Comparative Analysis & Characteristics of 3G and 4G GSM Network: A Survey

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***Abstract* - This paper includes performance and analysis & Characteristics of 3G GSM compare with 4G network on the basis of KPI report. The introduction of 4G LTE communication technology was basically designed to meet the increasing demand by users for high-quality multimedia services, data communication speed and improved quality of service (QOS). It is pertinent to note that, with an ever-increasing subscriber base, it is essential to assess and analyze the network performance. To perform this task, there is a need to use the key performance indicators (KPI).**

Performance & analysis of GSM network has following features: Blocked Call Analysis, Drop Call Analysis, Speech Quality Parameters, and Speech Quality Analysis, Handover Analysis, Coverage Analysis, Quality of SFH & Non-SFH network, Drop Call Rate, Call setup success rate, Blocked Call Rate, Hopping C/I.

***Index Terms* - MME, S-GW, HSS, PCRF, RSRP, RSRQ, SINR.**

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. The mobile users demand for more and more sophisticated and compact devices; therefore, the manufacturers are emphasizing on smaller devices with increased processing and high-level security. 3G devices are good but still there exists room for improving image processing and speed of processor so that they can be used for high demanding 4G applications. The applications like 3D games, high-definition camcorders and larger mega pixels cameras need efficient application processors . Fourth generation (4G) also called latest Generation Network offers one platform for different wireless networks.

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.

Troubleshooting

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

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.

Blocked Call

Cause troubleshooting: Access Failures, CCCH Overload at the Base Station, Uplink Interference at the Base Station, Low Rx lev at the Base Station, Base Station TRX decoder malfunctioning, Downlink Low Rx lev (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.

II.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.

Network Initiated Drops
Certain network features, like preemption, can kill an ordinary call to provide connection to an emergency class subscriber. A handover is the key to survival from dropping calls. But if there are problems in the Handover process itself, then this will not avoid a drop. Dropped calls can be effectively reduced by improving coverage, detecting and reducing interference, setting appropriate Handover Margins, thresholds for handovers and the correct selection of neighbors. Use of DTX and dynamic downlink power control will also reduce average interference which should lead to some improvements.

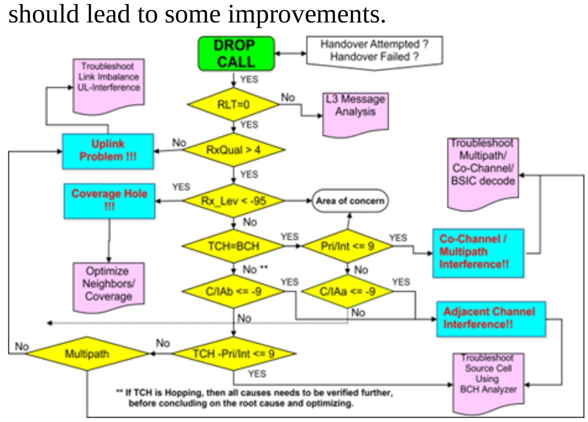

Fig1: Flow Chart of Dropped Call Troubleshooting

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.

III.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.

Audio holes
Blank period of speech, due to malfunctioning of Tran coder boards or PCM circuits.

Voice Clipping
Occurs due to improper implementation of DTX.

Mean Opinion Score (MOS)
ITU standard for estimating speech quality.

IV. SPEECH QUALITY TROUBLESHOOTING

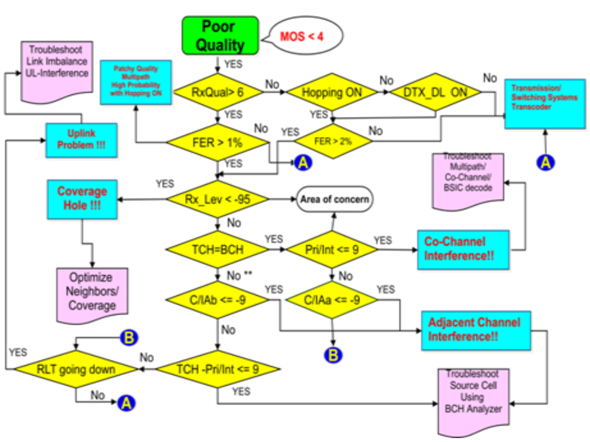

Fig 2:Flow Chart of Speech Quality Troubleshooting

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

V.HANDOVER TROUBLESHOOTING

Weak Neighbors
Total Attempted Calls, Total Dropped Calls, Total Blocked Calls, RxQUAL Full, RxLeve Full,
RLT Current Value, ARFCN, Neighbor Cell Measurements, RR Message, Phone State, Sequency number.
Table 1:Represent Receiving Signal Vs Timing Advance Plot of testing BTS Cluster

