Development of Efficient Handoff Queuing Scheme for Minimizing Call Drop Due to Handoff failure in GSM Systems

[1.] Aniebiet Kingsley Inyang [2.] Engr. (Dr.) F. K. Opara [3.] Uduak Idio Akpan
[1,2]Electrical and Electronics Engineering Dept., Federal University of Technology, Owerri, Imo State
[3]Electrical/Electronics and Computer Engineering Dept., University of Uyo, Uyo, Akwa Ibom State, Nigeria

***Abstract*—Generally, in wireless cellular networks, performance modeling and analysis are very important in designing effective schemes to utilize the limited resource. Over the years, performance analysis on mobile networks has been carried out with certain assumptions and methods. Some are done under restricted assumptions on some time variables using analytical modeling method or via simulations or measurements. In this research, an analytical approach is adopted to model and analyze the performance of Global System for Mobile Phones by developing a new Handoff Scheme. This scheme integrates the handoff queue into the M+G scheme. This helps to further minimize handoff failure. Using simulation in MatLab, this Scheme is evaluated in terms of handoff failure probability. This approach is applied in the analysis of mobility management and connection performance with emphasis on the prioritized. The arrival rates of originating and handoff calls are assumed to be Poisson while time variables such as call holding time, cell residence time, channel holding time, registration area (RA) residence time, and inter-service time are assumed to be exponentially distributed.**

Keywords—Handoff Failure; Handoff Queue; Mobile Networks; Quality of Service; Call Drop.

I INTRODUCTION

Mobility is a major feature of GSM communication system. This is characterized by the desire for continuous service. In other to achieve this seamless connection, the system must support handoff (or handover) from one cell to another. Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection while a call is in progress [1]. Usually, handoff occurs when the mobile terminal crosses a cell boundary or when there is deterioration in quality of the signal in the current channel. Poorly designed handoff schemes tend to generate very heavy signaling traffic and, thereby, a dramatic decrease in quality of service. With the increased demand for wireless communication systems, a promised Quality of Service (QoS) is required in a satisfactory manner, to manage the incoming new calls and handoff calls more efficiently .Quality of Service (QoS) provisioning in wireless networks is a challenging problem due to the scarcity of wireless resources, i.e. radio channels, and the mobility of users. Handoff mechanism is a fundamental mechanism used for QoS provisioning in a network. It restricts the access to the network based on resource availability in order to prevent network congestion and service degradation for already supported users. An originating call request is only accepted if there exist enough idle resources to meet the QoS requirements of the arriving call without violating the QoS for active calls. Admitting too many calls (handoff or new) results in a situation where the mutual interference between the connections degrades the QoS for the new user as well for the ongoing connections. Therefore, call admission control plays a very important role in providing the user with the requested QoS as well as making an efficient use of the available capacity and preventing the system from an outage situation due to overloading [2]. Call admission control (CAC) is such a provisioning strategy to limit the number of call connections into the networks in order to reduce the network congestion and call dropping. In wireless networks, another dimension is added: call connection (or simply call) dropping is possible due to the users' mobility. A good CAC scheme has to balance the call blocking and call dropping in order to provide the desired QoS requirements. Due to users' mobility; CAC becomes much more complicated in wireless networks. An accepted call that has not completed in the current cell may have to be handed off to another cell. During the process, the call may not be able to gain a channel in the new cell to continue its service due to the limited resource in wireless networks, which will lead to the call dropping. Thus, the new calls and handoff calls have to be treated differently in terms of resource allocation. Since users tend to be much more sensitive to call dropping than to call blocking, handoff calls are normally assigned higher priority over the new calls [3]. The large amount of radio resources used for handoffs and the effect of handoff techniques on system interference, user satisfaction level and capacity create a demand for efficient handoff techniques. When the handover rate of the system increases, the probability of an ongoing call to be dropped, due to a lack of free channel is high. In the non prioritized scheme, there is equal probability of new call blocking and handoff dropping [4]. However, the handover prioritization schemes result in a decrease of handoff dropping and in an increase of new call blocking probability. The concept of these strategies is to reserve a number of channels called guard channels exclusively for handoff calls [5].

