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Call Admission Control algorithm for Wireless Multimedia Networks

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Abstract : Wireless multimedia networks are becoming increasingly popular as they provide users the convenience of access to information and services anytime, anywhere and in any format. The upcoming wireless cellular infrastructures such as third generation (3G) and fourth generation (4G) are deemed to support new high-speed services with different Quality-of-Service (QOS) and their respective traffic profiles. Different wireless multimedia services have diverse bandwidth and QOS requirements, which need to be guaranteed by the wireless cellular networks. The call admission control algorithm deals with multiple classes of calls having different requirements, requesting different Quality of Service (QOS) and with different priorities for admission into the network. In this paper we present a Adaptive Call admission Control algorithm for the next generation of wireless cellular networks at the connection level, where the bandwidth allocated to the ongoing calls can be dynamically adjusted by Bandwidth up gradation and degradation algorithms. This framework supports establishing a priority mechanism for handoff calls over new calls and also establishing a priority mechanism for different types of traffic classes (CBR, VBR, UBR). The performance of proposed adaptive CAC algorithm is evaluated based on the New Call Blocking Probability, Hand off Call Dropping rate with the existing CAC algorithm for wireless multimedia networks. By simulation results it is shown that our proposed algorithm achieves less New Call Blocking Probability, Hand off Call Dropping rate for different traffic classes.
Keywords : CBR, VBR, UBR, QOS, 3G

1. INTRODUCTION

In wireless/Mobile cellular networks, a mobile user's QoS requirements can be objectively expressed in terms of probabilistic connection-level QoS parameters related to connection establishment and management, such as New-Call Blocking Probability (NCBP) and Handoff Call Dropping Probability (HCDP). The NCBP is the probability that a new call will be rejected; a measure of service connectivity. New call blocking occurs when the entire bandwidth of the wireless system medium is busy upon a new call request. The HCDP is the probability that a handoff call will be rejected; it measures service continuity during handoffs. The procedure of moving from one cell to another, while the call is in progress, is called handoff. To fulfill handoff, the mobile requires that the base station in the cell that it moves into allocate the required bandwidth. If no bandwidth is available in the new cell, the handoff connection is dropped. This kind of dropping refers to blocking of ongoing connections due to the mobility of the users. Since call dropping of established connections is usually more annoying than rejection of a new connection request, it is widely believed that a wireless cellular network must give handoff connection requests a higher priority than is given to new connection requests.

A call admission control (CAC) algorithm is another key factor that enables efficient system resource utilization while ensuring that connection-level QoS requirements are satisfied. CAC is always performed when a mobile initiates communication in a new cell, either through a new call or a handoff.

2. EXISTING CALL ADMISSION CONTROL ALGORITHMS AND THEIR LIMITATIONS

Many researchers have studied call Admission Control in wireless networks. Some of the existing results utilize optimization techniques in deriving CAC protocols [1]. The easiest and most simple admission control protocol is FCFS. If a request arrives and there is enough bandwidth to accommodate it, the call is admitted, otherwise rejected. FCFS produces a good utilization of the medium, but is biased against calls, which require high bandwidth, along with no support for priority. In another method, [2] the network is divided into cells. A new call is admitted only if it satisfies the feasible state condition. A feasible state is one in which the number of newly arriving calls is less than or equal to maximum number of calls that can be admitted in the cell.

In [3-6], the well-known guard channel scheme and its variations were proposed to give higher priority to handoff connections over new connections by reserving a number of channels called guard channels for handoff call connections. All these schemes are static in the sense that the number of guard channels is determined mainly based on a prior knowledge of the traffic patterns, thereby being unable to cope with network dynamics. Moreover, only one traffic class, i.e., voice traffic, is considered.

Recently, several CAC algorithms and bandwidth adaptation algorithms (BAAs) have been proposed in wireless networks.

In [7-9], it is assumed that all calls belong to a single class of adaptive multimedia traffic and receive varying bandwidth assignments from a discrete set of integer bandwidth values.

In [8] and [9], new QoS parameters for adaptive multimedia in wireless networks are introduced.

Multiple classes of adaptive multimedia services in cellular wireless networks have been introduced in the literature [10-12] without considering the prioritization between new call arrivals and handoff calls for each class of traffic.

