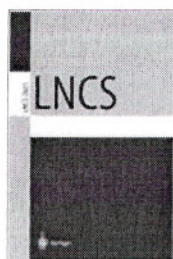


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Automated Learning

An Adaptive Uniform Fractional Guard Channel Algorithm: A Learning Automata Approach

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In [1], a learning automata (LA) based call admission policy is given which accepts new calls as long as the pre-specified level of QoS is maintained. The simulation results show that this policy cannot maintain the upper bound on the level of QoS. In this paper, we propose a new LA based algorithm in which a LA is used to accept/reject new calls. This algorithm can be considered as an adaptive version of uniform fractional guard channel policy. In order to study the performance of the proposed call admission policy, computer simulations are conducted. The simulation results show that the level of QoS is satisfied by the proposed algorithm and the performance of given algorithm is very close to the performance of uniform fractional guard channel policy which needs to know all parameters of input traffic. Unlike the uniform fractional guard channel policy, the proposed policy is fully adaptive and doesn't require any information about the input traffics.

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An Adaptive Uniform Fractional Guard Channel Algorithm: A Learning Automata Approach

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Abstract. In [1], a learning automata (LA) based call admission policy is given which accepts new calls as long as the pre-specified level of QoS is maintained. The simulation results show that this policy cannot maintain the upper bound on the level of QoS. In this paper, we propose a new LA based algorithm in which a LA is used to accept/reject new calls. This algorithm can be considered as an adaptive version of uniform fractional guard channel policy. In order to study the performance of the proposed call admission policy, computer simulations are conducted. The simulation results show that the level of QoS is satisfied by the proposed algorithm and the performance of given algorithm is very close to the performance of uniform fractional guard channel policy which needs to know all parameters of input traffic. Unlike the uniform fractional guard channel policy, the proposed policy is fully adaptive and doesn't require any information about the input traffics.

1 Introduction

Introduction of micro cellular networks leads to efficient use of channels but increases the expected rate of handovers per call. As a consequence, some network performance parameters such as *blocking probability of new calls* (B_n) and *dropping probability of handoff calls* (B_h) are affected. In order to maintain B_h and B_n at a reasonable level, *call admission algorithms* are used, which play a very important role in the cellular networks because directly control B_n and B_h . Since B_h is more important than B_n , call admission algorithms give the higher priority to handoff calls. This priority is implemented through allocation of more resources (channels) to handoff calls. A general call admission policy, called *fractional guard channel policy* (FG), accepts new calls with a probability that depends on the current channel occupancy and accepts handoff calls as long as channels are available [2]. Suppose that the given cell has C full duplex channels. The FG policy uses a vector $\Pi = \{\pi_0, \dots, \pi_{C-1}\}$ to accept the new calls,

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where $0 \leq \pi_i \leq 1$, $0 \leq i < C$. The FG policy accepts new calls with probability of π_k when k ($0 \leq k < C$) channels are busy. There is no algorithm to find the optimal vector Π^* . A restricted version of FG is called *guard channel policy* (GC) [3]. The GC policy reserves a subset of channels, called *guard channels*, for handoff calls (say $C - T$ channels). Whenever the channel occupancy exceeds the certain threshold T , the GC policy rejects new calls until the channel occupancy goes below T . The GC policy accepts handoff calls as long as channels are available. It has been shown that there is an optimal threshold T^* in which B_n is minimized subject to the hard constraint on B_h [4]. An algorithm for finding such optimal threshold is given in [4]. In order to have more control on B_h and B_n , *limited fractional guard channel policy* (LFG) is introduced [2]. The LFG can be obtained from FG policy by setting $\pi_k = 1$, $0 \leq k < T$, $\pi_T = \pi$, and $\pi_k = 0$, $T < k < C$. It has been shown that there are an optimal threshold T^* and an optimal value of π^* for which B_n is minimized subject to the hard constraint on B_h [2]. The algorithm for finding such optimal parameters is given in [2]. In [5], a restricted version of FG policy, called *uniform fractional guard channel policy* (UFG), is introduced. The UFG policy accepts new calls with probability of π independent of channel occupancy. The UFG policy can be obtained from FG by setting $\pi_k = \pi$, $0 \leq k < C$. In order to find the optimal value of parameter π , a binary search algorithm is given [5].

