B.VenkataSai Sireesha, Dr.S.Varadarajan, Vivek and Naresh/ International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 1, Issue 4, pp. 1479-1485

Increasing Of Call Success Rate In GSM Service Area Using RF Optimization

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***Abstract*—**

The Call Set up Success Rate is one of the most important Key performance Indicators (KPIs) used by all mobile operators. However there is no standard measurement possible for this parameter. Therefore the different operators can measure it differently. How to optimize the BTS coverage area successfully along with better service is the real challenge .In this paper the main motive is to identify the causes of call setup failures in a GSM service test area and necessitate steps to increase the call success rate using RF optimization. RF Optimization is a very important process in any service provider's operating lifecycle which is a critical set of activities in the life cycle of any GSM wireless network.

RF Optimization involves drive testing, post processing, data analysis, recommendations and action steps. Optimization will be continuous and iterative process of improving network quality. By successful optimization, the Quality of Service, reliability and availability of RF Coverage area is highly improved.

Keywords **---Call Setup Success Rate, GSM, KPI, RF Optimization, SDCCH, TCH.**

I INTRODUCTION

The mobile communication aims to offer anytime and any where communications between any objects. GSM, One of the fastest growing and most demanding of all telecommunications technologies. GSM Network usually called as 'cellular network' (as the whole coverage area is divided into different cells and sectors) 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. BTS is then connected to the base station controller (BSC) via A-bis 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) via A-interface.

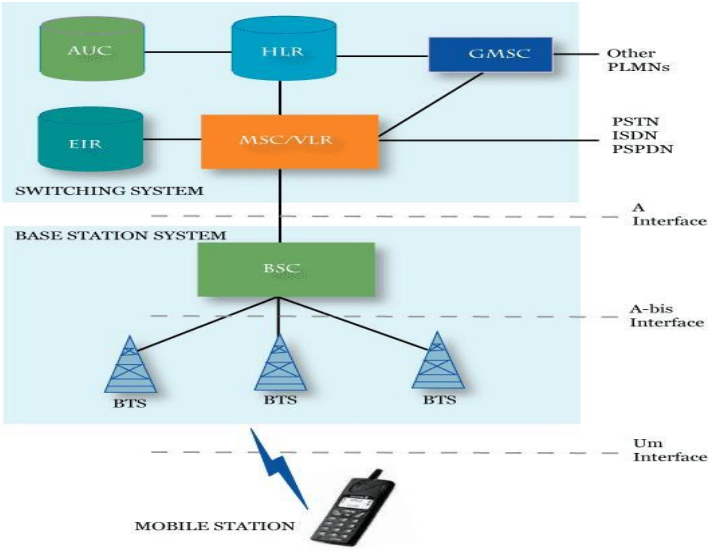


Figure 1: GSM NETWORK ARCHITECTURE

GSM network performance and QoS evaluation are the most important steps for the mobile operators as the revenue and customer satisfaction is directly related to network performance and quality. Radio frequency network optimization (RNO) teams play a very significant and vital role in optimizing an operational network to meet the ever increasing demands from the end users.

Usually the following tasks are assigned to RNO teams:

1) Finding and correcting any problems after site implementation and integration.
2) Meeting the network quality criteria agreed in the contract.
3) To improve the existing network coverage and capacity
4) To improve the offered service quality for fulfillment of customer demands.
5) To maintain the KPIs under pre-defined threshold.

6) To sustain the QoS criteria being imposed by country's regulatory authority.
7) To standardize and benchmark the network performance with that of competitor's network to attract more customers; keeping a balance between cost and quality

8) To effectively reuse the available bandwidth and frequency carriers in order to avoid internal interference and service degradation.