II REVIEW OF RELATED WORKS

[6] Proposed a handoff scheme based on Queuing for voice calls. The Queue accommodates both the originating calls and handoff requests. In [7], a scheme where the handoff calls are queued and no new calls are handled before the handoff calls in the queue is presented. In [8] the concept of prioritization of handoff calls over new calls is employed, since it is desirable to complete an ongoing call rather than accepting a new one. They developed a channel assignment policy as well as using the idea of buffering handoff calls in case there are no available channels. [9] Investigated the call admission control strategies for the wireless networks where the average channel holding times for new calls and handoff calls are significantly different, the traditional one-dimensional Markov chain model may not be suitable, two-dimensional Markov chain theory must be applied. They proposed a new approximation approach to reduce the computational complexity. It seems that the new approximation performs much better than the traditional approach. [10] Presented a method for improving the quality of service (QoS) in multimedia wireless systems based on prioritization of handover requests. A strategy called signal strength for multimedia communications (SSMC) was proposed. In this strategy, the authors calculated a handoff priority for every multimedia service using three values: the static priority value, the degradation rate of the received signal strength (ΔRSS), and the RSS level itself. Then, each handoff request is queued and handled according to its priority value. They presented the detailed algorithm and analyze its performance on a 25-cell network. Then, its performance was compared with other methods by simulations. The results indicated that this method can effectively reduce the handoff call dropping probability compared to non-priority schemes. Tekinay and Jabbari [8] presented a measurement-based prioritization scheme (MBPS) to employ a dynamic priority queuing discipline instead of first in/first out (FIFO). [12] Proposed a signal prediction priority queuing (SPPQ) scheme to improve MBPS algorithm by using both RSS and the change in RSS (ΔRSS) to determine the priority ordering in the handoff queue. A new handoff queuing scheme that handles the channels reserved for handoff calls depending on the current status of the queue was proposed in [14]. This mechanism of queuing reduces the forced termination of ongoing calls. In [13], the authors developed an effective and efficient handoff scheme using mobile controlled handoff and fractional guard channel techniques. The mobile station measures the signal strength from surrounding base stations and interference level on all channels. A handoff can be initiated if the signal strength of the serving base station is lower than that of other base station by certain threshold. They proposed two models to calculate the blocking probability of new calls and the dropping probability of handoff calls. They carried out the numerical analyses of both the models to investigate the impact on performance of the parameters and comparisons with conventional channel reservation schemes.

III SYSTEM MODEL DESCRIPTION

This research introduces buffer to the M+G Scheme proposed by Madan et al [11], to prevent congestion in a mobile wireless network. The effect of buffer size under several scenarios will be investigated to evaluate the blocking probabilities of new and handoff calls. Performance comparison of both the new policy and the traditional methods will be measured. If users request connection to the base station at the same time, the system checks the type of origin of the call. The handoff decision may be made by the MS or the network based on the Received Signal Strength (RSS), Traffic pattern, Location management etc., while handoff is made the channel assignment plays an important role. The total channels in the BS can be allocated to different types of calls. If the originating calls and handoff calls are treated in the same way, then the request from both kinds are not served if there are no free channels. In another scheme, Priority is given to the handoff call request by reserving a minimum number of channels to the handoff call. If there is C number of channels available, the M number of channels is reserved to the handoff calls and the remaining (K) channels are shared by the handoff and originating call requests. The handoff call request is dropped only if there are no channels available in the cells. To overcome this drawback of dropping the handoff calls, our system presents a new model of queuing scheme in which the handoff calls are queued to get the service. In this research, we consider a system with homogenous cells and a finite number of channels (C). In this system, we focus our attention on a single cell, called the marked cell and the base station with two types of traffic: new call and handoff call. The system reserves C-K out of the C channels to the handoff calls while the remaining K channels are for both handoff and originating calls.

