORK

Quality of Non-SFH network

Description	Measured Results	Good/Bad
96 % of samples should have RxQUAL equal to or less than 4	-- NA --	Good

Table 2: Represent Quality of Non-SFH network

Quality of SFH network

Description	Measured Results	Good/Bad
95 % of samples should have FER less than or equal to 2% or SQI should be better than 18	SQI --- 43 % FER --- 95 %	Good

Table 3: Represent Quality of SFH network

DROP CALL RATE

Description	Measured Results	Good/Bad
Drop call rate should be less than or equal to 1%	0 %	Good

Table 4: Represent Drop Call rate During call forwarding

CALL SETUP SUCCESS RATE

Description	Measured Results	Good/Bad

Call setup success rate should be greater than or equal to 96%	100%	Good

Table 5: Represent Call Setup Success Rate after call mature

XIII. BLOCKED CALL RATE

Description	Measured Results	Good/Bad
Blocked Call Rate should be less than or equal to 1%	0 %	Good

Table 6: Represent **Blocked Call rate if Call not Sucess**

XIV. HOPPING C/I

Average C/I on hopping carriers = 19.0

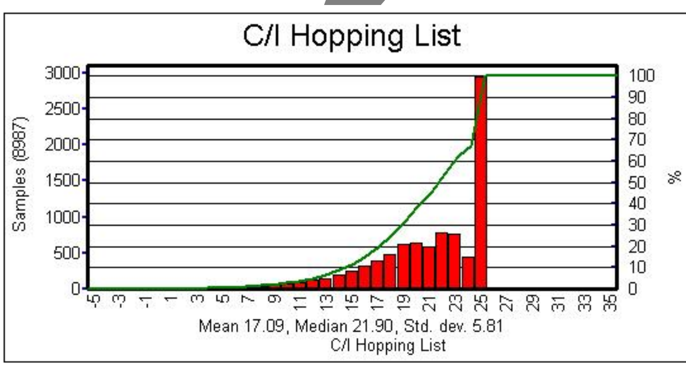

Fig 3: Represent C/I Hopping List Vs Samples Rate

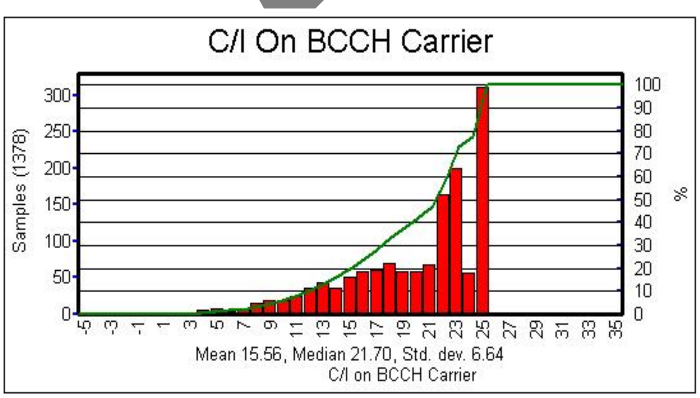

Fig 4: Represent Co-channel interference on BCCH Carrier Vs Samples Rate

XV. PATH BALANCE OF CARRIER FOR SEC. 1

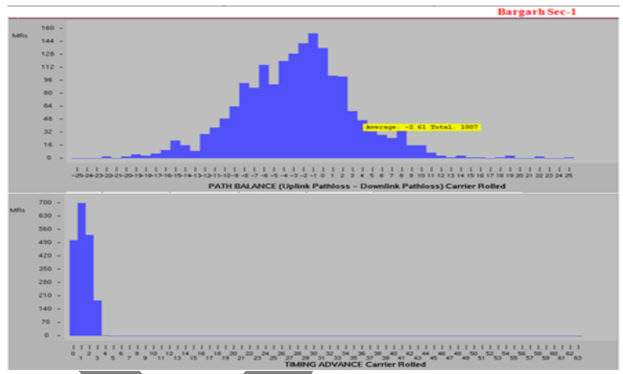

Fig 5: Represent Path Balance Of Carrier For Sector-1

PATH BALANCE OF CARRIER FOR SEC. 2

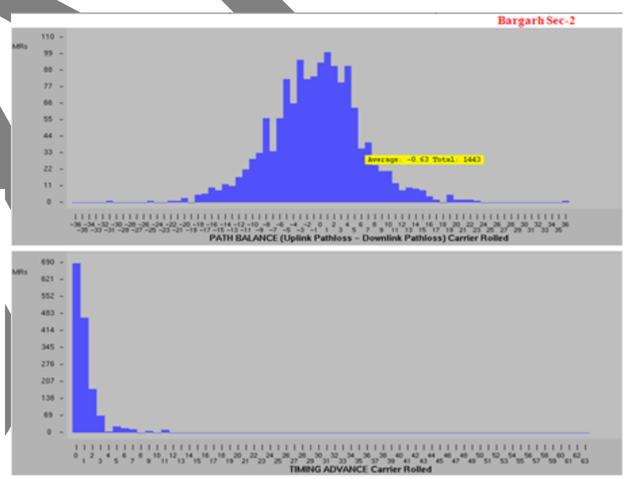

Fig 6: Represent Path Balance Of Carrier For Sector-2

PATH BALANCE OF CARRIER FOR SEC. 3

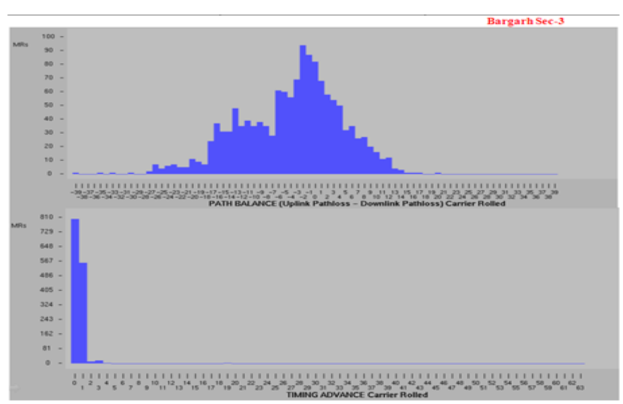

Fig 7: Represent Path Balance Of Carrier For Sector-3

XVI. CONCLUSION

BAD Spot 1 has poor quality and Call Drop, this spot is covered by Cell 47450, Poor Coverage. Level below -99 dbm , But Call should not Drop, the other Problem is Interference, Mobile is Hopping on 101 and 84, 93 is also the BCH, Co-Channel on BCH is very high., 50% of the time quality will be poor, But Poor Quality is consistent, Channel 84 is also suffering from Interference, No Adjacent Channel on 82 and 97, This means there is Co-Channel on 84 also., It could also be multipath issue on 82.

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