II RF Optimization Process

Optimization process can be explained by below step by step description:

Problem Analysis

- Analyzing performance retrieve tool reports and statistics for the worst performing BSCs and Sites
- Examining Planning tool Coverage predictions
- Analyzing previous drive test data
- Discussions with local engineers to prioritize problems
- Checking customer Complaints reported to local engineers

Checks Prior to Action

- Cluster definitions by investigating BSC borders, main cities, freeways, major roads
- Investigating customer distribution, customer
- habits (voice/data usage)
- Running specific traces on Network to categorize problems
- Checking trouble ticket history for previous problems
- Checking any fault reports to limit possible hardware problems prior to test

Drive Testing

- Preparing Action Plan
- Defining drive test routes
- Collecting RSSI Log files
- Scanning frequency spectrum for possible interference sources
- Re–driving questionable data

Subjects to Investigate

- Non–working sites/sectors or TRXs
- In–active Radio network features like frequency hopping
- Overshooting sites – coverage overlaps
- C/I, C/A analysis
- High Interference Spots
- Call setup failure reasons
- Drop Calls
- Capacity Problems
- Not happening handovers
- Accessibility and Retainability of the Network
- Equipment Performance
- Faulty Installations

After the Test

- Post processing of data
- Plotting RX Level and Quality Information for Overall picture of the driven area
- Initial Discussions on drive test with Local engineers
- Reporting urgent problems for immediate action
- Analyzing Network feature performance after new implementations
- Transferring comments on parameter implementations after new changes

Recommendations

- Defining missing neighbor relations
- Proposing new sites or sector additions with Before & after coverage plots
- Proposing antenna azimuth changes
- Proposing antenna tilt changes
- Proposing antenna type changes
- BTS Equipment/Filter change
- Re–tuning of interfered frequencies
- BSIC changes
- Adjusting Handover margins (Power Budget, Level, Quality, Umbrella
- Handovers
- Adjusting accessibility parameters
- Changing power parameters

Tracking

- Re–driving areas after implementing recommendations
- Create a tracking file to follow–up implementation of recommendations

Key performance parameters

For radio network optimization it is necessary to have key performance indicators. These KPIs are parameters that are to be observed closely when the network monitoring process is going on. Mainly, the term KPI is used for parameters related to voice and data channels, but network performance can be broadly characterized into coverage, capacity and quality criteria also that cover the speech and data aspects.
The CSSR indicates the proportion of calls that were completed after being generated, in the radio network.
KPIs can be subdivided according to the areas of functioning, such as area level, cell level and TRX level. Area-level KPIs can include SDCCH requests, the

dropped SDCCH total, dropped SDCCH A-bis failures, outgoing MSC control handover (HO) attempts, outgoing BSC control HO attempts, intra-cell HO attempts, etc. Dropped SDCCH total and distribution per cause, UL quality level distribution, DL quality/level distribution etc. The TRX level includes the likes of UL and DL quality distribution.

III DRIVE TESTING

The quality of the network is ultimately determined by the satisfaction of the users of the network, the subscribers. Drive tests give the 'feel' of the designed network as it is experienced in the field. The testing process starts with selection of the 'live' region of the network where the tests need to be performed, and the drive testing path. Before starting the tests the engineer should have the appropriate kits that include mobile equipment, drive testing software, and a GPS (global positioning system) unit. When the drive testing starts, two mobiles are used to generate calls with a gap of few seconds. The third mobile is usually used for testing the coverage.

a) COVERAGE

Drive test results will give the penetration level of signals in different regions of the network. In urban areas, coverage is generally found to be less at the farthest parts of the network, in the areas behind high buildings and inside buildings. This leads to an immediate scrutiny of the antenna locations, heights and tilt. The problems are usually sorted out by moving the antenna locations and altering the tilting of the antennas. If optimization is being done after a long time, new sites can also be added.

