Managing radio part of mobile networks under increased traffic

SANJIN NURBOJA
BH Telecom Ltd, Sarajevo
Obala KulinaBana 8, 71000 Sarajevo
BOSNIA AND HERZEGOVINA
sanjin.nurboja@bhtelecom.ba, www.bhtelecom.ba

VLATKO LIPOVAC
University of Dubrovnik
Branitelja Dubrovnika 29, 20000 Dubrovnik
CROATIA
vlatko.lipovac@unidu.hr,www.unidu.hr

Abstract: - Proper operation of a cellular mobile network is largely dependent on its radio part, during both regular operation as well as under conditions of sudden network traffic peaks. In order to accomplish this goal, networks that are mostly designed and configured for the conditions of normal daily operation need to undergo certain adjustments and so meet the required quality and capacity levels even in situations of dramatically increased traffic, such that occur during holidays, major sport events, concerts etc. This paper analyzes the ways how to modify the radio part of networks to adequately address conditions of highly increased traffic. With this goal, statistics and performance indicators are used as a starting point for the analysis, aiming to provide guidelines on how to achieve the minimum required quality and capacity for the network operation, so enabling appropriate quality of experience on the part of network services user.

Key-Words: - mobile networks, radio part, traffic, load, modification model

1 Introduction

One of the main problems of mobile communication networks is to find the optimal adjustment of the system parameters to match current real traffic conditions. Key-performance-indicators (KPI) of the network should be continuously monitored and analyzed, and when necessary appropriate actions must be undertaken to customize the operation of mobile networks to new requirements. The performance of the entire mobile network is largely dependent on performance of its radio part, whose improvement process presumes reduction of overload, congestion, call drops, etc. One of the goals with this respect is optimal use of existing equipment by adjusting the appropriate parameters. As radio network design itself can be a limitation, it is necessary to adapt and modify the performance of the radio network by adjusting its parameters. With this respect, analyzing and resolving problematic situations during high traffic peaks is the main issue and motivation of this paper, specifically focused on adaptation of the mobile network radio part to the conditions of significantly increased traffic.
This goal was planned to be reached through the analysis of the needed resources under increased traffic, proper selection and application of the appropriate model of changes, as well as optimal revision of existing capacity in order to provide additional resources for critical situations.

2 Test System

Unfortunately, a common approach to situations of increased traffic in the network under test (being of no exception regionwide) is still reactive one based on individual network parameters or sections changes with little if any comprehensive proactive strategy including all aspects of the 2G and 3G radio network, i.e. provide a layered exploration to complex radio network, which will include base station controllers, as well as SW applications that are necessary for the manipulation.
Implementation of the radio part of the mobile network is often to the large extent determined by the network equipment manufacturer; we used Ericsson radio network for testing, but focusing the the range of functions standardized for all equipment manufacturers. The mobile network under test was of the operator BH Telecom in Sarajevo and the network management carried out

by Ericsson Operation System Support (OSS) system. Event Based Applications for GSM, Business Objects and ENIQ¸ were used for measuring the key-performance-indicators (KPI) and statistical analysis (short and long term). Base station controllers were used for applying the modification model via applications such as WinFIOL, CNA, BSM, AMOS, OSS Network and Common Explorer, etc. The implementation of parameter changes was carried out on the test system at the selected location. Generally speaking, the mobile system consists of a user part (MS), the radio part (base station controllers (BSC) and base stations (BS), the core network and the surveillance system (as part of the OSS). The so-called general circumstances define current technological development of the radio system and the regulations that come from the standardization bodies (3GPP, ETSI, ITU-T). On the other hand, real circumstances are related to the capabilities and technical limitations that come from the equipment manufacturer (Ericsson in this case). The framework in which we made the system adjustment in situations of extremely high traffic is determined by the above-mentioned two-fold limitations. The developed model for modification was periodically applied to the existing system before and during situations with highly increased traffic, as we tried to minimize the effects of performance degradation.

Situations with high load can be differentiated by their character. Events such as concerts, sports matches etc., they are considered local, and so are addressed by local BTSes, while events like national holidays stretch over much wider geographical area whose coverage usually includes the entire radio network. Consequently, for local character events only the performance of relevant base stations is of interest (BTS outside the selected test clusters), while the events of regional and national character engage all BTSes or test cluster to demonstrate the advantages and disadvantages at the macro level, and consequently on the whole system.

The test cluster consisted of six base stations connected to the single BSC and RNC, and further to the core network.

