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Bandwidth Allocation in Mobile ATM Cellular Networks

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Abstract**—**Bandwidth allocation in wired network is less complex and to allocate bandwidth in wireless networks is complex and challenging, due to the mobility of source end system.This paper proposes a new approach to bandwidth allocation to higher and lower priority mobile nodes.In our proposal bandwidth allocation to new mobile node is based on bandwidth utilization of existing mobile nodes.The first section of the paper focuses on introduction to bandwidth allocation in wireless networks and presents the existing solutions available for allocation of bandwidth. The second section proposes the new solution for the bandwidth allocation to higher and lower priority nodes. Finally this paper ends with the analytical evaluation of the proposed solution.

Keywords**—**Layered Approach, Bandwidth allocation, CBR, ABR,QOS.

I. Introduction

BANDWIDTH allocation in mobile cellular network is a challenging task due to unpredictable movement of the mobile node. Hence QOS is difficult to be maintained due to cell loss and delay in variation

There are various solutions are available for bandwidth allocation in wireless networks. According to [1] the reservation for bandwidth is based on the predicted movement of the mobile node which results in unnecessary allocation earlier. Credit based bandwidth allocation method is described in [2]. In [4] the bandwidth reservation is based on the incoming and outgoing handoff predictions. According to [3] bandwidth reservation is based on ITS navigation system, which utilizes path information. It results in more computational time.

II. Bandwidth Allocation in Cellular Networks

There are many issues related to bandwidth allocation in wireless networks. These issues directly degrades the QOS. The issues are since the cell size is reducing and the users per cell is increasing, the probability of blocking the locally generated calls is increased and the probability of dropping the handoff is also increased.

It is very difficult to maintain the QOS with the above problems. In order to over come this problem,it has become necessary to develop certain mechanism where cell loss and delay can be reduced and bandwidth should be managed properly.

In our cellular network every cell has base station and all are connected together and connected to the broadband network. Base stations maintain the tables regarding the bandwidth information about all the mobile nodes in their respective cells. Whenever new mobile node generated locally or migrated from neighbouring cell the base station will follow the procedure given and allocate the bandwith and update the bandwidth table.

III. Proposed Solution for Bandwidth Allocation

In our proposal we consider two types of services namely CBR (Constant Bit Rate) and ABR (Available Bit Rate) and three groups of users.

The three groups of users are

1) The users who utilize their bandwidth fully that have been allocated to them.We term these users as active group.
2) The users who utilize part of the bandwith allocated to them.We term these users as semi active group.
3) The users who not at all utilize their bandwidth allocated to them. We term these users as passive group.

According to the above group classification, we have divided the bandwith into three regions as follows:

1) Active Group Region- In active region we assume that two types of users namely ABR and CBR who are utilizing the allocated bandwith fully.Therby this region is fully occupied.

2) Semi Active Group Region: In this region we assume two types of users namely ABR and CBR who utilize part of their allocated bandwidth.We assume part of the bandwidth is left available.

3) Free region- The users who did not utilize their bandwidth at all due to bottle neck or any other problem.In this region the bandwith is freely available.

This regions capacity is changed depending on the bandwidth utilization by different users in different groups.

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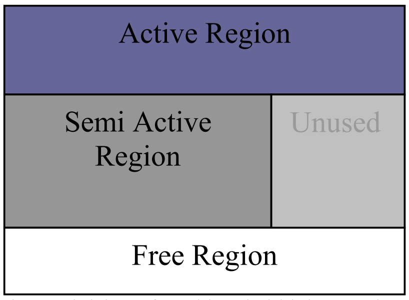

Fig. 1 Division of total bandwidth into regions

In our proposed solution, the bandwidth allocation is done for three scenarios.

1) CBR mobile node either locally generated or handoff.
2) ABR mobile node locally generated.
3) ABR mobile node migrating from neighbouring cell(handoff).

1) CBR mobile node either locally generated or handoff.