Coverage also becomes critical in rural areas, where the capacity of the cell sites is already low. Populated areas and highways usually constitute the regions that should have the desired level of coverage. For highway coverage, additions of new sites may be one of the solutions.

b) CAPACITY

Data collected from the network management system is usually used to assess the capacity of the network. As coverage and capacity are interrelated, data collected from drive tests is also used for capacity assessment. Once the regional/area coverage is planned and executed in the normal planning phase, optimization should take into consideration the provision of as much coverage as possible to the places that would expect high traffic, such as inside office buildings, inside shopping malls, tunnels, etc.

c) QUALITY

The quality of the radio network is dependent on its coverage, capacity and frequency allocation. Most of the severe problems in a radio network can be attributed to signal interference. For uplink quality, BER statistics are used, and for downlink FER statistics are used. When interference exists in the network; the source has to be found out. The entire frequency plan is checked again to determine whether the source is internal or external. The problems may be caused by flaws in the frequency plan, in the configuration plans (e.g. antenna tilts), inaccurate correction factors used in propagation models, etc.

d) DRIVE TEST TOOL: JDSU E6474A v15.2

Agilent's E6474A drive test tool has revolutionized and simplified end to end troubleshooting. The software allows users to correlate signaling procedures from the air interface and radio access network interfaces in a single view to detect and troubleshoot problems from the mobile phone to the network.

The benefits of using this drive test tool are:

- Automatic correlation of data collected from both the radio and network interfaces to find end-to-end performance issues more easily.
- Mobile device and network combined protocol decoding as well as call trace groupings to enable a complete understanding of mobile access network behaviors.
- Detection of lost and delayed messages from the air interface.
- Isolation of base station with RF performance, capacity and interference problems to perform root cause analysis.

DRIVE TEST PROCEDURE

After collecting the required information form the BTS and the OMC-R, the drive test is started. The equipment is set up in a vehicle and long calls as well as short calls are generated. A long call is a call which is generated as well as terminated by the user himself. A short call is a pre programmed call generated by the system for a very small duration, say 10 seconds or more. A long call is used to measure the handover success rate as well as the Rx quality, while CSSR and Rx level are measured on a short call. The drive test is done over a distance of 3 km or more from the starting point. Various parameters are observed and recorded during the drive test. The drive test procedure is as follows:

Tool may be setup for two mobiles One for Long call and another for short calls (2 min)

In the route map following are to be enabled for Analysis.

- Rx Level
- RX Quality
- Survey Markers (like CSSR, DCR & H/O Symbols)
- Cell site Database.
- All statistics for the Calls in the Point -1 to be enabled.

Conduct the Drive Test – covering all sectors by observing the following Parameters:

- Rx Level
- Rx Quality
- Interference on BCCH & Hopping Frequencies.
- Call setup failure reasons

- Observe whether the nearest sector is serving or not.

The data, as per the requirements are observed and recorded. The data is analyzed for performance. The design is validated and based on the data analysis, the percentage of good network and bad network is concluded. For the test network, the good design and bad design percentages are calculated based on the integration of test samples. Further, the causes for the bad design are contemplated and the total outcome is broken into fragments for in-depth analysis of the root cause. These fragments are compared against standard values and wherever possible the design is improved.

The improvisation of design is based on the optimized solutions suggested. As per the possible optimized solutions, necessary changes are made in the design of the network. The changes are made so as to maintain the quality and performance of the network. The analysis of the drive test is depicted in a graphical form, like a bar chart and conclusions are derived based on the charts.

IV. Post Processing

Actix Analyzer

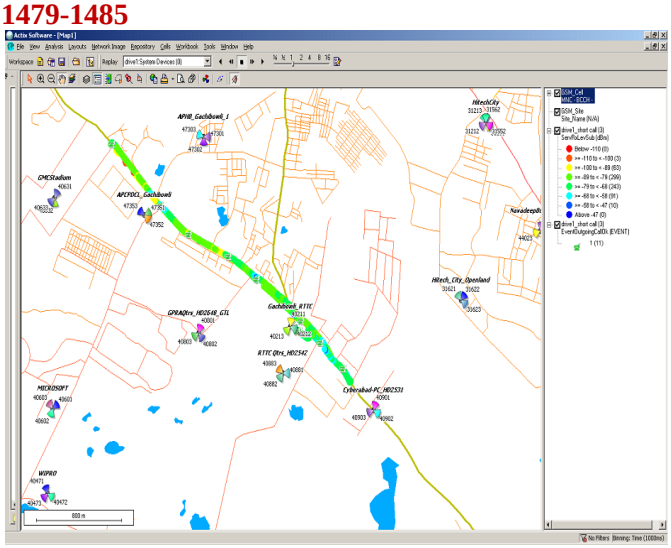
Actix Analyzer is a software application running under Microsoft Windows on a PC that provides a series of analysis tools for post-processing cellular network data. The tools are designed to address applications such as:

