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An Optimal Channel Assignment Scheme

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Abstract. In this paper, we introduce an optimal channel assignment algorithm for two traffic classes: voice and data, which maintains predefined upper bounds on the dropping probabilities of both handoff transaction and handoff voice calls in cellular mobile networks. The proposed channel assignment scheme minimizes blocking probability of both types of new calls subject to the hard constraint on dropping probabilities of handoff transaction calls and handoff voice calls. The proposed channel assignment scheme can easily be extended to multi-classes traffics.

Keywords Mobile Transactions, Call Admission Control, Guard Channels, Two-Threshold Guard Channels, Wireless Networks

1 Introduction

There has been a rapid development in wireless cellular communications and the next generation of the cellular networks are expected to eventually carry multimedia traffics- voice, data, images, video, or combinations of them. Since the wireless spectrum remains as the prime limited resource in such networks, therefore it is necessary to develop mechanisms that can can provide mechanisms that can provide effective bandwidth management while satisfying the *quality of service* (QoS) for all types of traffic. In order to use channels efficiently, the micro-cellular networks are introduced in which the service area is partitioned into regions called cells. Each cell has a fixed server computer called *base station* (BS) and is located at its center. A number of base stations are connected to a fixed computer called *mobile switching center* (MSC) which also acts as a gateway of the mobile network to the existing wired-line networks. The base stations are connected to the wired-line network and communicate with mobile computers through wireless links and with mobile switching centers through wired-line links. A mobile computer can have wireless communication with any other computer in the network, fixed or mobile, only through the base station of its cell.

A simplified structure for next generation cellular systems consists of a set of mobile computers and a set of fixed computers. Fixed computers are either fixed hosts or base stations. Fixed hosts are information servers with associated databases and are connected to the existing wired line network. Fixed computers communicate with each other through a fixed wired-line network and the mobile computers communicate with other computers by employing wireless communication. In such a system, mobile users access the data bases located on the information servers by submitting transactions. These transactions are submitted from mobile computers to base stations by using wireless connections and then sent to the information servers via the existing wired network. During execution time of a transaction, user may be participated to enter some data needed by the transaction. Since cost of a call setup is very expensive, it is assumed that during data entry period the communication link is kept. During the execution time of a transaction, a mobile computer may move from one cell to another cell. When the mobile computer enters a new cell, the base station of new cell should provide an idle channel to the mobile computer to continue its communication. This process called *handoff* and must be transparent to the mobile user. If there is no

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idle channel in the new cell, then the connection will be dropped. The dropping of an active transaction is undesirable to the mobile user and also wastes the system resources, because the database should be rolled back and the transaction will be started later. The dropping probability of handoff calls and the blocking probability of new calls are two important QoS measures of the cellular networks. In order to have control on the dropping probability of handoff calls, *call admission policies* are introduced, which determine whether a call should be admitted or blocked. Both blocking probability of new calls (B_n) and dropping probability of handoff calls (B_h) are affected by call admission policies. Admitting more new calls generally improves blocking probability of new calls and blocking more new calls generally improves dropping probability of handoff calls. Since dropping of handoff calls is more serious than blocking of new calls, call admission policies give the higher priority to handoff calls, which is usually implemented through allocation of more resources (channels) to handoff calls [1]. Many schemes have been proposed to reduce the dropping of voice calls [2–6]. However, little attention is paid to wireless multi-media networks and transaction calls. In what follows, we review some of proposed call admission policy in the cellular networks.

