IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 10, Issue 6, Ver. I (Nov - Dec .2015), PP 31-35
www.iosrjournals.org

Litrature Survey of Traffic Analysis and Congestion Modeling In Mobile Network

Aliyu Ozovehe[1], Okpo U. Okereke[2] and Anene E. C[2]
[1]*Trifield Technology Limited, Abuja, Nigeria*
[2]*Electrical and Electronics Engineering Programme, Abubakar Tafawa Balewa University, Bauchi, Nigeria*

Abstract: *Network congestion is one of the major problems of GSM service providers as the number of subscribers increase and new services are introduced. All the proposed techniques in literatures for controlling congestion are centered on two principles which are either to reject excessive traffic to prevent over-utilization of network resources or diverting excess load if overload occurs. These techniques do not specify how network resource can be provided to absorb rejected or diverted traffic so that revenue will not be lost during congestion and hence, they do not really address congestion during busy hour. Real-time traffic analysis is required to understand user traffic demand pattern on network resources for proper prediction of network congestion so that resources can be provided to take care of rejected or diverted traffic. However, available literature survey on mobile network congestion modeling showed that none of the existing literature: address congestion at the three basic elements of GSM network to characterize end-to-end connection; use busy hour traffic data to adequately dimension GSM network elements so that the network can cope with load B. Therefore, effective congestion control mechanism that can take these research gaps into consideration for proper forecasting and efficient dimension of the network resources to address busy hour congestion must be developed. This paper is a preliminary report on development of such accurate congestion prediction model through an ongoing research work using real live network data from one of the Service provider's networks in Abuja, Nigeria as a case study.*
Key words: *Busy hour, Key performance indicators, Network management system, Traffic congestion and Traffic load*

I. Introduction

The performance of mobile network is one important issue that concerns Service provider and Telecommunication regulator with the main goal of keeping subscribers satisfy. In order to achieve the best performance, service providers have to monitor and optimize the network continuously to meet Regulator target metric for all the key performance indicators (KPI). A Network Management System (NMS) with an online database is responsible for the collection of data on the networks (Motorola, 2001). To measure the network congestion, traffic patterns of a normal day is required for profiling. Traffic profile can be done using hours of a whole day along the x-axis and traffic in Erlangs along the y-axis. The distribution of daily traffic in Erlangs varies with the time of day which could be high intensity - peak hours and festive periods; low intensity hours during a normal daily activities. There are three different traffic profiles (Fiche and Hebuterne, 2004):

- Normal day corresponds to usual activities during a day - Load A
- High load condition corresponds to special days in a year - Load B
- Exceptional conditions corresponds to unexpected happenings –Load C

It is important that the network resources can serve traffic of load A and very good if it can serve the traffic of load B. However, it is very difficult to meet the third condition, because this load corresponds to unpredictable situations like natural hazards.

KPI that are used for traffic profile in mobile network are: busy hour Traffic (in Erlang), Call Setup Success Rate (CSSR), Handover Success Rate (HOSR), Stand-alone Dedicated Control Channel (SDCCH) congestion and Traffic channel (TCH) congestion, call drop rate (Adegoke et. al, 2008; Kollar, 2008) and traffic load.

TCH congestion is used to measure the demand for services and channels utilization in the network. Call Setup Success Rate and Handover Success Rate are used to measure the impact of congestion in the two most important procedures during a call attempt and movement during the call. SDCCH and TCH congestion are used to locate where exactly congestion appears in terms of logical channels, as these channels are the ones most affected in a congestion situation (Huawei, 2008). Meeting the metric target set for these KPIs by the Nigerian Communications Commission (NCC) remained the greatest challenge to Service providers in Nigeria. The NCC target values for cell and BSC metric is shown in Table 1 (NCC, 2012).

Table1: NCC target values for cell and BSC metric

KPI	NCC TARGET (%)
CSSR	>=98
CDR	<=2
HOSR	>=98
SDCCH CONG	<=0.2
CCR	>=96
TECH CONG	<=2

The decision by the Nigerian Communications Commission (NCC) to sanction all GSM operators in Nigeria for failure to meet quality of service (QoS) standards has shown that GSM network quality and reliability needed to be improved upon. A typical report by NCC for all GSM network providers in Nigeria is shown in Table 2 (NCC, 2012).

