Adaptive Admission Control Scheme for Multiservice Mobile Cellular Networks

David Garcia-Roger, Mª Jose Domenech-Benlloch, Jorge Martinez-Bauset and Vicent Pla

***Abstract*—. We propose a novel adaptive scheme that operates in association with either of two admission control policies, the Multiple Guard Channel (MGC) and the Multiple Fractional Guard Channel (MFGC) policies. We provide two different implementations of the scheme, which adapt the configuration parameters of the associated policy according to the perceived QoS. The numerical evaluation carried out shows that the QoS objective is met with an excellent precision and the convergence period is much shorter than in previous proposals (approximately in the range of a thousand seconds), confirming that our approach can satisfactorily deal with the nonstationarity of an operating network. Two other key features of our scheme are its simplicity and time independency.**

***Index Terms*—mobile cellular networks, multiservice, adaptive admission control, dynamic resource allocation.**

I. INTRODUCTION

ADMISSION control (AC) is a key aspect in the design and operation of multiservice mobile cellular networks that provide Quality of Service (QoS) guarantees. Terminal mobility makes it very difficult to guarantee that the resources available at the time of session setup will be available in the cells visited during the session lifetime. The design of the AC system must take into account not only packet level issues (like delay, jitter or losses) but also session level issues (like loss probabilities of both new session and handover requests).

We study a set of trunk reservation policies for which the decision to accept a new request, say for example of the service class r, depends only on the number of free resource units in the system.

For a monoservice scenario, it has been shown that two trunk reservations polices named the Guard Channel and the Limited Fractional Guard Channel are optimal for common QoS objective functions [1]. More recently, the multiservice scenario has been studied in [2], where it is shown that the performance of the Multiple Fractional Guard Channel policy is close to the performance of the optimal policy. In [2] the performance of an AC policy is evaluated by determining the maximum aggregated new request rate that can be offered to the system while meeting certain QoS requirements, which is known as the system capacity. The QoS objective is defined in terms of upper bounds for the new requests and handover requests blocking probabilities.

For the type of policies under study, two sets of parameters are required to determine the system capacity: those that describe the services as Markovian processes and those that specify the QoS objective. Typically, during the planning phase a scenario is considered, where the AC scheme is assumed to be static and the first set of parameters are assumed to be stationary. However, it is reasonable to envisage that fixed AC schemes are not suitable for all situations, mainly when the amount of offered traffic per service varies with time. In this nonstationary scenario, the common approach is to periodically estimate the parameters that describe the services.

In this paper we study the design of adaptive AC schemes suitable for multiservice mobile cellular networks that adjust the configuration of a trunk reservation policy in accordance with changes in the QoS perceived by the users. The configuration of an AC policy defines the action (accept/reject) that must be taken in each system state when a new or handover request arrives. It should be noted that in order to bound the handover blocking probability the AC policy may reject some specific new requests.

Recently, a considerable amount of adaptive AC schemes for cellular scenarios have been proposed. In these proposals the AC configuration is dynamically adapted based on the estimation of traffic or QoS parameters. Two relevant examples of this approach in a single service scenario are [3, 4]. A four parameter algorithm based on the estimation of the blocking probability perceived by handover requests is proposed in [3] to adjust the number of guard channels. A six hour period is defined during which the system accumulates information to estimate the handover blocking probability. This period is too long to capture the dynamics of operating mobile cellular networks. Besides, the value of the parameters proposed in [3] do not work properly when some traffic profiles are offered [4], (i.e. QoS objectives are not met). A two parameter probability-based adaptive algorithm, somewhat similar to that of Random Early Detection (RED), is proposed in [4] to overcome these shortcomings. The main

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advantage is that it reduces the new request blocking probability, once the steady state has been reached, and therefore higher resource utilization is achieved. Nevertheless, the convergence period is still of the order of hours.

Adaptive AC mechanisms have also been studied, for example in [5, 6, 7], both in single service and multiservice scenarios, but in a context which is somewhat different to the one of this paper. There, the adjustment of the AC policy configuration is based on estimates of the handover arrival rates derived from the current number of ongoing calls in neighbouring radio cells and the mobility pattern. In our context, the adaptive scheme adjusts the configuration of the AC policy deploying a novel approach which only makes use of the actions taken by the AC system and does not make use of any type of predictive information. Our scheme also uses a probabilistic approach to the problem, like in [4], but reduces considerably the convergence period.

In this paper, we study the performance of an adaptive approach associated with two AC policies that may be considered representative of the trunk reservation family in the multiservice scenario: *Multiple Guard Channel* (MGC) and *Multiple Fractional Guard Channel* (MFGC) [2].

Our contribution is an adaptive AC scheme that differs from previous proposals in: 1) the simplicity and time independency of the proposed adaptive AC scheme, which does not rely on measurement intervals to estimate the value of system parameters; 2) the possibility of identifying protected and 'best-effort' arrival streams, being the latter useful to concentrate on it the penalization that ineludibly occurs during overloads; and 3) the high precision in the fulfillment of the QoS objective.