The simplest call admission policy is called *guard channel* policy (GC) [2]. Suppose that the given cell has C full duplex channels. The guard channel policy reserves a subset of channels, called *guard channels*, allocated to the cell for sole use of handoff calls (say $C - T$ channels). Whenever the channel occupancy exceeds the certain threshold T, the guard channel policy rejects new calls until the channel occupancy goes below the threshold. The guard channel policy accepts handoff calls as long as channels are available. It has been shown that there is an optimal threshold T^* in which the blocking probability of new calls is minimized subject to the hard constraint on the dropping probability of handoff calls [4]. Algorithms for finding the optimal number of guard channels are given in [3–5]. These algorithms assume that the input traffic is a stationary process with known parameters. If the parameter B_h is considered, the guard channel policy gives very good performance, but the parameter B_n is degraded to a great extent. In order to have more control on the dropping probability of handoff calls and the blocking probability of new calls, *limited fractional guard channel policy* (LFG) is introduced [4]. The LFG scheme reserves non-integral number of guard channels for handoff calls. The limited fractional guard channel policy uses an additional parameter π. This policy is same to the guard channel policy except when T channels are occupied in the cell. In such situations, the limited fractional guard channel policy accepts new calls with probability π. It has been shown that there is an optimal threshold T^* and an optimal value of π^* for which the blocking probability of new calls is minimized subject to the hard constraint on the dropping probability of handoff calls [4]. An algorithm for finding such optimal parameters is given in [4]. In [6], *uniform fractional guard channel policy* (UFG) is introduced which accepts new calls with probability of π independent of channel occupancy. It is shown that there is an optimal value for the parameter of uniform fractional guard channel which minimizes the blocking probability of new calls with the constraint on the upper bound on the dropping probability of handoff calls. An algorithm for finding such optimal parameter is given in [6]. Then conditions for which the uniform fractional guard channel policy performs better than guard channel policy is derived. It is concluded that, the uniform fractional guard channel policy performs better than guard channel policy in low handoff traffic conditions. All of the above mentioned algorithms are special case of *fractional guard channel policy* [4]. Some policies allow either handoff calls [7] or new calls [8] to be queued until free channels are obtained in the cell. In [9, 10], a multi-media cellular network with two traffic classes are considered and call admission control is formulated as a semi-Markov decision process problem. Since, it is too complex to have a closed form solution for this semi-Markov decision process, Q-learning [9] and neuro-dynamic programming [10] are used. In [11], two traffic classes of voice and transactions are considered and static and dynamic guard channel schemes are proposed to maintain the upper bound of dropping probability of handoff transaction calls. In this approach, $(C - T)$ guard channels are reserved for handoff transaction calls, but new calls and handoff voice calls have the same priority. Thus, this scheme fails to maintain the upper bound for dropping probability of handoff voice calls. In [12], the two-thresholds guard channel scheme is proposed for cellular network that handle two different traffic types: voice and date (transactions). In the two-thresholds guard channel scheme, two guard channels are used to maintain the level of QoS for three traffic classes (new calls, handoff voice calls, and handoff transaction calls). In order to find the optimal number of guard channels an algorithm, which is called MinBlock, is introduced. This algorithm finds the optimal number of guard channels which minimizes the blocking probability of new calls subject to the hard constraints on the dropping probability of handoff calls. In [13], an optimal algorithm called MinChannels is given which finds the minimum number of channels required in a cell which satisfies all levels of QoS's for all traffic classes.

This paper addresses the bandwidth allocation issue for a typical cellular network that can handle two different traffic types: voice and data (transactions). The main focus of our channel assignment scheme is on QoS guarantee. The proposed channel assignment scheme, assigns the set of given channels to the cells with the aim that the overall blocking probability of new calls in the network must be minimized subject to the hard constraints on the dropping probabilities of handoff transactions and voice calls. In order to guarantee QoS in each cell, a two-guard channel scheme is used to reserve channels in each cell for higher priority calls. The limiting behavior of this policy is analyzed under the stationary traffic. In order to show the feasibility of the proposed scheme, computer simulations are conducted. The proposed channel assignment scheme can easily be extended to multi-class traffics.

The rest of this paper is organized as: Section 2 presents the performance parameters of two-thresholds guard policy. Section 3 gives an optimal algorithm to find the minimum number of channels and optimal number of guard channels of the proposed scheme and section 4 concludes the paper.

