ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 7, July 2015

Evaluating the Effect of FIFO Queuing Scheme on Originating and Handoff Calls in Cellular Networks

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Abstract: In cellular mobile communication networks, call blocking of originating calls and forced termination of handoff requests, are the main performance metrics in view of traffic considerations and they determine the Quality of Service (QoS). Assuming that call arrival processes both new and handoff are Poisson. Call service time distributions and cell residence times are typically allowed to follow arbitrary distributions due to the well-known insensitivity property of loss queuing systems. This paper aims to compare in terms of probability of blocking, which queuing system is more suitable at Mobile Switching Centre (MSC) by analysing queuing of originating calls and queuing of handoff calls using MATLAB. In this paper we provide numerical solutions for new and handoff calls blocking probabilities with arbitrary handoff inter arrival time distribution. The results can be seen as a generalization of the work by W.C.Y. Lee. This work can be used for more accurate shaping of cellular systems with realistic traffic.

Keywords: Quality of service, Originating calls, Handoff calls, Queuing, Call blocking probability, Mobile Switching Centre.

I. INTRODUCTION

The exponential growth of mobile communications has led the research exploitation to achieve an efficient use of the scarce spectrum allocated for cellular communications. In the cellular system, a geographical area is divided into multiple side by side cells, the mobile subscribers (MSs) are provided with telephone service within the cells. When MS moves across a cell boundary while maintaining it call, the channel in the old base station (BS) is released and an idle channel is required in the new BS [2] to keep the call.
BS informs the base station controller (BSC) about the request, which then verifies if it is possible to transfer the call into a new targeted cell or adjacent cell. The availability and unavailability of free channel is done by the BSC. Yet, the BSC does not differentiate between the channel requests either for fresh call or handover call. If a free channel is available in the new adjacent cell then handover request can be satisfied, and the mobile station switch to new cell. If there is no free channel in the adjacent cell and also in the targeted cell then it increases the dropping probability of handover calls [3].

This process of transferring the control of MS from one BS to another BS or one cell boundary to another cell boundary without interruption of service is termed Handoff or Handover [1], [2], [3], [4], [10], [13]. Handoff or handover is primarily of two types, namely, the hard handoff or the soft handoff [5]. Hard handoff is also referred to as “Break before Make connection”. MS is connected to only one BTS at a time. Soft handoff refers to as “Make before Break connection”. It is possible that, an MS may be in connection with more than one BTS at a time [6], [13], [14]

With the hard handoff, channel transfer is between two frequencies. In transition from cell to cell, the frequency connections from the old station are dropped gradually before connections are established in a cell. This occurs within a short duration. For the soft handoff, the transfer is between two code words. Two secure code channels are needed for the handoff process. This reduces the call capacity; however, the call drop rate is reduced due to this switching method. Primarily, there are two types of calls in a mobile communication; new calls/ originating calls and ongoing calls / handoff calls that requires new channel in a new cell to keep the call.

New calls are defined as calls that the mobile user springs up to enter the network and start a call, whilst handoff calls are referred to the ongoing calls that are transferred from one cell to another in order to prevent the termination of those calls (e.g. a mobile user in a car) [5], [7], [11] [12]. The latter is critical in cellular communication systems because .neighbouring cells are incessantly using a disjoint subset of frequency bands, so negotiations must take place between the mobile station (MS), i.e. the current serving base station (BS) and the next potential BS [12] which could be the targeted cell or the an adjacent cell.

In [9], the blocked and dropped users are treated separately; they redial with different probabilities and different rates. This paper paves way for treating both

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

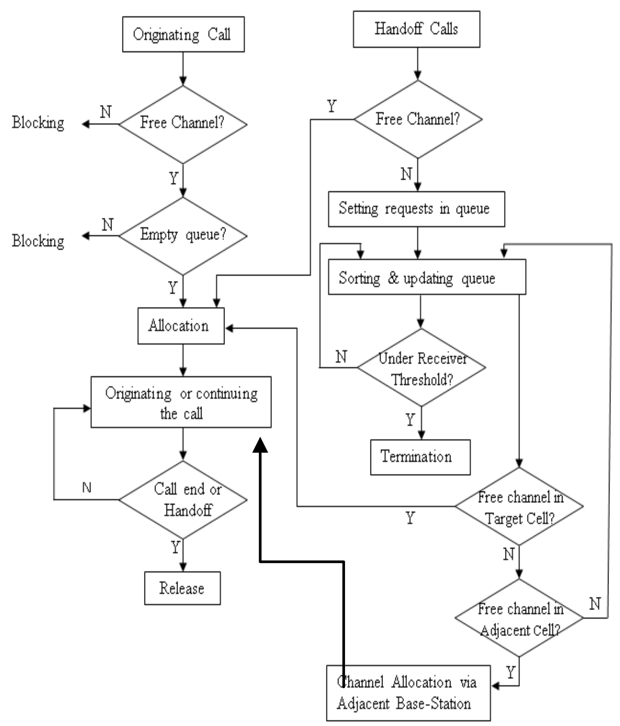
IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 7, July 2015