The remaining of the paper is structured as follows. Section II describes the model of the system and defines the AC policies used in association with the adaptive scheme. Section III describes the fundamentals of the adaptive scheme, explaining the policy adjustment strategy and how multiple services are handled. Section IV discusses some considerations related to the deployment of the adaptive scheme with trunk reservation policies. Section V presents the results of the performance evaluation of the proposed adaptive scheme under stationary and nonstationary traffic conditions, in different scenarios. Finally, Section VI concludes the paper.

II. SYSTEM MODEL AND ADMISSION CONTROL POLICIES

We consider the homogeneous case where all cells are statistically identical. Consequently the global performance of the system can be analyzed focusing on a single cell, under the assumption that the neighboring cells show independent random behavior. Nevertheless, the proposed adaptive scheme could also be deployed in non-homogeneous scenarios. In each cell a set of R different classes of users contend for C resource units. The physical meaning of a unit of resources depends on the specific technological implementation of the radio interface. For each service, new and handover arrival requests are distinguished, which defines $2R$ types of arrivals. For any class r, $1 \le r \le R$, new requests arrive according to a Poisson process with time-varying rate $\lambda_r^n(t)$ and request c_r resource units per session. The duration of a service r session is exponentially distributed with rate μ_r^s. The cell residence time of a service r session is exponentially distributed with rate μ_r^{re}. Hence, the resource holding time for a service r session in a cell is exponentially distributed with rate $\mu_r = \mu_r^s + \mu_r^{re}$. We consider that handover requests arrive according to a Poisson process with time-varying rate $\lambda_r^h(t)$, which we will suppose it is a known fraction of the value of $\lambda_r^n(t)$. We denote by P_i, $1 \le i \le 2R$, the blocking probabilities for each of the $2R$ arrival streams, being the blocking probabilities for new requests $P_i^n = P_i$ and being the handover blocking probabilities $P_i^h = P_{R+i}$. The QoS objective is expressed as upper bounds for both the blocking probabilities of new requests (B_r^n) and handover requests (B_r^h). Let the system state vector be $n \equiv (n_1, n_2, \ldots, n_{2R-1}, n_{2R})$, where n_i is the number of arrival stream i sessions in progress in the cell. We denote by $c(n) = \sum_{i=1}^{2R} n_i \cdot c_i$ the number of busy resource units in state n.

The definition of the AC policies of interest are as follows: 1) *Complete-Sharing* (CS). A request is admitted provided there are enough free resource units available in the system; 2) *Multiple Guard Channel* (MGC). Only one parameter is associated with an arrival stream i, $l_i, \in \mathbb{N}$. When an arrival of stream i happens in state n, it is accepted if $c(n) + c_i \le l_i$ and blocked otherwise; 3) *Multiple Fractional Guard Channel* (MFGC). Two parameters are associated with arrival stream i, $t_i \in \mathbb{N}$ and $q_i \in [0,1]$. When an arrival of stream i happens in state n, it is accepted with probability one if $c(n) + c_i < t_i$, with probability q_i if $c(n) + c_i = t_i$, and blocked otherwise. These two parameters may be summarized as $l_i = t_i + q_i$.

The performance evaluation of the adaptive scheme when applied to each policy is carried out for five different scenarios (A, B, C, D and E) that are defined in Table I, being the QoS parameters B_i expressed as percentage values. The parameters in Table I have been selected to explore possible trends in the numerical results, i.e., taking scenario A as a reference, scenario B represents the case where the ratio c_1 / c_2 is smaller, scenario C where f_1 / f_2 is smaller, scenario D where B_1 / B_2 is smaller and scenario E where B_1 and B_2 are equal. Note that the aggregated arrival rate of new requests is $\lambda = \sum_{r=1}^{R} \lambda_r^n$, being $\lambda_r^n = f_i \lambda$. The system capacity is the maximum λ that can be offered to the system while meeting the QoS objective.

III. FUNDAMENTALS OF THE ADAPTIVE SCHEME

While the optimality of static policies has been studied under stationary traffic conditions, with nonstationary arrival rates producing periods of overload and underload, as it occurs in real systems, the QoS obtained may diverge considerably from the objective. We propose an adaptive scheme which adjusts the configuration parameters of trunk reservation policies according to the AC decisions to maintain the blocking probabilities P_i close to their objectives. Two other

TABLE I
DEFINITION OF THE SCENARIOS UNDER STUDY

	A	B	C	D	E
c_1	1	1	1	1	1
c_2	2	4	2	2	2
f_1	0.8	0.8	0.2	0.8	0.8
f_2	0.2	0.2	0.8	0.2	0.2
B_1^n %	5	5	5	1	1
B_2^n %	1	1	1	2	1
	A, B, C, D, E				
B_r^h %	$0.1B_r^n$				
λ_r^n	$f_r\lambda$				
λ_r^h	$0.5\lambda_r^n$				
μ_1	1				
μ_2	3				

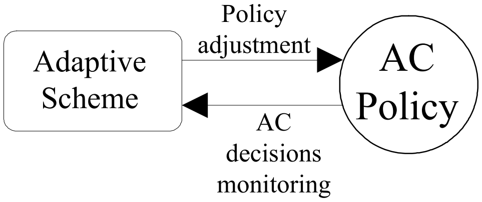


Fig. 1. Relation of the proposed adaptive scheme and its associated AC policy.