2 Two-Thresholds Guard Channel Scheme

In this section, we first give two-thresholds guard channel scheme and compute its blocking probabilities. Consider a particular cell of a cellular network with C channels and its state at time t denoted by $c(t)$ to be the number of busy channels. This network has two types of calls: voice and transaction calls. Assume that the quality of service (QoS) of handoff transaction calls must be greater than the QoS of other calls and the QoS of handoff voice calls must be greater than the QoS of new calls. In order to maintain such level of QoS, channels allocated to the given cell are partitioned into three subsets: *ordinary channels*, *shared guard channels for handoff calls* and *dedicated guard channels for handoff transaction calls*. The ordinary channels are shared between all types of calls while the shared guard channels for handoff calls are shared only between handoff transaction calls and handoff voice calls and dedicated guard channels for handoff transaction calls is used only for the handoff transaction calls. In order to partition the channel sets, we use two thresholds, T_1 and T_2 $(0 < T_1 \leq T_2 \leq C)$. The procedure for accepting calls in two-thresholds guard channel policy, as shown in figure 1, can be described as follows. When a handoff transaction call arrives and an idle channel is available in the channel pool, then the call is accepted and a channel assigned to it; otherwise the handoff transaction call is dropped. When a handoff voice call arrives, then it is accepted provided that number of busy channels is smaller than the thresholds T_2; otherwise the handoff voice call is dropped. When a new voice or a new transaction call arrives at cell, then it is accepted provided that the number of busy channels is smaller than the threshold T_1 $(T_1 \leq T_2)$; otherwise, the incoming call is blocked. In this scheme, the highest priority is given to the handoff transaction calls and the lowest priority is given to the new calls.

```
if (NEW CALL) then
    if (c(t) < T1 ) then
        accept call
    else
        reject call
    end if
end if
```

```
if (HANDOFF VOICE CALL) then
    if (c(t) < T2 ) then
        accept call
    else
        reject call
    end if
end if
```

```
if (HANDOFF TRANSACTION CALL) then
    if (c(t) < C ) then
        accept call
    else
        reject call
    end if
end if
```

Fig. 1. Two- guard channel call admission

In what follows, the blocking performance of two-thresholds guard channel policy is given. The blocking performance of two-thresholds guard channel policy is computed based on the following assumptions.

1. There are two types of calls in the cellular network: voice and transaction calls. The new transaction calls have the same priority as the new voice calls but the handoff transaction calls have the higher priority than the handoff voice calls which has the higher priority than the new calls.
2. The channel holding time of new voice calls and new transaction calls are exponentially distributed with mean μ_{nv}^{-1} and μ_{nt}^{-1}, respectively and the channel holding time of handoff voice calls and handoff transaction calls are exponentially distributed with mean μ_{hv}^{-1} and μ_{ht}^{-1}, respectively. Let $\mu_v^{-1} = \mu_{nv}^{-1} + \mu_{hv}^{-1}$, $\mu_t^{-1} = \mu_{nt}^{-1} + \mu_{ht}^{-1}$ and $\mu^{-1} = \mu_v^{-1} + \mu_t^{-1}$.
3. The arrival processes of new voice calls and new transaction calls are poisson processes with rate λ_{nv} and λ_{nt}, respectively. The arrival process of handoff voice calls and handoff transaction calls are

poisson processes with rate λ_{hv} and λ_{ht}, respectively. Let $\lambda = \lambda_{nv} + \lambda_{nt} + \lambda_{hv} + \lambda_{ht}$, $\lambda_h = \lambda_{hv} + \lambda_{ht}$, $\rho = \lambda/\mu$, $\alpha = \lambda_h/\lambda$ and $\alpha_t = \lambda_{ht}/\lambda$. Note that ρ is the total traffic in Erlangs seen by a cell, while α and α_t are the handoff traffic and handoff transaction traffic in Erlangs seen by cell, respectively.
4. The time interval between two calls from a mobile host is much greater than the mean call holding time.
5. Only mobile to fixed calls are considered.
6. The network is homogenous.

The assumptions 2 through 4 have been found to be reasonable as long as the number of mobile hosts in a cell is much greater than the number of channels allocated to that cell. The fifth assumption makes our analysis easier and the sixth one lets us to examine the performance of a single network cell in isolation.

In the proposed policy, $\{c(t)|t \geq 0\}$ is a continuous-time Markov chain (birth-death process) with states $0, 1, \ldots, C$. The state transition rate diagram of a particular cell in the network, which has C full duplex channels and uses two-thresholds guard channel policy is shown in figure 2.

