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Queue Modeling of Handoff Calls with Sub Rating in Wireless Cellular Networks

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Abstract

In wireless mobile communication the channel allocation and quality of service are the major factors and important issues to decide the system performance. Call dropping and handoff is a key element in wireless cellular networks in order to provide Quality of Service (QOS) to the users and to support user's mobility. From the user's point of view, the service of a handoff request is more important as the forced termination of an ongoing call is more annoying than the blocking of new calls. Therefore, in order to support QOS to the users we present two models, we give the priority to handoff calls with reserving some channels in model I and sub rating existing calls for new voice calls in model II. Then we calculate the blocking probability of new calls and dropping probabilities of handoff calls.

Keywords: Handoff, sub rating, wireless cellular networks, channel assignment, blocking probabilities, handoff dropping probabilities

1. Introduction

User mobility management is one of the important components of mobile multimedia systems. In a cell based network, a mobile should be able to seamlessly obtain transmission resources after handoff to a new base station. This is essential for both service continuity and quality of service assurance. A base station in a cellular network may receive new connection requests from mobile users within its cell as well as handoff requests from mobile users in the neighboring cells. Cellular radio is the fastest growing and most demanding area in the telecommunications industry. New generation cellular radio systems, offering practicality and versality and new mobile handsets supporting a range of innovative services and access to the mobile users, are the objectives and the main interests not only of the telecommunication companies, operators and providers, but also of the research community. The cellular architecture evolved out of the growing number of mobile communication users. Since this type of wireless network has been assigned a rather limited frequency spectrum by the Telecommunication Regulatory Authority of India (TRAI) an efficient use of the available frequencies is an essential issue. This is achieved by splitting up the coverage region into small service areas also referred to as cells. Each cell is serviced by a base-station (BS), which is located in the center of each cell. Groups of BSs are serviced by a so called Mobile Switching Center, which also acts as a gateway of the cellular network to an existing wired network. A mobile host (MH) is attached to one BS at any time except at the point of handover (transition from one BS to another). To know which BS a MH is attached to, BSs send out beacon signals. Based on the strength of the received signals the MH determines the serving BS. This BS is used by the MH to communicate through a wireless link, which is set up o request by assigning a radio channel-a frequency channel, time slot, code channel or a combination of these- to a MH. To make efficient use of the available frequency spectrum frequencies are reused in non-adjacent cells some distance away maintaining a certain level of carrier-to-interference ratio.

The rest of the paper is organized as follows. Section 2 described the related work of this field. Section 3 introduces the model description. The numerical results are presented in section 4. Section 5 concludes the paper.

2. Related Work

[1] Provided a comprehensive survey of the basic elements and the different types and phases of the handoff procedure. [2] Proposed and analyzed a priority based resource sharing scheme and the optimal LFGCP (Limited Fractional Guard Channel Policy) call admission control policies for maximal resource utilization of voice/data integrated cellular networks. [3] Studied prioritized and non prioritized schemes for cellular radio system. [4] Proposed hybrid channel allocation scheme with queuing of new calls and handoff calls for improvement of quality of service (QOS) of the Cellular system. [5] Proposed a distributed dynamic resource allocation (DDRA) strategy for a hierarchical cellular structure (HCS). In the DDRA, resources are shared not only between cells of the same hierarchy, but between layers, and this scheme performs much better than the FRA (Fixed Resource Allocation) strategy and even better than the FRA strategy with HDP (Hand down Procedure) and channel reallocations. [6] Proposed an efficient dynamic fair resource allocation scheme for supporting multimedia traffic in the uplink of wideband CDMA cellular

networks with QOS satisfaction and showed that the proposed scheme enhances radio resource utilization and guarantee statistical QOS under different fairness bound requirements. [7] Proposed two handoff schemes without and with preemptive priority procedures in integrated wireless networks and observed that the forced termination probability of voice handoff request calls can be reduced by increasing the number of reserved channels and by employing a preemptive priority handoff scheme. [8] Proposed a new traffic model with three different queues at each transceiver (TRX) per cell and compared their model with the model given by Hong and Rappaport [3] and found that the blocking probabilities of new model are less than existing one. [9] gave the priority to handover calls over new call attempts and blocked handover call are placed in a finite storage queue and evaluated the total handover forced termination probability.[10] Proposed four schemes: SFTT (Single-Queue, FIFO, Timeout, Average Timeout) scheme, SPTT (Single-Queue, Priority, Timeout, Average Timeout) scheme, DFTS (Dual-Queues, FIFO, Timeout, Statistical TDM) scheme, DPTS (Dual Queues, Priority, Timeout, Statistical TDM) scheme to reduce call completion rates and compared these schemes with NPS and FIFS. Handoff schemes with non preemptive and preemptive channel borrowing to improve resource utilization while keeping a good isolation among different services is proposed in [11]. Three different channel allocations schemes NPC, FSC and FRC and channel allocation models to analyze the channel allocation process for wireless networks discussed and shows that the usage of reserved channel can improve the GOS (Grade of Service) of base station greatly in [12].