originating call and handoff calls together in a single queue.
This paper is structured as follows. The introduction is carved into chapters I. Section II and III presents the system model and the methodology respectfully. Section IV presents the simulation results and conclusion is put up in section V.

II. SYSTEM MODEL

We assume that the cells are hexagonal in shape. The arrival rates of both originating calls and handoff calls are assumed to be Poissonian [8].There exist a fixed number of voice channels N, for each BS. These channels are apportioned to a subscriber on demand basis. However, these same channels are used to serve handoff or handover calls, which are also given on demand. When a subscriber requests service, a channel is allocated and remains dedicated for the entire duration (Holding time) of the call, H.



The FIFO decision algorithm [11]

The service rate, μ, which is the frequency of the allocation of N to a subscriber, is the reciprocal of H. Therefore, the average calling time or holding time per subscriber is given by H=1/μ. The requests rate of the originating call and the handoff calls are represented by λ_o and λ_h respectively. The traffic intensity ascribable to originating call is tending as $\beta_1 = \frac{\lambda_o}{\mu}$ whilst, the traffic load of handoff calls is also given by $\beta_2 = \frac{\lambda_h}{\mu}$. The total traffic load is thus written as

$$a = \frac{\lambda_o}{\mu} + \frac{\lambda_h}{\mu} \qquad (1)$$

The offered traffic load (ρ) can be defined as traffic load of handoff requests to total traffic load

$$\rho = \frac{\lambda_h}{\lambda_h + \lambda_o} \qquad (2)$$

When these arrivals are in excess of the total number of channels available, a method of queuing can be employed. M_1 Refers to the size of queue for originating calls and M_2 refers to the size of queue for handoff calls. When requests at MSO exceed the available channels at a particular cell site, any excess requests are blocked in order to service the already established ones. The call blocking probability (CBP) is defined as the probability that the new calls finds all the channels busy and blocked [13]. In this paper, blocking of originating calls and handoff call requests are considered together. Blocking is determined by a dimensionless unit known as Erlang B. It is the measure of carried load on service providing elements such as telephone circuits or telephone switching equipment. It is also the measure of the Grade of Service (GOS) for a trunked system that provides no queuing for blocked calls. Erlang B is based on the assumptions stated in [1] and thus, the probability of blocking is given as:

$$P(b) = \frac{\frac{a^n}{N!}}{\sum_{n=0}^{N} \frac{a^n}{n!}} \qquad (3)$$

N is the number of channels,ais the offered traffic.
Equation (3) fits the instance where extra call requests are not blocked but rather queued with the assumptions that: Callers never hang off whilst in queue. All calls start and end in the same time period being estimated for. Callers never try to call back after having hanged up while in queue. These deficiencies make the formula predict that more agents should be used than are really needed to maintain a desired service level. The probability of blocking with queuing is thus written as:

$$P_q(0) = \left[N! \sum_{n=0}^{n-1} \frac{a^{n-N}}{n!} + \frac{1 - \left(\frac{b_1}{N}\right)^{M_1+1}}{1 - \left(\frac{b_1}{N}\right)} \right]^{-1} \qquad (4)$$

When only the originating calls are queued, the blocking probability for originating calls is given by:

$$Boc = \left(\frac{b_1}{N}\right)^{M_1} P_q(0) \qquad (5)$$

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
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The resulting blocking probability for handoff calls is given by:

$$Bhc = \frac{1-\left(\frac{b_1}{N}\right)^{M_1+1}}{1-\left(\frac{b_1}{N}\right)} P_q(0) \qquad (6)$$

When the handoff calls are queued, the blocking probability for handoff calls is presented as:

$$Bhc = \left(\frac{b_2}{N}\right)^{M_2} P_q(0) \qquad (7)$$

And the blocking probability for origination calls is written as:

$$Boc = \frac{1-\left(\frac{b_2}{N}\right)^{M_2+1}}{1-\left(\frac{b_2}{N}\right)} P_q(0) \qquad (8)$$

