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Partition Base CAC with Queuing Model for 802.16e

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Abstract— Call Admission Control (CAC) plays a vital role in providing Quality of Service (QoS) performance of the system. IEEE 802.16 standard does not describe the procedure for implementing CAC. There is a need of efficient CAC algorithm that simultaneously manages traffic and wisely utilizes the available bandwidth resources. In this paper a CAC scheme is proposed which works on partitioning the bandwidth into four portions, namely, CBR (constant bit rate), VBR (variable bit rate), HO (handover), and shared portion. Waiting Queues are implemented in CBR and VBR portions for lowering blocking probability and Fuzzy logic is implemented in HO portion for lowering dropping probability. Simulations are done to evaluate the performance of this proposed scheme. Comparison is also done with the existing Fuzzy based CAC scheme. Results showed that the proposed scheme performs better in bandwidth utilization and lowering of blocking probability and dropping probability

Keywords — CAC, Partition-base, Fuzzy Logic, Waiting Queues, Blocking Probability, Dropping Probability, Bandwidth Utilization.

I. INTRODUCTION

IEEE 802.16 standard based technology WiMAX is used for providing broadband very high speed wireless access to a very large coverage area. It covers an area of several kilometres in radius at a data rate of about 75 Mbps [1], [2]. It is the first internet packet mobile internet solution for enabling efficient and scalable networks for providing data, video and voice. It is a WMAN standard that operates on scalable bandwidth, OFDM and OFDMA access mode and also different cyclic prefixes [1], [2]. Its services can be provided to variety of devices such as personal computers, notebook, cameras, music players, gaming devices and many more.

Classification of types of traffic expected in WiMAX is identified by WiMAX forum in [1] and is divided into following categories: Unsolicited grant services (UGS), Real time polling services (rtPS), Non-real time polling services (nrtPS), Best effort (BE) and Extended real-time polling services (ertPS). UGS services are for CBR traffic such as VoIP, rtPS are for those applications that send VBR traffic on periodic basis such as MPEG video, nrtPS are for non real time applications having VBR traffic, ertPS is also for variable packet size applications such as VoIP with silence suppression and BE is used for admitting traffic without any QoS needs. BE connection receives bandwidth allocation when all other scheduling service types have been satisfied. Careful implementation of scheduling and CAC can result in a better QoS. Mostly the scheduling algorithm and CAC algorithm were designed separately; each has to be efficient in managing the available network resources. Scheduling performs the work of handling packet delay for slot allocation whereas CAC handles the work of link bandwidth utilization.

In this paper CAC scheme based on partition bandwidth and Queuing model has been proposed for mobile WiMAX in point to multipoint (PMP) mode. This scheme has been implemented at the base station (BS). It uses grant per subscriber station (GPSS) mode in the downlink frame. The traffic is admitted or rejected based on the nature of partition and its available bandwidth. The rest of the paper is organised as follows: Section II discusses previous work, Section III describes the system model, Section IV deals with proposed CAC algorithm with Queuing model, Section V presents simulation results and conclusion is drawn in Section VI.

