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# Prioritized Channel Assignment to Multimedia Calls in Wireless Cellular Networks

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**Abstract**

Two important Quality of Service (QOS) parameters in cellular networks are call blocking probability (CBP) and handoff dropping probability (HDP). CBP represents the probability that a new call is blocked due to unavailability of channels. HDP represents the probability that a handoff call is dropped if no channel is available in the new cell. How to keep the probability of handoff drops within a prespecified limit is a very important measure of Quality of Service (QOS) issue in cellular networks because mobile users should be able to maintain ongoing sessions during their handoff from one cell to another. It is generally presumed that a handoff call always has an acceptable signal quality, however, there may be a small probability that such calls do not have adequate signal quality and they cannot be sustained by the new base station due to poor signal quality. We have taken a note of this in case of handoff calls. Two models are proposed to calculate the blocking probability of new calls and the dropping probability of handoff calls, using fixed channel assignment (FCA) scheme in a cellular system.

**Keywords:** Cellular Networks, handoff call, call blocking probability, handoff dropping probability, guard channels

## 1. Introduction

With the proliferation of wireless devices such as mobile phones, the demand for wireless communications has grown exponentially over the last decade and is expected to be even more in the near future. More and more multimedia traffic are being transmitted via wireless media and such applications require diverse QOS. Due to the intrinsic scarcity of wireless channels, it is challenging to provide diverse QOS while achieving high bandwidth utilization. When a mobile user tries to communicate with another user or a base station, it must first obtain a channel from one of the base stations that hears it. An allocated channel is released under two scenarios: the user completes the call or the mobile user moves to another cell before the call is completed. If a channel is available, it is granted to the user otherwise the new call is blocked. The procedure of moving from one cell to another while a call is in progress is called handoff. While performing handoff, the mobile unit requires that the base station in the cell to that it moves into will allocate it a channel. If no channel is available in the new cell, the handoff call is blocked. Poorly designed handoff schemes tend to generate very heavy signaling traffic, and thereby, a dramatic decrease in QOS. Therefore, minimizing the handoff dropping probability is usually considered in the wireless system design. The aim of present work is to design a channel assignment system so to prevent handoff as far as possible.

In this paper, we propose two models; in model I preference is given to coming handoff calls. If all the unreserved channels are occupied, the cell stops providing channels to the coming new call and allocates reserve channels to the coming handoff call. Model II allocates available reserve channels to the coming handoff call first. When there is no reserve channel available, the handoff call will be allotted channels from general pool along with the coming new call on FCFS basis.

The rest of this paper is organized as follows. Section 2 describes the related work. Section 3 describes the model. Numerical results are shown in section 4. Conclusion of the paper is given in the section 5.

## 2. Literature Survey

An extension to the non-uniform compact pattern allocation algorithm called Compact Pattern with Maximized Channel Borrowing (CPMCB) is presented in [1] to minimize both the blocking rate of new calls and the handoff failure rate. An analytical model is presented in [2] to compute the blocking probability for linear highway and circular cellular systems with centralized and distributed dynamic channel allocation. A dynamic strategy that uses the estimated holding times and mobility pattern information is proposed in [3] and addressed the problem of providing resources to mobile connections during handoff between base stations. Four schemes: the SFTT (Single-Queue, FIFO, Timeout, Average Timeout), SPTT (Single-Queue, Priority, Timeout, Average Timeout), DFTS (Dual-Queues, FIFO, Timeout, Statistical TDM), DPTS (Dual-Queues, Priority, Timeout, Statistical TDM) are proposed in [4] to reduce call completion rates. Then they observed that the call completion probabilities of these four schemes are all better than the NPS (Non-Prioritized scheme) and FIFO (First in First Out) schemes. The authors in [5] considered three different admission control schemes depending on how many neighboring base stations participate in the admission decision of a new connection request. In cellular mobile communication systems, the number of channels available is limited [6]. Hence it is very important to effectively allocate channels. Therefore some channel assignment strategies with handover prioritization, guard channels, have been proposed in literature. To handle poor-signal quality handoff calls, a new handoff technique by combining the MAHO (Mobile-Assisted Handoff) and GC (Guard Channel) techniques is proposed in [7]. In this technique, the MT (Mobile Terminal) reports back not only the RSSI (Received Signal Strength Indicator) and the BER (Bit Error Rate) but the number of free channels that are available for the handoff traffic as well. Different predictive channel reservation schemes for cellular networks are studied in [8], predictive channel reservation schemes allow the reservation of a channel for an ongoing call in an adjacent cell before its owner mobile station moves into that cell, so that the call is sustained when the mobile station moves into the adjacent cell. Three channel allocation models for three different channel allocation schemes are proposed in [9]. Two traffic models for cellular networks have been considered in [10] and conclude that the second model gives a better quality of service in the system. The authors in [11] deals with a new complex telecommunication traffic model based on prioritized handover and finite storage queuing. The prioritized handover is achieved by reserving a small number of channels only for the handover calls and also, only handover-blocked calls are allowed to enter a finite storage queue. A new dynamically adaptive channel reservation scheme (DACRS) for handoff calls is developed and a performance metric equation is proposed in [12] that makes a trade off between the two probabilities depending on the network preferences and studied the performance of various proposed channel reservation schemes. A new admission control policy for cellular mobile network is proposed in [13] and showed that by integrating the concept of buffering and dwell time of the call, the new call blocking probability and handoff call dropping probability is reduced. A channel allocation scheme is presented in [14] with dynamic threshold for two different types of traffic: Voice call and data call and achieves better performance in resource management. Authors in [15] considered a priority scheme CPS (Cutoff Priority Scheme) that reserves a certain number of frequency channels to favor handoff calls. Under this scheme, the blocking probabilities of new calls and handoff calls in a cell are expressed as functions of the number of channels.