However, in this paper, we provide a bandwidth allocation policy that takes into account the separation between incoming traffic for each class and prioritizes handoff calls over new calls. A prioritization in the process of bandwidth adaptation among multiple classes of multimedia services is presented in [12] where the bandwidth of calls with lower priority is preferably adapted.

However, in this approach the authors assume no handoff dropping which make their work impractical. However we assume that a handoff call can be dropped if it doesn't satisfy the adaptation condition.

The traffic performance metrics, considered by CAC, are as follows:

•**Carried Load***:* This represents the ratio of the bandwidth used by completely serviced calls to the total capacity of mobile network. If a call is forced-terminated, the bandwidth used by the call is not taken into account.

•**Call Dropping Probability***:* It is the probability that an accepted call is forced terminated before it completes the service.

•*C***all Blocking Probability***:* It means the likelihood that a new arriving call is blocked. Actually, it depends on the CAC scheme.

•**Call Completion Probability***:* It means the probability that a newly arriving call completes its service without forced-termination.

•**Handoff Failure Probability***:* It is the probability that a handoff fails because the target call has no free channel. This is also called as forced-termination probability.

3. NON ADAPTIVE CAC ALGORITHM

The non-adaptive scheme is simulated assuming that a call must be allocated its maximum bandwidth to be admitted and once accepted its bandwidth cannot be changed throughout the lifetime; if such bandwidth is not available, the call is either blocked or dropped depending on whether the call is a new or handoff call.

Each base station in the non-adaptive scheme is allocated a reservation target (R_{Target}) that is updated periodically according to the projected demands of anticipated handoffs from neighboring cells (incoming from neighboring cells and outgoing from the cell). A new call is accepted if the remaining resource after its acceptance is at least R_{Target}. For handoff call, the admission control rule is more lenient: it is admitted as long as there is sufficient remaining capacity to accommodate the handoff, regardless of value of R_{Target}.

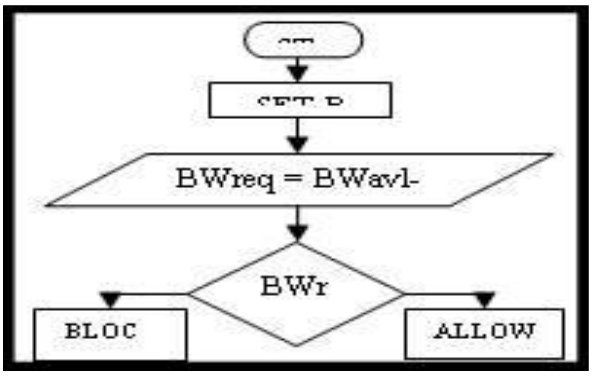

Fig1. Non Adaptive Algorithm

4. PROPOSED CALL ADMISSION CONTROL ALGORITHM

The design of the Adaptive Call Admission Control Algorithm is tailored to achieve the following implementation goals:

i. Establishing a priority mechanism for different types of traffic;

ii. Developing a framework to handle different types of traffic instead of only one as proposed in most of the current research;

iii. Establishing a priority mechanism for handoff calls over new calls;

iv. Maximizing the bandwidth utilization;

v. Reducing the information exchange among base stations.

5. PRE-REQUISITE FOR THE ADAPTIVE CAC ALGORITHM

A new call is admitted as long as the output power levels, at the consulted BSs, stay below a certain predefined threshold. When the maximum output power constraint is limited on a BS basis, the admission decision is based on this algorithm:

Admit a new user into the network if

$$Pb < Pbt$$

Where,

Pb = transmitted output power from *BSb* before the new user is admitted, i.e.

Pb = *pi* at *BSb*,

Pbt =predefined threshold.

pi = output power from the *ith* transmitter.