III. METHODOLOGY

A system of queuing both originating calls and handoff calls together in the same queue was not considered in [1]. However, the study from this paper establishes that, for cell sites with very low traffic intensity per channel ratio and approximately equal rates for originating and handoff calls, there is the need to queue both originating and handoff call arrivals. The delay probability with queuing then changes to:

$$P_q(0) = \left[N!\sum_{n=0}^{N-1}\frac{a^{n-N}}{n!} + \frac{1-\left(\frac{b_1+b_2}{N}\right)^{M_1+M_2}}{1-\left(\frac{b_1+b_2}{N}\right)} \right]^{-1} \qquad (9)$$

Hence, equation (10) is the blocking probability for originating calls for this system.

$$Boc = \left(\frac{b_1+b_2}{N}\right)^{M_1+M_2} \left[N!\sum_{n=0}^{N-1}\frac{a^{n-N}}{n!} + \frac{1-\left(\frac{b_1+b_2}{N}\right)^{M_1+M_2}}{1-\left(\frac{b_1+b_2}{N}\right)} \right]^{-1} \qquad (10)$$

The blocking probability of handoff calls is now written as:

$$Bhc = \frac{1-\left(\frac{b_1+b_2}{N}\right)^{M_1+M_2}}{1-\left(\frac{b_1+b_2}{N}\right)} \left[N!\sum_{n=0}^{N-1}\frac{a^{n-N}}{n!} + \frac{1-\left(\frac{b_1+b_2}{N}\right)^{M_1+M_2}}{1-\left(\frac{b_1+b_2}{N}\right)} \right] \qquad (11)$$

IV. SIMULATION RESULTS

In this section, by means of numerical analysis, we show the probability of blocking OC and HC when OC is given priority, also, the probability of blocking OC and HC when priority is given to HC. Simulations in this work are implemented using MATLAB2 version R2012a.

A. Results and Analysis for Osu

Here, we consider cell sites having traffic intensity to channel ratio greater than 1 or 100%.
The following parameters are used for the analysis;

- Originating calls arrival rate, = 3.1414 per sec,
- Handoff calls arrival rate, = 0.0844 per sec.
- The mean holding time = 16.47 sec,
- The number of available channels = 32.
- The traffic intensity generated = 53.13Erlang.
- Traffic intensity to channel ratio= 1.66.

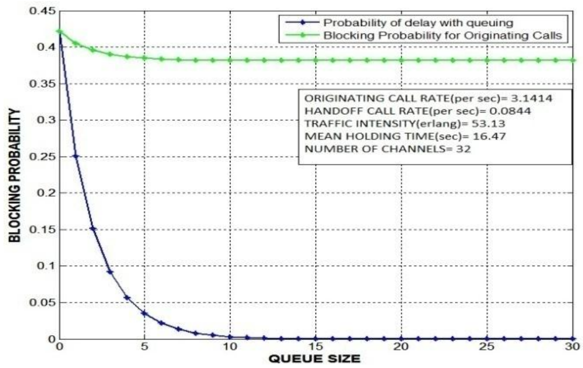

Fig 1: Queuing of OC Blocking Probability of OC at Osu

The occurrence is differs to the reference case in [1]. This happens because the number of channels in the system is few so the total traffic generated as per the number of channels available is extremely high, and hence more blocking occurs.
Since the originating calls arrival rate is high and the allocated number of channels is low, there are no spare channels to serve handoff calls. Hence, the uttermost increase in the blocking probability of handoff calls as shown in Fig 2 below. It is observed that, the blocking probability increase from 0.42 at 0 queue size to 1 at queue size of 10. This means any handoff call request after the 10 queue size will be dropped.

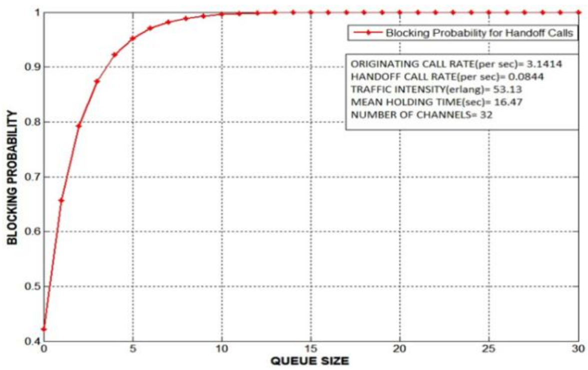

Fig 2: Queuing of OC Blocking Probability of HC at Osu

DOI 10.17148/IJARCCE.2015.47130

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 7, July 2015

Now, we consider instance where handoff calls are queue for a period of time when the available channels are ran through. It is deduced from Figure 3 a speedy drop from the initial probability of blocking to 0 just at queue size of 2. Such a cell site will perform perfectly with as little queue size as 2.