The selected locations for BTSes in the city of Sarajevo were: Campus of the University of Sarajevo, Railway Station, School of Electrical Engineering, Faculty of Forestry, Holiday Inn hotel and Dolac Malta Post Office. All of them incorporated 2G base stations at 900MHz and 1800MHz, and 3G base stations at 2100MHz. The BSCs in the test networks were organized on a regional basis. At the time of the testing, the system used six BSCs and a single RNC.

The test system without adjustments during the events of interest exhibited degraded performance. The initial analysis revealed the percentage of time congestion on SDCCH channels to exceed 10%, resulting with hard drop of availability of signaling channels. Consequently, this leaded to the decrease of network resorces for allocation of TCH channels. The percentage of SDCCH Establishment Success Rate went below 90% with rising traffic level, resulting with reduction of successfully established SDCCH and TCH channels, so hardly affecting the quality-of-experience (QoE) on the part of the user, regarding the availability of network resources.

3 Modification model

The model is represented by the flowchart on Fig.1.

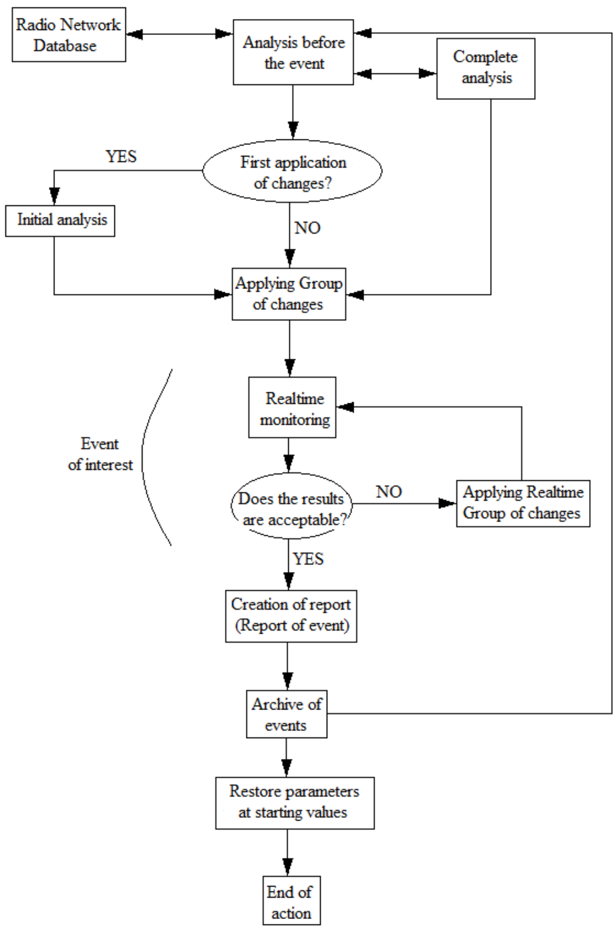

Fig.1 Flowchart for the modification model

The analysis before the event – baselining - incorporates comprehensive measurement of the statistics (short and long term) with the aim of collecting accurate information about the behaviour of the radio system. Measurements of the statistics were performed during normal system utilization, then during high traffic without changing any

ISBN: 978-960-474-308-7

parameters (initial analysis), and finally during highly increased traffic with changed parameters on individual cells or group of cells. Depending on the targeted geographic area, the system analysis can be done at the cell level, at the level of the whole BTS, for a specific cluster of BTSes or at the level of the entire radio system. The baselining is performed in order to acquire more accurate information about the behavior of the system in a given area before the occurrence of an event (concert, holiday, etc.). The recommended time interval for the baselining is 30 days (or more) before the event. By this way, it is possible to identify the behavior of the system (e.g. traffic trend) in a given area, depending on user habits (use of voice channels, mobile internet, text messaging, etc.), so that system modification is applied to increase the capacity and/or quality. After the appliance of the modification model before occurrence of the event, it is necessary to further analyze the consequences on the neighboring BTSs. The results of the analysis must be taken into consideration when it comes to the next application of the modification model. The analysis before the event also includes assessing HW and SW status of individual base stations, in order to determine the feasibility of the adjustment implementation. For the purpose of this type of analysis it is necessary to create and update the radio network database that contains information about the HW and SW capabilities of BSes and BSCs. During the baseline analysis it is necessary to record the HW and SW status of the parameters before applying the group of modifications to the BS, as well as the state of the BS parameters of the BSCs and the RNC. This is done in order to restore the parameters to their original values after the event of interest. In order to identify the optimal group of modifications to be applied, various types of analyses could be performed before the event: system baseling, baselining based on identifying traffic trends, baselining before the event coming out of HW and SW configurations for a specific BTS, baselining by constant monitoring overall statistics throughout the year, baselining by means of the results on the adjacent cells, baselining by making use of the archive of previous events etc. The initial analysis of the system (the first time modification of the system) represents the first iteration of analysis before the event, and is carried out in order to monitor the behaviour of the system before and during the events of interest, as well as marking the critical points that may occur. Achieving the minimum required quality and capacity of the network during peak traffic situations, as compared to the KPI values for standard daily load (average world NetQB values) is the imperative.