On the other hand, when the output power is limited on a channel basis, the admission decision follows the following rule: Admit a new user if

$$Pj < Pcht$$

Where,

Pj = output power used by channel j

Pcht = predefined threshold

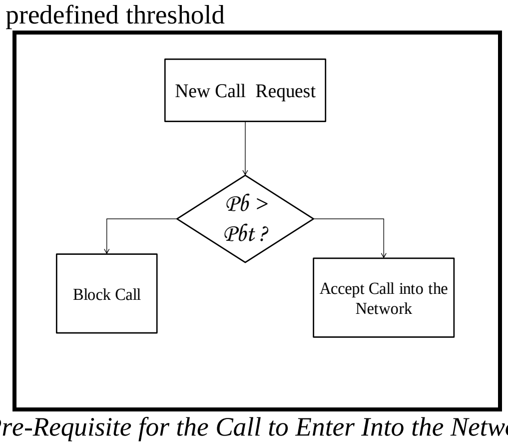

Fig2. Pre-Requisite for the Call to Enter Into the Network

- The system, first checks to see if there is sufficient power available at the base station to support the service that is requested.
- If there is insufficient power at the base station, the Call in question is blocked from entering the system.
- Or else if there is sufficient amount of power at the base station, then the incoming call is allowed to enter into the

network and thereby is handled by the CAC algorithm for further processing.

6. ADAPTIVE CAC

The proposed Adaptation Bandwidth Algorithm (ABA) is utilized to adaptively determine the bandwidth for call admission. The algorithm will be triggered whenever there is a call arrival acceptance event or a service departure event. In this work, our objectives are to minimize NCBP, HCDP and to efficiently utilize the system resources.

Ideally, every call in a cell should be allocated the maximum bandwidth (BW_{Max}) whenever possible. However, if the cell is over-loaded, some of the calls in the cell might receive a bandwidth lower than the requested bandwidth. When a new call or a handoff call arrives, some of the calls already in the cell are made to lower their bandwidth (the minimum bandwidth is BW_{Min}) to accommodate the newly arrived call. On the other hand, when a call completes or handoffs to other cells, some of the remaining calls in the cell may be provided an increase in their bandwidth (the maximum bandwidth is BW_{Max}).

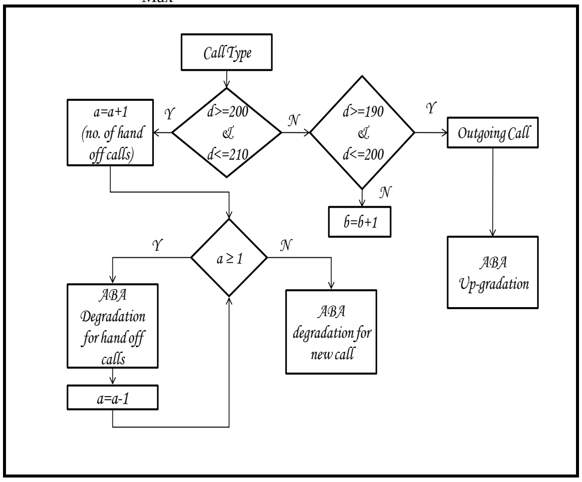

Fig3. Adaptive Call Admission Control Algorithm

There are two types of calls in any network i.e incoming and outgoing. Whenever there is an outgoing call from the network, the ABA upgradation algorithm is invoked. Incoming calls are classified into two types, which are, hand off calls and new connections. As long as there is an incoming hand off call in the network, the ABA degradation for hand off calls is performed. Only after all the hand off calls are allocated BW in the network, the new incoming calls are processed. In this way, hand off calls are given priority over the new calls.

7. ADAPTIVE BANDWIDTH ALLOCATION

The proposed adaptation bandwidth algorithms use different of above ideas to allocate, increase, and decrease bandwidth for the calls in a cell. For accepted arrivals, if there is enough available bandwidth, the algorithm allocates the amount of bandwidth as per the negotiation with the CAC determined by the call. In the vise versa case, some lower priority call's bandwidth will be decreased to their average bandwidth (the average bandwidth is BW_{Avg}) to accommodate the new arrivals. In the case of accepted Handoffs, if there is sufficient available bandwidth, the algorithm allocates the amount of bandwidth as per the negotiation with the CAC determined by the call. In the case of a vise versa condition, some lower priority calls' bandwidth will be decreased to lower their bandwidth (the minimum bandwidth is BW_{Min}) to accommodate the new handoffs arrivals. For call departures (call completely terminated or moved to another cell), the available bandwidth within the cell increases, and the algorithm will then selectively increase the bandwidth of some calls in the cell that have higher priority and smallest degradation level.