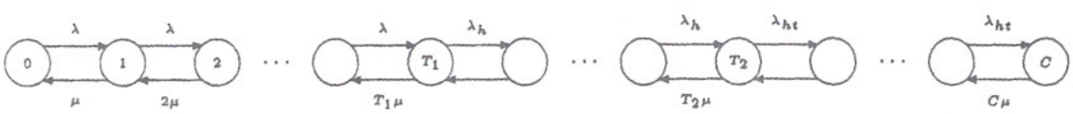

Fig. 2. Markov chain model of cell

Because of the structure of the Markov chain, we can easily write down solution of steady-state balance equations. Define the steady state probability $P_n = \lim_{t\to\infty} \text{Prob}[c(t) = n]$. Then, we have the following expression for P_n $(n = 0, 1, \ldots, C)$.

$$P_n = \begin{cases} \frac{\rho^n}{n!} P_0 & n \leq T_1 \\ \alpha^{-T_1} \frac{(\rho\alpha)^n}{n!} P_0 & T_1 < n \leq T_2 \\ \alpha^{-T_1} \left(\frac{\alpha}{\alpha_t}\right)^{T_2} \frac{(\rho\alpha_t)^n}{n!} P_0 & T_2 < n \leq C, \end{cases} \tag{1}$$

where P_0 is the probability that all channels are free and obtained from equation $\sum_{n=0}^{C} P_n = 1$. Thus P_0 is equal to the following expression.

$$P_0^{-1} = \sum_{n=0}^{T_1} \frac{\rho^n}{n!} + \alpha^{-T_1} \sum_{n=T_1+1}^{T_2} \frac{(\rho\alpha)^n}{n!} + \alpha^{-T_1} \left(\frac{\alpha}{\alpha_t}\right)^{T_2} \sum_{n=T_2+1}^{C} \frac{(\rho\alpha_t)^n}{n!} \tag{2}$$

Note that if we set $T_1 = T_2 = C$, then expression (1) reduces to the classical Erlang-B formula [14] and if we set $T_1 = T_2 = T$, then expression (1) reduces to the classical guard channel policy [2]. Now we can write expressions for dropping probability of handoff calls. The dropping probability for handoff transaction calls using C channels, $C - T_2$ dedicated guard channels and $T_2 - T_1$ shared guard channels is equal to

$$\begin{aligned} B_{ht}(C, T_1, T_2) &= P_C \\ &= \alpha^{-T_1} \left(\frac{\alpha}{\alpha_t}\right)^{T_2} \frac{(\rho\alpha_t)^C}{C!} P_0 \end{aligned} \tag{3}$$

and the dropping probability for handoff voice calls is equal to

$$\begin{aligned} B_{hv}(C, T_1, T_2) &= \sum_{n=T_2+1}^{C} P_n \\ &= \alpha^{-T_1} \left(\frac{\alpha}{\alpha_t}\right)^{T_2} \sum_{n=T_2+1}^{C} \frac{(\rho\alpha_t)^n}{n!} P_0. \end{aligned} \tag{4}$$

Similarly, the blocking probability of new calls is given by the following expression.

$$B_n(C,T) = \sum_{n=T_1+1}^{C} P_n \tag{5}$$

$$= \alpha^{-T_1} \sum_{n=T_1+1}^{T_2} \frac{(\rho\alpha)^n}{n!} P_0 + \alpha^{-T_1} \left(\frac{\alpha}{\alpha_t}\right)^{T_2} \sum_{n=T_2+1}^{C} \frac{(\rho\alpha_t)^n}{n!} P_0.$$

$B_{ht}(C,T_1,T_2)$, $B_{hv}(C,T_1,T_2)$ and $B_n(C,T_1,T_2)$ have interesting properties which are utilized in our channel assignment scheme. In this section, we study some important properties of $B_{ht}(C,T_1,T_2)$, $B_{hv}(C,T_1,T_2)$ and $B_n(C,T_1,T_2)$. From equations (3) trough (5), it is clear that the blocking probability of new calls is not smaller than the dropping probability of handoff voice calls and the dropping probability of handoff voice calls is not smaller than the dropping probability of handoff transaction calls.