CBR user is a higher priority user. In scenario 1, the mobile node will check in free region for the availability of the required bandwidth. If the bandwidth is sufficiently available, then the base station will allocate the negotiated bandwidth. If the required bandwidth is not sufficiently available in free region, it will add up the partially unutilized bandwidth available in semi active region .If on adding up the free region's bandwidth and unutilized bandwidth of semi active region is not sufficient to meet the negotiated bandwidth, then the part of the bandwidth allocated for ABR user in semi active region will be reduced and will be added to meet the negotiated bandwidth. If the required capacity is not achieved then it will reduce portion of ABR bandwith in active region and add to the above sum of bandwidths. After adding up if the required bandwith is not possible to be allocated then this node is kept in CBR queue. If the call is handoff CBR node then preference will be given to it against locally created node. Always handoff node will be given preference against locally generated node for allocation of bandwidth.

The bandwidth of the existing ABR sources is reduced equally.

2) ABR mobile node locally generated.

ABR is a low priority user. In this scenario ABR base station will look for any handoff calls. If handoff call is not available then ABR node will check in free region to get the required bandwidth at least equal to minimum cell rate.(MCR). If bandwidth is available then the base station will allocate this MCR to the mobile node. If the MCR equivalent of the bandwidth is not available then it look for unutlized portion of the semiactive region to meet the negotiated bandwith or at least MCR. In order to get connected to the network ABR node should have at least MCR, so that later on it can get more bandwith after an interval of time.

3). ABR mobile node migrating from neighbouring Cell (handoff).

In this scenario, like previous two scenarios it will check in free region and semi active region for available bandwidth. This will be given priority against locally generated ABR mobile node. The previous base station will intimate about MCR, ACR and PCR value to the next base station., so after handing off this base station will try to allocate ACR and if not available at least MCR should be given for time being until the ACR is reached. The base station will not drop the handoff calls so that the continuity of the data flow is to be maintained. In case of non availability of MCR the node will be kept in ABR queue.

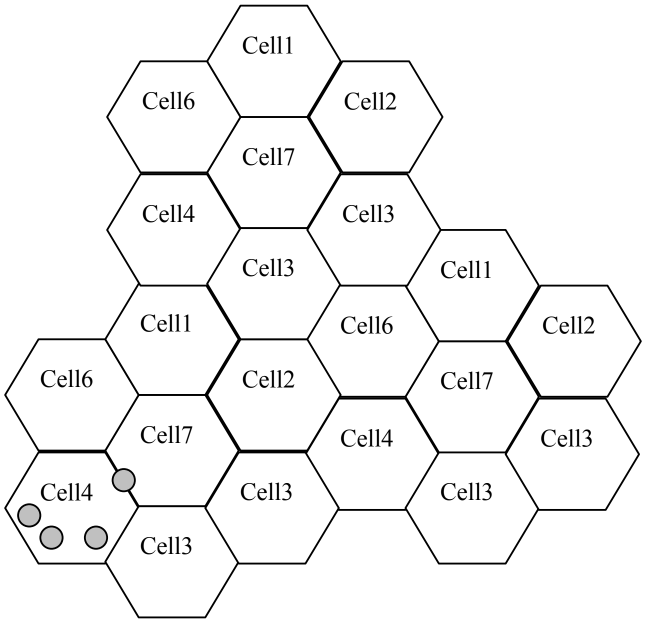

Fig. 1 Cellular Network

TABLE I
BANDWIDTH TABLE MAINTAINED BY THE BASE STATIONS

Region	*Nodes*	*Bandwidth Allocated*	*Bandwidth Utilized*	*Bandwidth Unused*
	A_{CBR1}			
	A_{CBR2}			
	A_{CBR3}			
Active Region	A_{ABR1}			
	A_{ABR2}			
	A_{ABR3}			
	S_{CBR1}			
	S_{CBR2}			
	S_{CBR3}			
	S_{ABR1}			
Semi Active Region	S_{ABR2}			
	S_{ABR3}			
Free Region				

IV. ALGORITHM FOR BANDWIDTH ALLOCATION

Algorithm for bandwidth allocation to CBR(Scenario1)

If negotiated bandwidth is available in free region then

Allocate the bandwidth

Else

If negotiated bandwidth is not sufficiently available in free region then

Allocate the bandwidth by adding up the available bandwidth in free region and unutilized bandwidth in semi active region.

Else

IF negotiated bandwidth is not sufficiently available after adding up bandwidth of free region and unutilized semi active bandwidth then

Reduce the part of bandwidth from ABR nodes in semi active region and add to the sum of bandwidth from free region, unutilized bandwidth from semi active region and part of the reduced bandwidth from ABR in semi active region.