To support Ad-CAC the ABA algorithm performs two main procedures: degradation and upgrading. The degradation procedure is triggered when an accepted arriving call (new or handoff) arrives to an overloaded cell. The upgrading procedure is triggered when there is an outgoing handoff call or a call completion in the given cell.

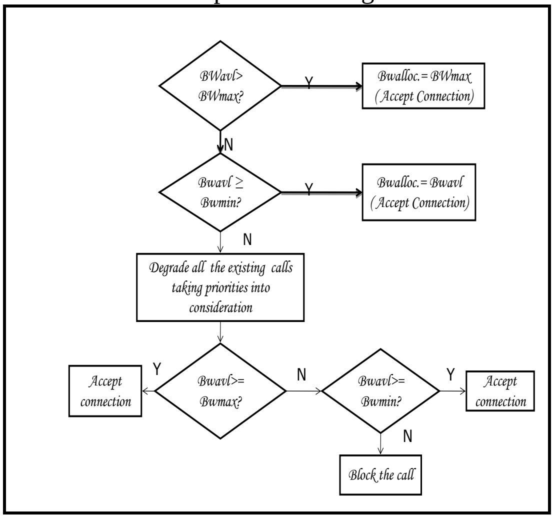

Fig4. ABA Degradation Algorithm

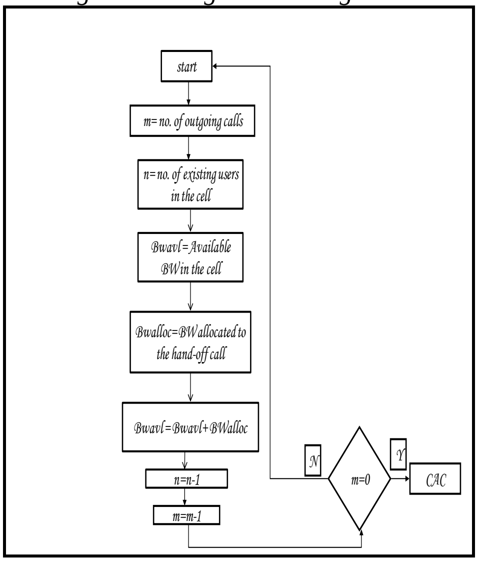

Fig5. ABA Up-Gradation Algorithm

8. SIMULATION MODEL

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A discrete-event simulation model for a wireless cellular network environment in a two-dimensional (2-D) topology in which each cell has exactly six neighboring cells is extensively developed using MATLAB. The simulated area consists of 7 Omni-cells and has a uniform geographic distribution. It is assumed that a base station is located in the center of a hexagonal. The cell radius is set to 200m while the handoff region set to 10m.The cells are wrapped around so the topology of the simulated environment represents a sphere and making the handoff rates in all the cells is approximately similar. Data sources are assumed to be of bursty nature. Connections requests are generated according to a Poisson process with rate ë (connections/second/cell) in each cell of different the traffic classes. A newly generated connection can appear anywhere in the cell with an equal probability. In order to represent various multimedia applications, six different application groups are assumed based on the connection duration, bandwidth requirement and class of service. The different application groups include Constant Bit Rate (CBR), Variable Bit Rate (VBR), and data traffic sources (Unspecified Bit Rate-UBR). The six application groups are carefully chosen for a simulation; they are typical traffic seen in wireless networks and their respective parameter values are chosen from Table. The value closely represents realistic scenarios.

It is assumed the system uses Fixed Channel Allocation (FCA). Hereafter, whenever the bandwidth of a call is referred to, the meaning is denoted as the bandwidth level that is adequate for guaranteeing desired QoS for this call with certain traffic characteristics. A cell that has a maximum bandwidth capacity for each base station is set to 20 Mbps. Two types of calls share the bandwidth of the cell: new calls and handoff calls. The bandwidth required for VBR and UBR is assumed to follow a geometrical distribution between the minimum and maximum values shown in the Table. The connection duration is also assumed to follow a geometric distribution between the minimum and maximum values shown in the table. New connections from all the six application groups are generated with equal probability.