We assume that both new and handoff call attempts are generated according to a Poisson process with mean rates λo and λ_h, respectively. The effective incoming call traffic rate up to K channel is ($\lambda o+\alpha\lambda_h$), since any poor signal quality handoff call is immediately dropped. An incoming call traffic rate from K to C channel capacity is ($\alpha\lambda_h$). If the handoff requests find the entire channels occupied, it is then put on the handoff queue pending the release of a channel. We assume also that, the channel holding time TH has an exponential distribution with mean ($1/\mu$). The model diagram and state transition diagram for this traffic model is shown in Figure1 and figure2.

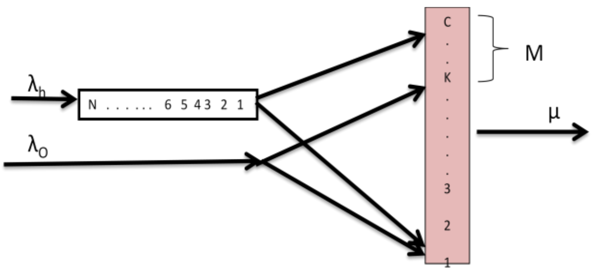

Figure1 System Model for the Proposed Scheme

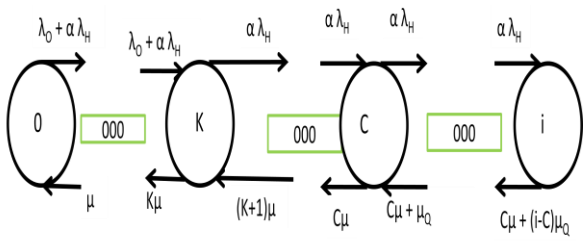

Figure 2 State Transition Diagram

IV SYSTEM MODEL ANALYSIS

The state of the call which is the number of calls in progress for the base station containing that call can be denoted as S. where

i = 0, 1, 2, 3, ….. M, (M+1)…. (C-1), C. (1)

The probability that the BS is in state i is given as P(i) can be solved as usual using the birth-death process.

The state balance equations as derived from the states transition diagram are

$$\begin{cases} i\mu P(i) = (\lambda_o + \alpha\lambda_H)P(i-1) & 0 \le i \le K \\ i\mu P(i) = (\alpha\lambda_H)P(i-1) & K \le i \le C \\ [C\mu + (i-C)\mu_Q]P(i) = \alpha\lambda_H P(i-1) & C \le i \le \infty \end{cases} \quad (2)$$

The normalization condition given as

$$\sum_{S=0}^{C} P(s) = 1 \quad (3)$$

Using the above equation recursively, along with the normalization condition of equation (3), the steady-state probability $P(i)$ is easily found as follows:

$$P(i) = \begin{cases} \frac{(\lambda_o+\alpha\lambda_H)^i}{i!\mu^i}P(0) & 0 \le i \le K \\ \frac{(\lambda_o+\alpha\lambda_H)^k(\alpha\lambda_H)^{i-k}}{i!\mu^i}P(0) & K \le i \le C \\ \frac{(\lambda_o+\alpha\lambda_H)^k}{i!\mu^i}\frac{(\alpha\lambda_H)^{i-k}}{\prod_{j=C}^{i}[C\mu+j(\mu_Q)}P(0) & C \le i \le \infty \end{cases} \quad (4)$$

Where P(0) is given as,

$$P(0) = \left\{\sum_{i=0}^{K}\frac{(\lambda_o + \alpha\lambda_H)^i}{i!\,\mu^i} + \sum_{i=K+1}^{C}\frac{(\lambda_o + \alpha\lambda_H)^k(\alpha\lambda_H)^{i-k}}{i!\,\mu^i} + \sum_{i=C+1}^{\infty}\frac{(\lambda_o + \alpha\lambda_H)^k}{i!\,\mu^i}\frac{(\alpha\lambda_H)^{i-k}}{\prod_{j=C}^{i}[C\mu + j(\mu_Q)]}\right\}^{-1} \quad (5)$$