Else

If negotiated bandwidth is still not sufficient then

Reduce the part of the bandwidth from the ABR node in active region.

Sum the bandwidth in free region, unutilized bandwidth in semi active and part of the bandwidth from ABR in semi active and active regions.

Else

If negotiated bandwidth is not still sufficient then

Either Renegotiate the bandwidth or Place the call in CBR queue.

Algorithm for bandwidth allocation to Handoff ABR (Scenario2)

If call is locally generated then block the call

If negotiated bandwidth is available in free region then

Allocate the bandwidth

Else

If negotiated bandwidth is not sufficiently available in free region then

Allocate the bandwidth by adding up the available bandwidth in free region and unutilized bandwidth in semi active region.

If negotiated bandwidth is not still sufficient then

Either Renegotiate the bandwidth or Place the call in ABR queue.

Algorithm for bandwidth allocation to Locally generated ABR (Scenario3)

If there is handoff call then

Locally generated ABR is dropped

Bandwidth Allocated = NIL

Else

If there is no hand off call then

If negotiated bandwidth is available in free region then

Allocate the bandwidth

Else

If negotiated bandwidth is not sufficiently available in free region then

Allocate the bandwidth by adding up the available bandwidth in free region and unutilized bandwidth in semi active region

Else

If negotiated bandwidth is not still sufficient then

Either Renegotiate the bandwidth or Place the call in ABR queue.

V. Analytical Evaluvation of the Three Scenarios

The following notations are used in the evaluation

$B_C(t)$ is the bandwith available in free region
B_{CBR} and B_{ABR} are the bandwidths of CBR and ABR nodes.
$B_0(t)$ is the zero bandwidth.
$B_l(t)$ is the total left over bandwidth in semi active region

Δ is the fraction used in calculating the required bandwidth.
$BS_{ABR}(t)$, $BA_{ABR}(t)$ is the ABR mobile nodes in active and semi active regions respectively.

Δ Has to be chosen in such a way that ABR'S bandwidth should be maintained at least equal to MCR, so that ABR should be in the cell with minimum bandwidth.

CBR mobile node either locally generated or handoff

$$B_{CBR} \leftarrow B_C(t) \quad (1)$$

$$B_{CBR} \leftarrow B_C(t) + B_l(t) \quad (2)$$

$$B_{CBR} \leftarrow B_C(t) + B_l(t) + \sum_i [BS_{ABRi}(t) * \Delta] \quad (3)$$

$$B_{CBR} \leftarrow B_C(t) + B_l(t) + \sum_i [BS_{ABRi}(t) * \Delta] + \sum_i [BA_{ABRi}(t) * \Delta] \quad (4)$$

ABR mobile node handoff

$$B_{CBR} \leftarrow B_C(t) \quad (1)$$
$$B_{CBR} \leftarrow B_C(t) + B_l(t) \quad (2)$$

ABR mobile node locally generated (if there is no handoff information)

If there is handoff
$$B_{ABR} \leftarrow B_0(t) \quad (1)$$

If there is no handoff
$$B_{ABR} \leftarrow B_C(t) \quad (1)$$

$$B_{ABR} \leftarrow B_C(t) + B_l(t) \quad (2)$$

VI. Example of Bandwidth Allocation

3CBR (3) 2ABR (2)	2CBR (1) 2ABR (1) 2 left	1

Bandwidth for the existing nodes is as follows.

We consider total 9 mobile nodes in our example, in which 5 in Active region and 4 in Semi Active region.

Active Region

No. of CBR mobile nodes =3
No. of ABR nodes = 2
Let each CBR node bandwidth be 1Mbps
Total CBR node bandwidth = 3Mbps
Let each ABR node bandwidth 1Mbps
Total ABR node bandwidth = 2Mbps
Total Bandwidth at active region = 5Mbps

Semi Active Region

No. of CBR mobile nodes = 2
Let each CBR node bandwidth be 1Mbps
Total CBR node allocated bandwidth = 2Mbps
Let total CBR node bandwidth unutilized = 1Mbps
Total CBR node utilized Capacity = 2Mbps