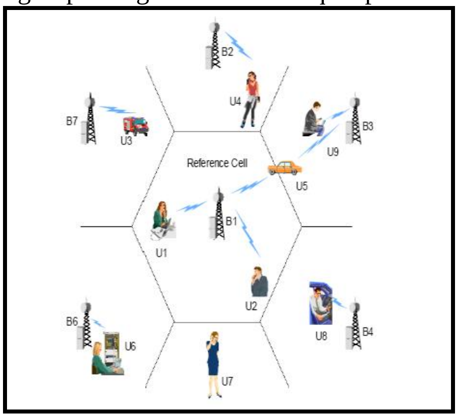

Fig6. A Six Cell Model

The figure above shows the arrangement of 6 cells. It also shows the new call arrival and hand off call in a cell. The CAC is performed on the reference cell which as a base station B1. There are 6 existing users in cell, out of which, two users use CBR traffic, one user uses VBR traffic and three users use UBR traffic.

Among the 10 incoming users, there are two users carrying the CBR-1 , two of them carrying CBR-2, another two carrying VBR-1, other two carrying , two more carrying UBR-1, one user carrying UBR-2 and the final user carrying UBR-3 traffic.

9. TRAFFIC CHARACTERISTICS

The following different traffic classes are assumed as the experimental parameters.

Traffic type-Class No	Type of Media	Minimum BW required	Average BW required	Maximum BW required	Priority
CBR -1	Voice Servie and audio phone	30kbps	30kbps	30kbps	6
CBR -2	Video phone & Video Conference	256kbps	256kbps	256kpbs	5
VBR-1	Interactive multimedia and video on demand	1Mbps	3Mbps	6Mbps	4
UBR-1	Image, Paging, Fax	5Kbps	10Kbps	20Kbps	3
UBR-2	Remote login and data on demand	64Kbps	256Kbps	512Kbps	2
UBR-3	File transfer and retrieval service	1Mbps	5Mbps	10Mbps	1

Table1. Traffic Characteristics and Experimental parameters

CBR: It stands for Constant Bit Rate.
VBR: It stands for Variable Bit Rate
UBR: It stands for Un-specified Bit Rate

10. RESULTS AND ANALYSIS

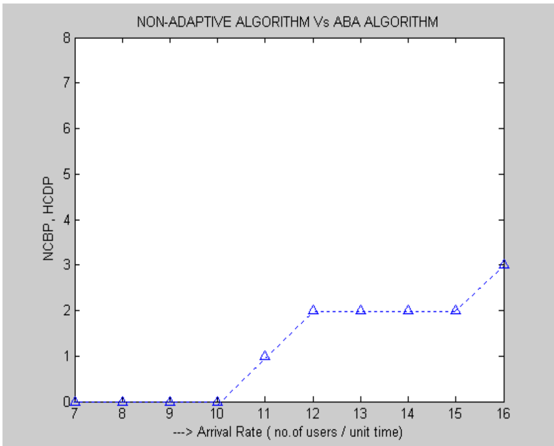

Fig7

........................Non-Adaptive CAC

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Fig7 shows the New Call Blocking Probability (NCBP) and Hand-off Call dropping Probability (HCDP) in a Non-Adaptive CAC algorithm.

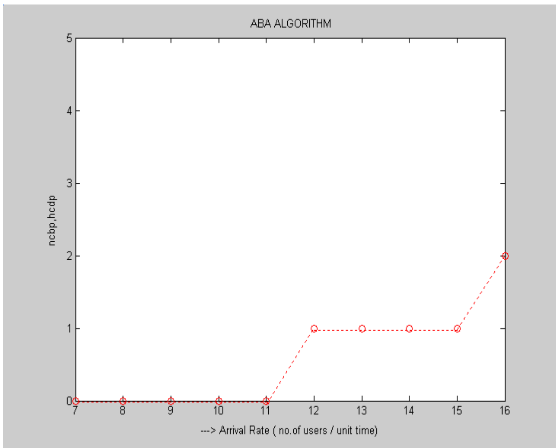

Fig8

............Adaptive CAC

Fig 8 shows the New Call Blocking Probability (NCBP) and Hand-off Call dropping Probability (HCDP) in the proposed Ad- CAC algorithm.