The blocking probability of originating call is given as

$$P_{BO} = \sum_{i=K}^{C} P(i) \quad (6)$$

Assuming the handoff request fails at position q+1 after joining the queue, the probability of this failure is $P_{hf|q}$. This probability can be derived as,

$$P_{hf|q} = 1 - \left(\frac{\mu_Q}{C\mu + \mu_Q}\right)\prod_{i=1}^{q}\left\{1 - \left(\frac{\mu_Q}{C\mu + \mu_Q}\right)\left(\frac{1}{2}\right)^i\right\} \quad (7)$$

The handoff failure probability P_{HF} is the probability that the handoff request fails to get a channel ($P_{(i)}$) and the probability that it fails after joining the queue ($P_{(q)}$).
This can be expressed as

$$P_{HF} = \sum_{q=0}^{\infty} P(C+q)\,P_{hf|q} \quad (8)$$

$P(C+q)$ has been found to be

$$P(C+q) = \frac{(\lambda_o + \alpha\lambda_H)^k}{i!\,\mu^i}\frac{(\alpha\lambda_H)^{i-k}}{\prod_{j=C}^{i}[C\mu + j(\mu_Q)}P(0) \quad (9)$$

Therefore, P_{HF} is expressed as,

$$P_{HF} = \frac{(\lambda_o + \alpha\lambda_H)^k}{i!\,\mu^i}\frac{(\alpha\lambda_H)^{i-k}}{\prod_{j=C}^{i}[C\mu + j(\mu_Q)}P(0)P_{hf|q} \quad (10)$$

$$P_{HF} = P_{(i)} \,\&\, P_q = \frac{(\lambda_o+\alpha\lambda_H)^k}{i!\mu^i}\frac{(\alpha\lambda_H)^{i-k}}{\prod_{j=C}^{i}[C\mu+j(\mu_Q)}\left\{\sum_{i=0}^{K}\frac{(\lambda_o+\alpha\lambda_H)^i}{i!\mu^i} + \sum_{i=K+1}^{C}\frac{(\lambda_o+\alpha\lambda_H)^k(\alpha\lambda_H)^{i-k}}{i!\mu^i} + \sum_{i=C+1}^{\infty}\frac{(\lambda_o+\alpha\lambda_H)^k}{i!\mu^i}\frac{(\alpha\lambda_H)^{i-k}}{\prod_{j=C}^{i}[C\mu+j(\mu_Q)]}\right\}\left[1 - \left(\frac{\mu_Q}{C\mu+\mu_Q}\right)\prod_{i=1}^{q}\left\{1 - \left(\frac{\mu_Q}{C\mu+\mu_Q}\right)\left(\frac{1}{2}\right)^i\right\}\right]^{-1} \quad (11)$$

V IMPLEMENTATION OF SCHEME

The notable feature of this scheme is the integration of buffer (queue) for handoff request in the M+G scheme. The scheme also considers signal strength and channel availability and for handoff decision. At the arrival of the request, the scheme performs a check on the signal power of the request. This is denoted by the factor α. The value for this factor ranges from zero to 1 (0 < α ≤ 1). As the value of α increases, it implies that the signal strength is stronger. For the request to be processed initially, this factor must be at acceptable level (0.7). If the signal power of the request is greater than or equals to 0.7 (threshold), the request is admitted for further checks. After the signal power has been established, the scheme then determines if there are free channels in the shared channel. It assigns any channel available to the request on the basis of first in first out irrespective of the type of request. This is because both handoff and originating calls are treated equally in these shared channels. If there are no channels in the shared channels, the next action is to determine the type of request. The originating call request is refused when there is no free channel in the shared channels. For the handoff request, the scheme checks for a free channel in the reserved channels and assigns it. If the reserved channels are congested, the handoff requests are put in the FIFO handoff queue. Any released channel in the poll is assigned to the first handoff request in the queue. If the queue waiting time exceed the maximum allowable waiting time, the handoff request is denied or reattempted. This is illustrated in the flow chart below in Figure 3.3

