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Trend Analysis of Key Cellular Network Quality Performance Metrics

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Abstract

Assessment and analysis of key quality performance indicators of a cellular network is better done over a period of time like days or months in order to have a proper perspective of the reliability of performance of the network or of its base stations (BSs) as had been done in this work than to do so over hourly periods of the day or in isolated manner. This normally helps to consider investigating various social and environmental factors that may be affecting the functionality, reliability, and capacity of the network systems. The effect on one key performance indicator is proved to be more likely to affect all other performance indicators of the network or its base stations as was discovered for majorly the fourth day of our measurements. With the highest total traffic occurring on the fourth day other indicators were also worsen, thereby affecting the service quality experienced by the users. KPIs considered were Total Traffic, CSSR, CDR, HoSR, SDCCH Cong, SDR, TCH Cong and TCHA BH.

Keywords: Key Performance Indicator (KPI), Quality of Service (QoS), Networks, Users, Calls, Metrics.

Introduction

Quality of Service of mobile cellular networks which was defined by ITU-T Rec E.800 [1] as "the collective effect of service performance that determine the degree of satisfaction of a user of the service," has many performance attributes or metrics which have continue to give telecommunication experts and operators lot of keen considerations for continual optimality. Managing network performance requires that relationships existing between QoS KPIs and their effects on the quality of experience (QoE) of the users be identified and rated [2]. Standard network metrics that are measured to rate the quality of service provided by a network operator require proper analysis in order to determine how well the network is actually meeting the ultimate need of satisfying the users' requirements. [3] noted that QoS measurements are essential for quality assurance and benchmarking though they are carried out at high effort and costs. In audio service, such parameters as overage, accessibility and audio quality are usually considered. The coverage parameter is usually determined by measuring the signal strength in order to obtain the size or footprint of the cell. Accessibility determines the network ability to successfully handle calls from initiation to connection and disengagement. In audio quality the clarity of audio communication by network mechanisms is monitored.

Characteristics of cellular networks that determine the quality of performance are captured by the key performance indicators (KPIs) for the purposes of evaluation and monitoring. Network performance is very dynamic due to a lot of atmospheric/environmental phenomena, variability of users' needs and unpredictability of users' mobility, system functionalities, and a host of other constraints. Therefore, network operators must continue to analyze trends in the performance of their networks following results of measurements and performance data gathering systems and software, which include protocol analyzers, drive testing, system monitoring protocols, and the operations and maintenance centers (OMC).

In this study, trends in the performance of a particular base station was analyzed making use of data obtained for eight major key performance indicators over a period of 30 days.

Key Quality Indicators

Service quality indicators are a set of agreed quality of service (QoS) parameters that are used for benchmarking the performance of network operations. The indicators chosen for mobile network services are considered [4]:

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1. to have main influence on the customers satisfaction with regard to the service;
2. to identify technical QoS aspects, which can be influenced by the performance of the network or the terminal;
3. to be measurable by technical means;
4. to be relevant for network operator's national and international benchmarking.

Key quality indicators (KQIs) or rather key performance indicators (KPIs) are usually categorized in the following five phases during the use of a mobile service from the perspective of the customers [4,5]:

1. Network Availability: Probability that the mobile service are offered to a user.
2. Network Accessibility: Probability that the user performs a successful registration on the PLMN, that is, the network indication on the display of the mobile is a signal to the customer that he can use the service of this network operator. It includes KPIs like SDCCH Congestions, TCH Congestions, Assignment Success, etc.
3. Service Accessibility: If the customer wants to use a service, the network operator should provide him as fast as possible access to the service. This includes KPIs that describe how successful the service access is (Call Setup Success Rate) as well as KPIs that describe setup time (Call Setup Time).
4. Service Integrity: This describes the Quality of Service during service use. This includes KPIs that describe the quality of the service (MOS for voice quality).
5. Service Retainability: This describes the termination of services (in accordance with or against the will of the user). It is the measure of the ability of the network to keep up a call. It includes KPIs that count the time that a service can be retained (Call Drop Rate or Call Holding Time, Handover, etc).

