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Call Drop Minimization Techniques for Handover Calls in Mobile Cellular Networks

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Abstract— The mobility of mobile terminals results in the transfer of calls from one cell to another. This transfer could lead to call drop when handover is unsuccessful. Call drop minimization techniques are methods of reducing the number of dropped handover calls as well as improve fairness between new and handover calls. This paper studies the effect of combining handover prioritization schemes and retrial queues, as call drop minimization techniques, on calls entering the network. Results show that with the call drop minimization techniques, there is a minimal drop in handover calls.

Index Terms— Call drop, Guard Channel, Handover, Prioritization, Quality of Service, Reservation, Retrial.

1 INTRODUCTION

Call drop is one of the greatest problems facing the cellular network industry today. Determining the drop call probability and finding ways of minimizing call drop to its lowest level is one area of research that is being continuously studied [1], [2], [3], [4]. Calls are dropped mostly during the handover process. Calls can also be dropped as a result of propagation conditions, user behaviour or signal reception [5], [6]. However in this paper the focus of call drop is as a result of the handover process. Due the proximity between cells, there is always the need for an active call to be handed over from one cell to another. Unsuccessful handover calls will be dropped. Dropped calls will reduce the network's quality of service (QoS) standard and impact negatively on the network. A lack of quality increases the expenses incurred by the network administrator and increases customer dissatisfaction.

In cellular networks, once a channel is occupied it cannot serve either a new or handover call. A handover call should be given a higher priority than a new call because the handover call is already using up the network resources [5], [9]. Nevertheless an amount of fairness should be introduced between the two types of calls [2].In other to achieve this fairness, several handover prioritization techniques have been proposed in literature. These techniques are also referred to as call drop minimization techniques. The optimal schemes in handover prioritization are guard channels and handover queue [6].

Guard channels offer a means of improving the probabilityof successful handovers by simply reserving a number of channels for handovers only. This prioritization scheme provides improved performance with an attendant reduction in the total carried traffic [7]. However, the reduction in carried traffic affects the new calls as well as the handover calls.

It increases the drop rate of new calls and reduces the drop rate of handover calls. The number of channels reserved would characterize the degree of fairness of this scheme. Nevertheless, this channel reservation technique is not sufficient to manage the number of dropped handover calls. Therefore, handover queuing system was introduced to manage the handover calls that are in danger of being dropped. This queuing system would allow the handover calls to be retried. All calls retry for service when blocked and cannot be served immediately. The arrival rate of retrying calls is very much greater than that of new calls [3], [10]. Therefore retrying calls impact greatly on the quality of the network. To minimize the effect of retrying calls on the network, a retrial queue is introduced to manage retrying calls. The retrial queue is a queuing system which takes into consideration the retrial of calls wishing to be served after a random interval and usually for a random amount of time [12]. However, in order to avoid congestion in the network only first retrials will be considered in this paper.

In this paper, call minimization techniques based on guard channels, handover call queue and the retrial queue is presented. The effect of a combination of these techniques on the handover call drop probability (P_H) and the handover call queue size on the blocking probability (P_B) was evaluated. Furthermore, the probability of the forced termination of handover calls was also evaluated.

The rest of the paper is structured as follows: Section II discusses the various call minimization techniques and analyzes each technique. Section IIIdiscusses the results obtained. Section IV concludes the paper.

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2 CALL MINIMIZATION TECHNIQUES

2.1 Guard Channels

The guard channels are used to prioritize handover calls over new calls. Assume an isolated node in an isolated cell having n channels. Handover calls can be prioritized by reserving g channels while the remaining n-g channels are made available to both new and handover calls [15]. A handover call can be dropped or retried when all the channels are occupied. A schematic showing the guard channels is given in figure 1.