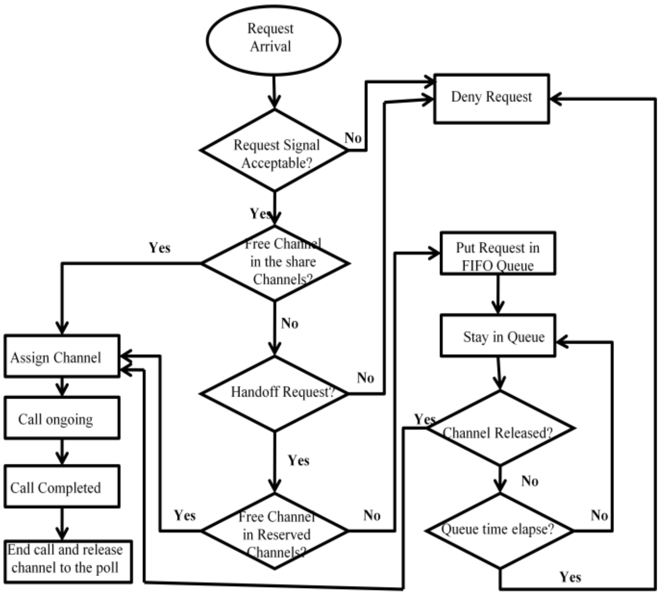

Figure 3 Scheme Flow Chart.

VI THE NUMERICAL /COMPUTATIONAL RESULTS

This section presents the numerical analysis and results for the proposed model. The effects and impacts of the various parameters on the various system performance metrics are carried out in this section also. This is done by taking the numerical examples and developing computations for the system performance in terms of handoff blocking or failure probability. MatLab software was used to determine the numerical values of the various parameters.

A *System parameters*

In this section the system parameters and their values for the computation of the results are presented. The number of channels was varied from 1-34, the originating call arrival (λ_o) was fixed at 2.5/s and the Handoff arrival (λ_H) was fixed at 2.0/s. The signal strength factor (α) was varied from 0.8 to 1. The reserved channel size was varied from 6 – 34 to assess its impact on the system performance. We also fixed the new call duration (mean $1/\mu_N$) and handoff call duration (mean $1/\mu_H$) at90s and 95s respectively. Details of the data are as presented in table 4.1 below.

TABLE 1 System Parameters for the Proposed Scheme

PARAMETER	VALUES
No of Channels (C)	Varies from 1 to 50
Queue Sizes	Varies from 15 to 2000
New call arrival (λ_N)	2.5/s
Handoff arrival (λ_H)	2.0/s
Signal strength factor (γ)	Varied from 0.7 – 0.9
Reserved (Guard) channels (R)	Varied from 2 – 34
Total call duration	5 mins
Maximum Queue time	5 seconds(s)
Offered traffic (ρ)	Varied from 10 – 100

B *Discussion of the Results*

Figure 4 shows Handoff Failure Probability against Reserved Channel size at channel of 50 and α at 0.7. This implies that the signal strength is acceptable. It is shown from Figure 4 that the handoff failure probability decreases as the reserved channel increases. This depicts that as the reserved channel is increased, more handoff calls can be handled thereby minimizing the probability of failure. Figure 5 depicts the Handoff Failure Probability against Reserved Channel size at channel of 34 and α at 0.7. The behavior is similar to the one in figure 5. It is observed that the handoff failure has further increased as the result of reduction in the channel size from 50 to 34. Figure 6 shows the Handoff Failure Probability against Reserved Channel size at traffic of 100. Figures 7, 8 and 9 show the Handoff Failure Probability against queue size at traffic of 100, 40 and 50 erlang respectively. A close look at the two figures shows that increasing the traffic from 50 to 100 erlang results in increase in the handoff failure. This can be explained from the fact that the more the traffic the more likely the channels will be occupied and less chance for admission of new handoff requests.

Figure 10 and figure 11 depict the effect of Traffic loads on Handoff probability at queue sizes of 100 and 2000 respectively. There is direct variant relationship between the traffic and the failure probability. The increase in traffic resulted in a significant increase in the failure probability. This is because channels get congested as the traffic pattern increases which causes the handoff requests to be rejected.

