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Evaluational Study Of A Self Organizing Network (SON) And A GSM Congestion Monitoring System (CMS)

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Abstract – As the number of subscriber increases in the Global System for Mobile communication (GSM) heterogeneous networks, the exponential growth in mobile wireless networks traffic stress the need for a congestion Monitoring system (CMS) for the network to sustain high resources in the Quality of Service (QoS) and Quality of Experience (QoE). It is therefore necessary to note that if congestion in a network is not isolated then there will be an inevitable crash of the network. In this work, KPI of Self-Organized Network (SON) is critically reviewed, a congestion monitoring system for GSM was designed to illustrate the number of calls the system receives per day and this is recorded on daily bases to ascertain the level of congestion. The paper proposed and designed a system that monitors congestion in a network as a mean of network sustenance and also looked at SON as an optimization technique.

Keywords – Cellular network, Mobile congestion, GSM, congestion Monitoring system (CMS), radio frequency (RF) Call set up success rate (CSSR), Call Drop Rate (CDR), Handover Success Rate (HSR), Radio traffic channel (TCH)

I. Introduction

All GSM operators use Key Performance Indicators (KPIs) to judge their network performance and evaluate the Quality of Service (QoS) regarding end user perspective. All the events being occurred over air interface are triggering different counters in the Base Station Controller (BSC). 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.

The term 'self-organized cellular networks' refers to the capability of a wireless communication system- as an autonomous system to be able to rectify itself when there are bottlenecks. Self-organized (cellular) network is a concept based on Artificial Intelligence which aims at building intelligence into computer networks or systems via network modular programming [1,2]. Various application of SON in mobile cellular architecture could be likened to how a robot operates such that learning comes from experience. For instance, when a robot comes across a barrier at first instance- it tends to avoid it by changing its course at any other time. The key feature of a self-organized system is its ability to learn. In the case of using a robot for illustration, learning from previous action-event pairs is inevitable. [3,4]

The general objective of Self Organized Network (SON) is to build intelligence into the network such that it enhances the work of operators, increase fault tolerance and scalability of the network, thereby reducing network complexity, Capital and Operational expenditure (CAPEX and OPEX) [5,6] towards a seamless planning, configuration, and coordination and optimization procedures of the network. This work is required to analyze, design and implement a system that could be used to monitor the level of congestion on a GSM base station, the system would store information about base stations, phone number and calls, the output would include the following,: list of the various base stations, showing the levels of congestion at any level of the day and list all GSM lines, showing the total duration each line spend on the network at any day.

The growing need of the driving public for accurate traffic information has spurred the deployment of large scale dedicated monitoring infrastructure systems, which mainly consist in the use of inductive loop detectors and video cameras. On-board electronic devices have been proposed as an alternative traffic sensing infrastructure, as they usually provide a cost-effective way to collect traffic data, leveraging existing communication infrastructure such as the cellular phone network. A traffic monitoring system based on GPS-enabled smartphones exploits the extensive coverage provided by the cellular network, the high accuracy in position and velocity measurements provided by GPS devices, and the existing infrastructure of the communication network. This article presents a field experiment nicknamed Mobile Century, which was conceived as a proof of concept of such a system. Mobile Century included 100 vehicles carrying a GPS-enabled Nokia N95 phone driving loops on a 10-mile stretch of I-880 near Union City, California, for 8 h. Data were collected using virtual trip lines, which are geographical markers stored in the handset that probabilistically trigger position and speed updates when the handset crosses them. The proposed prototype system provided sufficient data for traffic monitoring purposes while managing the privacy of participants. The data obtained in the experiment were processed in real-time and successfully broadcast on the internet, demonstrating the feasibility of the proposed system for real-time traffic monitoring. Results suggest that a 2–3% penetration of cell phones in the driver population is enough to provide accurate measurements of the velocity of the traffic flow.

II. Review Of Related Works

According to [7], “Game Theory is the study of mathematical models of strategic interaction between rational decision-makers. It is applicable in all fields of social science, as well as in logic and computer science. Originally, it addressed zero-sum games, in which one person’s gains result in losses for the other participants.” [8] itemized the following as the rationale for Game theory in Self-Organizing optimization (self optimization) in cognitive networks: such as modeling and analysis of the interactions among multiple decision makers. And the result of the game can be predicted and thus, the system performance can be enhanced by controlling the utility function and the action update rule of each decision-maker.