3. Model

We consider a system with homogenous cells and a fixed number of channels which are permanently assigned to each cell. In such a system, we focus our attention on a single cell, called the marked cell and the channel allocation process of base station with two types of traffic: new call and handoff call. There are totally N channels in each cell, including m reserved channels. We provide at most N-m channels to the coming new calls and at least m channels to the handoff calls. This model requires the following key assumptions:

1) The arrival of new connection requests in a cell forms a Poisson process with rate λ_n.
2) The arrival of handoff requests in a cell forms a Poisson process with rate λ_h.
3) The arrivals of new voice call requests form a Poisson process with a mean rate of λ_{nv}.
4) The departure of a new call with mean value of μ_n and the departure of handoff calls follows an exponential process with rate μ_h.

We can derive the leaving rate $\mu = (\mu_n + \mu_h)$

5) The change in arrival rates is moderate in the sense that the network reaches steady state between any two changes in the arrival rate.

We can derive the call arriving rate $\lambda = \lambda_n + \lambda_h$

3.1 Model I

In cellular communication system, it is important to give priority to the ongoing calls in comparison to the new calls. In this model m channels among the total N channels are reserved for serving the hand-off calls only. The remaining N-m channels serve both new and handoff calls. The steady state probabilities for this scheme are given below:

Let P_k be the probability that there are k calls in the cell. According to the state transition diagram in Fig. we can obtain the stationary distribution of the probability model as follows:

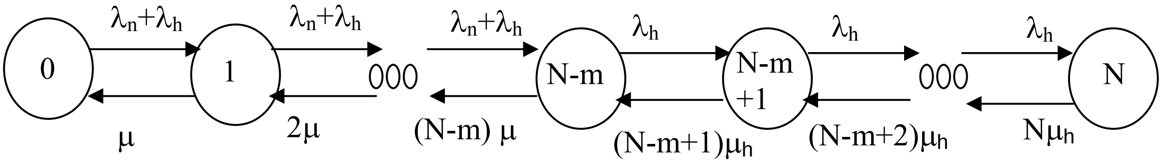


Fig. 1 Transition State Diagram for Model I

$$P_k = \begin{cases} \dfrac{1}{k!}\left(\dfrac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^k p_0, & 0 \le k \le N-m \\ \dfrac{1}{N-m!}\left(\dfrac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m} \dfrac{1}{(k-(N-m))!}\left(\dfrac{\lambda_h}{\mu_h}\right)^{k-(N-m)} p_0, & N-m+1 \le k \le N \end{cases}$$

Where

$$p_0 = \left[\sum_{k=0}^{N-m} \frac{1}{k!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^k + \sum_{k=N-m+1}^{N} \frac{1}{N-m!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m} \frac{1}{(k-(N-m))!}\left(\frac{\lambda_h}{\mu_h}\right)^{k-(N-m)}\right]^{-1}$$

The blocking probability P_b that a coming new call finds all N-m shared channels busy and will, therefore, be blocked is

$$P_b = \sum_{k=N-m}^{N} P_k$$

The dropping probability P_{hd} that a coming handoff call finds all N-m shared channels and m reserved channels are busy and will, therefore, be dropped is

$$P_{hd} = P_N = \frac{1}{N-m!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m} \frac{1}{m!}\left(\frac{\lambda_h}{\mu_h}\right)^{m} p_0$$

3.2 Model II

The sub-rating scheme is incorporated to enhance the capacity to serve more handoff attempts in the previous model. When all the N channels are busy and a new voice or handoff voice call originated, a new channel is created by sub-rating of a reserve channel to serve that call on the blocked cell. Using the birth-death rates as depicted in figure 2, we obtain the steady state probabilities as