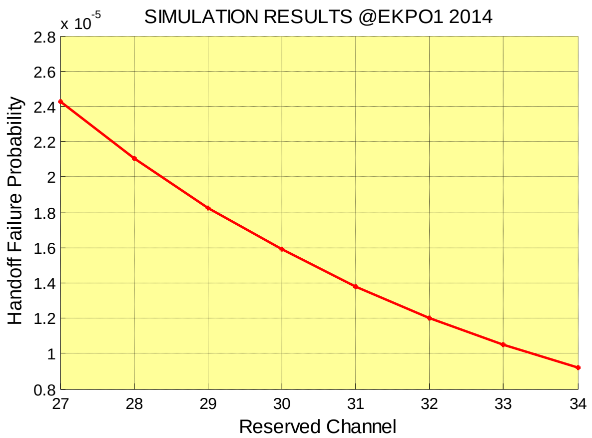

Figure 4 Handoff Failure Probability against Reserved Channel size at channel of 50

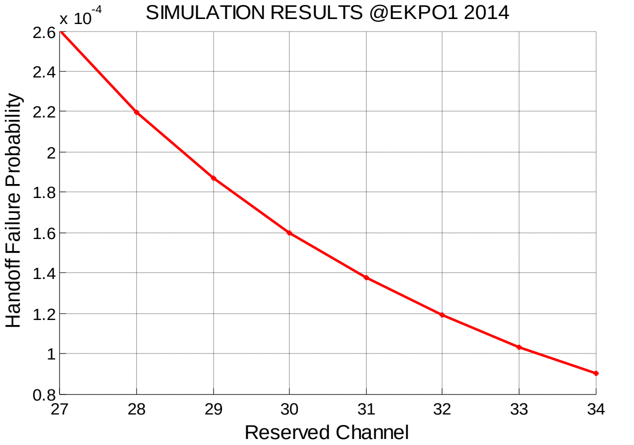

Figure 5 Handoff Failure Probability against Reserved Channel size at channel of 34

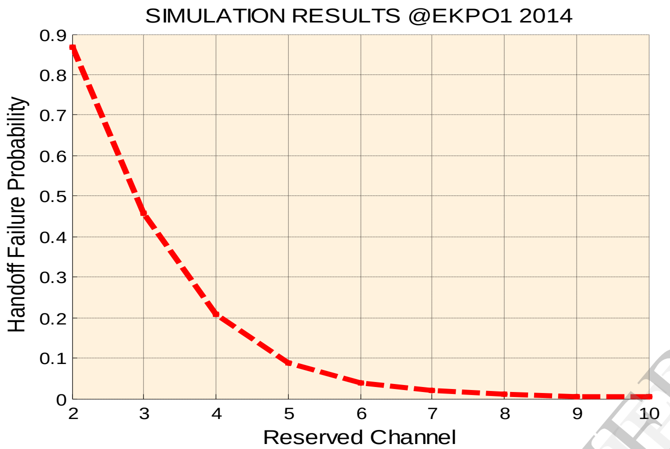

Figure 6 Handoff Failure Probability against Reserved Channel size at traffic of 100 erlang

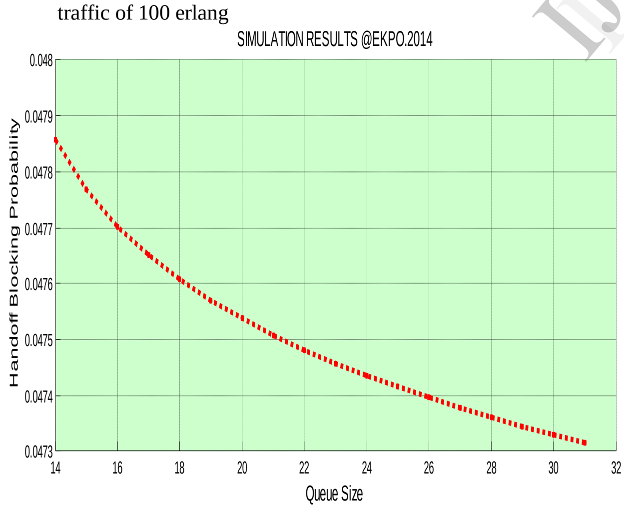

Figure 7 Handoff Failure Probability against Reserved Channel size at traffic of 100 erlang

