# Performance Analysis and Estimation of Call Admission Policy Parameters for Multiple Traffic Classes in Wireless ATM Networks

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## Abstract

**In this paper we propose an admission control policy for wireless ATM networks. The policy is based on the well know method, threshold-based guard channel policy. We modify it to deal with two different types of traffic classes; namely: CBR traffic class and ABR traffic class where we assume two different thresholds, one for each traffic class. In addition, we propose to buffer the handoff ABR calls if no free channels are available rather than rejecting them. For handoff CBR calls, we propose two methods, namely: a blocking method and preemptive method. For the blocking method, we reject the handoff CBR calls if no channels are available. For the preemptive method, we accept handoff CBR calls in case of no available channels if ongoing ABR calls exist where we buffer one of them in order to serve the handoff CBR call. We study the effect of the thresholds, buffer size and the application of the proposed methods on call blocking probabilities. Based on these results. We develop in the second part of the paper an algorithm that uses the proposed policy to estimate the appropriate thresholds and buffer size which meet a certain required call blocking probabilities for each traffic type.**

## *I) Introduction*

One of the main design issues in wireless ATM is the implementation of call admission policy. Based on call admission policy function, the condition for accepting a ne call request is the availability of sufficient resources to guarantee the QoS parameters without affecting the existing calls. For wireless ATM networks, two types of quality of services parameters have been introduced which are: new call blocking probability and handoff call blocking probability [1].

Several admission policies were proposed which deal with different types of traffic classes. Tekiany *et al* in [2] illustrate the concept of prioritization of handoff calls ove new calls since it is desirable to complete an ongoing call rather than accepting a new one. They proposed some channel assignment techniques to realize this concept as well as the idea of buffering handoff calls in case no free channels are available. In [3] Ramjee *et al* presented the threshold-based guard channel policy for a single traffic type which is considered a simple and efficient method to provide priority for handoff calls over new calls. In this policy, some guard channels are allocated only to handoff calls. A threshold is defined which - if exceeded by the number of busy channels - the new calls would be blocked. The authors illustrated three methods to optimize a linear objective function of the ne and handoff blocking probabilities. In [4] Naghshineh *et al* proposed a distributed call admission algorithm where the dynamically vary the threshold value depending on input traffic to the cell to enhance the handoff call blocking probability in case of overloading. In [5] Acampora *et al* proposed a traffic class-based admission policy which satisfies the QoS requirements for each traffic class b allocating sufficient resources to each type. The proposed the capability of buffering calls which can tolerate delay if no free channels are available.

In this paper, we modify the threshold-based guard channel policy to deal with different types of traffic classes which is standardized by the ATM forum such as constant bit rate (CBR) and available bit rate (ABR) and - at the same time - add the capability for buffering delay-insensitive traffic class. Our aim is to study the effect of buffering delay-insensitive traffic class and ho this reflects on its QoS parameters and the QoS parameters of other traffic classes while applying the guard channel policy on different types of traffic classes

The paper is organized as follows. Section II describes our proposed admission policy. The mathematical model for the wireless ATM network system that implements the proposed policy is then explained in section III. This is followed by a performance analysis of the proposed call admission policy in section IV. An algorithm to estimate the parameters of the proposed call admission policy is described in section V followed by a numerical example to illustrate the algorithm steps in section VI. Conclusion of the paper is given in the last section.

## *II) Call Admission Policy*

Mainly, two different thresholds are introduced; one for each traffic class. Each threshold is used to determine the maximum number of the channels allocated to the calls of its corresponding traffic class after which the new calls of that traffic class are rejected.

Thus, the proposed admission policy deals with two sets of parameters; namely:

- *Quality of service parameters, which comprise*

- New call blocking probability: It determines the percentage of the number of new calls blocked due to unavailability of free channels upon new call request. In our case, two probability values are considered; namely: $P_{NCBR}$ and $P_{NABR}$, for new CBR calls and ne ABR calls, respectively.
- Handoff call blocking probability: It determines the percentage of the number of handoff calls dropped due

to the unavailability of free channels upon a handoff call request. In our case two probability values are considered; namely: $P_{HCBR}$ and $P_{HABR}$, for handoff CBR calls and ne ABR calls, respectively.

- Delay: The amount of delay added to the handoff ABR call connection time due to buffering the handoff ABR call request until a channel is released ($D_{HABR}$).

