ISSN 2229-5518

Development of an Adaptive Algorithm for an Improved Congestion Control in a GSM Network

G. K. Azever, S. M Sani, A. M. S Tekanyi and A. D Usman

Department of Electrical and Computer Engineering*, Ahmadu Bello University, Zaria Nigeria,*

Abstract - In this paper, we developed an adaptive algorithm for improved bandwidth utilization in a GSM network and to reduce congestion. The work adopted the joint scheme based on call admission control (CAC), bandwidth degradation and load balancing techniques, while using Dijkstra algorithm to determine the shortest path to route calls among the collocated base station cells. The developed joint scheme algorithm is implemented using NetBeans IDE 6.9.1 platform to generate call traffic so as to obtain call parameters results, including NCBP and HCDP values of interest. These performance metrics namely, New Call Blocking Probability (NCBP) and Handover Call Dropping Probability (HCDP) were evaluated to determine the results prior to, and after, the application of the joint scheme algorithm. Simulation results shows that call blocking and call dropping reduced by 48.3% and 52.3% respectively of the algorithms used before and after the application of joint scheme. This signifies that the developed congestion control scheme has better quality of service due to minimum number of call blocked and call dropped in the network.

Keywords: CAC, NCBP, HCDP, Adaptive Algorithm, Bandwidth degradation and Load Balancing

.

1. INTRODUCTION

The ever-growing demand for mobile services provided by GSM communications has resulted in making network congestion a real problem to contend with. The problem of congestion is one of network management issue that affects the quality of service (QoS) rendered by network providers. The problem of congestion and lack of proper capacity planning strategy by the network providers are often regarded as critical issues that demand serious attention due to their potential havoc [1]. Congestion in the context of network management occurs when the resource demands exceed the available capacity; as such packets are lost due to too much queuing in the network [2]. Consequently, a congestion control scheme helps the network to recover from the congestion state, thereby improving network performance as well as bandwidth utilization. Therefore, congestion control refers to the actions taken by the network to minimize the intensity, the spread and duration of congestion [3].

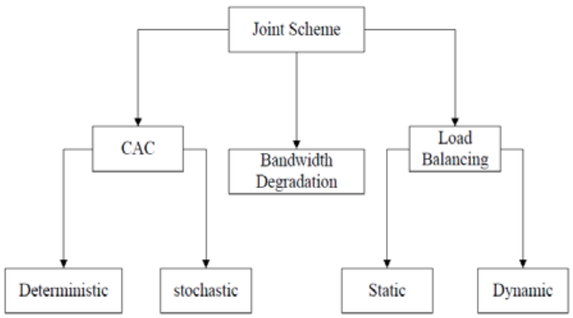

Figure 1: Developed Congestion Control Scheme

In order to address the issue of network congestion, several control schemes including the proposed joint scheme of Figure 1, have been made to forestall and manage the congestion in mobile networks like the GSM network by numerous researchers. Some of the adopted techniques include channel borrowing, cell-splitting, cell sectoring, development of micro-cells, dynamic channel allocation and deployment of soft handover schemes [4],[5]. These techniques of controlling congestion employed so far in all systems either reject excessive traffic to prevent overload from occurring or diverting traffic to avoid overload [1].

- *Author azevergeorge@yahoo.com is currently pursuing master's degree program in communication Engineering in Ahmadu Bello university Zaria, Kaduna state, Nigeria. E-mail: sojasteve@mail.com*
- *Dr. Suleiman Mohammed Sani is currently a Senior Lecturer in the Department of Electrical and Computer Engineering in Ahmadu Bello University Zaria, Nigeria. E-mail: smsani@abu.edu.ng.*
- *Dr. A. M. S Tekanyi is currently a Lecturer I in the Department of Electrical and computer Ahmadu Belo University Zaria, Nigeria. E-mail: amtekanyi@abu.edu.ng*
- *Dr. A. D. Usman is a senior lecturer in the department of electrical and computer engineering, Ahmadu Bello university Zaria*

2. Contribution/Scope

The significant contribution is the development of an adaptive algorithm that reduces call blocking and call dropping for congestion control in GSM networks.