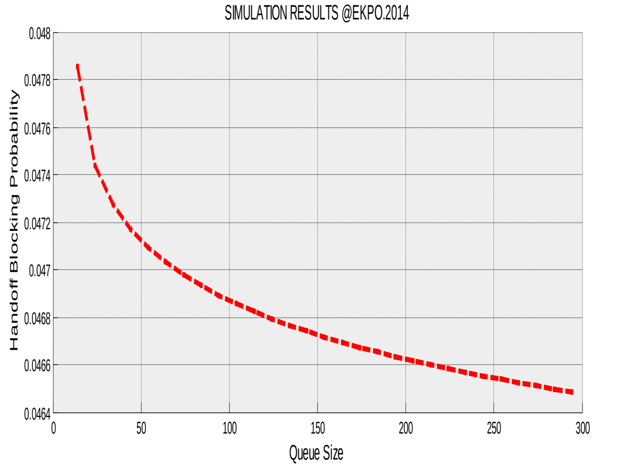

Figure 8 Handoff Failure Probability against Reserved Channel size at channel of 40

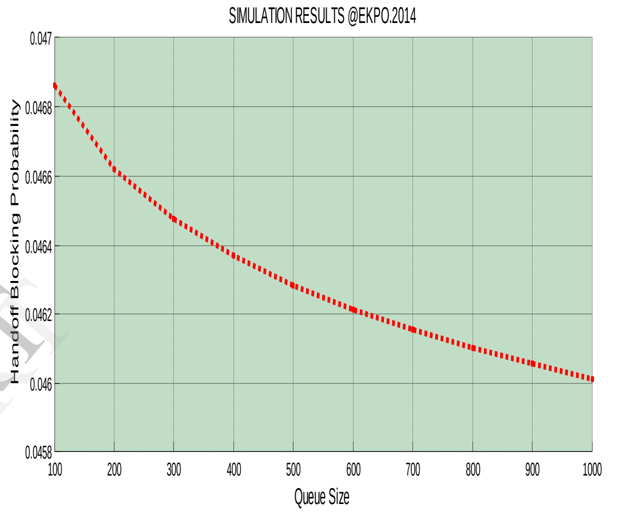

Figure 9 Handoff Failure Probability against Reserved Channel size at traffic of 50 erlang