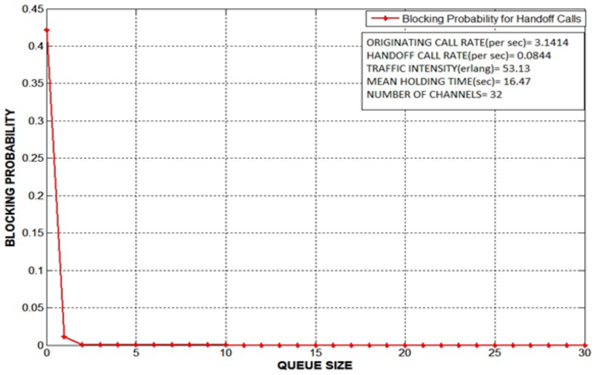

Fig 3: Queuing of HC Blocking Probability of HC at Osu

Finally, we analyse corresponding effect of queuing handoff calls on the blocking probability of originating calls. It is seen that there is a fringy rise in blocking of originating calls from the delay probability when handoff calls are queued. The blocking probability of originating calls then reduces as the queue size increases. It is best to queue handoff call at this cell site because it yields maximum performance.

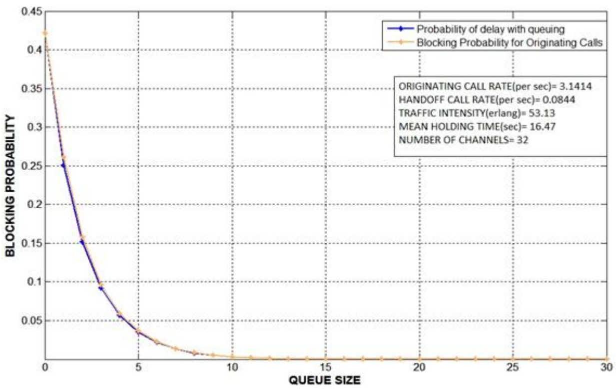

Fig 4: Queuing of HC Blocking Probability of OC at Osu

B. Results and Analysis for Accra Mall

The results below are based on the new proposed queuing scheme. It is worth noting that, queuing both the originating calls and handoff calls at cell sites with very low traffic intensity per channel ratio and approximately equal rates for originating and handoff calls yields optimum performance.

The following parameters are used for the analysis;

- Originating calls arrival rate, = 0.373 per sec,
- Handoff calls arrival rate, = 0.012 per sec.
- The mean holding time = 44.23sec,
- The number of available channels = 27.
- The traffic intensity generated = 16.99Erlang.

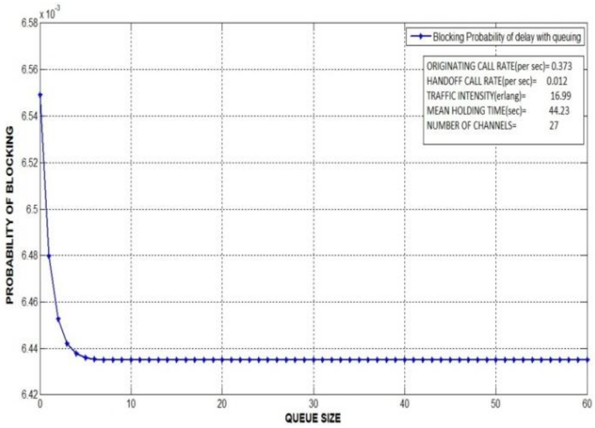

Fig 5: Queuing OC and HC: Blocking Probability of OC and HC at Accra Mall.