## 3. Model Description:

We consider a cellular system where each cell consists of a total of N channels, including H reserved channels and N-H general channels. Call arrivals are assumed to be generated according to Poisson distribution with rates $\lambda_n$ and $\lambda_h$ for new calls and handoff calls respectively. Service requirements for both streams are identical and exponentially distributed. Channel occupancy times for new and handoff calls are exponentially distributed with mean $\frac{1}{\mu_n}$ and $\frac{1}{\mu_h}$ respectively. It is generally presumed that a handoff call always has an acceptable signal quality, however, there may be a small probability that such calls do not have adequate signal quality and they cannot be sustained by the new base station due to poor signal quality. If a handoff call possesses poor quality then it will not be allowed to utilize the service facility because it will not work. Let $\beta$ be the probability that a call is of a poor signal then $\alpha=1-\beta$ is the probability that a call is of proper signal. If $\lambda_h$ is the arrival rate of handoff calls, the effective arrival rate of handoff calls will be considered as $\alpha\lambda_h$.

### 3.1 Model I

In this model we reserve H channels as guard channels reserved for handoff calls and remaining are general channels available to both new calls and handoff calls. However, even in the general case preference is given to handoff call vis-à-vis new calls. When the general channels are occupied and a new handoff call arrives then it is allotted a channel from guard channel and other new calls are blocked. When all the channels, including guard channels, are occupied then handoff calls will be dropped and new call will be blocked.

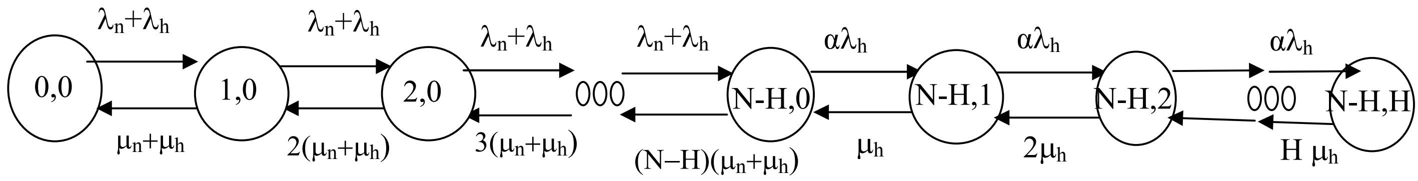


**Fig. 1 Transition State Diagram for Model I**

There can be two possible scenarios:
Case I: General Channel is not fully occupied at time t, i.e. $k \le N\text{-}H$. In this case, the coming handoff call will share general channels along with the coming new call.

Let $P_k$ be the probability that there are k channels in the base station are occupied. According to the state transition diagram in Fig. 1, we can obtain the stationary probability as follows:

$$P_k = \frac{1}{k!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^k P_0 \qquad , k \le N - H$$

Case II: If general channel is fully occupied at time t, i.e. k>N-H. At that instant, all general channels will be blocked and the cell will allocate available reserve channels to new coming handoff call. However, new calls will not be entertained i.e. they will be blocked. In this case the stationary probability is desired as follows:

$$P_k = \frac{1}{(N-H)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-H} \frac{1}{(k-(N-H))!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^{k-(N-H)} P_0 \qquad , k > N - H$$

where

$$P_0 = \left[1 + \sum_{k=1}^{N-H} \frac{1}{k!}\left(\frac{\lambda_h + \lambda_n}{\mu_n + \mu_h}\right)^k + \sum_{k=N-H+1}^{N} \frac{1}{(N-H)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-H} \frac{1}{(k-(N-H))!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^{k-(N-H)}\right]^{-1}$$