II. RELATED WORK

Several studies have been done on CAC in providing QoS in IEEE 802.16 networks. In [3] a CAC scheme based on fuzzy associative memory was developed for lowering the dropping probability in mobile wireless networks but this scheme does not considered the multiple classes of users with different QoS requirements. In [4] a CAC scheme consisting of three components: joint-admission controller, threshold-based bandwidth reservation and bandwidth adaption controller was considered for bandwidth utilization and reducing of both call blocking and call dropping probability. In [5] simulations were conducted for CAC scheme based on estimating the bandwidth requirements of VBR traffic to increase resource utilization of system. It considered only UGS traffic and only rtPS traffic. In [6] a token bucket CAC scheme was adopted to satisfy both the bandwidth and delay guarantees to admitted connections. In [7] a partition-base bandwidth CAC scheme was considered consisting of CBR and VBR traffic portions. In [8] the work of [7] was improved by considering the third partition for HO traffic. It aims at lowering the blocking and dropping probabilities. For further lowering of dropping probability a fuzzy logic based CAC was implemented in [9] which implements fuzzy logic in HO portion to dynamically adjust the bandwidth of all the partitions when the traffic drops occur. In [11] a CAC technique having channel partition with queuing model was demonstrated for providing QoS in next generation wireless networks. It showed that as the utilization rate increases, the blocking probability was also increased for all the user classes. In [12] a soft computing system for resource partition and call admission algorithm for dynamic resource management of femto cells networks was proposed. The bandwidth was divided into partitions for each type of service classes and one partition for shared partition where traffic of all types can be accommodated. It is implemented in combination with Bayesian based content aware CAC

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III. SYSTEM MODEL

The system model in this network consists of one BS for generating new calls (CBR, VBR) and other BS for generating HO calls. Subscriber stations (SS) are distributed all over the coverage areas of BSs. Hilly-terrain environment with moderate to heavy tree density reflecting category A of Erceg model is considered which is very close to real world scenario. For calculating path loss (PL) [1] equation 1 is used:

$$Pl = 20\log_{10}\left(\frac{4\pi d_o}{\lambda}\right) + 10\gamma\log_{10}\left(\frac{d}{d_o}\right) + 6\log_{10}\left(\frac{f}{2000}\right) - 10.8\log_{10}\left(\frac{h}{2}\right) + s, \quad d>d_o. \tag{1}$$

Where d_o is reference distance (100m), γ is path loss component, d is distance between BS and SS, f is transmission frequency, h is height of BS antenna and s is shadowing factor. Signal to noise ratio (SNR) is obtained by using equation 2 [10] as:

$$SNR = \frac{\varepsilon\theta\vartheta}{PL * \psi}, \tag{2}$$

where ε is BS transmitted power, θ is BS antenna gain, ϑ is SS antenna gain, and ψ is receiver sensitivity. Based on SNR value calculated using (2) the required coding rate and modulation scheme is determined using Table I.

TABLE I
Coding Rate and Modulation Scheme

S/N	**Modulation**	**Coding Rate**	**SNR (dB)**
1	QPSK	½	5.0
		¾	8.0
2	16-QAM	½	10.5
		¾	14.5
3	64-QAM	½	16.0
		2/3	18.0
		¾	20.0

For implementing fuzzy logic in Ho portion Mandani fuzzy model was used which has three inputs: number of call drops in HO portion, available bandwidth in the CBR and VBR portions with one output and HO bandwidth adjustment. The five membership functions of number of total drops are given as:
f (VS S M B VB).
The five membership function of available bandwidth which is positive difference between CBR and VBR is given as:
f (VS S M B VB).
The output contains eight membership functions for the adjustment of bandwidth:
f (Z VS S SM M MB B VB).
Where variables stand for Z=zero, VS=very small, S=small, SM=small medium, M=medium, MB=medium big, B=big, VB=very big.
For input variables having five membership functions each, a total of twenty five different combinations of IF-THEN fuzzy rules can be formed. From these rules only one rile is triggered when traffic drop occurs. For example if total traffic drop is medium and available bandwidth is medium then fuzzy logic should adjust the HO portion to small medium. The same amount of bandwidth, depending upon which portion (CBR or VBR) has higher available bandwidth, is reduced from that portion. Mathematically, it is represented by equation 3 as:

$$h = C - V, \quad h = \begin{cases} 1, & if\ C > V \\ 0, & otherwise, \end{cases} \tag{3}$$

$$k = C * h * \sum_{i=1}^{25} Fz(i) + V * \vec{h} * \sum_{i=1}^{25} Fz(i), \tag{4}$$