Other application areas of game theory in cellular networks include: Reinforcement learning with logic equilibrium for power control- a preliminary game theoretic solution for cognitive small cells, a hierarchical dynamic game approach for spectrum sharing and service selection, an evolutionary game for self-organized resource allocation.

[9] The proposed prototype system provided sufficient data for traffic monitoring purposes while managing the privacy of participants. The data obtained in the experiment were processed in real-time and successfully broadcast on the internet, demonstrating the feasibility of the proposed system for real-time traffic monitoring. Results suggest that a 2–3% penetration of cell phones in the driver population is enough to provide accurate measurements of the velocity of the traffic flow.

[10] Reports study conducted to demonstrate a cost-effective and efficient method using handoffs in wireless cellular communications for monitoring traffic flow, predicting congestion The algorithm uses handoff information and the simulation results showed that the system was able to successfully find the location of the mobile vehicle in a relatively short time and accurately estimate the average speed. The paper describes simple procedure for cellular network performance estimation. In this paper, it has been analytically proved that we can optimize an existing cellular network using different methodologies and fine parameter tuning to offer remarkable QoS to the end users.

[11] Presents real GSM radio frequency (RF) network performance evaluation on the basis of four major KPIs which includes, Call set up success rate (CSSR), Call Drop Rate (CDR), Handover Success Rate (HSR) and Radio traffic channel (TCH) congestion rate. It also focuses to analyze the live network performances.

[12] Recommended accommodation of more and more users in existing network having only limited resources. This is in order to effectively reuse the available bandwidth and frequency carriers in order to avoid internal interference and service degradation.

[13] In order to be capable to measure the network performance, the patterns of a normal day should be considered, while for performance evaluation congestion situations should also be analyzed.

2.1 KPIS For GSM Radio Network Optimization And Achieving Remarkable Qos:

2.1.1 CSSR (Call Set up Success Rate). Call set up success rate is one of the major KPI, which

Should be optimized to improve QoS. CSSR is defined as rate of call attempted until TCH successful assignment.

Result = [(CT01+CT02)/CT03]*100, Where counter CT01 counts SD channels successfully seized for Call termination and CT02 counts SD channels successfully seized for Call origination. CT03 counts SD seizure requests.

In this case SD (usually called SDCCH stands for Stand-alone dedicated control channel) and TCH stands for Traffic channel. A number of issues are related for its degradation as addressed below. a) Issues Observed: CSSR might be affected and degraded due to following issues: Due to radio interface congestion. Due to lack of radio resources allocation (for instance: SDCCH). Increase in radio traffic in inbound network. Faulty BSS Hardware. And Access network Transmission limitations (For instance: abis expansion restrictions.

2.1.1.1 How to diagnose CSSR degradations as well as improvements:

i. Radio link Congestion statistics monitored using radio counter measurement.
ii. Drive Test Reports.
iii. Customer complaints related to block calls have been reviewed.

Improvement Methodologies for CSSR

i. Radio Resources enhancement (Parameter modification/changes in BSS/OMCR) such as half rate, traffic load sharing and direct retry parameters implementation.
ii. Transmission media Expansion to enhance hardware additions (such as TRX).
iii. Faulty Hardware Replacement (such as TRX) in order to ensure the resources availability in live network.

2.1.2 CDR (Call Drop Rate).

Call drop is one of the major issue which affect the quality of service of the telecom network. Call drop

Improvement is a key objective for any cellular operator to provide continuous call maintenance after it is established for customer satisfaction which is linked with their venue of the company. There are many studies conducted measure the call dropping probability in the cellular network [12, 13]

2.1.3 HSR (Handover Success Rate).

Handover Success rate is one of the major KPI that should be optimized to improve handover quality: HSR Defined as Rate of successful handovers (intracell + intracell).

Result = [(CT07+CT08)/ (CT09+CT10)] *100

Condition for this result implies CT07 counts no. of incoming successful handovers & CT08 counts no. of outgoing successful handovers. CT09 counts no. of outgoing HO requests while CT10 counts no. of incoming HO requests. A number of issues are related for its degradation as illustrated below: Issues Observed: HSR might be affected and degraded.