No. of ABR mobile nodes = 2
Let each ABR node bandwidth = 1Mbps
Total ABR node allocated bandwidth = 2Mbps
Total ABR unutilized bandwidth = 1Mbps
Total ABR utilized Bandwidth = 1Mbps
Total utilized bandwidth in Semi Active region = 2Mbps
Total unutilized bandwidth in Semi Active region = 2Mbps

Let If the node is CBR user, and negotiated bandwidth is 3Mbps

$$B_{CBR} \leftarrow B_C(t) \quad (1)$$

B_{CBR} = 1Mbps

$$B_{CBR} \leftarrow B_C(t) + B_l(t) \quad (2)$$

B_{CBR} = 3Mbps

Let $\Delta = 0.1$

$$B_{CBR} \leftarrow B_C(t) + B_l(t) + \sum_i [BS_{ABRi}(t) * \Delta] \quad (3)$$

$B_{CBR} = 3+[1]*0.1$
$B_{CBR} = 3.1\text{Mbps}$

$$B_{CBR} \leftarrow B_C(t) + B_l(t) + \sum_i [BS_{ABRi}(t) * \Delta] + \sum_i [BA_{ABRi}(t) * \Delta] \quad (4)$$

$B_{CBR} = 3.1+[2]*0.1$
$= 3.3\text{Mbps}$

$B_{CBR} = 3.3\text{Mbps}$ is one of the negotiable bandwidth for the locally generated node. For the handoff node the bandwidth has to be calculated same as before handoff, this can be achieved by increasing or decreasing the Δ value in calculations.

Scenario diagrams

Positions of regions before Allocation.

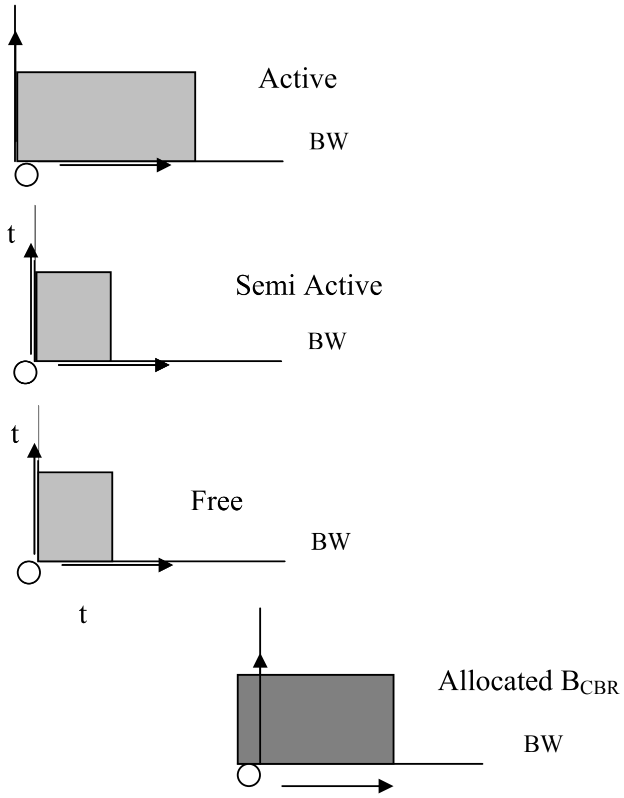

Fig. 2 Capacity in regions & B_{CBR} allocation

The value of delta has to be chosen in such a way that bandwidth to be allocated, should be less than the sum of bandwidths of ABR in active, leftover bandwidth and bandwidth of ABR in Semi active, and bandwidth in free regions, because at least minimum bandwidth (MCR) should be there with ABR nodes.

$$B_{CBR} < \sum_i BA_{ABRi}(t) ++ \sum_i BS_{ABRi}(t) + B_l(t) + B_C(t)$$

VII. Conclusion

In our proposed solution in allocation of bandwidth based on bandwidth utilization of existing nodes in the cell will help in avoiding the delay and cell loss. Higher priority node (CBR) will get bandwidth without fail and faster. Since the priority is given to handoff nodes and flexibility in changing the ABR nodes bandwidth will avoid the cell loss and cell delay variation. Our solution will try to provide maximum bandwidth to the ABR user, in worst case at least minimum bandwidth should be allocated, and can be increased later. Instead of reserving the bandwidth we are utilizing part of the bandwidth of low priority existing nodes and freely available bandwidth from those nodes who are not at all utilizing their allocation. From this approach overall QOS can maintained.

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