Table 2: NCC April 2012 QoS Report

S/N	OPERATORS	CSSR		CDR		HoSR		SDCCH		CCR		TCH CoNG.	
		MAR' 12	APR' 12	MAR' 12	APR' 12	MAR' 12	APR' 12	MAR' 12	APR' 12	MAR' 12	APR' 12	MAR' 12	APR' 12
1	MTN	97.07	96.42	1.33	1.41	95.14	94.67	0.58	0.61	95.78	95.20	1.33	0.89
2	GLO	98.33	98.02	1.13	1.17	97.73	97.67	0.39	0.39	97.44	97.45	1.09	1.09
3	EMTS	94.38	96.88	0.86	1.22	89.67	91.28	1.64	1.36	93.05	95.81	1.40	1.95
4	AIRTEL	97.39	97.48	0.86	0.92	96.64	96.33	0.58	0.47	96.56	96.59	0.54	0.55
5	NCC TARGET	≥98%		≤2%		≥98%		≤0.2%		≥96%		≤2%	

This work is an ongoing research effort to unravel the causes of network degradation using one of the Service provider's networks in Abuja as a case study. The work is not limited to BSC level network performance as reported in Table 2; it is an end-to-end traffic and congestion analysis of access and core network elements to characterize the entire network performance.

To ensure that network costs are minimized without compromising QoS, networks are usually design such that during busy hour, only 2% of call attempts will be blocked if all the channels are in use. In practice, this is not the case when there is congestion (Huei-Wen and Yi-Chou 2003). To unravel the course (s) of the congestion, GSM network performance evaluation are done by network service providers, consulting companies, Telecommunication Regulators and independent researchers using NMS measurements KPIs in order to bench mark the performance of the network in terms of GoS and QoS. Usually, extensive measurements from live network or simulation of network data are required to determine optimal cellular network dimension in order to reduce network congestion and improve QoS. We present in this work a review of such related works on the basis of network elements they have addressed.

II. Mobile Network Traffic Analysis and Comparative Studies

Traffic analysis is important for evaluating the performance of existing networks and network optimization. Generally, performance evaluation seeks to address the questions of accessibility to service, service retainability, and connection quality and network coverage. The events that occurred in BTS trigger different counters in the BSC and MSC memory that is used for performance monitoring and network evaluation. Various KPIs that are used to measure network performances are derived with the help of these counters using different formulations (Haider et al. 2009).

In practice, the performance can be monitored at different sections of the network (Kennedy, 2005) and in GSM, calls are routed from MS to BTS to BSC to MSC and vice-versa and the network performance can be evaluated using any of these three basic elements of the network. This is the approach used by all the existing literature on GSM network performance in terms of resource allocation and resource utilization. Some of the early works on GSM network elements performance were done mostly on access part of the network particularly at BTS level. For example, Jabbari (1996) proposed a traffic model for mobile network, using Markov chain to determine call blocking and handoff failure probabilities when no queuing of new or handover calls is performed while Min et al. (1997) modeled the effect of user mobility on the performance of mobile networks using office hours traffic data. Location updates were analyzed to evaluate the probability of call dropping when handover is needed.

Likewise, Francisco and Luis (1999) analyzed seventy eight traffic channels and showed that a single dedicated channel is enough for a good quality service. Hugo et al. (2000) investigated GSM/GPRS system performance using dedicated number of GPRS channels and some idle periods between voice calls for GPRS data packet transfers. Reservation of more channels brings handover failure and dropped call probability to very small values but lack of ordinary channels produces a larger new calls blocking probability. Papaoulakis et al. (2002) presented the results of study of DCS1800 Um-interface using daily traffic measurement data. The performance indicators used are Traffic, CSSR, HOSR, SDCCH and TCH congestion. The analysis shows the limitations of the system to accommodate extreme offered traffic without adding more resources. A model combining simulations for paging, signaling and traffic channels was developed by Allen et al. (2003) to investigate the optimal dimensioning of a finite physical resource allocated across multiple logical channels with multiple traffic types.

Boulmalf and Akhtar (2003) evaluated the performance of GSM1900 Um-interface of two different vendors using daily measurement data for one week. The performance indicators used are peak hour traffic; CSSR; Handover Failure; congestion on control channels (SDCCH blocking rate); congestion on traffic channels (TCH blocking Rate); drop on traffic channels; drop on control channels; cells with TCH congestion rate exceeding 2% and TCH Mean Holding Time.In another work, Božidar (2006) analyzed traffic data from a trunked radio network operated by Ecomm in UK using OPNET model. The findings indicated that traditional Erlang models for voice traffic may not be suitable for evaluating the performance of trunked radio networks. In a related work, Ojesami et al. (2011) formulated a dynamic channel allocation model using Markov chain technique as an improvement on Xialong and Geyong (2007).