2.1.4 TCH (Traffic Channel) Congestion Rate.

TCH Congestion Rate (TCHCR) Traffic channel Congestion (TCH) rate is one of the major KPI, which should be optimized to improve QoS: we defined TCH as Rate of blocked calls due to resource unavailability.

Result =(CT11 / CT12)*100

Where CT11 counts number of assignment failures when no TCH available while CT12 counts number of normal.

BEST PRACTICE FOR NETWORK EVALUATION FLOW

Network performance and indicators are badly affected due to wrong site integrations especially in terms of definition and parameter point of view.

Requirements of self-optimization Network

1) Frequency allocation Plan 2)
2) Broadcast control channel (BCCH) Plan 3)
3) Neighboring cells Plan
4) Interference (C/I, C/A) values
5) Best Server Plots
6) Site Audit Reports In order to be capable to measure the network performance, the patterns of a normal day should be considered, while for performance evaluation congestion situations should also be analyzed.

III. WIRELESS COMMUNICATION SYSTEM:

A mobile communication system consists of a transmitter, a receiver and a channel is created. The transmitter consists of a burst builder, modulator, up-sampler and filter. The generated information (data) bits are input to the burst builder block, which attaches unique words and guard bits to form a frame structure. The generated burst is input to the modulation block, which performs the mapping of bits to symbols. The modulated signal is passed through an up-sampler and a pulse shaping filter to give a continuous and band limited signal, which is transmitted through a high frequency carrier. The receiver on the other hand, consists of a matched filter, down sampler, demodulator and a BER calculator. The noise added can be modeled as AWGN. The channel should take fading effects into consideration.

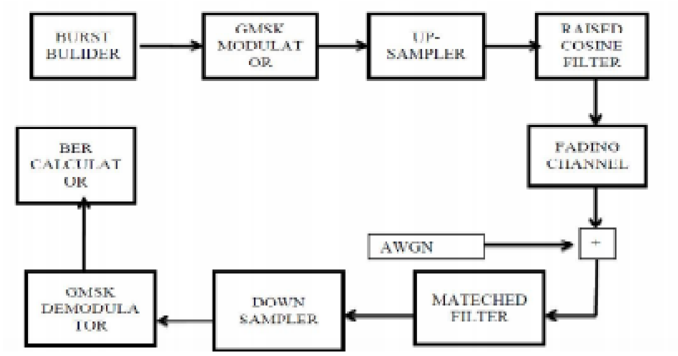

Fig 3.1 Block diagram of a typical wireless cellular System [14]

Figure 3.1 illustrates a general block diagram of a wireless cellular system which the GSM network is a subset of it. We have also formed the design below from this general published framework.

3.1 Analysis and design of GMS CMS

The aim is to ensure that communication is seamless and congestion free. The advantages of the system is to report congested network on time as to allow maintenance and troubleshooting.