3. Related Works

Considerably amount of works has been carried out in this area the few once are reviewed as follows:

The work [6] combined admission control with bandwidth adaptation to enhance the QoS provisioning. The technique blocked a new call if the number of ongoing calls was greater than or equal to a stated threshold value or there was no bandwidth available in the given cell to accommodate the new call. However, bandwidth was not adaptive to all the outgoing calls that could be adjusted on the arrival of any incoming calls or at the completion of an ongoing call. In the work [7] combined bandwidth reallocation policy with adaptive call control. The significant difference between their work and that of [6] was that the bandwidths of all the outgoing calls were adjusted on the arrival of any incoming calls or at the completion of an ongoing call. Still, their work was only focused on adaptive call control technique and other congestion control schemes were not considered. [1] Presented a combined scheme that used load balancing strategy to aid an efficient adaptive call admission control scheme. The combined algorithms were implemented on Java platform using real life Call Data Record (CDR). The Results obtained with combined scheme shows better performance when compared with CAC scheme. However, their work was

ISSN 2229-5518

algorithm based algorithm and there was no analytical model for designing the algorithms used. Furthermore, [8] proposed service class based on joint call admission control and adaptive bandwidth management scheme for heterogeneous wireless networks. The scheme made call admission decision based of service class of incoming calls using Markov analytical model. They derive NCBP and HCDP for the joint call admission control. However load balancing technique was not considered.

These reviewed considered the congestion mechanism based on call admission control, bandwidth degradation, load balancing or any combination of the two these techniques. As a result, their works gave high values of congestion parameters NCBP and HCDP. In this paper, however, an adaptive algorithm for bandwidth optimization and congestion control is developed considering call admission control, bandwidth degradation and load balancing so as to effectively control congestion with a view to improve the quality of service of a GSM network

4. Developed Methodology and Discussion

The developed approach was carried out into two phases namely: development of the joint scheme algorithm and its implementation as shown in figure 2[9].

From the CAC part of Figure 1, the input parameters such as the number of cells n, cell capacity C, and simulation time t were inserted into the algorithm and run to generate calls. Whenever CAC algorithm accepts an arrival call being new or handover, the system allocates maximum bandwidth for the call. Thus, if the Bandwidth Available is larger than or equal to the Bandwidth Maximum, the arrival call is accepted and incremented [7], [10]. Otherwise, the arrival call will be blocked/dropped due to lack of insufficient bandwidth for the requested call.

In the bandwidth degradation flow chart illustrated in Figure 1, the call failure types from CAC algorithm are further processed by the degradation algorithm. The algorithm checks for the availability of the unused resources and also whether these resources are enough for the requested bandwidth of the incoming call (that is, $BW_{avail} \geq$ BW requested). If yes, the arrival call is accepted and incremented to the next incoming call. Therefore, calls with the largest allocated bandwidth greater than BW_A, lower or equal priority to arrival call are degraded to have lower bandwidth not less than BW available [7], [9]. If the saved bandwidth is larger than or equal to bandwidth needed, the arrival call is allocated the bandwidth requested and accepted. Otherwise, a call rejected.

The last step is the development of load balancing algorithm. As shown in Figure 1, the CAC and bandwidth degradation are developed either to admit or reject call(s) into network. If the call is rejected as a result of insufficient bandwidth, the load balancing algorithm then collects the failed call and checks if the resource available space

ISSN 2229-5518

(unused bandwidth) in a cell is greater than zero. If yes, the arrival call is accepted and migrated to lightly loaded cell in the cluster of cells in the BSC [1]. Otherwise, the call is regarded as a blocked/dropped.

SI **5.Simulation of Joint Scheme Algorithm**

The developed joint scheme algorithm was implemented using Java (NetBeans IDE) programming environment. A Compaq Laptop Computer System (Presario CQ56) with system properties (processor of AMD V160 2.40GHz, RAM OF 2.00GB, of 32bits, window 7) was used. The simulation of the developed joint scheme was performed in two phases; the first Simulation combines CAC and bandwidth degradation algorithms which serve as the baseline model. Secondly, the simulation of algorithm which combines the three techniques namely, CAC, bandwidth degradation and load balancing was carried out. All the simulation was carried out for an average of six hours and it was done on an hourly basis [9].