There is one problem common to all these works at BTS level, exclusive handover channels were employed for easy compliance of QoS standards for ongoing calls and handover failure reduction. However, the disadvantage is that new calls blocking increase as a result of the reduction of available ordinary channels. The solution should have been that resources should be added to maintain GoS of the network as proposed in the work of Papaoulakis et al. (2002) and supported by (Flood, 1998).

Some researchers have worked on either BSC level only or both BTS and BSC of the network. For example, Boulmalf et al. (2009) evaluated the performance of GSM-1900 BSC utilization using eight months daily traffic data and established peak hour for the network. The performance indicators used are peak hour traffic, TCH mean holding time, TCH Utilization, congestion on TCH, drop call on TCH, congestion on CCH and drop call on CCH. The work shown that traffic increase from Monday through Friday and forecasted traffic over time using regression analysis. Also, Popoola et al. (2009) used network accessibility, service retainability and network coverage to evaluate QoS on BSC of four GSM networks in Nigeria. The result of the study showed that the QoS of GSM network is not reliable.

Haider et al. (2009) presented procedure for GSM network performance evaluation of BTS and BSC on the basis of four KPIs: CSSR, CDR, HSR and TCH congestion rate. This work needs to be improved upon by using real live network data to verify the accuracy of the procedure. Also, Biebuma et al. (2010) proposed a mobility model to evaluate BSC performance and customer behaviour in GSM network by capturing the traffic volume from 18 BSCs for one year. Osahenvemwen and Emagbetere (2011) analyzed some BSC performance using offered traffic, carried traffic, block traffic, call completion rate (CCR), busy hour call attempt (BHCA) and GOS as traffic performance indicators. The data was analyzed using excel package to determine the busy hour which was observed to be 18:00 GMT.

To re-route calls to less busy cells within a BSC area, Alarape et al. (2011) combined dynamic load balancing technique with call admission control (CAC). The combined algorithms were implemented on JAVA platform using real life call data record (CDR) taken from Globacom Nigeria Limited. New Call Blocking and Handoff Call Dropping Probabilities (NCBP and HCDP) were used to measure the performance results. The two probabilities were computed for CAC and the combined scheme. The results obtained showed that there is significant reduction in the values of both NCBP and HCDP of cells considered for the new combined scheme when compared with that of the CAC only. However, this technique can only work in clusters with many BTS.

The work of Mughele and Wole (2012) investigated the causes of congestion using a survey research design methodology, live data from MTN BTS and BSC, as well as customer feedback. The study showed that a major cause of MTN network congestion is lack of adequate network resources to cope with the demand of its teeming subscribers. Similarly, Ohaneme et al. (2012) simulated some traffic models in MATLAB environment for evaluating performance of GSM networks using Call Completion Ratio (CCR) and Answer Seizure Ratio (ASR) on four mobile network's BTS and BSC in Nigeria. The result showed that the QoS is not reliable as a result of network congestion. However, the work did not identify the cause or proffer solution to the congestion problem. Similarly, Oladeji et al. (2013) established traffic pattern for 6 BSCs over 24 hours in

Nigeria for a period of five months and the analysis showed that the busy hour is 20:00 on five of the BSCs and 14:00 on one of the BSCs.

The major problem is that these works did not capture MSC network elements and hence they do not show end-to-end subscriber perspective of the performance of the network.

There are very few works that used live traffic data to investigate the performance of GSM core network (i.e. MSC) due the unwillingness of network Providers and Regulators to provide such data. Madhusmita and Saraju (2011) evaluated GSM network utilization using eight months measurements data of some BSCs and MSCs. The work showed that busy hour vary from one MSC to the other, weekday traffic is more than that of weekend traffic, channel availability is well within limits and SDCCH congestion is beyond threshold limits for the investigated BSCs. In a related development, Osahenvemwen and Emagbetere (2012) investigated 10 routes of Globalcom BSC and MSC network performance for six months period. The result shows that the offered traffic and carried traffic both have only a slight variation from each other which indicates that network is not congesting. Also, the TCH availability in MSC is high indicating that high amount of subscribers can access the network through the A-interface without experiencing congestion.