In-view of these key quality categories, [6] gave an expansive set of KPIs and their optimal values as follows:

1. Service Performance
    1. RTT Delay (Ms) (800)
    2. Application Throughput (kbps) (25 Kbps)
    3. Call Setup Time
2. Network Congestion
    1. Point of Interconnection (POI) Congestion (<0.5%)
3. Connection Establishment (Accessibility)
    1. Call Setup Success Rate (CSSR) (>95%)
    2. Standalone Dedicated Control Channel (SDCCH) Congestion (<1%)
    3. TDH Congestion (<2%)
4. Connection Maintenance (Retainability)
    1. Call Drop Rate (CDR) (< 2%)
    2. Worst Affected Cells for Call Drop Rate (<5%)
    3. Connection with Good voice quality (>95%)
5. Service Quality
    1. Prepaid – Prepaid Service Success Rate
    2. Number Portability – Drop Rate
    3. Handover Success Rate
6. Network Availability
    1. BTSs Accumulated downtime (<2%)
    2. Worst Affected BTSs due to downtime (<2%)

In his presentation, [7] gave a holistic picture of the Complete KPI Set as shown in figure 1.

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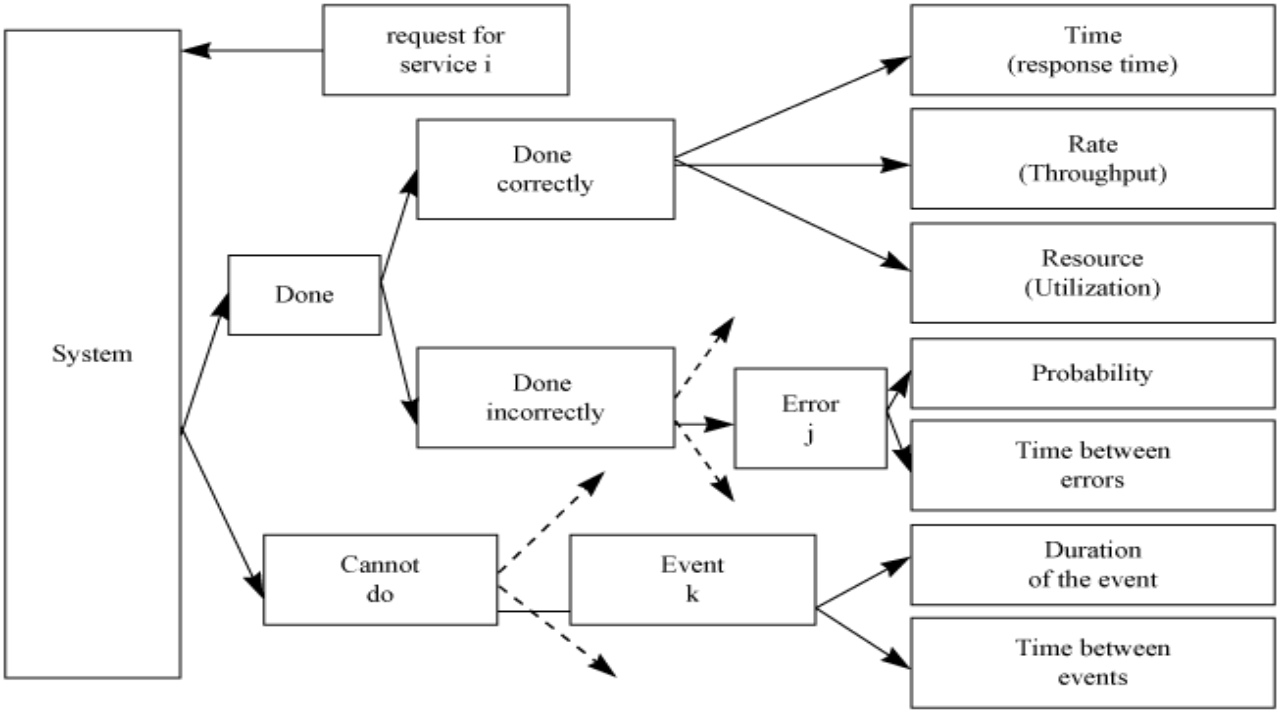

Figure 1: Complete KPIs Set.

KPI Data Monitor

The performance of a network serving base stations are monitored continuously on real-time basis and empirical data that determine the quality of services offered to users [8] had to be obtained. Some of the key performance indicators of quality that are monitored are the Tot Traffic, SDDCH Congestion Rate, CSSR, CDR, HoSR, SDR, TCH Congestion and TCHA BH.