Where C signifies available CBR bandwidth, V is available CBR bandwidth, $\vec{h}$ is logical not of h and Fz(i) is one of the twenty five fuzzy rules, evaluated to logic 1 if rule is true. The HO portion bandwidth is adjusted as given in equation 5:

$$y = HO = k * p_o \tag{5}$$

Where p_o is one of the output membership functions that are expressed in percentage of selected bandwidth portion and HO is the available bandwidth before the adjustment is done by Fuzzy logic. For implementing waiting queues, let λ be the arrival rate of all calls. Departure rate is about one-tenth of arrival rate. Arrival and departure rates are assumed to follow independent Poisson process. Let the average service time of calls for all services is negative exponential distribution with mean rate $1/\mu$. The admission controller queues the incoming call requests for bandwidth grant. If there will be free bandwidth than the request at the top of the queue will be serviced that is bandwidth will be allocated. Waiting queues are implemented in both CBR and VBR partitions. They are not implemented in the HO portion.

IV. PROPOSED CAC ALGORITHM WITH QUEUING MODEL

The proposed scheme partitions the total bandwidth into four portions: CBR partition, VBR partition, HO partition and the shared partition. The traffic is admitted according to its characteristics. If there is no available bandwidth in the respective portion of traffic they are admitted into shared partition. The traffic is entered or departed by issuing DSA (dynamic service addition) for new traffic, DSC (dynamic service change)for existing traffic, DSD(dynamic service delete) for exit of existing traffic and HSR (handover service request) for HO traffic. The admission controller in proposed scheme keeps the track of amount of available bandwidth in each portion. When a user of VBR or CBR service class requests for the bandwidth the admission controller admits it into respective waiting queue and checks if there is available bandwidth. If the bandwidth requirements can be satisfied the call is admitted else the call has to wait in waiting queue. Whenever there will be available bandwidth the CAC allocates the bandwidth to that call which is on the top of the queue. All the admission controlling tasks are performed by the CAC controller without disturbing the QoS of existing calls in the system. The aim behind this task of CAC scheme is to minimize blocking of calls as small amount of delay is considered better than not providing services at all. When bandwidth request of HO call arrive then the availability of bandwidth is checked in HO partition if not then in shared partition else the HO request is dropped and fuzzy logic is implemented in HO portion to dynamically adjust the bandwidths of CBR, VBR and HO portions. The aim behind this procedure is to lower the dropping probability of calls. The detailed procedure for CBR and VBR portions is given in Algorithm I. The procedure for HO traffic is detailed in Algorithm II.