All of mentioned call admission policies are static and assume that all parameters of traffic are known in advance. These policies are useful when input traffic is a stationary process with known parameters. Since the parameters of input traffic are unknown and possibly time varying, the adaptive version of these policies must be used. In order to have such adaptive policies, a learning automata based call admission policy is introduced [1]. This policy accepts new calls as long as the dropping probability of handoff calls is below of a pre-specified threshold. Simulation results show that, performance of this policy is very close to the performance of the UFG policy when the handoff traffic is low, but this policy cannot maintain the upper bound on the dropping probability of handoff calls.

In this paper, we propose an adaptive version of UFG policy which maintains the upper bound on the dropping probability of handoff calls. The proposed algorithm uses a learning automaton to accept/reject new calls and the pre-specified level of dropping probability of handoff calls is used to determine penalty/reward for selected action of automaton. The simulation results show that, the performance of the proposed algorithm is very close to the performance of the UFG policy which needs to know all traffic parameters in high handoff traffic conditions. It is shown that probability of accepting new calls converges to the optimal value found by the algorithm given in [5]. Since learning automaton is adaptive and doesn't require any information about its environment, the proposed algorithm is adaptive and doesn't need any information about input traffics.

The rest of this paper is organized as follows: Section 2 presents UFG policy and the adaptive UFG algorithm is given in section 3. The computer simulations is given in section 4 and section 5 concludes the paper.

2 Uniform Fractional Guard Channel Policy

UFG policy accepts handoff calls as long as channels are available and accepts new calls with probability π independent of channel occupancy. The description of UFG policy is given algorithmically in figure 1.

```

if (HANDOFF CALL) then
    if  $c(t) < C$  then
        accept call
    else
        reject call
    end if
end if
if (NEW CALL) then
    if ( $c(t) < C$  and  $\text{rand}(0,1) < \pi$ ) then
        accept call
    else
        reject call
    end if
end if

```

Fig. 1. Uniform fractional guard channel policy

The objective is to find a π^* that minimizes the blocking probability of new calls with the constraint that the dropping probability of handoff calls must be at most p_h . The value of p_h specifies the QoS of the network. It is too complex to obtain an exact solution for this problem. Hence, a search algorithm is given in [5] to determine the optimal value of π for given traffic and constraint p_h .

3 Adaptive UFG Algorithm

In this section, we introduce an adaptive version of UFG policy which uses a learning automaton. This algorithm is used to determine admission probability π when the parameters a and ρ (or equivalently λ_h , λ_n and μ) are unknown or probably time varying. The proposed algorithm adjusts parameter π as network operates. This algorithm gives the higher probability to handoff calls by allowing the handoff calls to be accepted with higher probability than new calls. This algorithm can be described as follows: The proposed algorithm uses one reward-penalty type learning automaton with two actions in each cell. The action set of this automaton corresponds to {ACCEPT, REJECT}. The automaton associated to each cell determines the probability of acceptance of new calls (π). Since

initially the values of a and ρ are unknown, the probability of selecting these actions are set to 0.5. When a handoff call arrives, it is accepted as long as there is a free channel. If there is no free channel, the handoff call is dropped. When a new call arrives to a particular cell, the learning automaton associated to that cell chooses one of its actions. Let π be the probability of selecting action ACCEPT. Thus, the learning automaton accepts new calls with probability π as long as there is a free channel and rejects new call with probability $1 - \pi$. If action ACCEPT is selected by automaton and the cell has at least one free channel, the incoming call is accepted and action ACCEPT is rewarded. If there is no free channel to be allocated to the arrived new call, the call is blocked and action ACCEPT is penalized. When the automaton selects action REJECT, the incoming call is blocked and the base station estimates the dropping probability of handoff calls (\hat{B}_h). If the current estimate of dropping probability of handoff calls is less than the given threshold p_h , then action REJECT is penalized; otherwise action REJECT is rewarded.