NetQB measurements represent quarterly Ericsson measurments of KPI indicators from 149 different 2G networks and 74 different 3G networks in 2010. The goals to be achieved with this respect are summarized as it follows:

<u>Quality of 2G network</u>
- Random Access Success Rate:
  bringing above 95% (NetQB 98.8%)
- SDCCH Drop Rate:
  pushing below 2% (NetQB 0.86%)
- TCH Drop Rate:
  pushing below 3.5% (NetQB 0.98%)
- TCH Assignment Success Rate:
  bringing above 95% (NetQB 98.94%)
- Handover Success Rate:
  bringing above 95% (NetQB 97.86%)
- SDCCH Establishment Success Rate:
  bringing above 90% (NetQB iznad 95%)

<u>Capacity of 2G network</u>
- TCH Time Congestion:
  pushing below 3% (NetQB 0.4%)
- SDCCH Time Congestion:
  pushing below 2% (NetQB 0.0829%)

<u>Quality of 3G network</u>
- Speech Call Completion:
  bringing above 90% (NetQB 98.391%)
- PS Interactive Call Completion:
  bringing above 90% (NetQB 98.899%)
- Speech Drop Rate:
  pushing below 3.5% (NetQB 0.694%)
- PS Interactive Drop Rate:
  pushing below 8% or on a daily level
  (NetQB 0.017 %)
- RRC CS Connection Success:
  bringing above 90% (NetQB 99.358%)
- RRC PS Connection Success:
  bringing above 90% (NetQB 99.481%)
- RRC Connection Success:
  bringing above 90% (NetQB 99.4195%)

<u>Capacity of 3G network</u>
- Uplink and Downlink Channel Element (CE)
  utilization: over 90% is considered to be congested
- Code Usage for R99, 5 HS and 10 HS codes:
  over 90% is considered to be congested
- R99 and HS Throughput Downlink:
  bringing to a daily level
- R99 and EUL Throughput Uplink:
  bringing to a daily level
- Speech Accessibility:

ISBN: 978-960-474-308-7

bringing above 90% (NetQB 99.078%)
- PS Interactive Accessibility:
bringing above 90% (NetQB 98.915%)

After the analysis is done we can determine the appropriate group of changes. The group of changes defines a set of modified parameters that will affect the system before the occurrence of an event of interest, in order to improve the behavior of the system at the time of peak traffic. The choice of adjustment method in the group of modifications are made in relation to the KPI that is to be brought within the desired limit value. For example, with the BTS showing high usage of SMS messages, we will apply the group of modification parameters enabling the increase of SDCCH channels etc.
The following 2G functionalities within the group of changes were tested during the events of interest: inactive state of the mobile station (cell selection, cell reselection, location update and paging), active state of the mobile station (handover), GSM radio network functionality related to "Locating" algorithm (Hierarchical Cell Structure HCS, Cell Load Sharing CLS) and additional functionality of the 2G radio network (Dynamic Channel Allocation with Half Rate, Increased SDCCH capacity).
The following 3G functionality within group of changes were tested during the events of interest:
WCDMA RAN Capacity Management (System Resources Handling, RN Admission Control, RN Congestion Control) and WCDMA RAN Load Sharing (Inter-Frequency Load Sharing, Directed Retry to GSM, Load based HO to GSM, Inter-frequency Load based HO, HSDPA and non-HSPA Inter-frequency Load Sharing).
Previously made initial analysis revealed unsatisfactory values for the percentage of SDCCH Time Congestion and percentage of SDCCH Establishment Success Rate.
Because of the limited space of this paper, we will only demonstrate the procedure of bringing the percentage of SDCCH Time Congestion and percentage of SDCCH Establishment Success Rate into the desired range, by using the appropriate group of modifications regarding SDCCH capacity.