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

$$P_b = \frac{1}{(N-H)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-H} P_0$$

The dropping probability $P_D$ that a coming handover call finds all N-H general channel and H reserved channels busy, and will, therefore be dropped is

$$P_D = P_N = \frac{1}{(N-H)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-H} \frac{1}{H!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^{H} P_0$$

## 3.2 Model II

In this model any handoff call is allotted a channel from reserved channels and a new call is allotted a channel from remaining N-H channels. When the reserve channel is fully occupied with handoff calls then a handoff call is also allotted a channel from unreserved pool of channels along with new calls on FCFS basis. If all the channel are occupied, a new call is blocked and handoff call will be dropped.

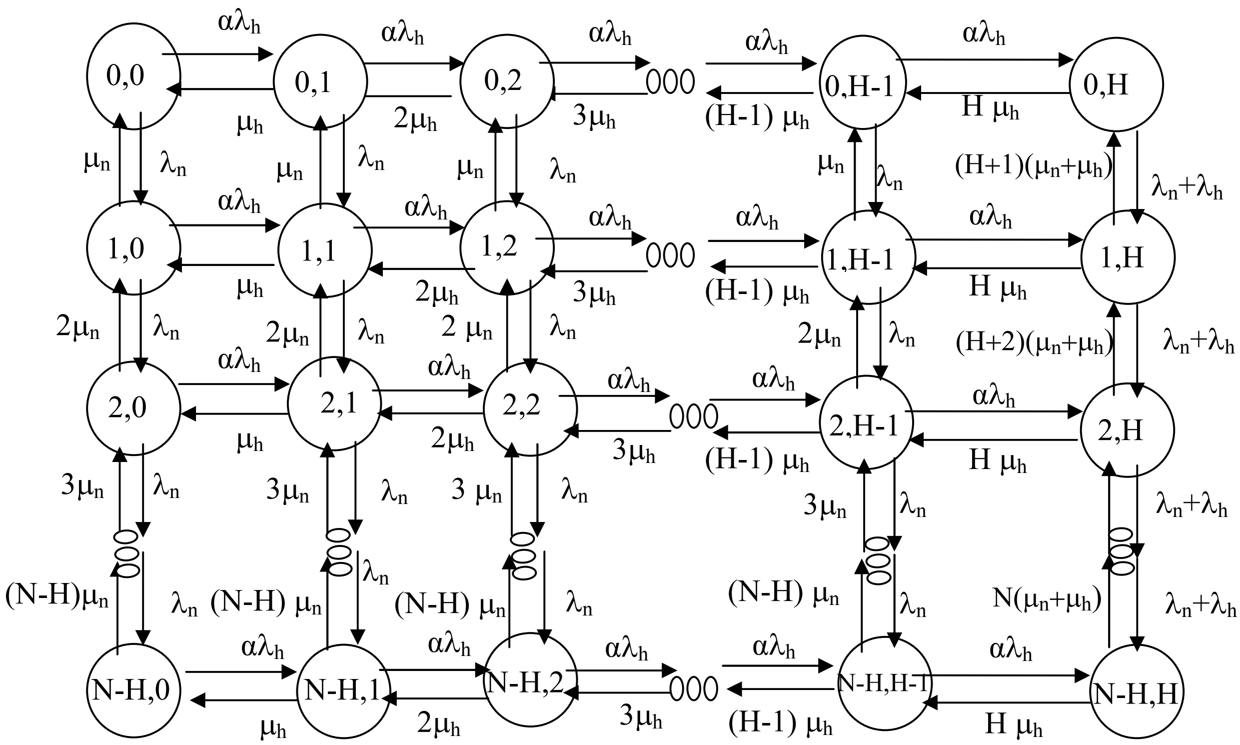


**Fig.2 Transition State Diagram for Model II**

In this case also two scenarios:

Case I: When reserve channels are not fully occupied, i.e. $j \leq H$, in this case, we should analyze the status of reserve channel and general channel respectively. Let $P_j$ be the probability that there are j calls in the reserved channel.

$$P_j = \frac{1}{j!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^j P_{0,RC} \qquad , j \leq H$$

Where

$$P_{0,RC} = \left[1 + \sum_{j=1}^{H} \frac{1}{j!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^j\right]^{-1}$$

On the other hand, the stationary distribution of general channel is deduced as follows. Here $P_k$ is the probability that there are k calls in the general channel, then

$$P_k = \frac{1}{k!}\left(\frac{\lambda_n}{\mu_n}\right)^k P_{0,SC} \qquad , k \le N - H$$