Field Measuring and assessing QoS parameters to obtain KPI data is usually done through drive testing over the coverage area of respective base stations under observation during which the data set collected can include information such as [9]:

1. Signal intensity
2. Signal quality
3. Interference
4. Dropped calls
5. Blocked calls
6. Anomalous events
7. Call statistics
8. Service level statistics
9. Quality of Service information
10. Handover information
11. Neighboring cell information
12. GPS location co-ordinates

Base Station Controller (BSC) consists of several counters in the OMC which are triggered during call setup to indicate and count the various process events, which serve to indicate performance of the base station, the radio iterface and the network as a whole. The readings of these counters are processed to obtain what is known as Key Performance Indicators (KPIs) [10]. KPIs provide useful information to analyze the achieved QoS and network performance. A set of periodic reports of QoS are therefore generated on daily, weekly, monthly, etc basis.

Shown in table 1 are KPI data taken on a GSM base station in the south western part of Nigeria over a period of 30 days in order to evaluate the performance trend of the base station.

Data Trend Analysis

This work studied the trend in the performance of the BS over a period of 30 days rather than just picking on the performance for hours or periods of a day like it is done in most publications [8]. In analyzing BS KPI data, [11] made use of a JAVA Optimization Software Plant to analyze both the raw data and the normalized data. Network performance analysis based on multivariate KPIs is of great note as found in [12], as it made use of statistical analytical methods of Correlation

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Analysis, Factor Analysis, Multidimensional Scaling, Correspondence Analysis and Cluster Analysis.

Table 1a: Measured KPIs of a GSM BS.

DAYS	TRAFFIC	CSSR	CDR	HoSR
1	7.00	93.75	0.96	95.81
2	7.42	91.62	1.01	92.72
3	8.40	91.32	0.96	92.06
4	36.66	54.69	6.74	99.21
5	7.57	88.12	1.77	95.70
6	7.54	92.26	1.19	95.78
7	7.12	95.72	0.23	96.11
8	7.69	92.55	1.03	93.67
9	7.37	94.05	0.86	94.50
10	9.50	93.46	1.62	93.74
11	8.11	97.13	0.22	96.97
12	7.31	96.25	0.69	96.55
13	7.01	92.85	0.68	95.11
14	7.28	94.27	0.30	95.16
15	7.10	94.62	0.58	96.21
16	18.72	90.35	2.10	93.83
17	6.93	92.80	0.44	95.50
18	7.68	94.84	0.97	92.61
19	7.33	93.17	1.20	93.94
20	6.34	94.25	0.69	97.18
21	6.85	94.70	0.66	95.62
22	7.50	93.51	0.72	97.52
23	8.08	93.08	1.10	95.31
24	8.23	94.07	0.64	91.75
25	9.09	93.94	1.04	91.05
26	10.41	94.20	0.90	100.00
27	11.50	94.00	0.83	87.50
28	12.46	93.95	1.20	81.82
29	8.69	89.94	1.72	91.82
30	7.90	93.19	0.44	96.35

Table 1b: Additional Measured KPIs of a GSM BS.

DAYS	SDCCH CONG	SDR	TCH CONG	TCHA BH
1	0.00	1.00	0.00	100.00
2	0.00	1.09	0.00	100.00
3	0.00	1.48	0.00	100.00
4	5.28	9.68	15.41	98.66
5	0.00	1.41	0.00	100.00
6	0.00	1.53	0.00	100.00
7	0.00	0.96	0.00	100.00
8	0.00	1.01	0.00	100.00
9	0.00	1.53	0.00	100.00
10	0.00	1.24	0.00	100.00

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11	0.00	0.60	0.00	100.00
12	0.00	1.15	0.00	100.00
13	0.00	1.34	0.00	100.00
14	0.00	1.41	0.00	100.00
15	0.00	0.87	0.00	100.00
16	0.00	0.49	0.00	100.00
17	0.00	1.00	0.00	100.00
18	0.00	1.03	0.00	100.00
19	0.00	1.00	0.00	100.00
20	0.00	1.06	0.00	100.00
21	0.00	0.87	0.00	100.00
22	0.00	0.90	0.00	100.00
23	0.00	1.74	0.00	100.00
24	0.00	1.80	0.00	100.00
25	0.00	1.22	0.00	100.00
26	0.00	0.94	0.00	100.00
27	0.00	0.99	0.00	100.00
28	0.00	1.50	0.00	100.00
29	0.00	2.42	0.00	100.00
30	0.00	1.61	0.00	100.00

Shown in figures 2 to 10 are plots of the captured KPI data displayed on table 1.