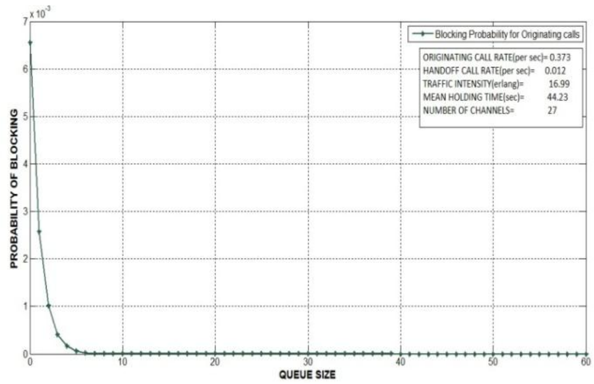

Fig 6: Queuing O.C and H. C: Blocking Probability for OC at Accra Mall

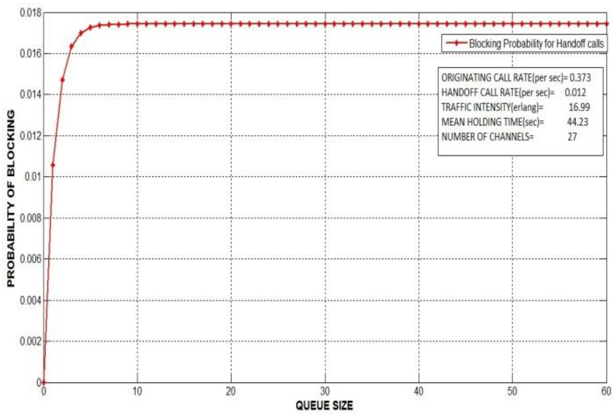

Fig 7: Queuing OC and HC: Blocking Probability for HC at Accra Mall

V. CONCLUSION

From the graphs the following conclusions are drawn. At Osu, there was a traffic intensity to channel rate of 1.66, which means that the simulation results differs to that in [1]. Queuing originating calls produced an increase in the blocking probability of originating calls and handoff calls which is higher than the desired GoS. It is better to queue handoff calls for such a cell site to achieve better performance.

However, the study from this paper shows that, for cell sites with very low traffic intensity per channel ratio and approximately equal rates for originating and handoff calls, there is the need to queue both originating and handoff call. This fits the conditions for Nano and Pico cells which would be implemented in the future,

REFERENCES

[1] W.C.Y. Lee. "Wireless and Cellular Telecommunications" Third Edition.
[2] K.S. Trivedi, S. Dharmaraja and X. Ma. "Analytic modelling of hand offs in wireless cellular networks"
[3] A. Kumar, A. Bhushan and M. Kumar. "A Study on Minimization of 2G/3G Handover Failure".
[4] A. Kumar, H. Purohit. "A Comparative Study of Different Type of Handoff Strategies in Cellular System".
[5] D Kaur and N. Kumar "Performance Analysis of Handoff in CDMA Cellular System". International Journal of Computers & Technology. ISSN 22773061, July 20, 2013.
[6] N. Ekiz, T. Salih, S. Kucukoner and K. Fidanboylu. "An Overview of Handoff Techniques in Cellular Networks" International Journal of Information and Communication Engineering. 2006.
[7] K. Parwani and G.N. Purohit. "Performance Measures of Hierarchical Cellular" ACEEE Int. J. on Network Security, Vol. 03, No. 01, Jan 2012
[8] T. Salih and K. Fidanboylu. "Modeling and analysis of queuing handoff calls in single and two-tier cellular networks" Elsevier, June 2006.
[9] J. Roszik, J. Sztrik and C. Kim."Retrial Question in the Performance Modelling of Cellular Mobile Networks Using Mosel"
[10] S.Y.Diaba, E.Affume and A. M. Oyibo." Performance Analysis of Queuing Priority Schemes in Cellular Communication". IJARCCE. Vol. 4, Issue 1, January 2015
[11] S.Alagu and T. Meyyappan. "A Novel Adaptive Channel Allocation Scheme to Handle Handoffs". Alagappa University, Karaikudi, Tamilnadu, India.
[12] B. Awasthi. "Hand Off Problem Analysis In Personal Communication System Using Splitted-Rating Channel Technique". International Journal of Scientific & Technology Research Volume 3, Issue 1, January 2014.
[13] S.Alagu and T. Meyyappan Novel Adaptive Channel Allocation Scheme to Handle Handoffs". IJCES International Journal of Computer Engineering Science , Volume1 Issue2, November 2011
[14] S. Dharma raja, K.S. Trivedi and D. Logothetis. "Performance modelling of wireless networks with generally distributedhandoffinterarrivaltimes".CACC, Department of ECE, Duke University, Durham, NC 27708, USA.