2.2 Handover Queue

The handover queue is established on the assumption that adjacent cells in a mobile cellular system are overlaid. Thus there is a considerable area (i.e. handover area) where a call can be handled by base station (BS) in adjacent cells. In this scheme, it is assumed that the same channel sharing method is used as that of a priority scheme except that provision is made for the queuing of handover requests. If a BS finds all channels in the target cell occupied, a handover request is put in the queue. If a channel is released when the queue for handover requests is not empty, the channel is assigned to the request at the head of the queue. If the received signal strength from the current BS falls below the receiver threshold level prior to the mobile being assigned a channel in the target cell, the call is forced to termination [12]. In this scheme, the first-in-first-out (FIFO) queuing strategy is used and a finite queue size, **R**, is assumed. This means that if a handover call finds the queue fully occupied, it will fail and be dropped by the system.The duration of a MS in the handover area depends on system parameters such as moving speed, the direction of the MS and the cell size. This duration is defined as the dwell time of a mobile in the handover area and it is denoted by T_Q. The dwell time is assumed to be exponentially distributed with the mean dwell time, $1/\mu_Q$.

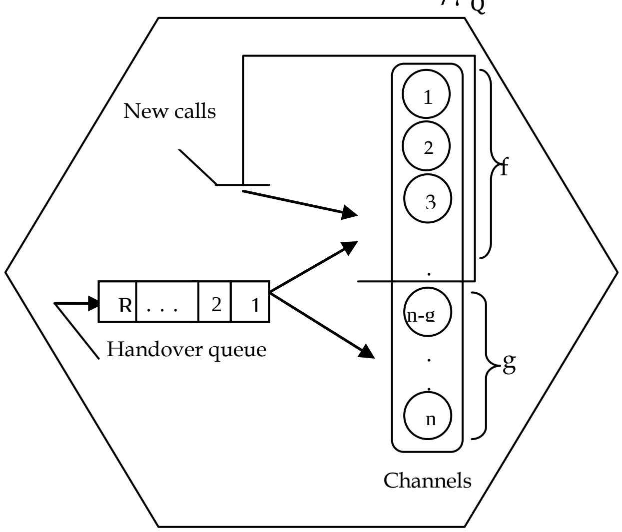

Figure 1: Schematic of the Guard channel; n-g to n are the guard channels reserved for handover calls when the free channels are all occupied while f are the free channels for all calls.

Analytical model

To develop the analytical model for figure 1, a markov chain representation was developed in figure 2. The total call arrival rate is denoted as λ while the handover call arrival rate is λ_H. All calls (both new and handover) that are served have a service rate of μ.

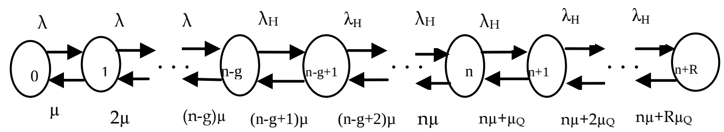

Figure 2: Markov chain representation

The steady state probabilities for a network with guard channels and handover queue will be determined as follows:

States

[0] $\lambda P(0) = \mu P_1$ (1)

[1] $\lambda P(0) + 2\mu P_2 = \lambda P_1 + \mu P_1$ (2)

[n-g] $\lambda P_{n-g-1} + (n-g+1)\mu P_{n-g+1} = \lambda_H P_{n-g} + (n-g)\mu P_{n-g}$ (3)

[n-g+1] $\lambda_H P_{n-g} + (n-g+2)\mu P_{n-g+2} = \lambda_H P_{n-g+1} + (n-g+1)\mu P_{n-g+1}$ (4)

[n] $\lambda_H P_{n-1} + (n\mu + \mu_Q) P_{n+1} = n\mu P_n + \lambda_H P_n$ (5)

[n+1] $\lambda_H P_n + (n\mu + 2\mu_Q) P_{n+2} = \lambda_H P_{n+1} + (n\mu + \mu_Q) P_{n+1}$ (6)

[n+R] $\lambda_H P_{n+R-1} = (n\mu + R\mu_Q) P_{n+R}$ (7)