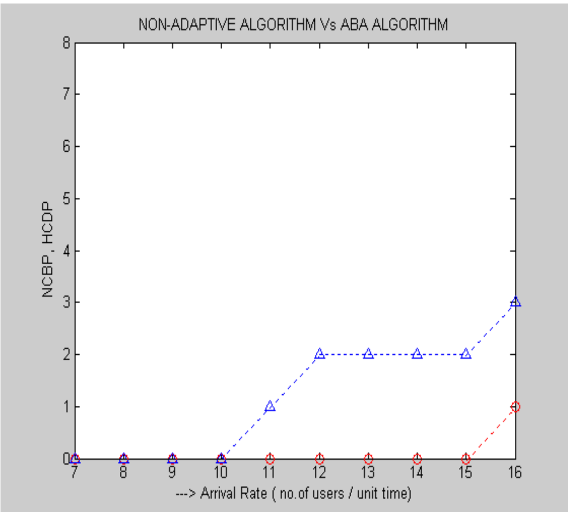

Fig9

Figure9 depicts the NCBP and HCDP versus the traffic load for adaptive multimedia and non-adaptive multimedia services, respectively. Clearly, the NCBP performance for adaptive multimedia is better than that for non-adaptive multimedia due to the CAC scheme and the bandwidth adaptation algorithm employed. The result indicates that the HCDP for adaptive multimedia and non-adaptive multimedia services is near zero under low traffic loads. This is trivially true by the nature of the algorithm as per our discussion in earlier sections. However, if the traffic is very heavy, HCDP is non-zero. For non-adaptive multimedia, HCDP is significant even under low traffic loads.

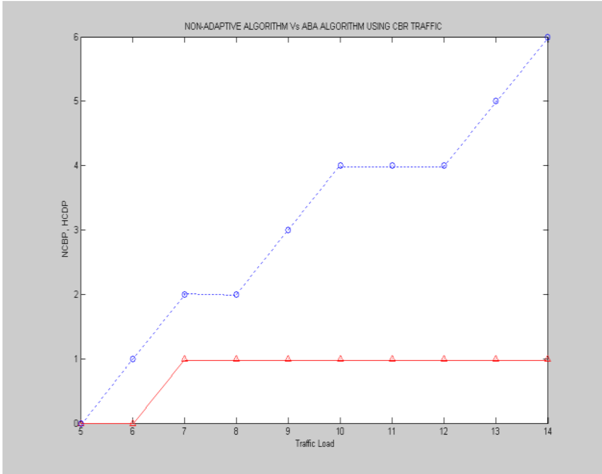

Fig10

Fig10 shows the NCBP and HCDP for a network consisting of only CBR traffic. Since it is the non-adaptive algorithm, the blocking and dropping probabilities are very high when compared to the adaptive algorithm.

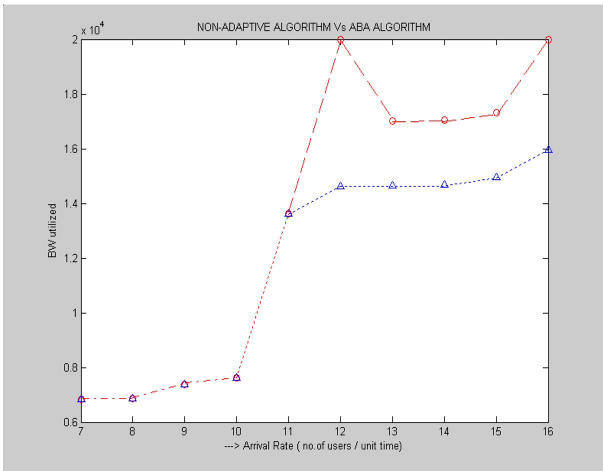

Fig11

Above figure11 compares the Bandwidth Utilization between Non-Adaptive and Adaptive Call Admission Control Algorithms. It shows that the Bandwidth utilized in Ad-CAC is much better than Non-Adaptive CAC, i.e., for the same amount of BW, Ad-CAC supports more number of users comparatively.

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