The main contribution of this paper is summarized in theorem 1, which is stated below and proved in [6].

Theorem 1. Adaptive UFG algorithm minimizes the blocking probability of new calls while the the dropping probability of handoff calls is smaller than p_h .

4 Simulation Results

In this section, we compare performance of the uniform fractional guard channel [5], the learning automata based call admission [1] policies and the proposed algorithm. The results of simulations are summarized in table 1. The simulation is based on the single cell of homogenous cellular network system. In such network, each cell has 8 full duplex channels ($C = 8$). In the simulations, new call arrival rate is fixed to 30 calls per minute ($\lambda_n = 30$), channel holding time is set to 6 seconds ($\mu^{-1} = 6$), and the handoff call traffic is varied between 2 calls per minute to 20 calls per minute. The results listed in table 1 are obtained by averaging 10 runs from 2,000,000 seconds simulation of each algorithm. The objective is to minimize the blocking probability of new calls subject to the constraint that the dropping probability of handoff calls is less than 0.01. The optimal parameter of uniform fractional guard channel policy is obtained by algorithm given in [6].

By carefully inspecting the table 1, it is evident that for some range of input traffics, the performance of the proposed algorithm is close to the performance of the UFG policy and performs better than the algorithm given in [1]. Since in the low handoff traffic conditions, the UFG policy doesn't maintain the upper bound on the dropping probability of handoff calls, the blocking probability of new calls for the proposed algorithm is greater than the blocking probability of new calls for UFG. When the handoff traffic becomes high, the UFG policy maintains the upper bound on the dropping probability of handoff calls and the performance of UFG policy and the proposed algorithm is very close. In such situations, the probability of accepting new calls converges to the optimal value found by the algorithm given in [5].

Table 1. The simulation results

λ_h	UFG			LA Based Algorithm [1]			Proposed Algorithm		
	π^*	B_n	B_h	π^*	B_n	B_h	π^*	B_n	B_h
2	0.9759	0.0239	0.0246	0.9255	0.0881	0.0194	0.7609	0.2085	0.0100
4	0.9093	0.0898	0.0236	0.8960	0.1196	0.0216	0.7043	0.2609	0.0100
6	0.8424	0.1572	0.0222	0.6821	0.3152	0.0100	0.6366	0.3186	0.0100
8	0.7757	0.2238	0.0203	0.7352	0.2722	0.0165	0.6171	0.3652	0.0100
10	0.7091	0.2898	0.0192	0.6559	0.3579	0.0140	0.6712	0.3372	0.0155
12	0.6424	0.3568	0.0176	0.6268	0.3869	0.0155	0.5478	0.4698	0.0100
14	0.5758	0.4240	0.0163	0.5381	0.4764	0.0129	0.4808	0.5154	0.0102
16	0.5091	0.4899	0.0150	0.5263	0.4839	0.0158	0.4518	0.5505	0.0111
18	0.4425	0.5570	0.0139	0.5036	0.4994	0.0185	0.4128	0.5893	0.0120
20	0.3758	0.6237	0.0133	0.5029	0.5018	0.0234	0.3670	0.6238	0.0135

5 Conclusions

In this paper, we proposed a new learning automata based algorithm in which a learning automaton is used to accept/reject new calls. This algorithm can be considered as an adaptive version of uniform fractional guard channel policy. We studied the performance of the proposed call admission policy through computer simulations. Simulation results show that in high handoff traffic conditions for which the UFG policy maintains the level of QoS, performance of the proposed algorithm is very close to performance of the UFG policy. In such situations, the probability of accepting new calls converges to the optimal value. In low handoff traffic conditions, the proposed algorithm performs better than the UFG policy.

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