3.1.1 We designed a use case diagram showing the interacting parties on the system and their roles. See figure 3.2

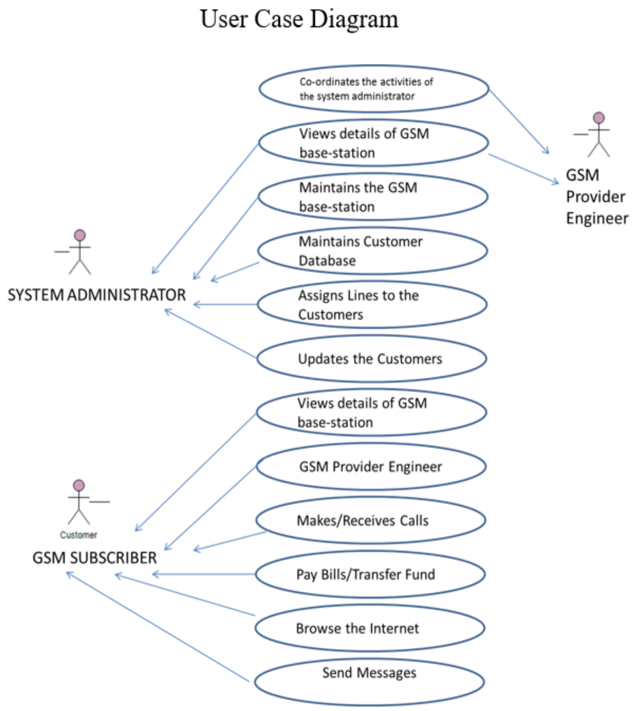

Fig 3.2 Use case diagram of a GSM congestion monitoring system

3.1.2 Class Diagram: In the design, we considered a class diagram as shown in figure 3.2

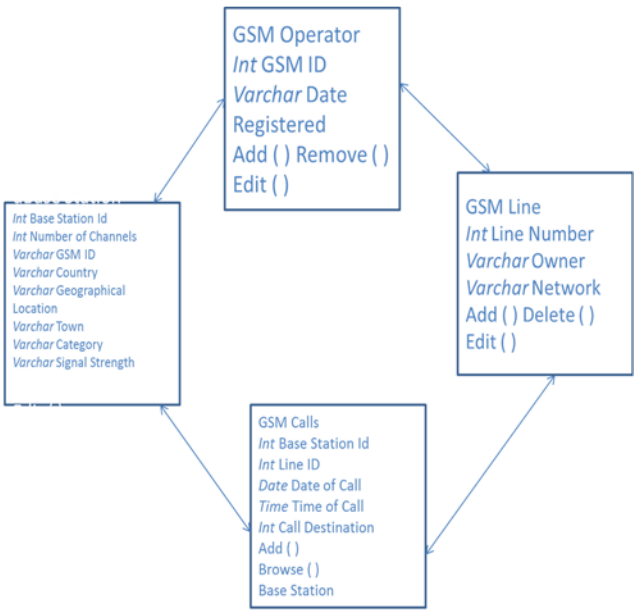

Fig 3.3 class diagram of a GSM congestion monitoring system

3.1.3 Entity Relationship Diagram of CMS:

Figure 3.4 shows the action flow in the system

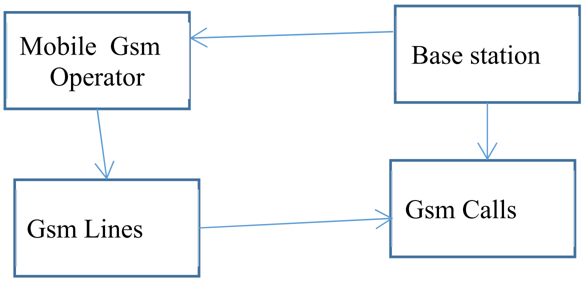

Fig 3.4 Entity Relationship diagram of a GSM congestion monitoring system

3.2 Causes of congestion on GSM network

In October 1986, the internet had the first of what became a series of congestion collapses in America [15] Presently, Nigeria is facing the same GSM congestion problem and having the following as the likely causes of the problem:

Lack of Adequate Base Stations On December 29, 2003 Vanguard published a report where Adrian Wood, MTN 278 managing director, made a declaration that they have one million; five hundred thousand subscribers and that they had only six hundred and seventy base stations all over the country. That gave an average of 2,238 subscribers to a base station, which is highly inadequate. By now the number of their subscribers has increased considerably due to landslide reduction in the prices of their network card. It is doubtful if their present ratio has not reached up to 15,000 subscribers to one base station.

Lack of Adequate Channels Since there are inadequate base stations, it therefore implies that there will be a lack of adequate channels to support the subscribers and the service rolled out by these operators. The number of channels determine the total number of subscribers that can be allowed to use a base station simultaneously at any point in time (NCC 2003). This trends remain the same because any time a base station is added to their network, a high level of promotion is usually rolled out in order to attract more customers, thereby returning the system to status quo.

Competition for Subscribers among the Operators It seems the highest priority of the GSM operators in Nigeria is the total sum of money they make from the subscriber and not the overall quality of service. Subsequently they have catching advertisements and often make false declarations to attract customers to their network, but they don t have the infrastructure to satisfy customer's demands.

Lack of Adequate End to End System in Nigeria the GSM operators are still depending on radio waves to transfer

IV. IMPLEMENTATION OF CONGESTION CONTROL

Congestion control in the GSM network Congestion is the unavailability of the network to the subscriber at the time of making a call [16]. Congestion occurs when there are limited resources at the service point. This type of congestion is known as traffic congestion. This traffic congestion identifies a block of GSM network otherwise known as the cell. One cell is a geographical area covered by one base transceiver station (BTS). The actual size of a cell depends on several factors such as environment, number of users etc. Cells are grouped within a base station controller (BSC).