Property 1. For any given values of $0 < T_1 \leq T_2 \leq C$, the following relations are held.

$$B_{ht}(C,T_1,T_2) \leq B_{hv}(C,T_1,T_2) \leq B_n(C,T_1,T_2)$$

Property 2. For the blocking probability of new calls, $B_n(C,T_1,T_2)$, the following relations hold, assuming that all other system parameters are fixed.

1. $B_n(C,T_1,T_2)$ is a monotonically decreasing function of T_1.
2. $B_n(C,T_1,T_2)$ is a monotonically increasing function of T_2.
3. $B_n(C,T_1,T_2)$ is a monotonically increasing function of C.
4. $B_n(C,T_1,T_2)$ is a monotonically increasing function of both C and T_2.
5. $B_n(C,T_1,T_2)$ is a monotonically decreasing function of C, T_1 and T_2 when relation $\frac{\rho}{T_1} < 1$ holds.

Property 3. For the dropping probability of handoff voice calls, $B_{hv}(C,T_1,T_2)$, the following relations hold, assuming that all other system parameters are fixed.

1. $B_{hv}(C,T_1,T_2)$ is a monotonically increasing function of T_1.
2. $B_{hv}(C,T_1,T_2)$ is a monotonically decreasing function of T_2.
3. $B_{hv}(C,T_1,T_2)$ is a monotonically increasing function of C.
4. $B_{hv}(C,T_1,T_2)$ is a monotonically decreasing function of C, T_1 and T_2 when relation $\frac{\rho}{T_2} < 1$ holds.
5. $B_{hv}(C,T_1,T_2)$ is a monotonically decreasing function of both C and T_2 if $\frac{\rho}{T_2} < 1$.

Property 4. For the dropping probability of handoff transaction calls, $B_{ht}(C,T_1,T_2)$, the following relations hold, assuming that all other system parameters are fixed.

1. $B_{ht}(C,T_1,T_2)$ is a monotonically decreasing function of T_1.
2. $B_{ht}(C,T_1,T_2)$ is a monotonically decreasing function of T_2.
3. $B_{ht}(C,T_1,T_2)$ is a monotonically decreasing function of C if $\rho < (C+1)$.
4. $B_{ht}(C,T_1,T_2)$ is a monotonically decreasing function of both C, T_1 and T_2 if $\rho < (C+1)$.
5. $B_{ht}(C,T_1,T_2)$ is a monotonically decreasing function of both C and T_2 if $\rho < (C+1)$.

Proof. The proof of above properties are given in [13].

3 Optimal Channel Assignment Scheme

In this section, we introduce a prioritized channel assignment algorithm for multi-cell cellular networks. Now we consider a multi-cell system consisting several clusters, where a typical cluster m contains N_m cells. Assume that a total of C full duplex interference free channels are allocated to the whole network and hence to each cluster. Under our prioritized channel assignment schemes, the allocated channels will be divided into N_m disjoint channel sets, where each channel set is allocated to one cell in cluster and the channel set of each cell is divided into three subsets: ordinary channels, shared guard channels used for handoff voice calls and dedicated guard channels used for handoff transaction calls. By applying our model to each cluster in the system, the prioritized channel assignment are obtained for whole network.

Assume the exponential channel holding time and Poisson arrivals for each call in section 2. Let $\Lambda_n = \sum_{i=1}^{N_m} \lambda_n^i$ be the total arrival rate of new calls over all cells in cluster m and λ_n^i is the arrival rate of new calls in cell i of cluster m. Define the overall blocking probability of new calls by

$$B_N = \sum_{i=1}^{N_m} \frac{\lambda_n^i}{\Lambda_n} B_n^i(C^i, T_1^i, T_2^i), \tag{6}$$

where $B_n^i(C^i, T_1^i, T_2^i)$ is the blocking probability of new calls in cell i when C^i channels are allocated to that cell and T_1^i and T_2^i are thresholds for that cell. The objective is to find the optimal value for tuple (C^i, T_1^i, T_2^i) $(i = 1, 2, \ldots, N_m)$, which minimizes the overall blocking probability of new calls subject to the hard constraint on the dropping probabilities of both handoff voice calls and handoff transaction calls. This problem is formulated as the following non-linear optimization problem.