- *Control parameters, which comprise*

- New_CBR_Threshold ($Th_{NCBR}$): It determines a fraction of the total number of the channels allocated to CBR calls after which the new CBR calls are blocked.
- New_ABR_Threshold ($Th_{NABR}$): It determines a fraction of the total number of the channels allocated to ABR calls after which the new ABR calls are blocked.
- Buffer size: It determines the value of the buffer size to queue the handoff ABR calls.

The call admission policy depending on the above QoS and control parameters applies the following conditions:

- For new CBR calls, upon request of a new channel if the number of channels allocated to CBR calls is less than the New_CBR_Threshold and a free channel is available, the new CBR call is accepted and a free channel is assigned to the call. Otherwise, the call request is rejected.
- For new ABR calls, upon request of a new channel if the number of channels allocated to ABR calls is less than the New_ABR_Threshold and a free channel is available, the call is accepted and a free channel is assigned to the call. Otherwise, the call request is rejected.
- For handoff ABR calls, the call request is accepted wheneve there is a free available channel. Otherwise if there is no free channels, the call request is buffered until a channel is released which can be assigned to the call. If the buffer is full then the handoff ABR call is rejected.
- For handoff CBR calls, two different methods are proposed which are:
  - Blocking method: The handoff CBR call is accepted whenever there is a free available channel, i.e. the call request is rejected if the number of busy channels equals the total number of channels.
  - Preemptive method: In case free channels are available, the handoff CBR call is accepted which is the same as the blocking method. However, in case of free channels are available, the call is accepted under the conditions that an ongoing ABR call exists which can be preempted and buffered so that the handoff CBR call can utilizes its channel.

Fig. (1) illustrates the admissible regions for the proposed call admission policy using blocking method.

### *III) Mathematical Model*

We assume that the total number of channels equals C, the buffer is capable of buffering a number of B call requests. It is further assumed that the arrival rates of the two input traffic types have Poisson distribution. The channel holding time for each traffic type is equal and has negative exponential distribution with average service rate equals $\mu$. For each of the two traffic types, CBR and ABR, we have two types of calls, new and handoff. Therefore, we have fou different arrival rates; arrival rate of new CBR calls ( $\lambda_{NCBR}$), arrival rate of new ABR calls ( $\lambda_{NABR}$), arrival rate of handoff CBR calls ($\lambda_{HCBR}$), arrival rate of handoff A calls ($\lambda_{HABR}$).

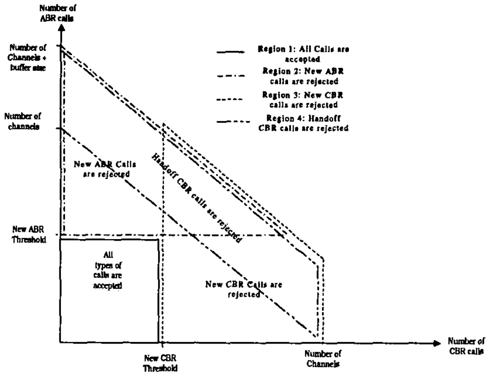

Fig. (1) Admissible regions for the proposed call admission policy using blocking method

For each of the two traffic types, CBR and ABR, we have two types of calls, new and handoff. Therefore, we have four different arrival rates; arrival rate of new CBR calls ( $\lambda_{NCBR}$), arrival rate of new ABR calls ( $\lambda_{NABR}$), arrival rate of handoff CBR calls ( $\lambda_{HCBR}$), arrival rate of handoff ABR calls ($\lambda_{HABR}$).

The total arrival rate for each traffic type is then:

$$\lambda_{TCBR} = \lambda_{NCBR} + \lambda_{HCBR} \qquad (1)$$

$$\lambda_{TABR} = \lambda_{NABR} + \lambda_{HABR} \qquad (2)$$

Since we have two types of input traffic, the system is modeled mathematically by a two-dimensional Markov chain where each state represents the number of CBR and ABR calls in the system. Assume that the total number of calls at each state is $N_{Total}$, where:

$$N_{Total} = N_{CBR} + N_{ABR} \qquad (3)$$

wit

$N_{CBR}$ = Number of CBR calls at a certain state ($N_{CBR}$ ranges from 0 to C).

$N_{ABR}$ = Number of ABR calls at a certain state ($N_{ABR}$ ranges from 0 to C+B).