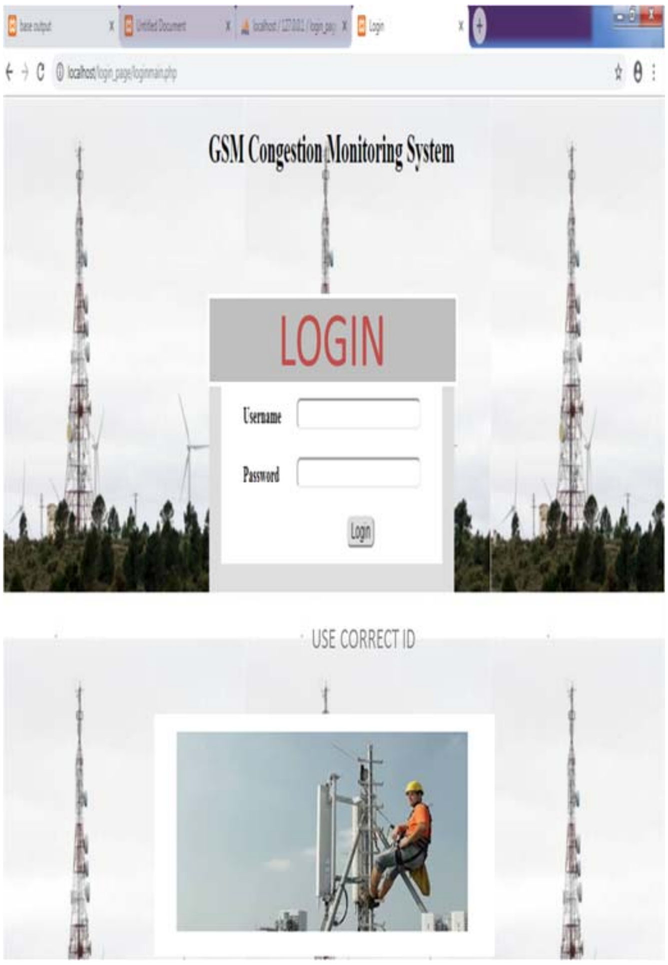

Fig 4.1: User Interface Of The Login Page

The diagram, FIG 4.1 above shows the login page of the system.

Fig4.2 User interface for the Registered GSM lines in the system

Fig 4.2: This illustrates the Number of GSM lines registered in the system A further look at the registered records for various lines as registered in the system with their time details

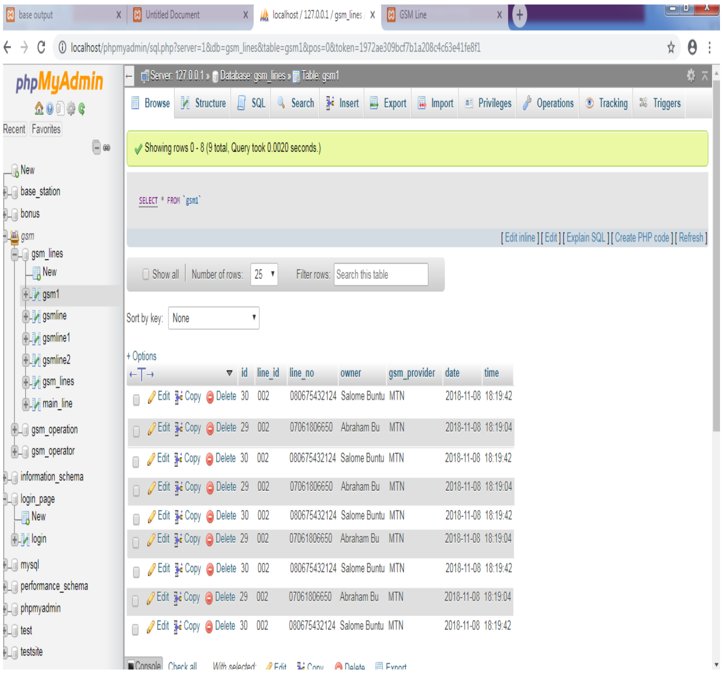

Fig 4.3 User Interface for GSM Line Record Database

Interface diagram that shows how the base stations are registered on the system.

Showing

Table 4.1: Base Station User Interface table

	BSTID),	Geographic Location	Country, State	State	Town	Number

Fig 4.4a: User Interface for Registered Base Stations Entry

This shows the record of different base stations that are already registered in the system.