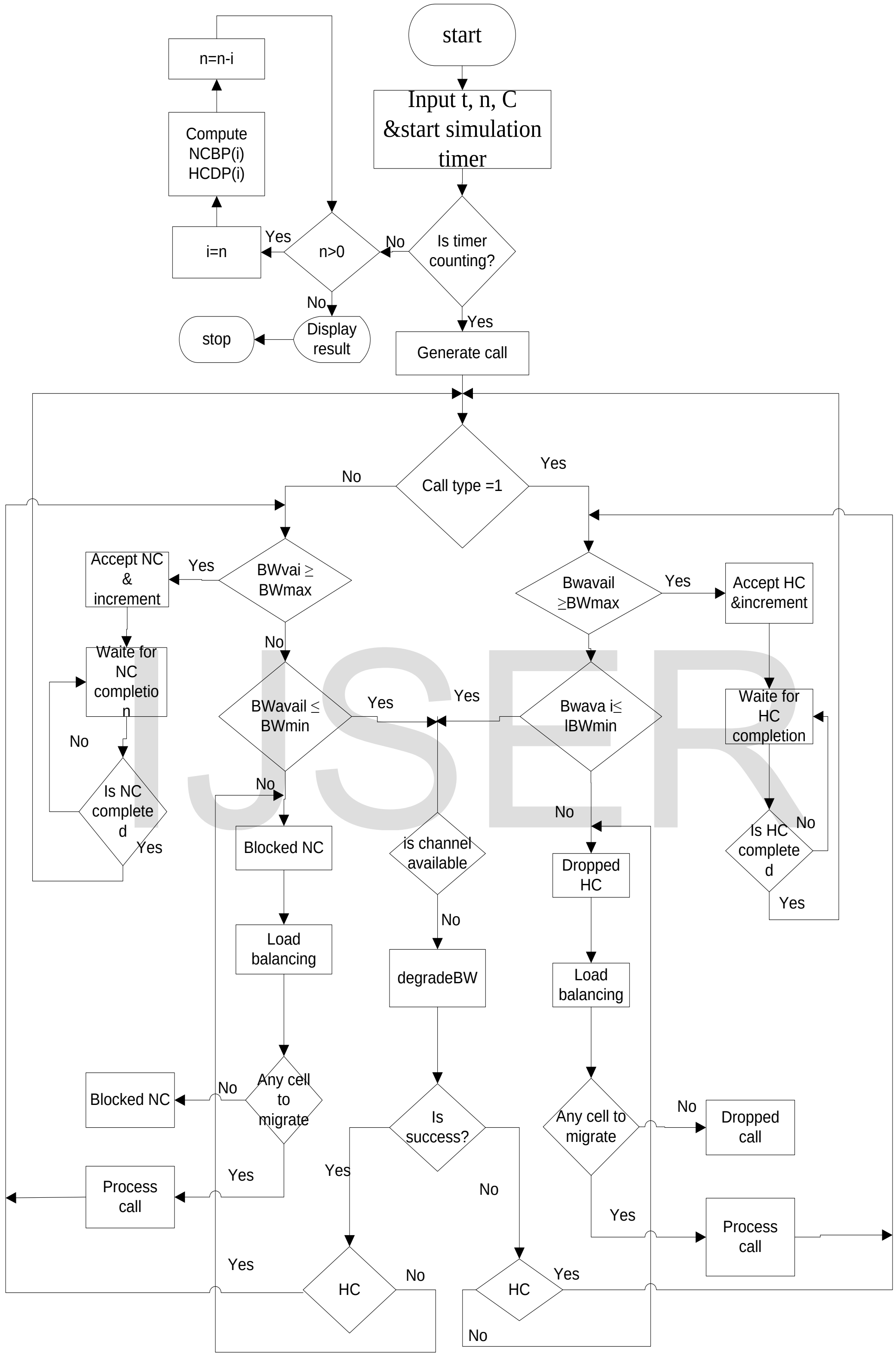
start
Input t, n, C &start simulation timer
Is timer counting?
No
Yes
n>0
Yes
i=n
Compute NCBP(i) HCDP(i)
n=n-i
No
Display result
stop
Generate call
Call type =1
No
Yes
BWvai ≥ BWmax
Yes
Accept NC & increment
Waite for NC completion
Is NC completed
No
Yes
No
BWavail ≤ BWmin
Yes
No
Blocked NC
Load balancing
Any cell to migrate
No
Blocked NC
Yes
Process call
Bwavail ≥BWmax
Yes
Accept HC &increment
Waite for HC completion
Is HC completed
No
Yes
Bwava i≤ lBWmin
Yes
No
is channel available
No
degradeBW
Is success?
Yes
No
HC
Yes
No
HC
Yes
No
Dropped HC
Load balancing
Any cell to migrate
No
Dropped call
Yes
Process call