Where

$$P_{0,SC} = \left[1 + \sum_{k=1}^{N-H} \frac{1}{k!}\left(\frac{\lambda_n}{\mu_n}\right)^k\right]^{-1}$$

The blocking probability

$$P_b = \frac{1}{(N-H)!}\left(\frac{\lambda_n}{\mu_n}\right)^{N-H} P_{0,SC}$$

The dropping probability

$$P_D = \frac{1}{H!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^H \frac{1}{(N-H)!}\left(\frac{\lambda_n}{\mu_n}\right)^{N-H} P_{0,RC} P_{0,SC}$$

Case II When Reserve channels are fully occupied, i.e., j=H, in this case, the coming handoff call will share general channels with the coming new call. Let $P_k$ be the probability that there are k channels in the general channel. According to the state transition diagram in Fig. 2, the stationary distribution of general Channel is derived as follows.

$$P_k = \frac{1}{H!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^H \frac{1}{k!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^k P_0$$

where $P_0$ of this model is given by

$$P_0 = \left[1 + \sum_{j=1}^{H} \frac{1}{j!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^j + \sum_{k=1}^{N-H} \frac{1}{H!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^H \frac{1}{k!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^k\right]^{-1}$$

The blocking probability $P_b$ that a new call comes and finds that all general channels are busy equals the dropping probability $P_D$ that the coming handoff call comes and finds that all channels are busy. It can be derived as follows:

$$P_b = P_D = \frac{1}{H!}\left(\frac{\alpha\lambda_h}{\mu_h}\right)^H \frac{1}{(N-H)!}\left(\frac{\lambda_n + \lambda_h}{\mu_n + \mu_h}\right)^{N-H} P_0$$

## 4. Numerical Result

We evaluated the obtained results for both the models numerically. For numerical evaluation we have considered the following hypothetical data but there is conformity with the standard results available in literature. The total number of available channels in cell is N=20, and the number of reserve channels varies from 1 to 8. We have taken the following values of parameters are $\lambda_n$=0.6, $\lambda_h$=0.7, $\mu_n$=0.05, $\mu_h$=0.01, $\alpha$=0.6.
Fig. 3 shows the behavior of new call blocking probability $P_b$ against number of reserved channels. The blocking probability of model II is higher than model I, because we are giving priority to handoff calls with poor signal quality, and handoff calls dropped due to poor signal quality are included in it. The dropping probability of handoff calls of model II against number of channels is given in Fig. 4. It is evident that dropping probability of handoff calls in model II is less than the corresponding probability in model I.

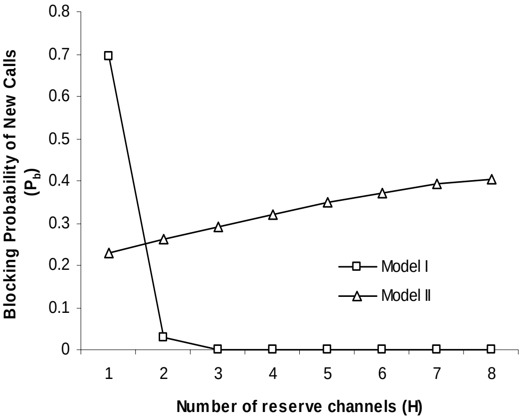


Fig. 3. Blocking probability of new calls vs. no. of reserved channels

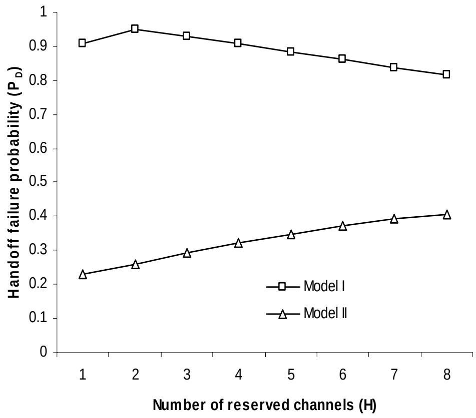


Fig. 4. Handoff failure probability vs. no. of reserved channels

Thus we conclude that model II gives better results in terms of lesser dropping probability however the blocking of new calls increases.

## 5. Conclusion

Two models for wireless cellular networks have been considered. In model I we reserve some channels for handoff calls and remaining channels are available to both new calls and handoff calls. In model II any handoff call is allotted a channel from reserved channels and a new call is allotted a channel from remaining channels. We conclude that the model II gives a better quality of service (QOS) for handoff calls by increasing the number of reserved channels.

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