We then follow the standard procedure for deriving the state probabilities. In particular, we write down the steady-state equations for the state probabilities in terms of the state transition matrix Q and the state probabilit vector $\Pi$:

$$\Pi Q = 0 \qquad (4)$$

$$\sum_i \pi_i = 1 \qquad (5)$$

wit

$$\Pi = \left[\pi_{0,0}\ \pi_{0,1}\ \pi_{0,2} \cdots\cdots\cdots\ \pi_{N_{CBR},N_{ABR}} \cdots\cdots\right]$$

After obtaining the state probabilities, the values of the new blocking probability, handoff blocking probability and average delay time are calculated using the following relations:

- For the new CBR call blocking probability, $P_{NCBR}$

$$P_{NCBR} = \Big( \sum_{N_{CBR}=Th_{NCBR}}^{C} \sum_{N_{ABR}=0}^{C+B-N_{CBR}} \pi_{N_{CBR},N_{ABR}} \Big) * \frac{\lambda_{NCBR}}{\lambda_{TCBR}+\lambda_{TABR}} \qquad (6)$$

- For the new ABR call blocking probability, $P_{NABR}$

$$P_{NABR} = \Big( \sum_{N_{CBR}=0}^{C} \sum_{N_{ABR}=Th_{NABR}}^{C+B-N_{CBR}} \pi_{N_{CBR},N_{ABR}} \Big) * \frac{\lambda_{NABR}}{\lambda_{TCBR}+\lambda_{TABR}}. \qquad (7)$$

- For the handoff CBR call blocking probability, $P_{HCBR}$
    - Using blocking method:

$$P_{HCBR} = \Big( \sum_{N_{CBR}=0}^{C} \sum_{N_{ABR}=C-N_{CBR}}^{C+B-N_{CBR}} \pi_{N_{CBR},N_{ABR}} \Big) * \frac{\lambda_{HCBR}}{\lambda_{TCBR}+\lambda_{TABR}}. \qquad (8)$$

- Using preemptive method:

$$P_{HCBR} = \Big( \sum_{N_{CBR}=0}^{C} \pi_{N_{CBR},C+B-N_{CBR}} \Big) * \frac{\lambda_{HCBR}}{\lambda_{TCBR}+\lambda_{TABR}}. \qquad (9)$$

- For the handoff ABR call blocking probability; $P_{HABR}$

$$P_{HABR} = \Big( \sum_{N_{CBR}=0}^{C} \pi_{N_{CBR},C+B-N_{CBR}} \Big) * \frac{\lambda_{HABR}}{\lambda_{TCBR}+\lambda_{TABR}}. \qquad (10)$$

- Average delay time for handoff ABR calls, $D_{HABR}$

$$D_{HABR} = \frac{\Big( \sum_{N_{CBR}=0}^{C} \sum_{N_{ABR}=C+1-N_{CBR}}^{C+B-N_{CBR}} (\pi_{N_{CBR},N_{ABR}} * (N_{CBR}+N_{ABR}))}{\lambda_{HABR}(1-P_{HABR})} \qquad (11)$$

*IV) Performance Analysis of the Proposed Call Admission Policy*

To illustrate the effect of the threshold values and the buffer size on $P_{NCBR}$, $P_{NABR}$, $P_{HCBR}$, $P_{HABR}$ and $D_{HABR}$, we applied Eqs. (6) - (10) to a numerical example where we assigned the following values for the policy parameters: C = 25, $1/\mu$ = 3 min.

$\lambda_{TCBR}/C\mu = \lambda_{TABR}/C\mu = 0.4$ Erlang/channel.

$\lambda_{HCBR}/C\mu = \lambda_{HABR}/C\mu = 0.2$ Erlang/channel.

B = 5.

*Results for admission policy with blocking :*

We will first study the effect of the control parameters which are thresholds and buffer capacity on the QoS parameters in case of applying the proposed call admission policy using blocking method.

The graph shown in Fig. (2) illustrates the effect of varying $Th_{NCBR}$ on $P_{NCBR}$, for a constant $Th_{NABR}$ (=10) and different values of B. It is clear that there is no effect of buffering on $P_{NCBR}$ except for high values of threshold, where we can observe a slight increase in the $P_{NCBR}$. Furthermore, it can be observed that $P_{NCBR}$ becomes constant for the values of $Th_{NCBR}$ where the sum of the two thresholds ($Th_{NCBR}$ and $Th_{NABR}$) exceeds the number of available channels (C = 25). This can be easily observed in Fig. (2) where $P_{NCBR}$ becomes constant for the values of $Th_{NCBR}$ which exceeds 15. The effect of varying $Th_{NCBR}$ on $P_{NABR}$ - under the same previous conditions - is shown in Fig. (3). It is evident that varying $Th_{NCBR}$ has no effect on $P_{NABR}$ and we can conclude that $P_{NABR}$ depends only on the value of $Th_{NABR}$. Also the effect of buffering on $P_{NABR}$ is negligible similar to the effect of buffering on $P_{NCBR}$. The effect of $Th_{NCBR}$ on $P_{HCBR}$ is shown in Fig. (4). As expected, $P_{HCBR}$ is degraded with larger $Th_{NCBR}$ but it becomes constant when $Th_{NCBR}$ equals 15. It is also clear that $P_{HCBR}$ increases slightly when a buffer is added to the system, but it remains constant as the buffer size increases. Therefore, we can neglect the effect of buffering on $P_{HCBR}$. Finally, the two graphs shown in Fig. (5) and (6) illustrate the effect of buffering A handoff calls on its blocking probability and average delay, respectively. It is evident that by introducing buffers, $P_{HABR}$, is enhanced considerably, and that the larger the buffer size, the smaller $P_{HABR}$ becomes.