4 Test Results Example

The functionality of increased SDCCH capacity is a very useful option for situations with peak traffic and for reducing congestion on SDCCH channels. It may be necessary to define the distribution of a number of SDCCH channels compared to the daily utilization [1] [4]. The group of modifications defines (using more SDCCH channels) up to 2 blocks of 8 SDCCH subslots per TRX in the cell. Increasing the number of SDCCH channels increases the capacity for signaling and SMS messages, while proportionately reducing the capacity for TCH channels (due to the use of the same HW capacity). If we want to increase the SDCCH capacity without reducing capacity on TCH channel, we must invest in HW expansion. The SDCCH parameter defines the number of SDCCH/8 channels in the cell. In cells with more channel groups, SDCCH/8 is defined in CHGR0 and the rest on the CHGR1. The standard recommendation for identifying the required number of SDCCH channels for a period of normal load for different number of transceivers (TRX-s) is given in Table 1 [1]:

TRX	SDCCH TS
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4

Table 1 Parameter settings for SDCCH

It should be noted that SDCCH TS in the table represents blocks of 8 SDCCH subslots used for signaling and SMS messages. In congested cells it is necessary to increase the number of SDCCH channels, while at the same time reducing the TCH channels, so the decision to increase SDCCH parameters should be adopted in relation to the level of SDCCH and TCH congestion. If there is massive congestion on SDCCH channels and no congestion on TCH channels, then increasing the SDCCH parameter will certainly lead to improved network performance. It is proposed to manually increase the number of SDCCH channels for 1 on all cells in the test system [2, 3] in order to enable additional capacity for signalling and SMS messages during periods of increased load. If necessary, it is recommended to add another SDCCH channel in cells in which real-time statistics monitor detects serious SDCCH congestion. It is recommended [5 - 8] to set SDCCH = 2 for cells where, at the instant of events of interest, the SDCCH was set to 1, then SDCCH = 3 for the cells where the value was 2, etc. After the event of interest, the SDCCH must return to its earlier values (due to network dimensioning for standard load).
The percentage of SDCCH Time Congestion during standard load was found to be in the range of up to 0.0829%, while the target value at the time of high

ISBN: 978-960-474-308-7

load was below 2%. The higher values would result in sudden drops and less availability of signaling channel, and thus network resources in terms of allocation of TCH channel. During a religious holiday of Eid al-Adha (16th november 2010), after using appropriate group of modifications for increasing SDCCH capacity, the percentage of congestion on SDCCH channels was found to be less than 2% in DM1 cells (approx. 0.55%) and DM2 (approx. 0.8%).

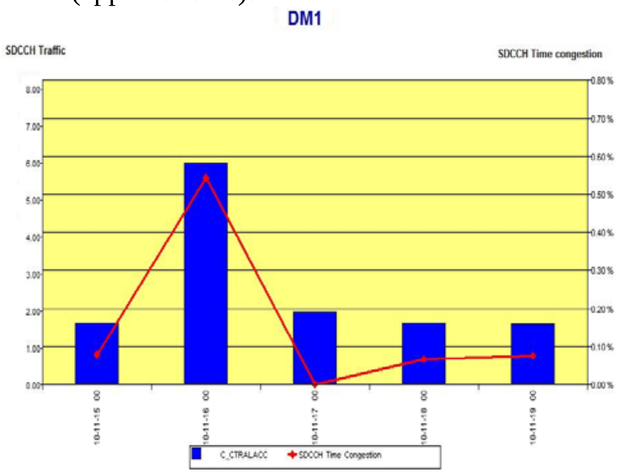

Fig.2 Reducing congestion on SDCCH channels on DM1 cell by increasing SDCCH capacity

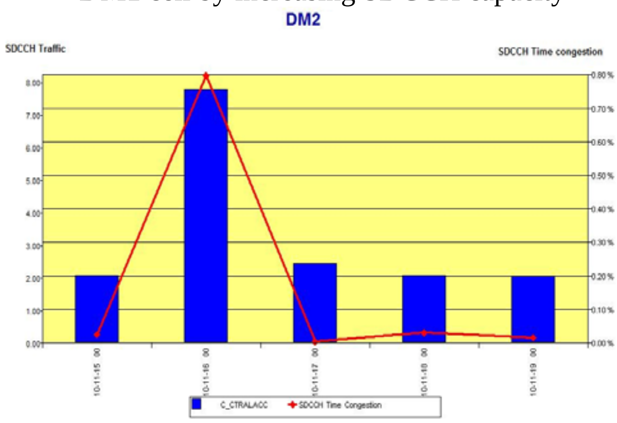

Fig.3 Reducing congestion on SDCCH channels on DM2 cell by increasing SDCCH capacity

In terms of KPIs for the percentage of successful establishment of SDCCH channel, the target value is above 90%. Any lower values indirectly indicate deterioration of network performance that users can experience. This KPI is most commonly used as an additional indicator that points to a specific user behavior (eg, problems with connection). Fig.4 and Fig.5 show the behavior of the system in terms of SDCCH Establishment Success Rate during a religious holiday, after using appropriate group of modifications for increasing SDCCH capacity. Note that the value of the SDCCH Establishment Success Rate during the holiday was above 90% on the DM1 (approx. 91%) and DM2 (approx. 95%) cells.