Description	Measured Results						Good/ Bad
	T A	> -65	-65 to-75	-75 to-85	-85 to-95	<- 96	
	0						
	-	27663	17589	6778	259	0	
	2						
	3						
	-	275	395	414	93	0	
	4						
	5						
	-	0	0	0	0	0	
	6						
Change in	7- 8	0	0	0	0	0	Good
Rx Level							
with distance	9-10	0	0	0	0	0	
	1						
	1						
	-	0	0	0	0	0	
	1						
	2						
	1						
	3						
	-	0	0	0	0	0	
	1						
	4						
	>						
	1	0	0	0	0	0	
	4						

Fig 3: Plot of testing Represent BTS Cluster

VI.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)	53%	
% of sample -65 to - 75(dBm)	34 %	Good
% of sample -75 to - 85(dBm)	12 %	
% of sample -85 to - 95(dBm)	1 %	
% of sample < -95(dBm)	0 %	

Table 2: Rx Level Vs Samples

VII.QUALITY OF SFH & NON-SFH NETWORK

Quality of Non-SFH network

Description	Measured Results	Good/Bad
95 % of samples should have RxQUAL equal to or less than 4	-- NA --	Good

Table 3: 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 --- 40 % FER --- 98 %	Good

Table 4: Represent Quality of SFH network

VIII.DROP CALL RATE

Description	Measured Results	Good/Bad
Drop call rate should be less than or equal to 2%	0 %	Good

Table 5: Represent Drop Call rate During call forwarding

IX.CALL SETUP SUCCESS RATE

Description	Measured Results	Good/Bad
Call setup success rate should be greater than or equal to 99%	100%	Good

Table 6: Represent Call Setup Success Rate after call mature

X.BLOCKED CALL RATE

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

Table 7: Represent Blocked Call rate if Call not Success

Plots of Coverage Analysis

1. Rx Level.
2. Rx Qual.
3. SQI.
4. FER.

Rx Level plots

Fig 8: Represent plots of Rx Level Sub

Rx Qual Plot

Fig 9: Represent plots of Rx Quality Sub Speech Quality Index Plot

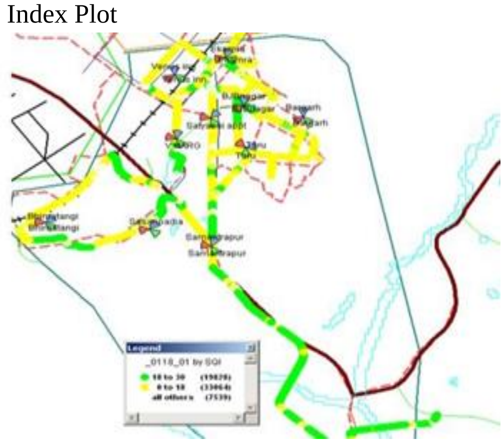

Fig 10: Represent plots of Speech Quality Index (SQI)

Frame Error Rate Plot

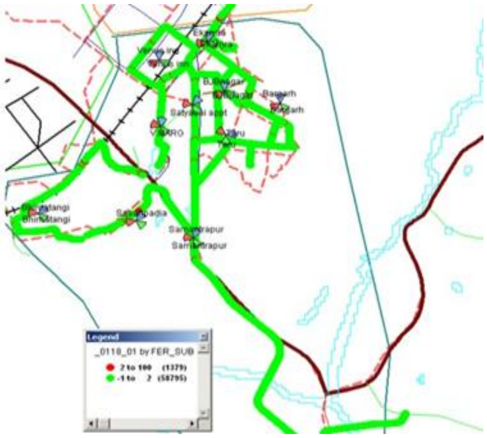

Fig 11: Represent plots of Frame Error Rate (FER)

VIII. 4G NETWORK AND THE KEY PERFORMANCE INDICATORS

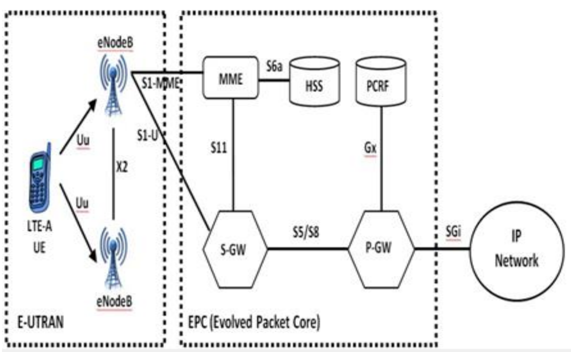

Fig 12: Represent 4G

The 4G Network was borne out of the need for higher data throughput in transmitting information from one point to the other on the Network. The mobile communication technology was intended to replace the 3G communication technology such that it provides all its services over a data network without having to use a circuit-switched system of communication. The Network is designed such that it uses Internet Protocol (IP). The 4G Network utilizes 20MHz bandwidth for communication, is designed to provide an optimum data throughput of 100Mbps to 1Gbps.