Fig. (7) illustrates the simultaneous effect of the two thresholds - $T_{NCBR}$ and $Th_{NABR}$ - on $P_{NCBR}$ for two different values of buffer size - 1 and 5 - using blocking method. Based on that figure, the minimum values for $P_{NCBR}$ can be deduced as follows:

$$P_{NCBRmin} \equiv \min P_{NCBR}(Th_{NCBR}, Th_{NABR}, B) = P_{NCBR}(C,0,B) \qquad (12)$$

Similarly, the minimum values for the other QoS parameters can be deduced as follows:

$$P_{NABRmin} \equiv \min P_{NABR}(Th_{NCBR}, Th_{NABR}, B) = P_{NABR}(0,C,B) \qquad (13)$$

$$P_{HCBRmin} \equiv \mathrm{mi}\ \ P_{HCBR}(Th_{NCBR}, Th_{NABR}, B) = (0, 0, 0) \qquad (14)$$

$$P_{HABRmin} = \mathrm{mi}\ \ P_{HABR}(Th_{NCBR}, Th_{NABR}, B) = (0, 0, \infty) = 0. \qquad (15)$$

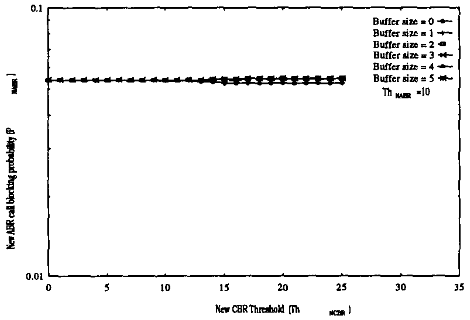

Fig. (2) $P_{NABR}$ versus $Th_{NCBR}$ for different values of buffer size B using blocking method - $Th0_{NABR}$ = 10

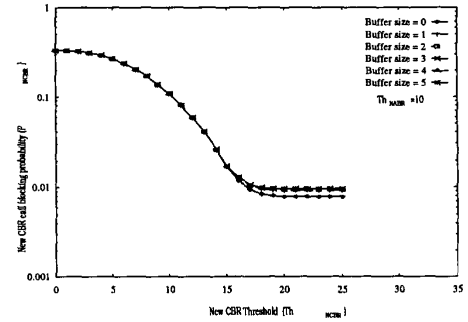

Fig. (3) $P_{NCBR}$ versus $Th_{NCBR}$ for different values of buffer size B using blocking method - $Th_{NABR}$ = 10

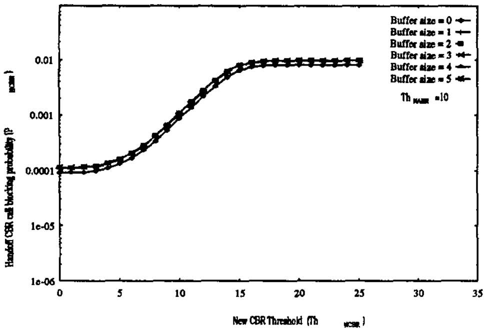

Fig. (4) $P_{HCBR}$ versus $Th_{NCBR}$ for different values of buffer size B using blocking method - $Th_{NABR} = 10$

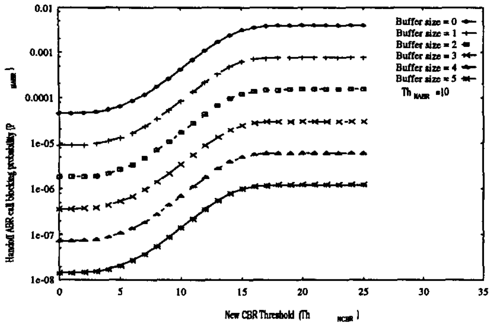

Fig. (5) $P_{HABR}$ versus $Th_{NCBR}$ for different values of buffer size B using blocking method - $Th_{NABR} = 10$