• Network performance optimization
• Feature testing
• Service validation
• Problem diagnosis and analysis
• Network bench-marking
• Competitive analysis

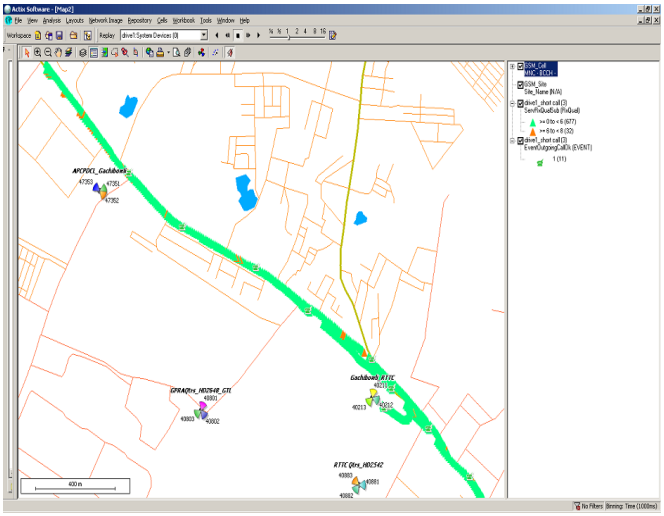
The platform for Actix Solutions, Analyzer, can load network performance data from many different sources

Drive Map Screenshots

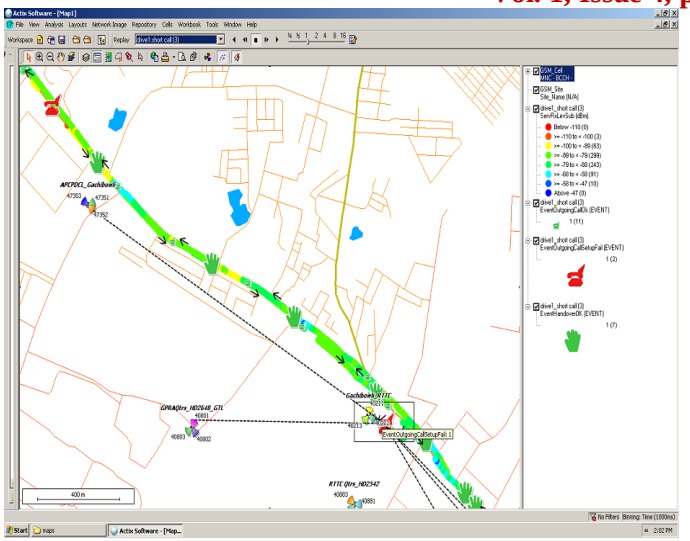
Short Call – Signal Level



Short Call- Signal Quality



Short Call – Call setup failure



V CALL SETUP SUCCESS RATE (CSSR)

The call setup success rate is one of the key performance indicators (KPI) used by the network operators to assess the performance of networks and have direct influence on the customer satisfaction with the service provided by the network and its operator.

CSSR is a term in telecommunications denoting the fraction of the attempts to make a call which result in a connection to the dialled number. This fraction is usually measured as a percentage of all call attempts made. The call setup procedure may be very complex and the point at which a call is considered successfully connected may be defined in a number of ways,. Please note, that if a call is connected successfully but the dialled number is busy then the call is counted as successful. The call setup success rate in conventional (so-called land-line) networks is extremely high and is significantly above 99.9%.