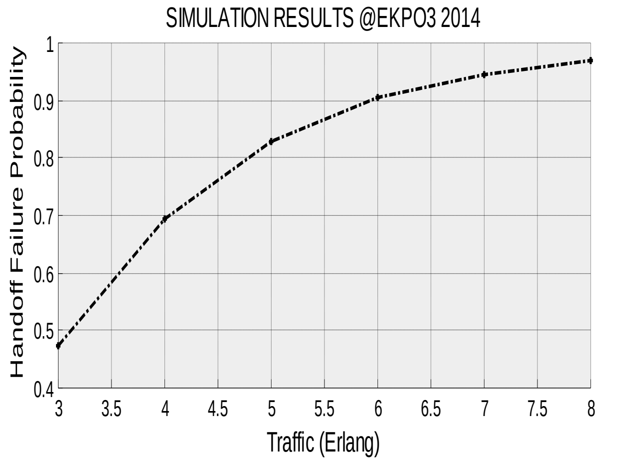

Figure 10 Handoff Failure Probability against Traffic Load at queue size of 100

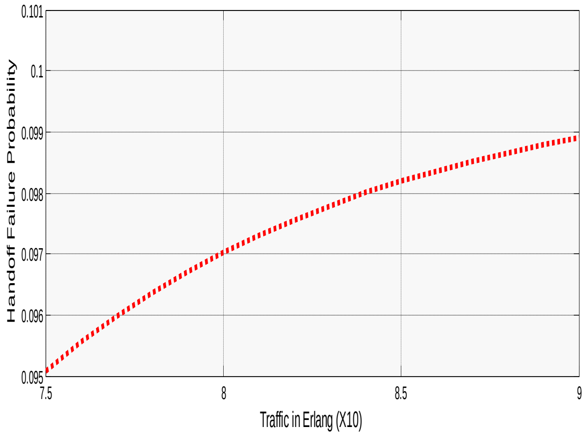

Figure 11 Handoff Failure Probability against Traffic Load at queue size of 2000

VII CONCLUSION

The proposed scheme provides a quality of service guarantee to the handoff calls and at the same time the exploitation of buffer resources to accommodate blocked handoff in order to improve the performance of the network. In this research, it has been shown that by integrating the concept of buffering (queue) to the M+G, the handoff call dropping probability has been considerably reduced. The performance of this new scheme in terms of dropping probabilities was carried out using MatLab. It has been shown that the use of the buffer in the in the proposed handoff scheme helps in further reducing handoff failure in mobile systems.

REFERENCES

[1] Q. Zeng and D. Agrawal, "Handoff in Wireless Mobile Networks: *Handbook of wireless networks and mobile computing*", Edicted by Ivan Stojmenovic. John Wiley and Sons,Inc., 2002.

[2] U. Akpan, C. Kalu, S. Ozuomba and A. Obot, "Development of an Improved Scheme for Minimising Handoff Failure due to Poor Signal Quality," *International Journal of Engineering Research and Technology*, Oct. 2013.

[3] Y. Fang and Y. Zhang, "Call Admission Control Schemes and Performance Analysis in Wireless Mobile Networks" *IEEE transactions on vehicular technology*, vol. 51, no. 2, 2002.

[4] Y. Ma, J. J. Han and K. Trivedi, "Composite performance and availability analysis of wireless communication networks", *IEEE Transaction on Vehicular Technology*, vol. 50, no.5, pp. 100–107, 2001.

[5] S. H. Oh and D. W. Tcha, "Prioritized channel assignment in a cellular radio network, "*IEEE Transactions on Communi-cations*", vol. 40, no.7, pp.1259–1269, 1992.

[6] A. A. Zeng, K. Mukumoto and A. Fukuda, "Performance Analysis of Mobile Cellular Radio System with Priority Reservation Handoff Procedure", *IEEE VTC-94*, Vol 3, 1994, pp. 1829-1833.

[7] R. Guerin, "Queuing Blocking System with Two Arrival Streams and Guard Channels", *IEEE Transactions on Communications*, 1998, 36:153-163.

[8] B. Jabbari and S.Tekinay, "Handover and Channel Assignment in Mobile Cellular Networks", *IEEE Communications Magazine*, 30 (11)1991, pp.42-46.

[9] F. R. Nigeria. "Nigerian Communications Act (No. 19 of 2003). Quality of Service Regulations", 2012, 99(4), B83-B117. Lagos, Nigeria: *The Federal Government Printer. (2012, 01 18).*

[10] R. Chang and S. Leu, "Handoff Ordering Using Signal Strength for Multimedia Communications in Wireless Networks:, *IEEE Transactions On Wireless Communications*, Vol. 3, No. 5, September 2004.

[11] B. B. Madan, S. Dharmaraja and K. S. Trivedi. "Combined guard channel and mobile-assisted handoff for cellular network,"; *IEEE Transactions on Vehicular Technology*. Vol. 57, No. 1. 2008

[12] H. G. Ebersman and O. K. Tonguz, "Handoff ordering using signal prediction priority queuing in personal communication system," *IEEE Trans. Veh. Technol*., vol. 48, pp. 20–35, Jan. 1999.

[13] V. Goswami and P. K. Swain, "Analytical modeling for handling poor signal quality calls in cellular network," *International Journal of Networks and Communications* 2012, 2(4): 47-54, 2012.