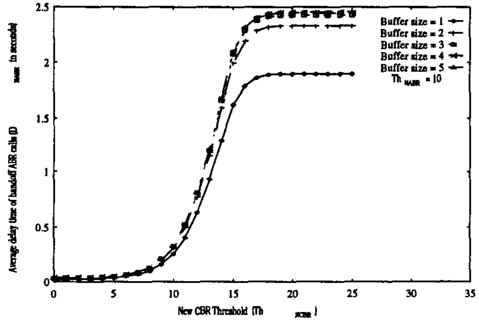

Fig.(6) $D_{HABR}$ versus $Th_{NCBR}$ for different values of buffer size B using blocking method

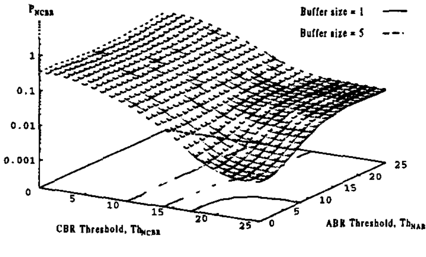

Fig. (7) Simultaneous effect of two thresholds - Th $_{NCBR}$ and $Th_{NABR}$ - on $P_{NCBR}$ using the blocking method

*Results for admission policy with preemption:*

We next study the effect of control parameters on QoS parameters for the proposed call admission policy using preemptive method under the same previous traffic conditions.

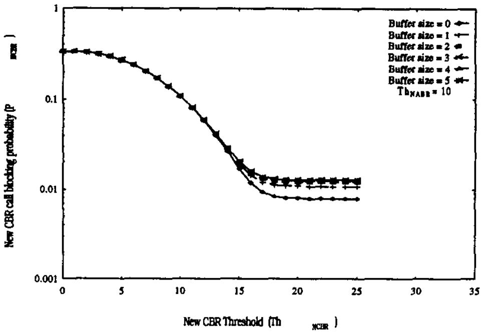

Fig. (8) $P_{NCBR}$ versus $Th_{NCBR}$ for different values of buffer size B using the preemptive method

It is clear by comparing Figs. (2) and (8) which illustrates the effect of thresholds and buffer size on $P_{NCBR}$ for both methods - blocking and preemptive - that both methods have the same effect on $P_{NCBR}$ with respect to behavior and value. Similarly, $P_{NABR}$ does not depend on the method used as shown in Figs. (3) and (9). However, preemptive method affects $P_{HCBR}$ as it becomes a function of the buffer size. As buffer size increases, $P_{HCBR}$ decreases as illustrated in Fig. (10). This is realized on the expense of degrading $P_{HABR}$ values as can be deduced from Figs. (5) and (11). Fo $Th_{NCBR} = 0$ and $B = 5$, $P_{HABR} \cong$ 1e-08 in the blocking method and $P_{HABR} \cong$ 3e-07 in the preemptive method. Also, the delay values increase for the preemptive method which can be deduced from Figs. (6) and (12). It is clear the minimum values for QoS parameters in case of blocking method do not differ if the preemptive method is used except for $P_{HCBR}$. The minimum value of $P_{HCBR}$ changed due to the application of preemptive method because it will depend on the buffer size. Therefore, the threshold values and the buffer size that minimize $P_{HCBR}$ are:

$$P_{HCBRmin} \equiv \text{mi} \; P_{HCBR}(Th_{NCBR}, Th_{NABR}, B) = P_{HCBR}(0, 0, \infty) = 0. \qquad (16)$$

Finally, it is to remarked that contour plots ar shown in the 3-dimensional surface in Fig. (7) which are depicted at different blocking probabilities values. Each contour is specifically function of the following:

Contour $\equiv$ K(Type of blocking probability, Th $_{NCBR}$, $Th_{NABR}$, Buffer size, Method type (Blocking or Preemptive)). These contour plots will be utilized late in the paper.