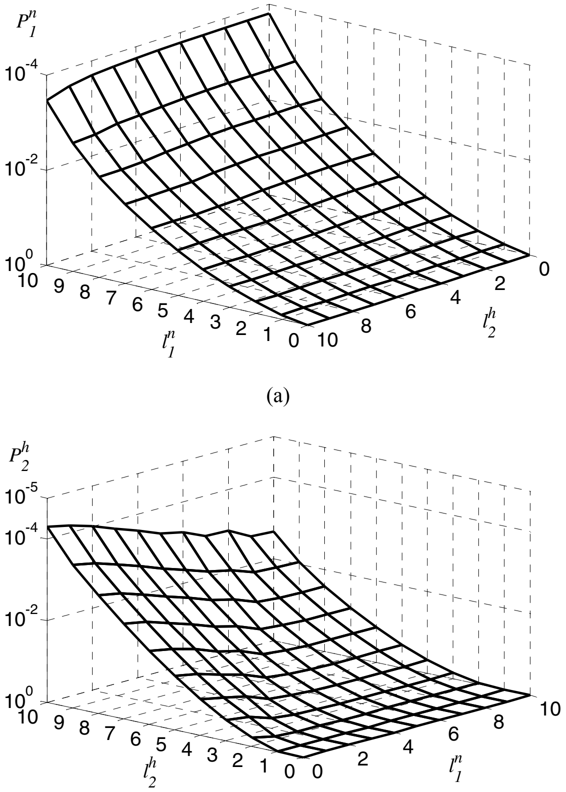
performance issues have been taken into account when designing our adaptive scheme: first, to achieve a short convergence period and, second, to enforce a specific behavior during overload situations.

Figure 1 shows the general structure of the proposed adaptive scheme. As seen, the adaptive scheme interacts with the AC policy, having as input the AC decisions taken by the AC and as output the necessary policy adjustment.

A. Policy Adjustment Strategy and Multiservice Handling Considerations

All previous adaptive schemes for guard channel policies built their policy adjustment strategy on the intuitive reasoning that more guard channels need to be provided to those arrival streams that do not meet their QoS objective. While mechanisms deploying this idea are not difficult to devise for single service scenarios, for the multiservice ones the problem is much more difficult.

We make use of the optimal *prioritization order* [8] concept to approach the problem. For trunk reservation policies, if $\mathbf{l} = (l_1, l_2, \dots l_{2R})$ is the policy configuration at which the system capacity is achieved, the permutation $\sigma^* \in \Sigma$, $\Sigma := \{(\sigma_1, \dots, \sigma_i \dots, \sigma_{2R}) \colon \sigma_i \in \mathbb{N},\ 1 \le \sigma_i \le 2R\}$, such that $l_{\sigma_1^*} \le l_{\sigma_2^*} \le \dots \le l_{\sigma_{2R}^*} = C$, is the optimal prioritization order. Selecting the optimal prioritization order is a complicated task as it depends on QoS constraints, traffic and system characteristics. For a stationary scenario, a methodology for determining it was proposed in [9]. Our adaptive scheme only requires the determination of the highest and lowest priority arrival streams. The procedure to identify these two arrival streams in a nonstationary scenario is left for further study.



(a)

(b)

Fig. 2. An example showing the dependency of the blocking probability perceived by the lowest (a) and highest (b) priority arrival streams with their configuration parameters.

The heuristic reasoning that lies behind the proposed policy adjustment strategy is that the adjustment of the configuration parameter associated with the arrival stream i, l_i, only affects P_i, the QoS experienced by that arrival stream. This assumption, which does not hold in general, tends to be more correct for the P_i of those arrival streams with a low ranking on the optimal prioritization order and less correct for those with a high ranking. As an example, Fig. 2 shows the dependency of the perceived blocking probabilities of the highest and lowest priority arrival streams in scenario A with $C = 10$ units of resources, when deploying the MGC policy and the offered traffic equals the system capacity. In this case, service 1 new arrival stream has the lowest priority, while service 2 handover stream has the highest priority. Fig. 2 (a) and (b) display the behavior of P_1^n and P_2^h with their respective policy configuration parameters l_1^n and l_2^h, while keeping the other configuration parameters at their optimum values. As seen, the assumption that the variation of the configuration parameter for arrival stream i, l_i, has only influence on P_i is quite correct for the lowest-priority arrival stream, whereas P_2^h is noticeably affected by variations in l_1^n.

Moreover, Fig. 2 (b) suggests that the adaptive scheme should never modify the MGC policy configuration parameter associated with the highest-priority arrival stream, unless severe performance degradation can be accepted. As observed, setting $l(\sigma^{*}_{2R}) = C$ seems to be a good option to achieve the QoS objective.