Figure 2: Flow chart of developed joint scheme model [9]

6. Results and Discussion

The simulation results obtained from the developed algorithm are of two sets: The first result Simulated prior to the application of joint scheme algorithm (PJS) which contained CAC and bandwidth degradation techniques as a baseline model. Secondly, result simulated from algorithm after the application of joint scheme (JS) which combines CAC, bandwidth degradation and load balancing schemes. In both results the performance metrics of interest: New Call Blocking Probability (NCBP) and the Handoff Call Dropping Probability (HCDP) were computed and compared between the two sets of results.

The mean values of NCBP and HCDP of blocked or dropped calls were calculated from each simulation run time results obtained and the cell number closely to the mean value is chosen as the cell of interest. This serves as a guide of selecting cell of interest to determine the percentage reduction of call blocking and call dropping of the results prior to and the application of joint scheme algorithm as shown Tables 1 and 2 respectively [9].

Table1: NCBP Results Cell of Interest

Run Time(hrs)	**No. ofCell Interest**		**Prior to Joint Scheme (PJS) Algorithm**			**Joint Scheme (JS) Algorithm**			**%Reduction**
	PJS	JS	New Calls	Blocked Calls	NCBP	New Calls	Blocked Calls	NCBP	
1	3	4	552	16	0.028986	527	6	0.011385	62.5
2	4	5	703	17	0.024182	613	6	0.009788	64.7
3	6	1	604	13	0.021523	791	8	0.010114	38.5
4	2	1	728	16	0.021978	785	9	0.002857	43.8
5	1	5	894	9	0.010067	901	8	0.008879	11.1
6	0	2	963	18	0.018692	988	9	0.007317	50

Table 2: HCDP Results of Cell of Interest

Run Time(hrs)	**No.of Cell Interest**		**Prior to Joint Scheme (PJS) Algorithm**			**Joint Scheme (JS) Algorithm**			**%Reduction**
	PJS	JS	Handover Calls	Dropped Calls	HCDP	Handover Calls	Dropped Calls	HCDP	

1	3	6	333	11	0.033033	506	4	0.013761	63.7
2	5	6	480	10	0.020833	522	4	0.014286	60
3	0	0	432	11	0.025463	598	6	0.010033	45.5
4	1	6	587	11	0.018732	585	5	0.008547	54.5
5	4	2	613	10	0.016313	728	6	0.008242	40
6	2	2	699	12	0.021672	802	6	0.007481	50

From Tables 1 and Table 2, simulation was carried out hourly, the NCBP prior to and after application of joint scheme algorithm **s**hows that, 16 calls were blocked in Cell 3 with 552 new calls while 6 calls were blocked in Cell 4 with 527 new calls. This shows 62.5% reduction in call blocking. However, For HCDP results, 11 calls were dropped in Cell 3 with 333 handover calls before the joint scheme algorithm while 4 calls were dropped in Cell 6 with 506 handover calls due to joint scheme algorithm. This gives 63.6% reduction in call dropping rate. Similar interpretations are applied to the remaining results.