Further analysis of equations (1) – (7) gives the steady state conditional probability as

$$P(i) = \begin{cases} \frac{(\lambda)^i}{i!\mu^i} P(0), & 0 \le i \le n-g \\ \frac{(\lambda)^{n-g} \quad \lambda_H{}^{i-(n-g)}}{i!\mu^i} P(0), & n-g < i \le n \\ \frac{(\lambda)^{n-g}}{n!\mu^n} \frac{\lambda_H{}^{i-(n-g)}}{\prod_{j=1}^{i-n}[n\mu + j(\mu+\mu_Q)]} \quad P(0), & n < i \le R \end{cases} \quad (8)$$

where $P(0)$ is the initial steady state probability. This implies that all the channel resources are free at that instant.

$$P(0) = \left[\sum_{i=0}^{n-g} \frac{(\lambda)^i}{i!\,\mu^i} + \sum_{i=n-g+1}^{n} \frac{(\lambda)^{n-g} \quad \lambda_H{}^{i-(n-g)}}{i!\,\mu^i} + \sum_{i=n+1}^{n+R} \frac{(\lambda)^{n-g}}{n!\,\mu^n} \quad \frac{\lambda_H{}^{i-(n-g)}}{\prod_{j=1}^{i-n}[n\mu + j(\mu+\mu_Q)]} \right]^{-1} \quad (9)$$

2.3 The Retrial Queue

When a call is blocked, it retries for access to a free channel. Since more than one call may retry at any given time interval, it is necessary to introduce a queuing system for the retrying calls. This queue allows calls that are retrying to wait for a given time based on a particular queuing discipline. The FIFO queuing discipline is assumed. The retrial probability for all retrying calls is denoted as Θ_1. The probability that a retrying call leaves the network without being served is denoted as $1-\Theta_1$. Only first retrials are allowed into the retrial queue. A schematic of the retrial queue with handover prioritization is shown in figure 3.

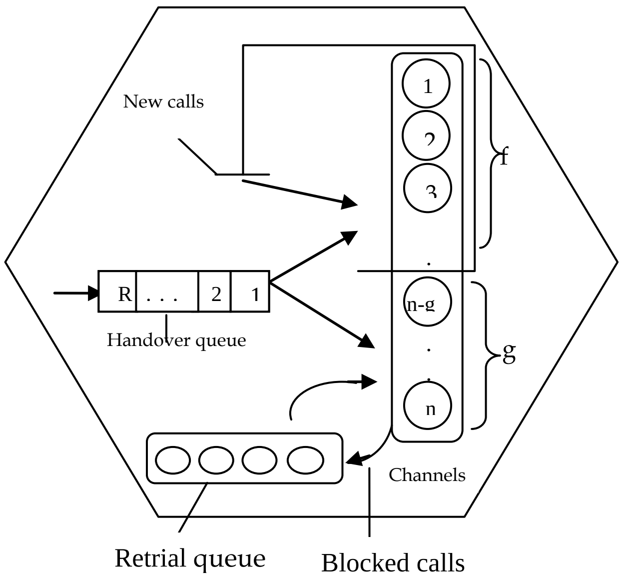

Figure 3: A schematic of the retrial queue with handover prioritization; all blocked calls are retried once.

Analytical model

The retrial queue will be analyzed by determining the steady state marginal probability. This probability can be derived by applying the Erlang's method and phase merging approximation [2, 8]. The total traffic intensity, q, between transition states into and out of the waiting spaces of the retrial queue is given in equations (10)

$$q = \frac{\lambda_N \theta \sum_{i=n-g}^{n} P_i}{j\alpha\left(\sum_{i=o}^{n-g-1} P_i + (1-\theta_1)\sum_{i=n-g}^{n} P_i\right)} \qquad (10)$$

By Erlang's formula the steady state marginal probability is expressed in equation (11)

$$\varphi_j = \frac{q^j}{j!}\varphi_0 \qquad (11)$$

From the above analysis, the probability of forced termination of handover calls (P_{FH}), the handover call drop probability (P_H) and the blocking probability of incoming calls (P_B) will be given to be

$$P_B = \sum_{i=n-g+1}^{n} \sum_{j=0}^{K} p(i,j) \qquad (12)$$

$$P_H = \sum_{j=0}^{K} p(n,j) \qquad (13)$$

$$P_{FH} = p(n+k)p_{fhk} \qquad (14)$$

where p_{fhk} is the probability that a handover request fails after joining the queue at the first position.