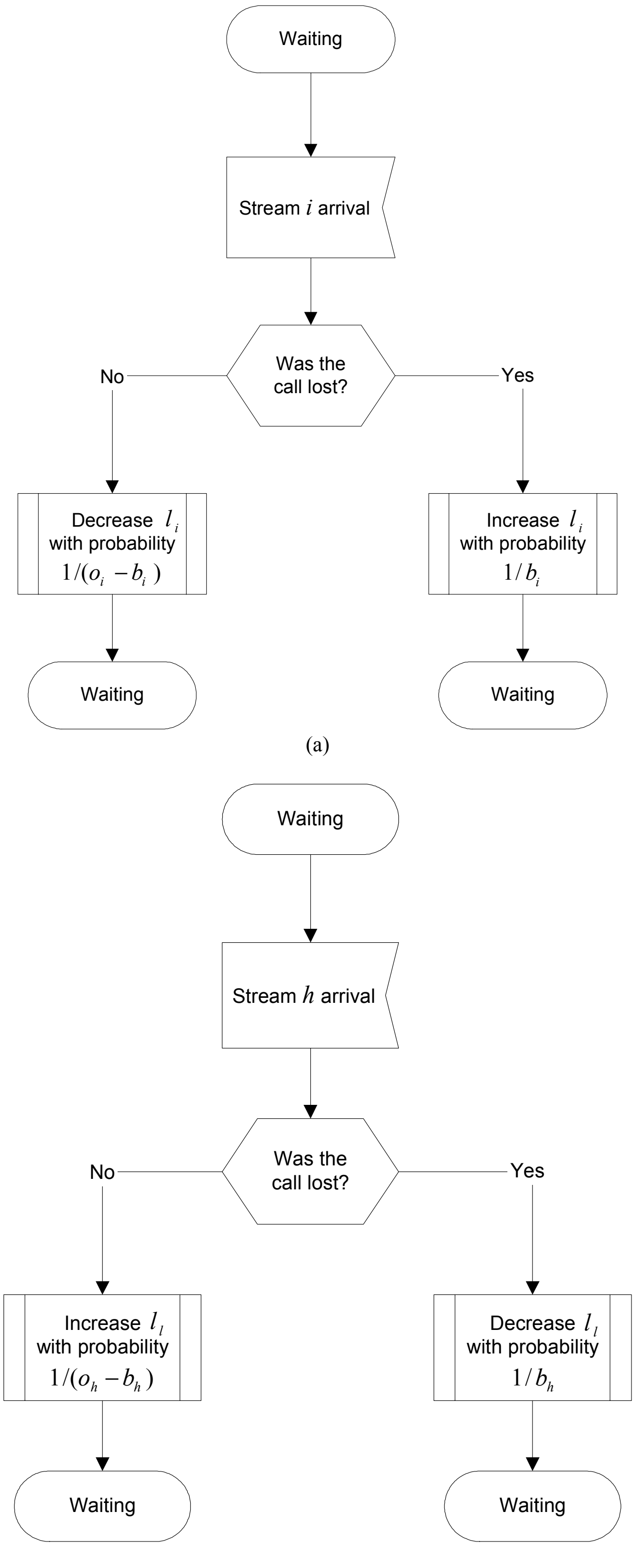
B. *Monitoring of Admission Control Decisions*

Some previous studies [5, 6, 7] assume a far more complex network model than ours, for example taking into account the state of neighboring cells to predict handover arrival rates, but some of their fundamental ideas are still relevant in our context. In contrast, other simpler approaches are used in [3, 4], which only consider the ratio of the rejected and total number of handovers requests.

All those strategies need an explicit time interval (sometimes called *update period*) during which data collection takes place and at the end of which a new estimation of some parameters is produced. The update period may be a fixed value [3, 4], which can be set as short as possible [5], or be associated with a specific number of incoming new requests [6].

A fixed update period needs some design considerations. If it is too small, the adaptive scheme will adapt quickly to network changes but probably achieving a poor performance. In contrast, if the update period is too long, the adaptive scheme is assisted by accurate estimations, but possibly not fast enough to cope with the dynamics of a real operational network. It should also be noted that the precision of the estimation will have an impact on the performance of the system. It is suggested in [3] that in order to achieve a given accuracy, the smaller the blocking probability objective is, the longer the estimation interval must be. Due to the low handover blocking probabilities required, this update period might be excessively long (of the order of hours in [3]).

Our adaptive scheme overcomes the time-dependency drawbacks mentioned previously. The only parameter observed is the QoS experienced by each service, however this observation is performed via an indirect approach, which is virtually time independent. Assuming a stationary arrival processes and being in the in steady-state regime, it seems intuitive that the adjustment mechanism should not modify the configuration parameters of those arrival streams for which the QoS objective is being met. We propose to perform a probabilistic adjustment at every AC decision that works as follows. Let us suppose that the QoS objective of the arrival stream *i*, B_i, may be expressed as a rational number $B_i = b_i / o_i$, where $b_i, o_i \in \mathbb{N}$. In the steady-state regime, it is expected that an arrival stream which $P_i = B_i$, experiences, in average, b_i rejected requests, and $o_i - b_i$ accepted requests, out of every o_i offered requests. Therefore, we propose that when an accept decision is taken then the policy adjustment strategy decreases the configuration parameter associated with that arrival stream (l_i) with probability $1/(o_i - b_i)$. On the other hand, we propose that when a reject decision is taken then the policy adjustment strategy increases the configuration parameter associated with that arrival stream (l_i) with probability $1/b_i$. Note that for AC policies using integer values for l_i (like MGC), the configuration adjustment, when effectively occurs, adds +1 or -1 to l_i. In contrast, for



(a)

(b)

Fig. 3. Adjustment of configuration parameters. (a) All streams but the highest priority arrival one (b) The highest priority arrival stream.