## *V) Algorithm for Estimating Parameters of the Proposed Call Admission Policy*

In this section, an algorithm is proposed to evaluate the control parameters for the proposed call admission policy for given QoS parameters. Due to the limited number of available control parameters; namely: $Th_{NCBR}$, $Th_{NABR}$ and buffer size B, the number of QoS parameters which can be guaranteed using the proposed call admission policy are also limited. We select the following as the controllable QoS parameters:

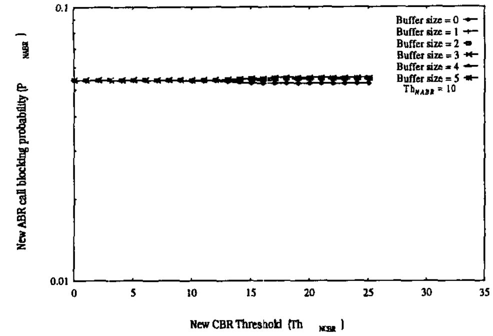

Fig.(9) $P_{NABR}$ versus $Th_{NCBR}$ for different values of buffer size B using the preemptive method

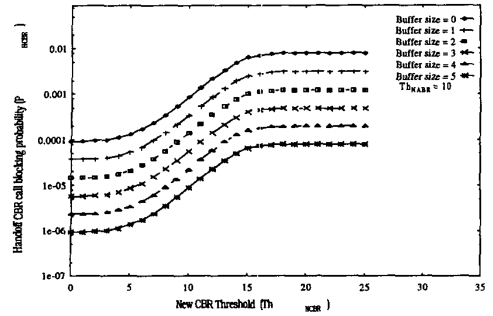

Fig. (10) $P_{HCBR}$ versus $Th_{NCBR}$ for different values of buffer size B using the preemptive method.

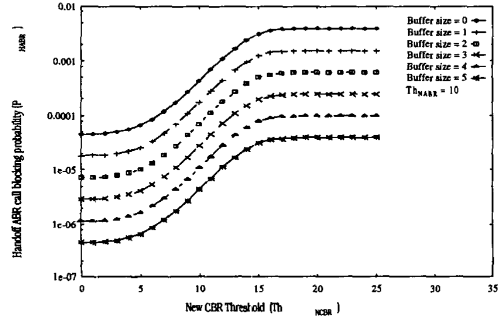

Fig.(11) $P_{HABR}$ versus $Th_{NCBR}$ for different values of buffer size B using the preemptive method

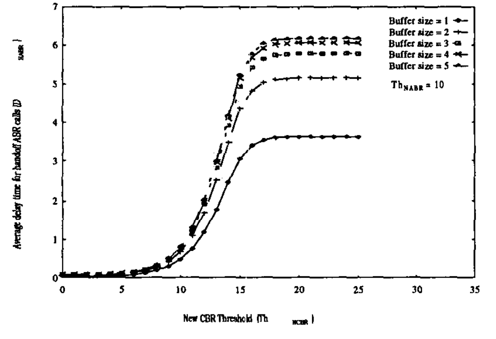

Fig. (12) $D_{HABR}$ versus $Th_{NCBR}$ for different values of buffer size B using the preemptive method

- Maximum new call blocking probability, $P_{NMAX}$: It is the maximum new call blocking probabilit guaranteed fo the two types of traffic classes i.e. $P_{NCBR} \leq P_{NMAX}$ and $P_{NABR} \leq P_{NMAX}$.

- Maximum handoff call blocking probability, $P_{HMAX}$ : It is the maximum handoff call blocking probability guaranteed for two types of traffic classes, i.e. $P_{HCBR} \leq P_{HMAX}$ and $P_{HABR} \leq P_{HMAX}$.

Meanwhile, the other QoS parameters may be minimized as much as possible, though they cannot be guaranteed to be below a certain value (such as maximum Delay, $D_{MAX}$).

In addition to the QoS parameters, the number of channels C will be given as an input to the paramete estimation algorithm. The solution is obtained b depicting the contour plot for each QoS parameter at the required value and estimating the region of intersection for the contour plots which will be realized at a certain buffer size. The region of intersection will define the region of thresholds for $Th_{NCBR}$ and $Th_{NABR}$.

The algorithm steps will be described and illustrated through a numerical example which is based on the same traffic conditions and number of channels as specified in section V. The values for $P_{NMAX}$ and $P_{HMAX}$ are set, respectively, at 0.1 and 5e-05.(These values are specifically chosen to illustrate the concepts not to reflect values used in actual design of cellula networks).

Step 1: The objective of this step is to verify that the specified number of channels can satisfy the specified QoS parameters. It must be justified that the maximum specified blocking probability for each traffic type is higher than the minimum value for each QoS parameter.