The 4G Network has four main parts, which are Mobility Management Entity (MME), Serving Gateway (S-GW), Home Subscriber Server (HSS), and Policy and Charging Rules Function (PCRF). The Core Network of the 4G Network is called Evolved Packet Core Network (EPC) or System Architecture Evolution (SAE).

Key Performance Indicators (4KPIs)

Key Performance Indicators are metrics put in place and are used to check and grade the quality of service delivered to subscribers on the Network. These metrics can be optimized when routine optimization is carried out on the Network to know the serving capacity of a site. They also serve as a measure of how good or bad the service received is. The efficiency of the obtained reference signal is quite close to the RSRP (reference signal received quality), and the interaction between the two is clear. This is used for handover and re-selection of cells in rankings. RSRP measured in decibel milliwatts (dBm) is the average power taken over resource items in increasing bandwidth that holds reference signals for different cells. Each resource block has 84 resource elements, and the resource blocks have a cumulative frequency domain size of 180 kHz, and time-domain size of 0.5ms. Within the time-frequency map, every user is assigned several so-called resource points. The higher the RSRP, the higher the channel efficiency measure allocated to the customer, and the higher the network blocks that a user gets, so the higher the network element modulation, the higher the bit rate. Signal to noise plus interference ratio (SINR) is defined as the ratio of signal intensity to the amount of neighboring cells' average interruption strength, and the background noise is the calculation of the unwanted portion of the signal received. The SINR may be calculated through its Resource Block (RB) from the user's equipment.

This calculation is very critical as it is used to decide the modulation code scheme (MCS) that will be appropriate for data transmission in the RB and thereby evaluate whether or not the throughput is sufficient. A consumer with a strong SINR rating would have a better performance, because higher-order MCS will be added to this signal, resulting in more bits being sent per modulation mark. The received signal strength indicator (RSSI) is close to that of the RSRP. The distinction is that RSSI is only determined in OFDM symbols bearing reference symbols from the non-serving co-channel, and serving cells, neighboring channel disturbance, and consumer device thermal noise. If the resource block number is specified, otherwise, RSRP and RSRQ are defined.

Throughput implies the rate of transmission of data over a user's allocated resource sheets. A person closest to the base station (eNodeB) would more definitely have a higher performance than those further removed from the eNodeB eating [3]. The scheduler within eNodeB employs the UE-sent Channel Quality Indicator (CQI) reports to collect.
The channel quality details received by the users and, on this basis, assign resources to each user.

RSRP and RSRQ Measurement in LTE
RSRP and RSRQ are key measures of signal level and quality for modern LTE networks. In cellular networks, when a mobile moves from cell to cell and performs cell selection/reselection and handover, it has to measure the signal strength/quality of the neighbor cells.
In LTE network, a UE measures two parameters on reference signal: RSRP (Reference Signal Received Power) and RSRQ (Reference Signal Received Quality).
In LTE network, a UE measures two parameters on reference signal:
RSSI – Received Signal Strength Indicator:The carrier RSSI (Receive Strength Signal Indicator) measures the average total received power observed only in OFDM symbols containing reference symbols for antenna port 0 (i.e., OFDM symbol 0 & 4 in a slot) in the measurement bandwidth over N resource blocks.
The total received power of the carrier RSSI includes the power from co-channel serving & non-serving cells, adjacent channel interference, thermal noise, etc. Total measured over 12-subcarriers including RS from Serving Cell, Traffic in the Serving Cell
RSRP – Reference Signal Received Power: RSRP is a RSSI type of measurement, as follows there are some definition of it and some details as well.
It is the power of the LTE Reference Signals spread over the full bandwidth and narrowband.
A minimum of -20 dB SINR (of the S-Synch channel) is needed to detect RSRP/RSRQ
RSRQ – Reference Signal Received Quality: Quality considering also RSSI and the number of used Resource Blocks (N) RSRQ = (N * RSRP) / RSSI measured over the same bandwidth. RSRQ is a C/I type of measurement, and it indicates the quality of the received reference signal. The RSRQ measurement provides additional information when RSRP is not sufficient to make a reliable handover or cell reselection decision.
In the procedure of handover, the LTE specification provides the flexibility of using RSRP, RSRQ, or both. It must to be measured over the same bandwidth:

- Narrowband N = 62 Sub Carriers (6 Resource Blocks)
- Wideband N = full bandwidth (up to 100 Resource Blocks / 20 MHz)

RSRP does a better job of measuring signal power from a specific sector while potentially excluding noise and interference from other sectors.
RSRP levels for usable signal typically range from about -75 dBm close in to an LTE cell site to -120 dBm at the edge of LTE coverage.
RSRP mapping 3GPP TS 36.133 V8.9.0 (2010-03)
The reporting range of RSRP is defined from -140 dBm to – 44 dBm with 1 dB resolution.
The mapping of measured quantity is defined in the table.

Reported value	Measured quantity value	Unit
RSRP_00	RSRP < -140	dBm
RSRP_01	-140 ≤ RSRP < -139	dBm
RSRP_02	-139 ≤ RSRP < -138	dBm
...	...	...
RSRP_95	-46 ≤ RSRP < -45	dBm
RSRP_96	-45 ≤ RSRP < -44	dBm
RSRP_97	-44 ≤ RSRP	dBm

RSRQ In formula:
RSRQ = N x RSRP / RSSI

- N is the number of Physical Resource Blocks (PRBs) over which the RSSI is measured, typically equal to system bandwidth
- RSSI is pure wide band power measurement, including intracell power, interference and noise
- The reporting range of RSRQ is defined from -3…-19.5dB

Reported value	Measured quantity value	Unit
RSRQ_00	RSRQ < -19.5	dB
RSRQ_01	-19.5 ≤ RSRQ < -19	dB
RSRQ_02	-19 ≤ RSRQ < -18.5	dB
...	...	...
RSRQ_32	-4 ≤ RSRQ < -3.5	dB
RSRQ_33	-3.5 ≤ RSRQ < -3	dB
RSRQ_34	-3 ≤ RSRQ	dB

SINR (Signal to Interference & Noise Ratio):
SINR is a measure of signal quality as well but it is not defined in the 3GPP specs but defined by the UE vendor.
It is not reported to the network. SINR is used a lot by operators, and the LTE industry in general, as it better quantifies the relationship between RF conditions and Throughput. LTE UEs typically use SINR to calculate the CQI (Channel Quality Indicator) they report to the network.
It is a common practice to use Signal-to-Interference Ratio (SINR) as an indicator for network quality. It should be however noted that 3GPP specifications do not define SINR and therefore UE does not report SINR to the network. SINR is still internally measured by most UEs and recorded by drive test tools.
4G in college

Here, present the results in relation to 4G Network in the college

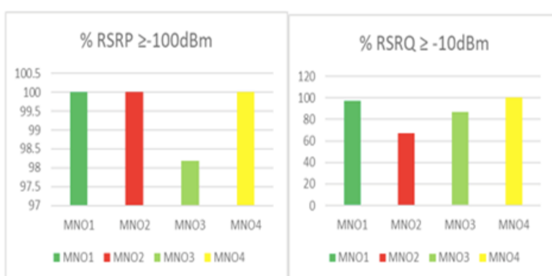

Figure 12: 4G results in College RSRP and RSRQ

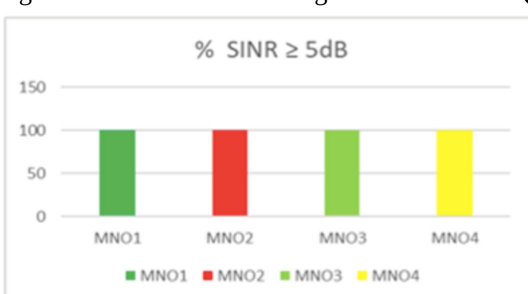

Figure 13: 4G results in College SINR

Result Discussion and Concluding remarks
The 4G test had no exceptional result in the areas in which the test was conducted. Shows that there are specific locations within the college where students can enjoy optimum 4G speed. The fact that we have recorded speed of up to 10Mbps within the College.

Future work

In future work we suggest that SIP could be combined with other mobility protocols to facilitate the mobility management and improve QoS in 4G networks.

IX.CONCLUSION

BAD Spot 1 has poor quality and Call Drop, this spot is covered by Cell 47450, Poor Coverage. Level below - 97 dbm , But Call should not Drop, the other Problem is Interference, Mobile is Hopping on 99 and 84, 99 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 84 and 99, This means there is Co-Channel on 84 also., It could also be multipath issue on 84. In 4G fact that we has recorded speed of up to 10Mbps within the College.

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