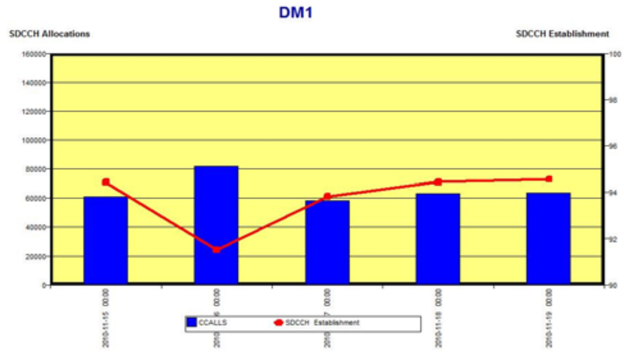

Fig.4 SDCCH Establishment Success Rate on DM1 cell during the holiday

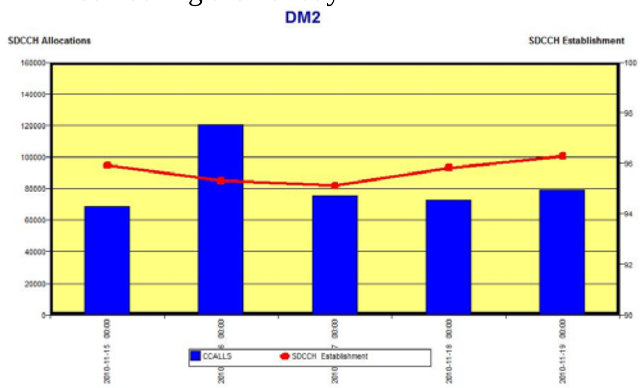

Fig.5 SDCCH Establishment Success Rate on DM2 cell during the holiday

Modifying the SDCCH parameter increases the network capacity in terms of SDCCH channel, and reduce the capacity of TCH channels, so it is necessary to find the proper balance with this regard, especially during periods of peak traffic. This will result in reducing congestion during the establishment of signalling data flow and sending SMS messages. At the same time, the increasing availability of SDCCH channels will increase the possibility of granting TCH channels.

4 Conclusion

Applying hierarchical approach to adaptation of the radio cellular network has proved to be necessary in order to introduce systematic approach and find comprehensive solutions to the problems that arise within periods of the peak traffic. The actions to be undertaken should be properly arranged in order to improve the adaptation and implementation of the management of the radio part of the mobile network during increased traffic. The model of changes is used for this purpose. Applying the group of modifications to increase the capacity of SDCCH channels enables reducing congestion time on SDCCH channels and increasing the percentage of successful establishments of SDCCH channels. This way the KPI parameters of interest were brought to the required level.

References:

[1] Ericsson library for operators, *ALEX (AXE Library Explorer) library*, 2010-.
[2] Ajay R. Mishra, *Fundamentals of Cellular Network Planning and Optimisation*, J.Wiley & Sons Ltd, 2004.
[3] Ajay R. Mishra, *Advanced Cellular Network Planning and Optimisation*, J.Wiley & Sons Ltd, 2007.
[4] Ericsson AB, *Optimization of the GSM radio part, BH Telecom mobile*, project 2005.
[5] Ericsson AB, *WCDMA RAN Configuration and Optimization with OSS-RC*, Ericsson Sweden Stockholm, Education Center, 2009.
[6] G. Gomez, R. Sanchez, *End-to-End Quality of Service over Cellular Networks*, J.Wiley & Sons Ltd, 2005.
[7] B. Walke, R. Seidenberg, M. P. Althoff, *UMTS The Fundamentals*, Communications Networks, Aachen University (Germany), J.Wiley & Sons Ltd, 2003.
[8] Jaana Laiho, Achim Wacker, Tomas Novosad, *Radio Network Planning and Optimisation for UMTS*, 2nd edition, J.Wiley & Sons Ltd, 2006.

ISBN: 978-960-474-308-7