The overall mean percentages of call reduction (call blocking and call dropping) of developed joint scheme are 48.3 %({ 62.5 + 64.7 + 38.5 + 43.8 + 11.1 + 50}/6) and 52.3 %({ 63.7 + 60 + 45.5 + 54.5 + 40 + 50}) respectively [9]. These results showed that the joint scheme model has greatly reduced call blocking and call dropping thereby enables the system to carry through more traffic and hence, increases the earned revenue as well as user satisfaction. The higher percentage of call dropping probability to call blocking probability is that handover calls are prioritized to new call [11], [12].

7.Conclusion

The algorithm was developed and implemented on a NetBeans IDE 6.9.1. Based on the simulation results, a significant reduction of 47.6% and 52.3% of call blocking and call dropping probabilities was achieved. This significant call reduction is due to load balancing thereby improving quality of service on GSM network. Further works can be focus on multi-class services especially data, video etc in the mobile network, and the further research work can be improved by using any suitable analytical method.

8. Acknowledgements

We acknowledge the efforts of Mr. Laide, PhD student of Computer Science Department of Ahmadu Bello University, Zaria working together for the implementation of the research work using NetBeans IDE 6.9 to achieved the target results.

REFERNECE

[1] M. A. Alarape, A.T Akinwale, and O. Folorunso, ‘’ A Combined Scheme for Controlling GSM Network Calls Congestion’’, International Journal of Computer Applications, vol.14, pp 0975 – 8887, 2011.

[2] E. K. Akut and S. M. Sani,,''Identification and modelling of dominant causes of congestion in a fixed-line network'', International Refereed Journal of Engineering and Science (IRJES), vol.2, pp 09-17, 2013.

[3] H. Johansson and J. Steensland, A Performance Characteristics of Load Balancing Algorithms for Parallel SAMR Applications. Retrieved on June10, 2012 from.www.it.uu.se/research/publications/lic/2006-010/paperC.pdf.

[4] T.S.Rappaport, ''Wireless Communications: Principles and Practice''. Upper Saddle River, N. J. London. Prentice Hall PTR, Prentice Hall International, 1996.

[5] Wireless Networks Spring. 2005. Available atwww.ccs.neu.edu/home/rraj/courses/G250/.../CellularNetworks.ppt. Accessed on 19th June, 2013.

[6] N. Nasser and H. Hussanein, ''Combined Admission Control Algorithm and Bandwidth Adaptation Algorithm in Multimedia Cellular Networks for QOS Provisioning''. IEEE, pp 1183-1186, 2004.

[7] M. Sanabani, S. Shamala, M. Othman and J. Desa, ''Adaptive Call Admission Control for Prioritized Adaptive Services in Wireless/Mobile Multimedia Cellular Networks''. *IJCSNS, International Journal of Computer Science and Network Security*, vol.6, pp 114-124, 2006.

[8] O. E. Falowo and H. A. Chan, '' Multiple-selection for Reducing Call Blocking/Dropping Probability in Cooperative Heterogeneous Wireless Networks,'' *EURASIP Journal on Wireless Communication and Networking*, vol.221 pp 1-12, 2012.

[9] G. K, Azever, S. M. Sani, and A. M. S Tekanyi, ''Development of an Adaptive Algorithm for Bandwidth Optimization and Congestion Control in a GSM Network: A Case Study of Etisalat", M.Sc Disertation, Department of Electrical Engineering, Ahmadu Bello University, Zaria, 2015.

[10] S. K. Satyanarayana, C. h. Satyanarayana, and V. S. Raju, '' Call Admission Control algorithm for Wireless Multimedia Networks''. *International Journal of Engineering Research vol.3, pp 30-35, 2014.*

[11] B. S. Shruti and V.D. Vidya, '' Call Admission Control for 3G wireless Mobile Cellular Network,'' International Journal of Engineering and Innovative Technology (IJEIT), vol.2, 176-189, 2013.

[12] K. G. Nantha and A. Arokiasamy, ''An efficient combined call admission control and scheduling algorithm to improve quality of service for multimedia services over next generation wireless networks,'' *Journal of Computer Science*, vol.11, pp 427-436,2015.