Problem 1. Minimize the overall blocking probability of new calls, B_N, subject to the following hard constraints.

$$B_{hv}^i(C^i, T_1^i, T_2^i) \leq p_{hv} \tag{7}$$

$$B_{ht}^i(C^i, T_1^i, T_2^i) \leq p_{ht} \tag{8}$$

$$\sum_{i=1}^{N_m} C^i = C \tag{9}$$

where $0 \leq T_1^i \leq T_2^i \leq C^i$ for all $i = 1, 2, \ldots, N_m$ in cluster m.

In what follows, we propose an algorithm for solving problem 1. In order to derive the solution procedure of problem 1, we first note the convexity property of B_n with respect to C (property 5). By definition, a function $f(z)$ defined on the set of integers $Z = \{z | z \text{ is an integer}\}$ is called convex if its first differences are increasing. That is, $f(z)$ is convex if $f(z) - f(z+1) \leq f(z-1) - f(z)$ for all $z \in Z$.

Property 5. If the thresholds T_1 and T_2 are fixed at any non negative integer t_1 and $t_2 \geq t_1$, respectively, then $B_n(C, t_1, t_2)$ is convex in C provided that $C \geq t_2$ and $\frac{\rho\alpha_t}{C+1} \leq 1$.

Using property 5, it is evident that by adding more channels to a cell while the level of QoS is fixed, the blocking probability of new calls is decreased. This property is shown graphically in figure 3.

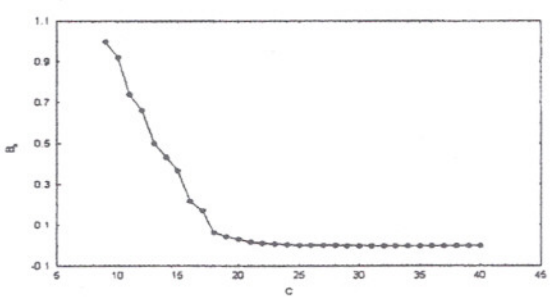

Fig. 3. Convexity of $B_n(C, T_1, T_2)$ with respect to C.

An optimal solution of the problem 1 is found by exploiting the convexity property of B_n. Initially for each cell i, the smallest number of channels required to satisfy the given QoS is found. To do this, we use the algorithm MIN-CHANNELS with the constraint $p_n = 1 - \epsilon$, where ϵ is a small positive value. Then the remaining channels, if any, are allocated to cells one by one. Let γ_i denotes the potential amount of decrement in B_n^i brought by allocation of an additional channel to cell i. Note that the additional channel can be used as an ordinary channel/ shared guard channel/ dedicated guard channel. In order to find the usage of the additional channel, the algorithm used for solving problem MinBlock [12] is used. The potential amount of decrement in B_n^i are computed for all cell i (for $i = 1, 2, \ldots, N_m$) according to the following equation.

$$\gamma_i = \frac{\lambda_n^i}{\Lambda_n} \left[B_n^i(C^i, T_1^{*i}, T_2^{*i}) - B_n^i(C^i + 1, T_1^{*i}, T_2^{*i}) \right].$$

Note that γ_i is always positive. Then a cell with the largest potential decrease in B_n is found among all cells in the cluster and an additional channel is assigned to it. This procedure is repeated until all available channels C in the cluster are used. Algorithm given in figure 4 summarizes this procedure.