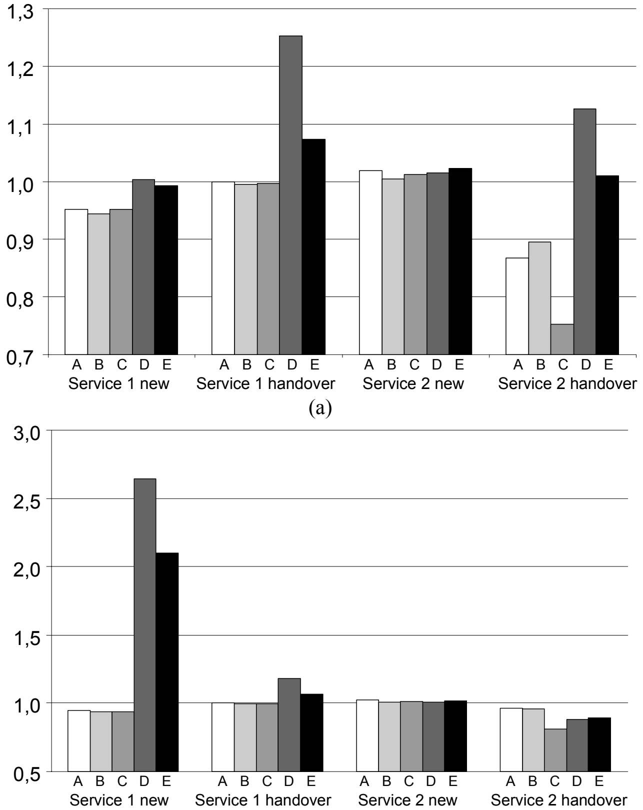
AC policies using fractional values for l_i (like MFGC), a constant parameter Δl_i that specifies the variation step of l_i can be defined.

IV. USE OF THE ADAPTIVE SCHEME FOR TRUNK RESERVATION POLICIES

In Fig.3 we specify two adjustment schemes. Fig. 3 (a) shows the flow chart of the adaptive scheme for any arrival stream *i*, except the highest-priority arrival stream, which integrates the fundamental concepts described so far. Several procedures, one for each arrival stream, run in parallel. As described, once an arrival of stream *i* happens, a decision is taken according to the current AC configuration parameter l_i. This AC decision, in turn, triggers an adjustment, either increasing or decreasing the configuration parameter l_i with a certain probability.

TABLE II
SYSTEM CAPACITY FOR THE FIXED AC POLICIES UNDER A STATIONARY TRAFFIC SCENARIO WITH 10 RESOURCE UNITS

	A	**B**	**C**	**D**	**E**
MGC	1.89	0.40	1.52	1.97	1.74
MFGC	2.05	0.41	1.66	2.03	1.81



(a)

(b)

Fig. 4. Performance of the adaptive scheme for the MGC policy under a stationary traffic scenario measured as the ratio of the achieved blocking probabilities to their objectives (P_i / B_i). (a) AC decisions of the highest-priority arrival stream are ignored. (b) AC decisions of the highest-priority arrival stream are used to adjust the configuration parameter of the lowest-priority arrival stream.

The other adjustment scheme is defined in Fig. 3 (b), which shows the flowchart of the adaptive scheme for the highest-priority arrival stream *h*. As observed, it adjusts the configuration parameter of the lowest-priority arrival stream using the AC decisions of the highest-priority arrival stream. It should also be noted that the number of procedures that compose our adaptive scheme is $2R-1$. As justified in Section III-A, the configuration parameter of the service with the highest priority should be left constant and equal to *C*.

Given that the adjustment mechanism for the highest-priority arrival stream is conveniently disabled, two options are now possible: just ignoring the AC decisions concerning the highest-priority arrival stream or using them to adjust the lowest-priority arrival stream.

1) *Ignoring AC events of the highest-priority arrival stream*: The simplest choice is to avoid running the adaptive scheme instance for the highest priority arrival stream, in which case $2R-1$ instances of Fig. 3 (a) are used. As will be justified in Section V, this choice has performance benefits when the offered load is below the system capacity (underload), but it has drawbacks when the offered load is above the system capacity (overload), since it leaves the highest-priority arrival stream unprotected.

2) *Using the AC decisions of the highest-priority arrival stream to adjust the configuration parameter of the lowest-priority arrival stream*: As suggested by Fig. 2 (b) this is an indirect way to influence the QoS perceived by the highest-priority arrival stream. In this particular case, reject decisions for the highest-priority arrival stream should trigger a decrease of the configuration parameter for the lowest-priority stream and vice versa, see Fig. 3 (b). Therefore $2R-2$ instances of Fig. 3 (a) and 1 instance of Fig. 3 (b) are used. Since the AC events of the lowest-priority arrival stream are not monitored, this will receive an unpredictable service, similar to a 'best-effort' service.