Raheem and Okereke (2014) utilized the training capability of Levenberg-Marquardt Algorithms (LMA) to develop a model that predict traffic congestion on a BSC - MSC link in Bauchi Metropolis of Nigeria using twelve month hourly traffic data. Regression analysis between predicted traffic congestion volumes and corresponding actual traffic congestion volumes was reported to have a correlation coefficient of 0.986 which demonstrate the accuracy of the prediction. However, the causes of congestion were not identified and solutions were not proffer to resolve the congestion.

From the foregoing, these reviewed works showed that previous researches had attempted to address the congestion problem either at access network level or core network level but none has considered both the access network and the core network at the same time. Hence, in this work, traffic will be analyzed at both access and core network (BTS, BSC and MSC) levels using live network traffic load and KPIs that affect these elements during busy hour for a period of two years so as to properly dimension the network elements. Ability to establish a correlation between these KPIs and the offered traffic load will help to proffer solutions to identify cases of channel congestion and also to determine the inputs to the artificial intelligence prediction model to be developed.

III. Research Gap

The reviewed works showed that all the existing literature did not:

- Address congestion at the three basic elements of GSM network to characterize end-to-end connection as it is proposed in this work.
- Use busy hour traffic data to dimension GSM network elements as it is proposed in this work.
- Properly establish the statistical basis of the cause(s) of the identified congestion as it is proposed in this work.
- Use sufficient data in their analysis to improve statistical quality of their results as it is proposed in this work.

IV. Conclusion

The need to address the poor QoS by GSM network operators calls for development of congestion prediction models that can accurately predict congestion and traffic demand pattern of GSM/GPRS networks users based on real live network data. The objective of this work is to analyze busy hour traffic at cells, BSC and MSC using NCC defined KPI target metrics which will help network operator to dimension network resources efficiently in order to have enough time to optimize the network and provide resource to avoid congestion and improve network performance.

Reference

[1]. Adegoke, A., Babalola I., and Balogun, W. (2008) "Performance Evaluation of GSM Mobile System in Nigeria," Pacific Journal of Science and Technology, pp. 436-441, 2008

[2]. Alarape, M.A., Akinwale, A.T. and Folorunso, O.,(2011), A Combined Scheme for Controlling GSM Network Calls Congestion. International Journal of Computer Application (0975-8887), Vol.14 No. 3

[3]. Allen, K., Fitzpatrick, P. and Ivanovich, M., (2003), Joint Traffic Signaling Capacity Analysis in GSM

[4]. Biebuma, J.J.,Orakwe, S.I and Igbekele, O.J., (2010), Traffic Modeling for Capacity Analysis of GSM Networks in Nigeria, Continental Journal of Information Technology, 4: 78 – 79.

[5]. Boulmalf, M., Abrache, J., Aouam, T., and Horroud, H. (2009) ,"Traffic Analysis of GSM Networks," IEEE Journal, pp. 498-503, 2009.

[6]. Boulmalf M. and Akhtar S., (2003), Performance Evaluation of Operational GSM's Air-Interface (Um), in Proc. of Applied Telecommunication Symposium," Orlando, Florida, pages 62-65, March 2003.

[7]. Božidar, V., (2006), Modeling and Characterization of Traffic in a Public Safety Wireless Network, Master of Applied Science Thesis, Simon Fraser University, Fall 2006.

[8]. Fiche, G. and Hebuterne, G. (2004), Communicating systems & networks: Traffic & performance. 2004. Kogan page. ISBN: 978-1-90399-635-5

[9]. Flood, J.E. (1998) Telecommunications Switching, Traffic and Networks, Chapter 4: Telecommunications Traffic, New York: Prentice-Hall, 1998.