Based on the numerical example are, these values a given by: $P_{NCBRmin} = 0.00208512$, $P_{NABRmin} = 0.00104256$, $P_{HCBRmin} = P_{HABRmin} = 0$.

It is clear that these values are lower than the specified QoS parameter. If this condition is not satisfied, then the number of channels must be increased (unfeasible solution).

Step 2: In this step, the regions for the two thresholds which satisfy the condition of $P_{NCBR}$ and $P_{NABR}$ lower than $P_{NMAX}$ are identified. The contour plots are depicted at the specified value of $P_{NMAX}$. The corresponding regions of $Th_{NCBR}$ and $Th_{NABR}$ are show in Fig. (13). Thus, the region which will be named, Region "1", is bounded by the following contours and lines:

- Contour 1: $K_{NCBR} = K(P_{NCBR}, Th_{NCBR}, Th_{NABR})$.
- Contour 2: $K_{NABR} = K(P_{NABR}, Th_{NCBR}, Th_{NABR})$.
- Line 1: $Th_{NCBR} = 25$.
- Line 2: $Th_{NABR} = 25$.

Step 3: The objective of this step is to define the region of thresholds, buffer capacity and method (blocking or preemptive) in order to satisfy the following two conditions:

- $P_{HCBR} < P_{HMAX}$.
- The region of thresholds obtained must intersect with region "1" defined in step 2 which guarantees the values of new call blocking probabilities.

Firstly, we select the blocking method to be used since it introduces lower delay values (for the ABR calls) than the preemptive method. Contour plots at the specified $P_{HMAX}$ value are drawn in Fig. (14). The buffer size selected equals zero since it gives the minimum value for $P_{HCBR}$ as defined in relation (15). The resulting region is bounded by the following contours and lines:

- Contour: $K_{HCBR} = K(P_{HCBR}, Th_{NCBR}, Th_{NABR}, B$, blocking method) where buffer size equals zero.
- Line 1: $Th_{NCBR} = 0$.
- Line 2: $Th_{NABR} = 0$.

It is clear in Fig. (14) that for our given example there is no intersection between the obtained shaded region and region "1". Therefore, the blocking method cannot satisfy the required QoS value and the preemptive method must be used. Contour plot are depicted for buffer size = 1 while preemptive method is applied. It is clear that there is still no intersection as shown in Fig. (15). Therefore, the buffer size is increased until intersection occurs (at B = 5) as shown in Fig. (16) and the region obtained (named region "2") will be bounded by the following contours and lines:

- Contour: $K_{HCBR} = K(P_{HCBR}, Th_{NCBR}, Th_{NABR}, B$, preemptive method) where buffer size equals 5 in ou example.
- Line 1: $Th_{NCBR} = 0$.
- Line 2: $Th_{NABR} = 0$.

Finally, our solution will be the intersection of region "1" and region "2" which will result in a new region; named: region "3". Region "3" will be bounded by contours and lines based on our example:

- Contour 1: $K_{NCBR} = K(P_{NCBR}, Th_{NCBR}, Th_{NABR})$.
- Contour 2: $K_{NABR} = K(P_{NABR}, Th_{NCBR}, Th_{NABR})$.
- Contour3: $K_{HCBR} = K(P_{HCBR}, Th_{NCBR}, Th_{NABR}, B$, preemptive method) where buffer size equals 5 in ou example.
- Line : $Th_{NCBR} = 25$.

Step 4: The objective of this step is to update the values of thresholds and buffer size to:

- specify a region where $P_{HABR} < P_{HMAX}$.
- guarantee that an intersection exists between that region and the previously specified region in step 3.

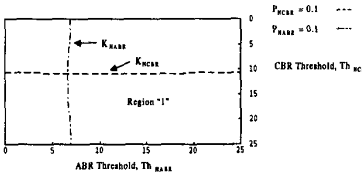

Fig. (13) Regions of $Th_{NABR}$ and $Th_{NCBR}$ that guarantee $P_{NCBR}$ and $P_{NABR} < P_{NMAX}$

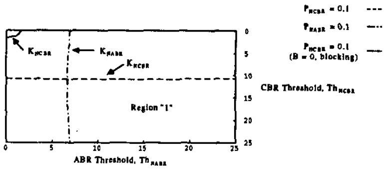

Fig. (14) Illustrating that there is no intersection between region "1" and shaded region using the blocking method that guarantee QoS parameters ($P_{NCBR}, P_{NABR}, P_{HCBR}$)