ID	BSTID	Geo Location	Country	State	Town	No of Channels	Date	Time
001	1	ABIA SOUTH	NIGERIA	ABIA	ABA	3	2018-11-17	09.27.14
002	2	NORTH EAST	NIGERIA	YOBE	DAMATURU	3	2018-11-17	09.35.43
003	1	ENUGU SOUTH	NIGERIA	ENUGU	NSUKKA	2	2018-11-17	09.51.17
004	2	SOUTH EAST	NIGERIA	RIVERS	OYIBO	2	2018-11-17	10.27.12
005	1	SOUTH WEST	NIGERIA	OGUN	OTA	17	2018-11-17	10.29.39
006	1	WEST	NIGERIA	LAGOS	IKEJA	30	2018-11-17	10.27.12
007	2	WEST	LAGOS	LAGOS	IPAJA	30	2018-11-17	11.12.20
008	1	NORTH CENTRAL	ABUJA	ABUJA	GARKI	29	2018-11-17	11.23.18
009	1	NORTH	NIGERIA	NIGER	NIGER	20	2018-11-17	11.30.21

Fig 4.4b: User Interface of Database for Registered Base Stations

This diagram illustrates the number of calls the system receives per day. It records the GSM ID, the Caller ID, Name of the Caller and the GSM provider. This is recorded on daily bases to ascertain the level of congestion.

V. Result And Conclusion:

5.1 Result:

Below is a record of calls made per day

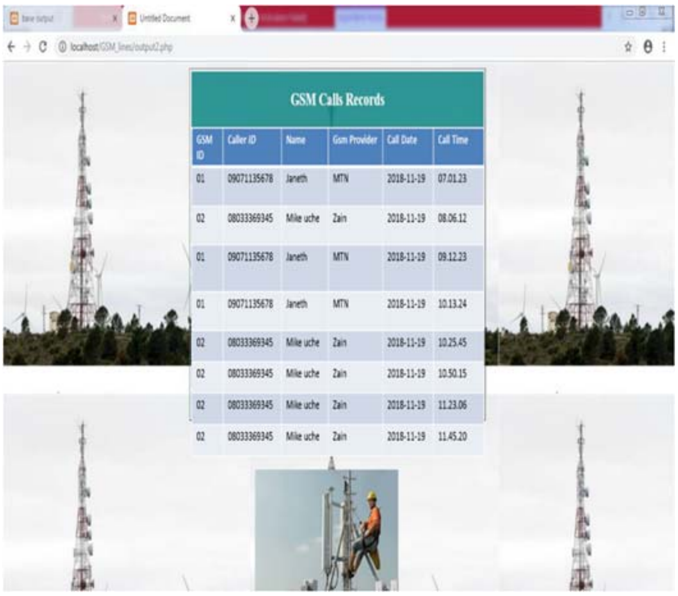

Fig 5.1: User Interface Database for Calls made per day

From our Analysis, We want to draw a simple analogy for CONGESTION LEVEL:

The congestion therefore:

Implies,

Congestion = $\boldsymbol{No.of\ calls\ per\ day/No.of\ channels}$

$\boldsymbol{No.of\ calls\ per\ day}$ = 8

$\boldsymbol{No.of\ channels}$ = 136

Illustrating how the system calculates per day we derive that the congestion is equal to

No of call per day/ no of channels

8/136

Therefore, Congestion of the system =0.058823

5.2 Conclusion

The paper describes simple procedure for cellular network performance estimation using KPI.. In this work, it has been analytically proved that we can optimize an existing cellular network using different methodologies and fine parameter tuning to offer remarkable QoS to the end-users. This work, KPI of Self-Organized Network (SON) is critically reviewed, a congestion monitoring system for GSM was designed to illustrate the number of calls the system receives per day and this is recorded on daily bases to ascertain the level of congestion this is illustrated in the calculated value in above result. Moreover, the issues discussed here are quite helpful for the analysis and performance evaluation of different cellular networks. Optimization teams use QoS reports in order to detect bad service quality areas. These reports also help to plan operators to enhance coverage, improve quality and increase capacity in the days to come. A mobile operator can also set its own QoS targets based on the KPIs in order to ensure end user satisfaction. QoS reports based on different KPIs are duly beneficial for Management team to compare network performance with the competitor's one (called benchmarking) and to plan network evolution and strategy

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