[10]. Francisco, A. M. and Luis, M. C., (1999), Mobility Effects on Teletraffic in GSM, Instituto de Telecomunicações / Instituto Superior Técnico, Technical University of Lisbon, 1999

[11]. Haider B, Zafrullah M. and Islam M. K. (2009),Radio Frequency Optimization and QoS Evaluation in Operational GSM Network, Proceedings of the World Congress on Engineering and Computer Science 2009 Vol I WCECS 2009, October 20-22, 2009, San Francisco, USA

[12]. Huawei., (2008), GSM Radio Network Optimization, Expert Training Manual, C&C08, EAST8000

[13]. Huei-Wen, F. and Yi-Chou T., (2003), Channel Allocation and Performance Study for the Integrated GSM/GPRS System, Department of Computer Science and Information Engineering, National Taiwan University of Science and Technology, IEEE, 2003

[14]. Hugo, A., José C., and Luis M. C., (2000), Analysis of a Traffic Model for GSM/GPRS, Instituto de Telecomunicações/Instituto Superior Técnico, Technical University of Lisbon, 2000.

[15]. Jabari, B.,(1996), Teletraffic Aspects of Evolving and Next-Generation Wireless Communication Networks, IEEE Personal Communications Mag., Vol. 3, No.6, Dec. 1996, pp4-9

[16]. Kennedy I.,(2005), Lost Call Theory, Lecture Notes, ELEN5007 – Teletraffic Engineering, School of Electrical and Information Engineering, University of the Witwatersrand, 2005

[17]. Kollar, M., (2008), Evaluation of Real Call Set up Success Rate in GSM, Acta Electrotechnica et Informatica, pp. 53-56, 2008.

[18]. Madhusmita, P and Saraju, P. P., (2011) , "Traffic Analysis and Optimization of GSM Network," IJCSI International Journal ofComputer Science Issues, pp. 28-31, 2011.

[19]. Min, Y. C.; Tai S. K.; Ho S. C.; Dan K. S., (1997), Modeling of terminal mobility to evaluate the number of location updates, 1997 IEEE International Conference on Volume 3, Issue , 8-12 Jun 1997 Page(s):1266 – 1270

[20]. MOTOROLA (2001), "CP02 Introduction to GSM Cellular," 2001

[21]. Mughele, E. S and Wole O., (2012), Congestion Control Mechanisms and Patterns of Call Distribution in GSM Telecommunication Networks: The Case of MTN Nigeria, African Journal of Computer and ICT. December, 2012- ISSN 2006-1781, Vol. 5 No.

[22]. Nigeria Communication Commission, (2012) "Nigeria Communication Commission," April 2012. [Online]. Available http://www.ncc.gov.ng/index.php

[23]. Ohaneme, C. O., Akpado, K. A., Alumona, T. L. and Emenike, I. S.,(2012), "Performance Evaluation of Mobile Network Interconnections in Nigeria," International Journal of Scientific and Engineering Research, pp. Volume 3, Issue 4, 2012.

[24]. Ojesanmi, O.A., Oyebisi, T.O., Oyebode, E.O. and Makinde, O.E., (2011), Performance Analysis of Congestion Control Scheme for Mobile Communication Network, International Journal of Computer Science and Telecommunications, Volume 2, Issue 8, November 2011

[25]. Oladeji E.O, Onwuka E.N, Aibinu M.A (2013) Determination of Voice Traffic Busy Hour and Traffic Forecasting in Global System of Mobile Communication (GSM) in Nigeria, 11th Malaysia International Conference on Communications 26th - 28th November 2013, Kuala Lumpur, Malaysia

[26]. Osahenvemwen, O. and Emagbetere, J., (2011), Determination of Busy Hour in Mobile Communication in Nigeria, Global Journal of Research in Engineering, 2011.

[27]. Papaoulakis K. N., Nikitopoulos D., Gkroustiotis E., Kechagias C., Karambalis C. and Karetsos G. (2002), A Comprehensive Study and Performance Evaluation of Operational GSM and GPRS Systems under Varying Traffic Conditions, Telecommunications Laboratory National Technical University of Athens Heroon Polytechniou 9, 15773 Athens, Greece. newton.ee.auth.gr/ist2002/papers/SessionT4/2502089

[28]. Popoola J. J., Megbowon I. O. and Adeloye V. S. A. (2009), Performance Evaluation and Improvement on Quality of Service of Global System for Mobile Communications in Nigeria, Journal of Information Technology Impact Vol.9, No. 2, pp. 91-106,2009

[29]. Raheem, M.A. and Okereke, O.U., (2014), A Neural Network Approach to GSM Traffic Congestion Prediction, American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-11, pp-131-138,2014

[30]. Xiaolong, J. and Geyong, M., (2007), Modeling Priority Queuing Systems with Multi-Class Self-Similar Network Traffic, Proceedings of ICC'07, pp. 13-19