$$p_{fhk} = 1 - \left(\frac{\mu+\mu_Q}{n\mu+\mu+\mu_Q}\right)\prod_{i=1}^{R}\left\{1-\left(\frac{\mu+\mu_Q}{n\mu+\mu+\mu_Q}\right)\left(\frac{1}{2}\right)^i\right\} \qquad (15)$$

3 RESULT DISCUSSION

Figure 4 gives a plot of the call blocking probabilities, P_B, versus the traffic intensity. Handover queue sizes, R, of zero and ten have been used to determine the influence of the queue on P_B. Guard channels were not reserved for handover calls. Also there are no retrial queues in place for new calls that need to be retried. From figure 4, the probabilities of blocked calls for the handover queue sizes of zero and ten are within a close range. This implies that the choice of R should be made small to reduce system complexity as well as the length of time a handover call spends in the queue. Therefore, it can be inferred that for a large R, the P_B is lower. This means that the queue enhances the performance of the system. Without the retrial and reservation scheme, the P_B is very high and this impacts poorly on the network QoS.

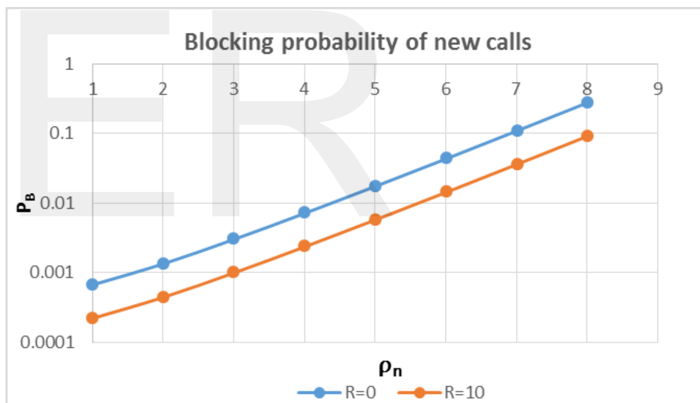

Figure 4: PB for different handover queue sizes

To reduce the number of dropped calls in the network to an acceptable value, the guard channels and a retrial queue were introduced into the network. Figure 5 shows that the handover call drop probability, P_H, has been minimized greatly when compared with the results in figure 4. This difference implies that for customer satisfaction as well as a reduction in a waste of scarce resources, call drop minimization schemes must be applied. Figure 6 shows the number of handover calls that have been forcefully terminated with respect to traffic intensity. These calls are forced into termination because the mobile terminal experiences an unsuccessful handover. It can be inferred from the figure that fewer calls are being dropped when the call drop minimization techniques are employed in the network.

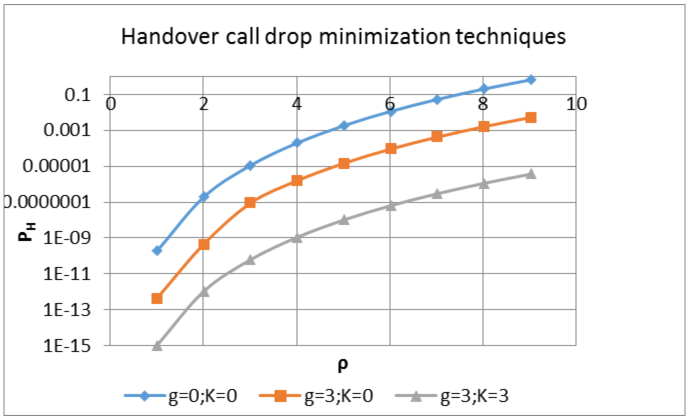

Figure 5: Graph showing the P_H when different call drop minimization techniques have been applied.