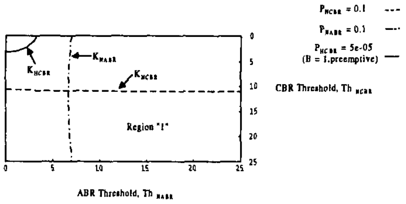

Fig. (15 )Illustrating that there is no intersection between region "1" and shaded region using the preemptive method at buffer size = 1 that guarantee QoS parameters ($P_{NCBR}, P_{NABR}, P_{HCBR}$)

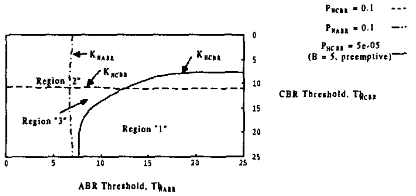

Fig. (16) Illustrating the regions for $Th_{NCBR}$ and $Th_{NABR}$ using preemptive method at buffer size = 5 that guarantee QoS parameters ($P_{NCBR}, P_{NABR}, P_{HCBR}$)

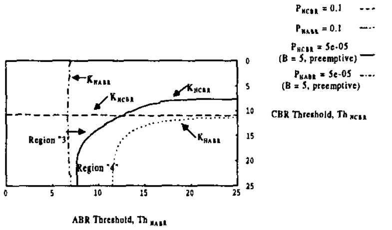

Fig. (17) Illustrating the common regions for $Th_{NCBR}$ and $Th_{NABR}$ using the preemptive method at buffer size = 5 that guarantee QoS parameters ($P_{NCBR}, P_{NABR}, P_{HCBR}, P_{HABR}$)

The method (blocking or preemption) has been specified in step 3, so the contou plot are depicted at the specified $P_{HMAX}$). If the obtained region intersects with region (3) then region (3) and the buffer size selected will be the solution to guarantee the required QoS values. If no intersection exists, the buffer size will be increased until intersection exists. In our example, the region; named: region "4" obtained to guarantee $P_{HABR}$ is lower than $P_{HMAX}$ is defined by the following contours and lines:

- Contour: $K_{HABR} = K(P_{HABR}, Th_{NCBR}, Th_{NABR}, B,$ preemptive method) where buffer size equals 5 in ou example.
- Line 1: $Th_{NCBR} = 0$.
- Line 2: $Th_{NABR} = 0$.

It is clear that region "3" is a subset of region "4"shown in Fig. (17), therefore region "3" and the buffer size selected which equals 5 in our example is the desired solution.

After obtaining the range of thresholds, we need to obtain the optimum values of thresholds. We can apply any one of the following criteria to obtain the optimum values.

*Minimum new call blocking probability* : If it is desired to obtain the lowest possible minimum new call blocking probability for each traffic type, the maximum value of the range of each threshold in region "3" is selected.

*Minimum delay*: In order to obtain the minimum possible delay needed, the minimum values of thresholds should be selected based on Fig. (30) which shows that the delay decreases as the values of thresholds decrease.

## *VI) Conclusion*

In this paper, we proposed a new call admission policy for wireless ATM networks with two different types of class; namely: CBR traffic class with low delay bounds and A traffic class with higher delay bounds. This policy is based on modifying the guard channel policy and introducing a buffe for queuing handoff ABR calls. We select to buffer handoff ABR calls because they can tolerate delay and because it is desirable to accept an ongoing call. We studied the effect of buffering on the QoS parameters for each traffic class. Ou study leads to the following conclusions:

- The value of new and handoff CBR call blocking probability ($P_{NCBR}$, $P_{HCBR}$) do not depend on the buffer size. They are only controlled by New_CBR_Threshold ($Th_{NCBR}$). Also the same result is applicable to new ABR call blocking probability which depends on New_ABR_Threshold ($Th_{NABR}$).
- The value of handoff CBR call blocking probability can be enhanced by applying the concept of preemption of an existing ABR call in case of no channels available to serve the handoff CBR call rather than blocking it. At the same time, preemption will not degrade the performance of ne call blocking probabilities.
- The value of handoff ABR call blocking probability ($P_{HABR}$) can be enhanced by increasing the buffer size. However, this increases the delay added to the call connection time.

Finally, based on these features, we proposed a parameter estimation algorithm which can estimate the values of thresholds and buffer size based on a given QoS parameters. Since one in general obtains a region of feasible solutions, these control parameters can be further optimized b specifying an additional performance index such as delay o utilization. These concepts have been demonstrated by means of numerical example. For future work, we are working on developing a search algorithm to define automatically the values of thresholds and buffer size rather than determining them using graphical solution as illustrated the paper.

## *VII) References*

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