CSSR is the number of successful attempts to make a call. Ideally, a network should be capable of accepting all the calls attempted to be made. The ideal value of CSSR is 1 i.e. the network should be capable of accepting 100 % of the calls made. CSSR is found out through a short call.

CSSR = Outgoing and incoming call setup/ Total number of Call attempts

CALL SET UP IN GSM NETWORK

The successful call set up consists of two procedures. The simplified description of these procedures is provided in the next text in such a way that the focus is only on the parts necessary to understand the philosophy of Call Set up Success Rate calculation correctly. First procedure is Immediate Assignment procedure which is used to create a signaling connection between the Mobile station (MS) and the network. It can be initiated only by the MS sending a CHANNEL REQUEST message on the Random Access channel (RACH) to the BTS that it requires a signaling channel (SDCCH). This message contains the information field establishment cause and random reference. The establishment cause gives the reason why the MS is requesting a SDCCH. Possible reasons are:

- Emergency call
- call re-establishment
- originating speech call
- Location updating.

Then it comes next signalization between the MS and network in order to activate the signaling channel, recognize the service being requested by the MS, etc. The successful seizure of SDCCH is acknowledged by sending the Establish Indication message from MS to BTS and then to BSC. Further coordination procedure (authentication, ciphering etc.) are now performed on the SDCCH.

Second procedure is Assignment procedure which is used to occupy a radio resource (speech channel). The MSC is initiator of this procedure. The MSC sends an ASSIGNMENT REQUEST message to the BSC requesting the assignment of a radio resource (RR). Then it comes next signalization between BTS and BSC in order to allocate and activate a suitable RR (Traffic channel - TCH).If the TCH is successfully seizured by MS, the BSC sends the ASSIGNMENT COMPLETE message.

The main reasons for unsuccessful call setups in mobile networks are lack of radio coverage (either in the downlink or the uplink), radio interference between different subscribers, imperfections in the functioning of the network (such as failed call setup redirect procedures), overload of the different elements of the network (such as cells), etc.

VI Call setup failure reasons

There could be so many reasons for a poor CSSR. Some are described as follows:

1. Low Signal Strength
2. SDCCH Congestion
3. CM Service Reject
4. TCH Failure Assignment
5. Hardware Problem

Optimization solutions

1. Low signal strength call setup failure causes due to weak signal, handover has not taken so that re selection is not happen.

Solution

By boosting up the signal strength, Rx level will increase due to this better handover taken place

And re selection is happened

2. No Access to SDCCH.

BSS detects channel request (in the form of RACH) from a source, requesting resources for networks transactions. After validation of the RACH, BSS will attempt to allocate a dedicated channel (SDCCH) for the source. One the

availability of SDCCH channel is confirmed, the BSS will send immediate assignment to MS indicating the dedicated SDCCH sub-channel (via AGCH), where by subsequent message exchange will be preformed over the dedicated SDCCH.

Case

a. Valid RACH (SDCCH Congestion)

Due to unavailability of SDCCH, BSS will response to MS with immediate assignment reject, terminating the transactions. In which case, call setup is termed as unsuccessful due to SDCCH congestion.

Invalid RACH (Invalid established cause detected in the received RACH)

b. Phantom RACHs

The received RACH is in fact generated from an "unknown source", where by it fails to continue the transaction after SDCCH has been allocated by the BSS. For instances, case of channel request detected by overshooting cells, handover access burst from distanced MS, hardware deficiency, UL/DL imbalance path, MS moving out of range would carry the Phantom RACHs symptoms.

Solution

Within the optima there are certain states which can be monitored before coming to conclusion that there is SDDCH problem:

a. SDCCH Blocking

b. SDDCH Congestion (Valid RACH)

If the SDCCH blocking greater than 1% or SDCCH Congestion greater than 2% than that mean that it is a capacity related issue and more slots should be assigned for SDCCH.

A TCH can be allocated by passing SDCCH. A parameter namely Immediate Assign Mode when enabled allocates TCH by passing SDCCH.