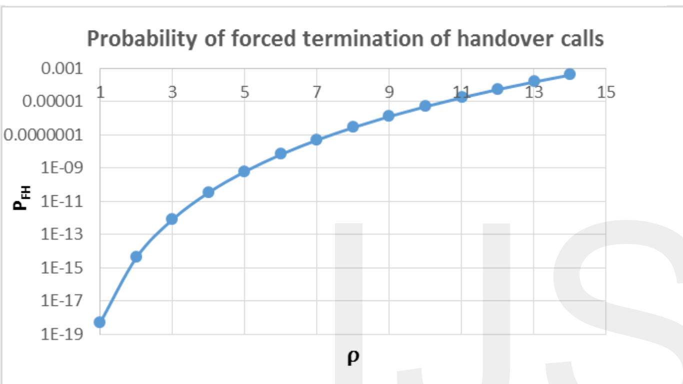

Figure 6: Probability of forced termination of handover calls versus traffic intensity with call drop minimization techniques.

4 CONCLUSION

Call drop minimization techniques are important schemes employed to reduce the number of calls dropped in mobile cellular networks. In this paper, various techniques have been discussed and implemented to minimize call drops. The guard channel scheme and handover call queuing scheme were used to reduce the number of handover calls dropped. On the other hand, the retrial queues reduce the number of blocked incoming calls.

REFERENCES

[1] J.M Gimenez-Guzman et al, "Analysis of a cellular network with user redials and automatic handover retrials," Proceeding of the 7th International Conference on Next Generation Teletraffic and Wired/Wireless Advanced Networking, pp 210-222, 2007.

[2] Anioke C.L. and Ani C.I., "A reservation and retrial queue analysis for cellular networks", International Journal of Engineering Research and Technology, February 2014.

[3] Tien Van Do, "Solution for a Retrial Queueing Problem in Cellular Networks," International Journal of Mathematical and Computer Modelling, volume 53, pp 2059-2066, June 2011.

[4] G. Borgia et al, "Drop Call Probability in established Cellular Networks," IEEE Vehicular Technology Conference, vol. 5, pg 2775-2779, June 2005.

[5] NasifEkiz, Tara Salih et al, "An overview of Handoff Techniques in cellular networks," World Academy of Science, June 2005.

[6] Qing-anZeng and Dharma P. Agranal, Handoff in wireless mobile networks. John Wiley & Sons Inc, 2002.

[7] G.P Basharin, V.E. Melukov, "Blocking Probability Analysis of New and Handover calls in Cellular Mobile Networks with Repeated Attempts," IEEE Proceedings of the 7th International Conference on Telecommunications, 2003.

[8] A. Melikov and M. Fattakhova, "Algorithmic Approach to Qos Analysis in Multi-service Cellular Wireless Networks" Journal of Transport and Telecommunication, volume 10, 2009.

[9] S. Louvros et al, "Handoff Multiple Queue Model in Microcellular Networks," Computer Communications Elsevier, vol. 30, pp 396-403, September 2006.

[10] Jahangir Khan et al, "Cellular Handover Approaches in 2.5G to 5G Technology," International Journal of Computer Applications (0975-8887), vol. 21, May 2011.

[11] M. AjmoneMarsan et al, "Approximate Markovian Models of Cellular Mobile Telephone Networks with Customer Retrials," IEEE International Conference on Communications, June 2000.

[12] ErtanOnur et al, "On the Retrial and Redial Phenomena in GSM Networks," IEEE Wireless Communications and Networking Conference, volume 2, pp 885-889, September 2000.

[13] J. Artalejo, G. Falin, "Standard and Retrial Queueing Systems: A Comparative analysis," RevistaMatematicaComplutense, Volume XV, pg 101-129, 2002

[14] VijoyPandey et al, "Call admission and Handoff Control in Multi-Tier Cellular Networks-Algorithms and Analysis," International Journal on Wireless Personal Communication, November 2006.

[15] Michael Mandjes and Kurt Tutschku, "Efficient Call Handling Procedures in cellular mobile networks,"Institute of Computer Science, University of Wurzburg, July, 1996.