Algorithm TTGC-MC

1. Solve problem MinChannels [13] for cell i (for $i = 1, 2, \ldots, N_m$) with constraint $p_n = 1 - \epsilon$, where ϵ is a small positive value.
2. **set** $S \leftarrow C - \sum_{i=1}^{N_m} C^i$
3. **if** $S = 0$ **then** terminate. $\{(C^i, T_1^i, T_2^i) | i = 1, 2, \ldots, N_m\}$ is optimal.
4. **if** S ¡ 0 **then** terminate. C channels cannot satisfy the specified QoS.
5. **for** $i \leftarrow 1$ **to** N_m **do**
6. Solve problem MinBlock for cell i with C^i and $C^i + 1$ channels.
7. **set** $\gamma_i \leftarrow \frac{\lambda_n^i}{\Lambda_n} \left[B_n^i(C^i, T_1^{*i}, T_2^{*i}) - B_n^i(C^i + 1, T_1^{*i}, T_2^{*i}) \right]$.
8. **end for**
9. **for** $i \leftarrow 1$ **to** S **do**
10. **set** $j \leftarrow \text{argmax}_i \gamma_i$.
11. **set** $C^j \leftarrow C^j + 1$.
12. **set** $\gamma_j \leftarrow \frac{\lambda_n^j}{\Lambda_n} \left[B_n^j(C^j, T_1^{*j}, T_2^{*j}) - B_n^i(C^j + 1, T_1^{*j}, T_2^{*j}) \right]$.
13. **end for**
14. $\{(C^i, T_1^{*i}, T_2^{*i}) | i = 1, 2, \ldots, N_m\}$ is the optimal solution.

end Algorithm

Fig. 4. Multi-cell prioritized channel assignment algorithm

Theorem 1. *Algorithm given in figure 4 finds the optimal solution of problem 1.*

Proof. The initial assignment is an undominated solution, in the sense that it uses the minimum number of channels to satisfy the constraints (7) and (8). This assignment results the maximum value of B_N subject to the constraints (7) and (8). Then the algorithm assigns channels one by one to cells which results the largest decrement in blocking probability of new calls. This strategy results the optimal solution. Let j_i be the index of the cell with the largest decrement in B_N at step i (for $i = 1, 2, \ldots, S$). Assume that there is another strategy which is optimal and chooses cell $k_i \neq j_i$ at step i. Thus we have $\gamma_{k_i} = \gamma_{j_i} - \delta_i$ for $\delta_i > 0$. Then interchanging cell j_i with cell k_i results in assignment

$$B_N^{k_i} = \sum_{l=1}^{N_m} \frac{\lambda_n^l}{\Lambda_n} B_n^l(C^l, T_1^l, T_2^l).$$

subtracting $B_N^{k_i}$ from $B_N^{j_i}$, we obtain

$$B_N^{j_i} - B_N^{k_i} = \delta_i.$$

Repeating this procedure for S steps, we obtain

$$\sum_{i=1}^{S} \left[B_N^{j_i} - B_N^{k_i} \right] = \sum_{i=1}^{S} \delta_i,$$

which is positive. Thus, no index other than the index with the largest value of γ_i would results in the optimal solution. Hence, the proposed cell selection mechanism minimizes the value of B_N subject to the hard constraints (7) and (8) and results in the optimal solution.

Example 1. Consider a cellular system with clusters having 7 cells. Assume that a total of 110 full duplex channels are available in this system. The upper bounds on the dropping probabilities of handoff voice calls and handoff transaction calls are set to 0.025 and 0.01, respectively. The call arrival rates, which are normalized to the call holding time, are given in table 1. The result of algorithm 3 is given in table 2.

4 Conclusions

In this paper, we considered the problem of channel assignment in the cellular mobile networks with two traffic classes. Since the dropping of handoff transaction calls is more undesirable than other calls and wastes the system resources, the proposed channel assignment scheme gives higher priority to handoff transaction calls. We derived blocking probabilities of the network and study their behavior. Then we introduced an optimal channel assignment algorithm for allocating channels to the cells, which minimizes the overall blocking probability of network subject to the all hard constraints on the quality of service of calls. The proposed method can easily be extended to multi-classes traffics.

Table 1. The traffic parameters of cellular network

Cell	λ_n	λ_h	λ_{ht}
1	4	4	1
2	6	6	1
3	8	6	2
4	7	4	1
5	5	6	2
6	10	8	2
7	4	3	1

Table 2. The result of prioritized channel assignment for multi-cell system

Cell	T_1	T_2	C	B_n	B_{hv}	B_{ht}
1	11	13	13	0.112727	0.008052	0.008052
2	13	16	16	0.233747	0.009029	0.009029
3	14	17	17	0.267828	0.008846	0.008846
4	13	15	15	0.154768	0.008658	0.008658
5	13	15	16	0.178981	0.021289	0.002365
6	19	21	22	0.198081	0.021024	0.001752
7	9	11	11	0.161206	0.009545	0.009545

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