V. PERFORMANCE EVALUATION

In this section, we evaluate the performance of the adaptive scheme associated with the AC policies of interest. The performance analysis is done by using Möbius$^{\text{TM}}$ [10]. Möbius$^{\text{TM}}$ is a software tool for modeling the behavior of complex systems, which supports Stochastic Activity Networks (SANs). Möbius allows to simulate the SANs that model the type of multiservice mobile cellular networks of interest in our study, and under certain conditions, even to numerically solve the associated continuous-time Markov chains. We used the numerical solution when it was feasible and, when it was unpractical due to the size of the state space, we resorted to the simulation.

Table II displays the system capacity when deploying the MGC and the MFGC policies without the adaptive scheme, for the five scenarios defined in Table I, $C=10$ resource units and stationary traffic. Please, refer to [11] or [2] for details on how to determine the system capacity.

A numerical resolution is done for the five scenarios with C=10 to evaluate the performance of the adaptive scheme when associated with the MGC policy. The evaluation of the adaptive scheme when deployed with the MFGC policy is done by simulation because for the Δl_i used (0.1 and 0.01) the size of the state space becomes too big.

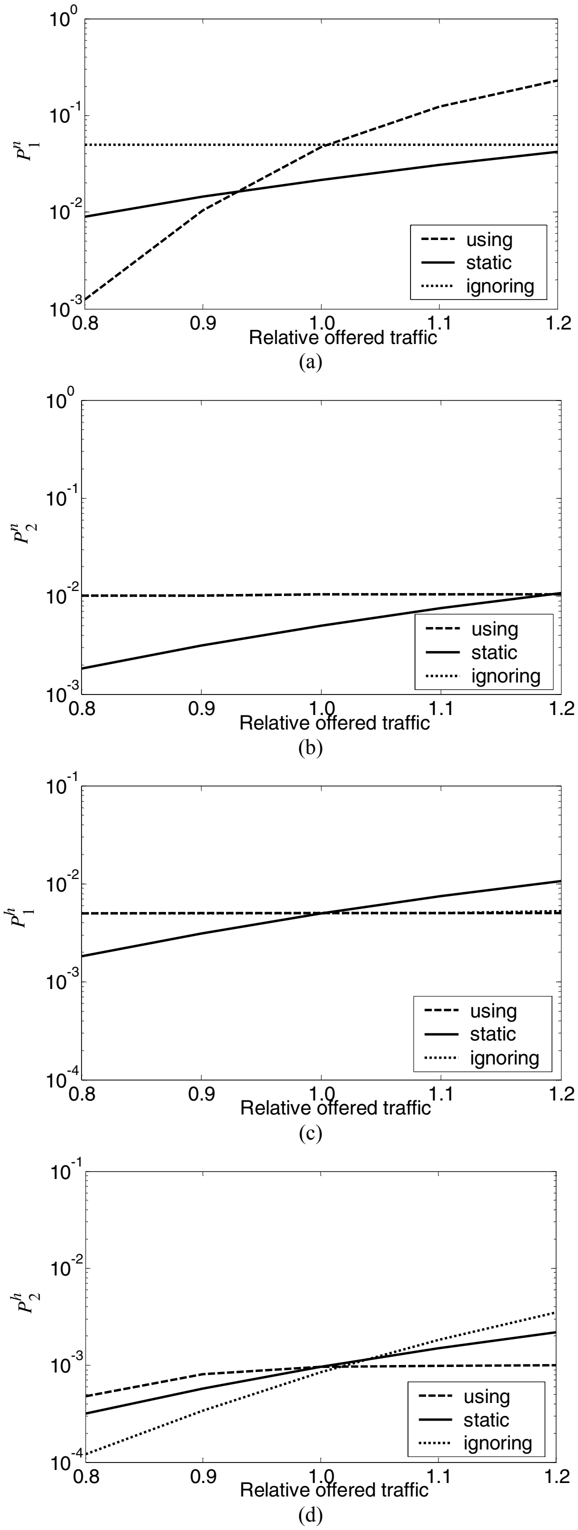
A. Performance under Stationary Traffic

The performance of the adaptive scheme associated with the MGC policy is shown in Fig. 4 (a) and (b), where handover requests of service 2 constitute highest-priority arrival stream and new requests of service 1 the lowest-priority arrival stream. The curves show the ratio of the achieved blocking probabilities to their objectives (P_i / B_i) obtained when ignoring the AC decisions of the highest-priority arrival stream (a) and when using them to adjust the configuration parameter of the lowest-priority arrival stream (b). In both cases a stationary traffic equal to the system capacity is offered to the system. To provide an additional insight Fig. 5 shows the blocking probabilities of the four arrival streams with respect to the offered traffic for scenario A with $C = 10$ resource units. Each figure displays the behavior of the optimal static policy, and the two alternative adaptive schemes. Fig. 5 (a) and (d) are of particular interest because they refer to the lowest and highest-priority arrival streams respectively. As mentioned, ignoring AC decisions of the highest-priority arrival stream tends to improve performance during underload, but a weak protection for this stream is obtained during overload. On the other hand, the use of the AC decisions of the highest-priority arrival stream to adjust the configuration parameter of the lowest-priority arrival stream penalizes the lowest-priority arrival stream to allow the highest-priority stream to achieve its QoS objective. It is not difficult to predict that the penalization can be severe during overloads, as Fig. 5 (a) shows. Finally, Fig. 5 (b) and (c) illustrate how the remaining arrival streams keep their QoS objectives adjusted in both situations, below and above the system capacity.