3 CM Service Reject

CM Service Request (MOC) or Paging Response (MTC) to BSC/MSC. Inside the CM service request message (MS initiated service request), MS informs the network the types of service it requires, whereby paging response is specific to MTC. Subsequently, BSS embraces the information with its own initiated connection request BSSMAP message, send to MSC to approval. MSC will response with either connection confirmed, confirming the success in link establishment between MS-BSC-MSC, and connection Refused, Indicating the termination of the specific network transaction.

4. TCH Failure Assignment

Upon completion of MS/BSC/MSC link established, MS issues Assignment Request to BSC, Requesting TCH Assignment to the dedicated MS. Subsequently, BSS will attempt to allocate free TCH for MS voice messaging. Once Assignment Command is received by MS, stating the availability of TCH for the MS, it will move to the dedicated TCH and responds with Assignment Complete. In turns, BSS will submit Assignment Complete to MSC as to complete the signal activity.

Case

TCH Congestion

Solution

For TCH Congestion certain features can be enabled like TCH queuing, Directed Retry and Congestion Relief. In case of the TCH queuing feature is enable, MS will queue in the Original SDCCH, waiting for the next available TCH. It is to be reminded that once Queuing timer expires. BSS will also terminate transactions, in which case, call setup is termed as unsuccessful due to TCH Congestion. The same situation also applies in situation where Congestion Relief feature is enabled. In the case of Directed Retry feature is enabled, MS will perform Handover to TCH of another cell if a valid handover neighbor is detected. The best thing to do is to add more radios in the cell to remove congestion. Interference analysis on a particular carrier can be done through an optimization tools like Neptune. Once interfering frequencies are determine, the frequency plan can be cleaned from such frequencies.

5. Hardware Problem

Hardware failures also play major role for poor CSSR. Improper functionality of any BTS hardware can affect the overall performance of sites.

Solution:

If there are no capacity or RF issues then equipment needs to be checked. Before starting the drive test make sure that the cell site are free for any hardware alarms. The important parameter to check is the path balance. If path balances are not fine then start checking the power from radio to connected antennas. If we take the examples of GSM 900 scenario, the link budget defines that the radio should transmit 40 watts power and at the top of the cabinet, 20 watts are received. While checking the power, if any components seem to procedure more losses than expected, change that component. Similarly check the power at antenna feeder ports. Some time due to the water ingress, connectors get rusty and needs to be replaced.

CONCLUSION

Due to the mobility of subscribers and complexity of the radio wave propagation, most of the network problems are caused by increasing subscribers and the changing environment. RF Optimization is a continuous process that is required as the network evolves. RF optimization is carried out in order to improve the network performance with the existing resources. Through RF Optimization, the service quality and resources usage of the network are greatly improved and the balance among coverage, capacity and quality is achieved.

FUTURE SCOPE

At present Drive Testing in GSM RF Optimization is being performing manually for the improvement of performance of the network. Instead of doing drive testing manually, there may be a scope of ANMS (Automatic Network Management System) process in which system, Drive Testing equipment can be attached to moving vehicle to serve in GSM test area and it can be monitored by the server. By using the internet, all the real time drive data can be simultaneously collected.

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I am **B.VENKATASAI SIREESHA** pursuing M.Tech in communication systems in S.V.University, tirupati. I am greatly indebted to our **Sri Venkateswara University** that has provided us a healthy environment to drive us to achieve our goals and ambitions.

I express my gratitude and thanks to the Head of Department **Dr Prof. S.Narayana Reddy** for his excellent supervision and guidance. My sincere thanks to our

professors for their excellent guidance and suggestions who are helpful either directly or indirectly in completion of this project.

I wish to express deep sense of gratitude to our guides **Dr.S.VARADHARAJAN, ASSOCIATE PROFESSOR and Mr.VIVEK and Mr.NARESH, for** their co-operation, encouragement and timely suggestions. I am very much glad for them for inspiring me with their words filled with dedication and discipline towards work.