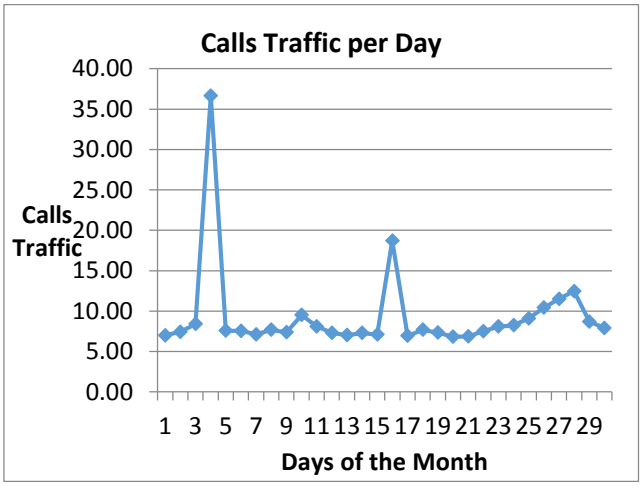

Figure 2: Plot of the Traffic of the Base Station.

Figure 2 shows that the BS had high total call traffic of 36.66, 18.72 and 11.50 on days 4, 16 and 28 respectively, which happen to be precisely intervals of 12 days to each other.

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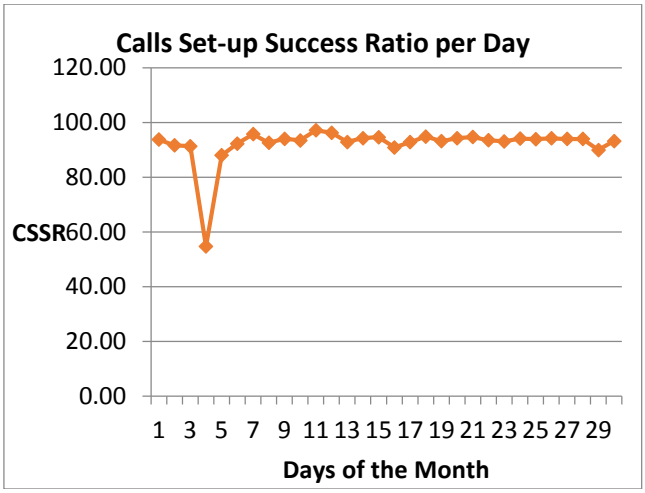

Figure 3: Plot of the Call Set-up Success Ratio of the Base Station.

Figure 3 shows that the Call Setup Success Ratio of the BS deepen seriously on day 4 when it had the highest total call traffic in the month. This must have been as a result of the capacity of the base station sub-systems (BSS) being over-stressed beyond its limit.

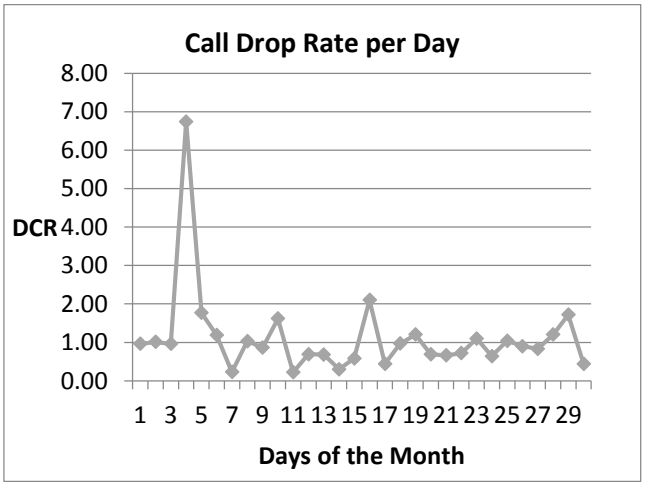

Figure 4: Plot of Rate of Dropped Calls of the Base Station.

In figure 4, Dropped Calls Rate (DCR) happened to be very high on day 4 when we had the highest total traffic and lowest Call Setup Success Rate (CSSR). On day 16 is at a higher value than all other days after day 4, followed by that on day 28. So the trend could be noticed, that when total traffic was high, call setup success rate was poor and more calls are dropped accordingly.