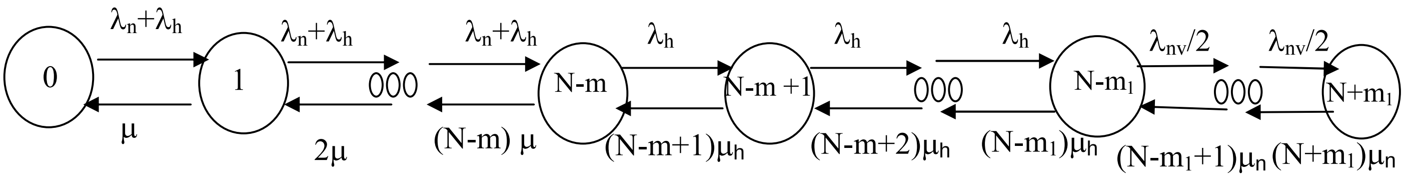


Fig. 2 Transition State Diagram for Model II

$$P_k = \begin{cases} \dfrac{1}{k!}\left(\dfrac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{k} p_0, & 0 \le k \le N-m \\ \dfrac{1}{N-m!}\left(\dfrac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m} \dfrac{1}{(k-(N-m))!}\left(\dfrac{\lambda_h}{\mu_h}\right)^{k-(N-m)} p_0, & N-m+1 \le k \le N-m_l \\ \dfrac{1}{N-m!}\left(\dfrac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m} \dfrac{1}{(m-m_l)!}\left(\dfrac{\lambda_h}{\mu_h}\right)^{(m-m_l)} \dfrac{1}{(k-(N-m_l))!}\left(\dfrac{\lambda_{nv}/2}{\mu_n}\right)^{k-(N-m_l)} p_0, & N-m_l+1 \le k \le N+m_l \end{cases}$$

Where P_0 is calculated by using normalizing condition $\sum_{k=0}^{N+m_l} P_k = 1$

P_0=

$$\left[\sum_{k=0}^{N-m}\frac{1}{k!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{k} + \sum_{k=N-m+1}^{N-m_l}\frac{1}{(N-m)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m}\frac{1}{(k-(N-m))!}\left(\frac{\lambda_h}{\mu_h}\right)^{k-(N-m)} + \sum_{k=N-m_l+1}^{N+m_l}\frac{1}{(N-m)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-m}\frac{1}{(m-m_l)!}\left(\frac{\lambda_h}{\mu_h}\right)^{(m-m_l)}\frac{1}{(k-(N-m_l))!}\left(\frac{\lambda_{nv}/2}{\mu_n}\right)^{k-(N-m_l)}\right]^{-1}$$

The blocking probability P_b that a coming new call finds all N-m shared channels busy and will, therefore, be blocked is

$$P_b = \sum_{k=N-m}^{N+m_l} P_k$$

The dropping probability P_{hd} that a coming handoff call

$$P_{hd} = \sum_{k=N-m_l}^{N+m_l} P_k$$

4. Numerical Result

To check the validity of the models described in above section we take numerical illustration and develop the necessary computation for blocking probabilities and dropping probabilities of handoff calls. In our study we have taken N= 20 channels in the cell, out of these eight are reserved for handoff calls (m =83) per cell and three channels are reserved for new voice calls (m_l=3) for model II. We choose the default values of parameters are $\lambda_n = 0.03$, $\lambda_h = 0.05$, $\lambda_{nv} = 0.04$, $\mu_n = 0.4$, $\mu_h = 0.3$.

Figure 3 shows that the new call blocking probabilities with offered load. It can be seen that the new call blocking probability of model I is slightly greater than that of model II, since the model I allocates reserve channels to the coming handoff call firstly.

Figure 4 shows the handoff call dropping probabilities with offered load. According to this figure, we can see that handoff call dropping probability of model II is greater than model I, it is obvious since we are giving the priority to new voice calls in model II.

Fig. 3

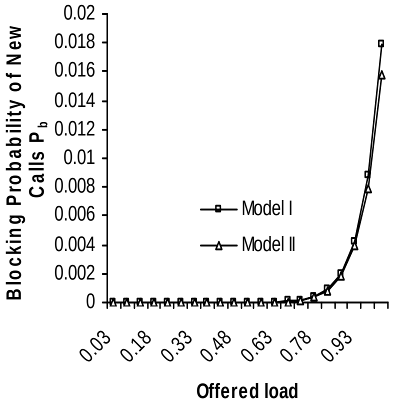
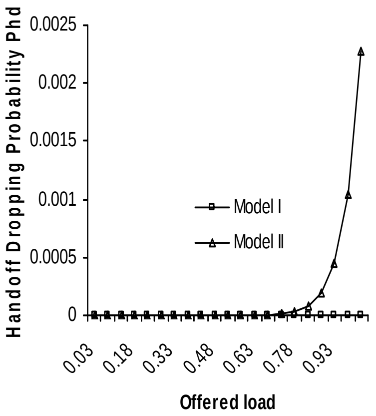


Fig. 4



5. Conclusion

In this paper two models for wireless cellular networks have been considered. In model I we are reserve some channels as guard channels for handoff calls, in the second model we are considering the sub-rating to give more channels to handoff calls and new voice calls. Then we conclude from the figures given in section 4 that model II gives the better results in term of lesser blocking probability of new calls but at the same time handoff dropping probability increases, it is obvious since we are giving the priority to new voice calls.

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