It is also interesting to note that if the AC decisions of the highest-priority arrival stream are used to adjust the configuration of the lowest-priority arrival stream then, during underload, the system tends to reject more requests than required from service 1 handover and service 2 new arrival streams. Nevertheless, as observed, both the highest and lowest-priority arrival streams benefit from this extra capacity.

TABLE III
RESOURCE UTILIZATION FACTOR WHEN DEPLOYING THE STATIC POLICY AND THE TWO ADAPTIVE SCHEMES

Relative offered traffic	**Static**	**Using**	**Static/ Using**	**Ignoring**	**Static/ Ignoring**
0.8	0.2104	0.2110	0.9973	0.2051	1.0260
0.9	0.2358	0.2361	0.9989	0.2307	1.0222
1.0	0.2607	0.2567	1.0155	0.2563	1.0172
1.1	0.2850	0.2698	1.0562	0.2819	1.0109
1.2	0.3085	0.2751	1.1212	0.3074	1.0034



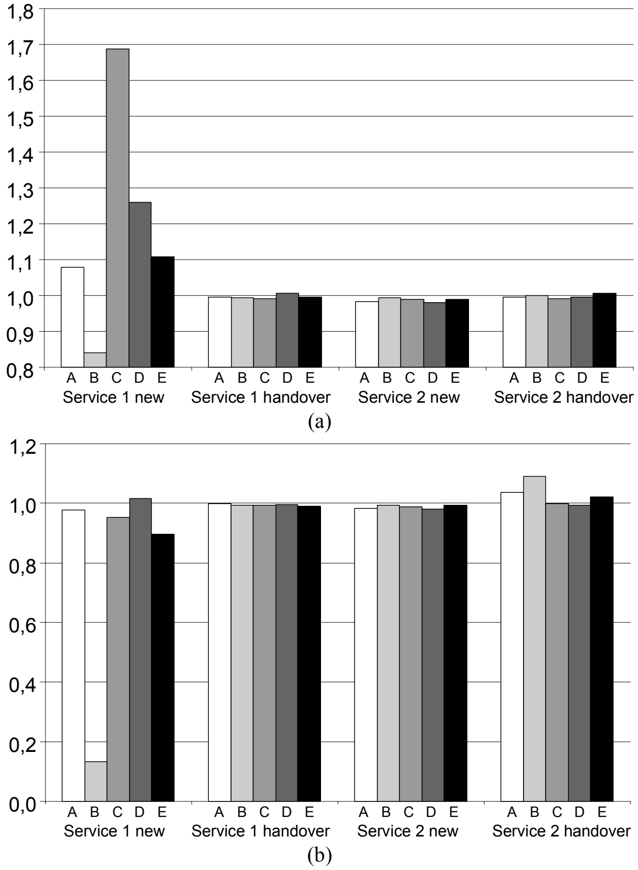
(a)

(b)

(c)

(d)

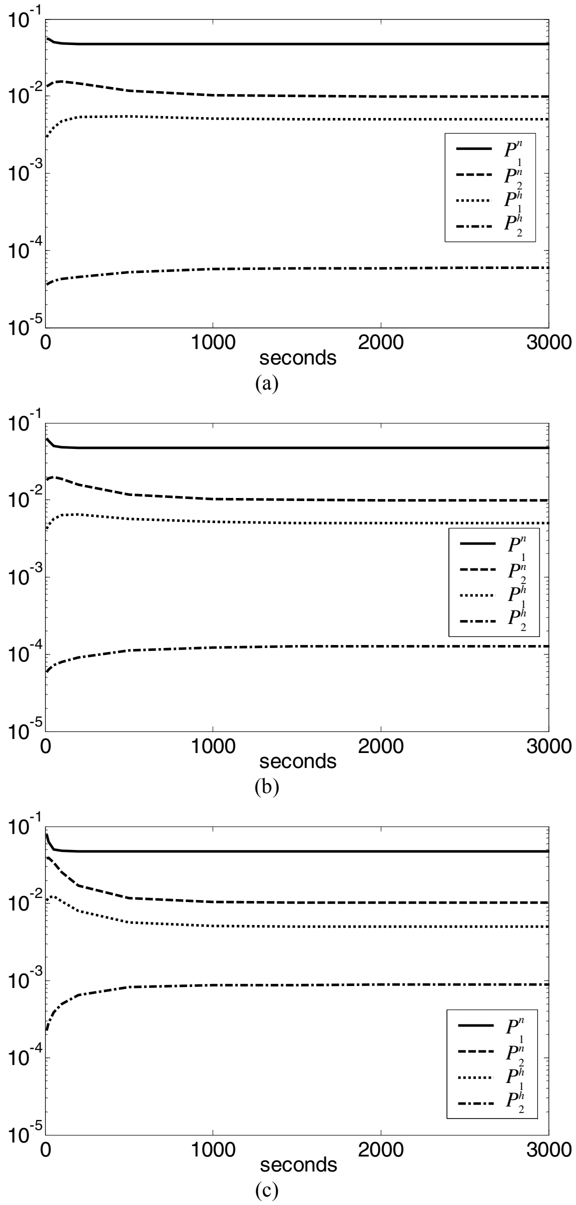
Fig. 5. Performance with respect to the offered traffic between the optimal static scheme and the adaptive schemes proposed (using and ignoring the AC decisions of the highest-priority arrival stream). A MGC policy is assumed, and the offered traffic is expressed as relative to the system capacity. (a) Service 1 new requests. (b) Service 2 new requests. (c) Service 1 handover requests. (d) Service 2 handover requests.