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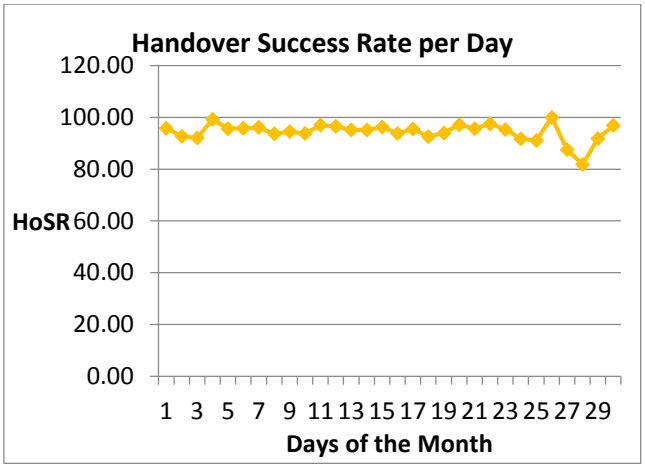

Figure 5: Plot of Handover Success Rate of the Base Station.

In figure 5 it is noticed that only on day 26 were all the calls moving into or out of the BS in question successfully handed over to neighbouring BSs. The worse case was on day 28 when only 81.82% of those calls were successfully handed over.

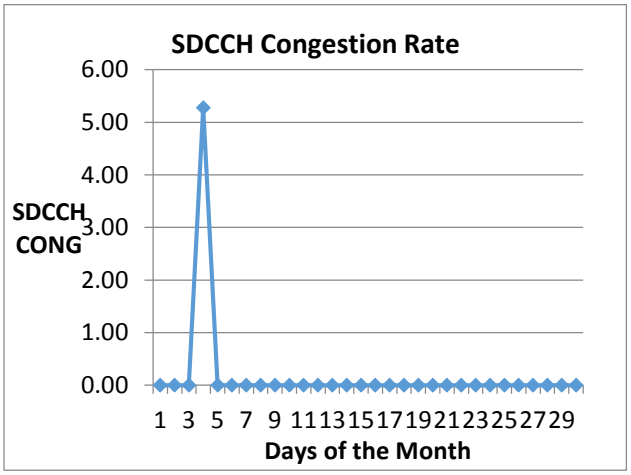

Figure 6: Plot of the SDCCH Congestion Rate of the BS.

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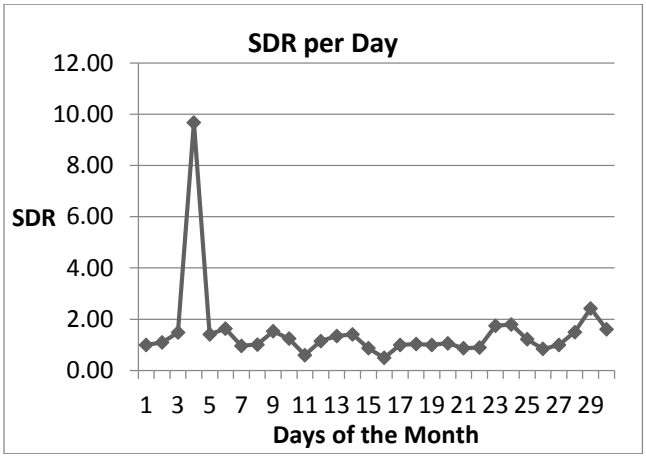

Figure 7: Plot of the Base Station Radio performance.

In figure 6 it is noticed that from the Standalone Dedicated Control Channel Congestion Rate (SDCCH Cong) the base station had a high rate of congestion, which was not suffered at all on any of the others in the month.

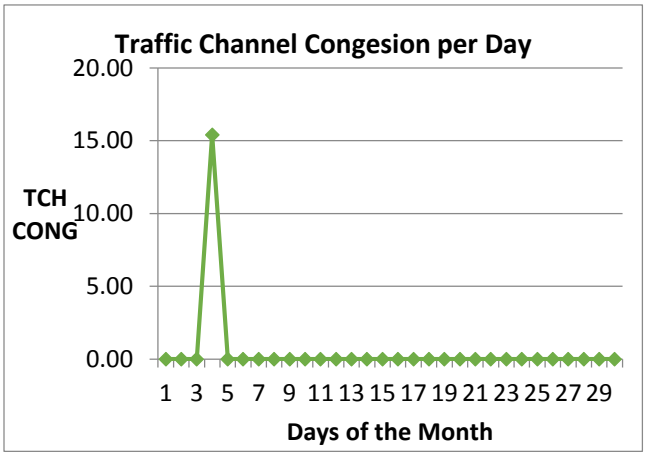

Figure 8: Plot of the Traffic Channel Congestion of the Base Station.

As was seen in figure 6 that the Stand-alone Dedicated Control Channel (SDCCH) was congested on the fourth day, so it also occurred in the Traffic Channel, that it was congested on same day.

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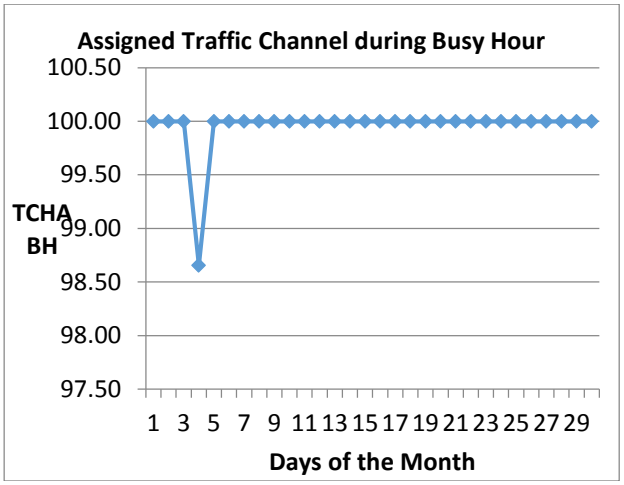

Figure 9: Plot of the Traffic Channel Assignment Busy Hour of the Base Station.

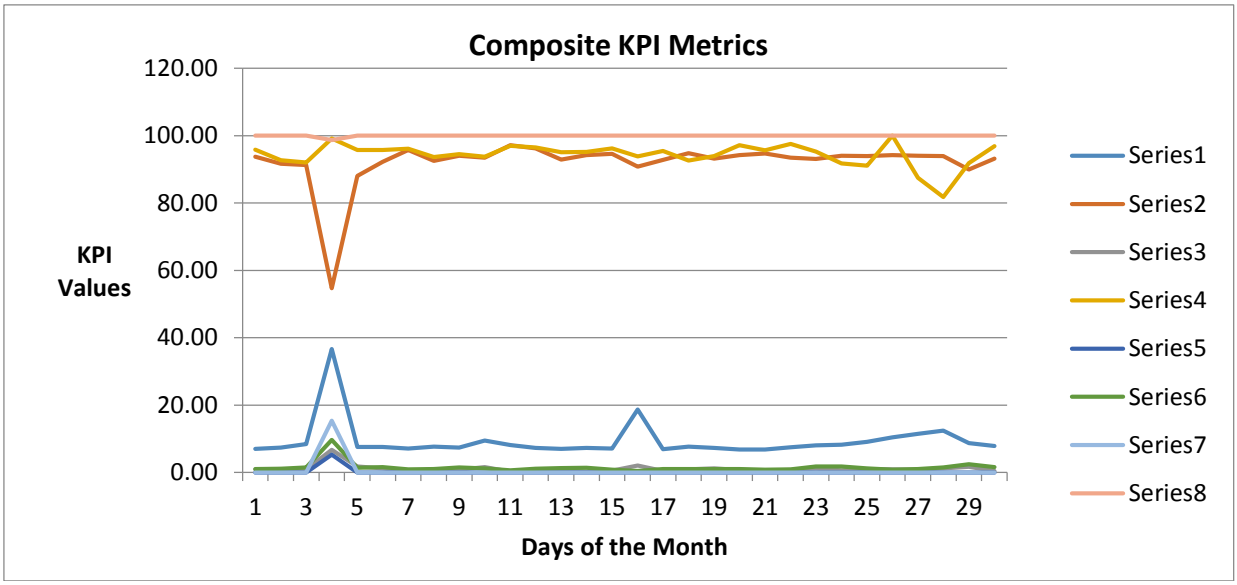

Figure 10: Plot of the Composite KPI Values for the Base Station.

Considering the Composite KPIs Chart in figure 10, it could be noticed that the various metrics worsen majorly on days 4, 16 and 28. This established the fact that degradation in a particular key performance indicator invariably affects the general performance of the network systems making the KPI counters to go the same non-reliability direction.

Conclusions

This study evaluated the performance of mobile cellular base station by carrying out assessment and analysis of eight key performance indicators (KPIs) over a period of 30 days and thereby showed the performance trend of the network over the coverage in question. From KPI data obtained from OMC counters performance record was noticed to be erratic on days 4, 16 and 28, which coincidentally were

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intervals of 12 to each other, but more erratic on day 4 where the total calls traffic was highest. This high total traffic introduced so much instability into the system that all other quality parameters were also disturbed. Therefore, a major instability in the system leads to general instability of all key performance metrics.

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