(a)

(b)

Fig. 6. Performance of the adaptive scheme for the MFGC policy under a stationary traffic scenario measured as the ratio of the achieved blocking probabilities to their objectives (P_i / B_i). (a) $\Delta l_i = 0.1$. (b) $\Delta l_i = 0.01$.



(a)

(b)

(c)

Fig. 7. Transient behavior of the adaptive scheme when used with the MGC policy and ignoring the AC decisions of the highest-priority arrival stream with different step increases. (a) 10%. (b) 20%. (c) 50%.

This is due to the fact that eventually the configuration of the lowest-priority arrival stream reaches the upper bound of *C*, i.e. its requests are admitted provided there are enough free resource units available in the system. During overload the lowest-priority arrival stream is the only one which absorbs the penalty. This behavior explains why the service perceived by the lowest-priority arrival stream is called a “best-effort” service.

Table III shows the resource utilization factor achieved by the static policy and by the two adaptive schemes. The poor resource utilization is due to the stringent QoS objectives we are imposing. As observed, the resource utilization achieved by the adaptive schemes is very close to the one obtained by the static policy, except during overload periods. It is clear that deploying the adaptive scheme which uses the AC decisions of the highest-priority arrival stream to adjust the lowest-priority arrival stream configuration offers a trade off between protection and resource utilization.

As the MGC policy has a relatively big granularity, we also introduced in our study the MFGC policy. Fig. 6 (a) and (b) show the performance of the adaptive scheme for the MFGC policy for values of Δl_i equal to 0.1 and 0.01 respectively, and using in both cases the highest-priority arrival stream AC decisions. As shown, as the granularity of the adjustment decreases the performance improves significantly.

B. Performance under Nonstationary Traffic

We study the transient behavior of the blocking probabilities in scenario A, when deploying the proposed adaptive scheme with the MGC policy under nonstationary traffic. Transient behavior may be numerically solved using randomization [12] (also known as Jensen’s method). The method involves transforming the continuous-time Markov chain into a discrete-time analogue. Jensen’s method is implemented by Möbius. We forced a step increase in the offered traffic at a time instant at which the adaptive scheme is in the steady-state regime supporting an offered traffic equal to the 66% of the system capacity.

Fig. 7 shows the transient behavior of the blocking probabilities for step increases of 10%, 20% and 50%, when the information provided by the highest-priority stream AC decisions is ignored. As observed, the adaptation speed is virtually independent of the amount by which the offered traffic is increased and is in the range of a thousand of seconds approximately for the scenario under study. This is a substantial reduction compared to the convergence time achieved by previous proposals, which are between 10 and 100 times higher [4, 3].

VI. CONCLUSIONS

We proposed a novel adaptive scheme that can be used in nonstationary scenarios with two of the most deployed admission control policies in multiservice mobile cellular networks, namely the Multiple Guard Channel (MGC) and the Multiple Fractional Guard Channel (MFGC) policies. Two of the key features of our scheme are its simplicity and time independency, which were achieved by avoiding dealing with measurement intervals to estimate the value of system parameters.

We provide two different implementations of the scheme. In the first one, the AC decisions related to stream i requests are used to perform a probabilistic adjustment of its own configuration parameter l_i, except for the highest-priority arrival stream, for which no adjustments are done. The second works as the first one, except for the highest and lowest priority arrival streams. For these, the AC decisions related to the arrival of requests from the highest-priority stream are used to perform a probabilistic adjustment of the configuration parameter of the lowest-priority stream. As a result, the lowest-priority stream will receive an unpredictable QoS, similar to a ‘best-effort’ service.

The numerical evaluation carried out shows that the QoS objective is met with an excellent precision and the convergence period is much shorter than in previous proposals (approximately in the range of a thousand seconds), confirming that our approach can satisfactorily deal with the nonstationarity of an operating network. Moreover, when the adaptive scheme is deployed with the MFGC policy, the precision with which the QoS objective is met can be configured.

Although a comparative study of the performance of our scheme under overloads is left for further study, we conjecture that it will perform substantially better than when deploying other adaptive schemes proposed previously. This is due to the fact that when using our second implementation, service perceived by one of the arrival streams is similar to a “best-effort” service, absorbing the penalty that and overload represents on the blocking probabilities. In fact, we envision that both implementations are not exclusive but can operate coordinately, being the first one used during underloads and the second during overloads.

Additional future work may involve the extension of our adaptive scheme to other families of AC policies, such as those for which the stationary state probabilities of the continuous-time Markov chain have a product-form solution. Another possible enhancement could be to base the adjustment mechanism not only on the AC decisions but also on additional information like the prediction of forthcoming handovers. Finally, it could be also interesting to enhance the adaptive scheme when deployed with the MFGC policy, reconfiguring automatically the Δl_i parameter when changes in the offered traffic occur.

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