Algorithm I
Proposed Scheme for New Traffic (CBR and VBR)

```
1.  Let the total bandwidth be B.
2.  Partition B into $B_c$, $B_v$, $B_h$, $B_s$ such that $B_c + B_v + B_h + B_s = B$.      //partition into CBR, VBR, HO and shared
3.  Let $Q_c$ and $Q_v$ be waiting queues for CBR and VBR partitions
4.  Let length of $Q_c$ and $Q_v$ be q_len
5.  Deploy the traffic randomly according to independent Poisson distribution; both new and existing.
6.  For n=1:N                                            // N is total number of traffic
7.  Compute the distance of the traffic from BS-1
8.  For calculated distance, compute the total path loss
9.  For calculated path loss, compute the SNR value
10. For the computed SNR value, determine the modulation and coding scheme
11. Based on the modulation and the coding rate, obtain the number of subcarriers and number of slots required by the
    traffic
12. Identify the traffic source i.e. from BS-1 or BS-2.
13. If Ha=0 && DSA=1
14. If SFID=1                                            //cbr  (UGS) traffic
    If max<$B_c$
    Allocate_rate=max
    Update $B_c$
    Else if max<$B_s$
    Allocate_rate=max
    Update $B_s$
    Else If $Q_c$<q_len
    Enter the call in $Q_c$
    Else reject the traffic
    Update traffic block
    End
15. Else If SFID=2
    If max<$B_v$                                         //rtPS traffic in VBR
    Allocate_rate= (max_rate+sustain_rate)/2
    Update $B_v$
    Else if max<$B_s$
    Allocate_rate=(max+sustain_rate)/2
    Update $B_s$
    Else If $Q_v$<q_len
    Enter call in $Q_v$
    Else reject the traffic
    Update traffic block
```

```
    End
16. Else                                                    //SFID=3 nrtPS
    Allocate_rate=(sustain_rate+min)/2
    Update $B_v$
    Else if max<$B_s$
    Allocate_rate=(sustain_rate+min)/2
    Update $B_s$
    Else if $Q_v$<q_len
    Enter the call into $Q_v$
    Else reject
    Update the traffic block
    End
17. Else if DSC=1                                           //traffic changing the service flow
18. If SFID>1
    Restore initial bandwidth to  $B_v$ or $B_s$            //depending on traffic of which partition has initiated request
    Update $B_s$ or $B_v$ or $B_s$
    If current_bandwidth of $B_v$ > max
    Allocate the bandwidth
    Else If current_bandwidth of $B_s$> max
    Allocate bandwidth
    Else IF $Q_v$<q_len
    Enter the call into $Q_v$
    Else reject
    Update traffic block
    End
19. Else If SFID=1
    Restore initial bandwidth to $B_c$
    If current_bandwidth of $B_c$>max
    Allocate the bandwidth
    Else If current_bandwidth of $B_s$>max
    Allocate the bandwidth
    Else If $Q_c$<q_len
    Enter the call into $Q_c$
    Else reject
    Update the traffic block
    End
    End
20. Else If DSD=1                                           //departure of admitted traffic
21. If SFID>1
    Update $B_v$ or $B_s$
    If $Q_v$>1
    Remove the call in front of $Q_v$
    Update $Q_v$
    Repeat steps from 13
    Else
    Update $B_c$ or $B_s$
    If $Q_c$>1
    Remove the call in front of $Q_c$
    Update $Q_c$
    Repeat steps from 13
    End
    End
    End
```

Algorithm II
Proposed CAC Scheme for HO Traffic

```
1.  Let the total bandwidth be B.
2.  Partition B into CBR, VBR, HO and shared ($B_c$,$B_v$,$B_h$,$B_s$)
3.  Deploy all the traffic randomly following independent poisson distribution; for both new and existing traffic
4.  For n=1:N                    //n is total number of traffic used in Simulation both new and existing traffic
5.  Compute the traffic distance from BS-1.
6.  For the computed distance, calculate the total path loses
7.  For the calculated path loss determine the SNR value
8.  After calculating the SNR choose the modulation and coding rate
9.  Based on modulation and coding rate, obtain the number of subcarriers and slots required by the traffic
10. Identify the traffic source (i.e from BS-2 or BS-1)
11. If Ha=1                            // this is HO with DSA=1
12.  If max < $B_h$ && SFID=1
    Allocate_rate=max
    Update $B_h$
    Else If max < $B_s$
    Allocate_rate=max
    Else reject
    Update drop
    Apply fuzzy logic to adjust $B_h$
    Update $B_h$ ,$B_v$, $B_c$
    End
13. Else If SFID =2
    Repeat 12 with Allocate_rate=max + avg / 2
14. Else If SFID=3
    Repeat 12 with Allocate_rate= avg + min / 2
15. Else IF SFID=4
    Repeat 12 with Allocate_rate= min
    End
16. If DSC=1                                              //traffic changing the service flow
    Restore initial bandwidth of service flow to $B_h$ or $B_s$      // depends on which portion the traffic is admitted
    Update $B_h$ or $B_s$
    If current bandwidth of $B_h$ > new request
    Allocate bandwidth
    Else if current bandwidth of $B_s$ > new request
    Allocate bandwidth
    Else reject
    Update drop
    Apply Fuzzy logic to adjust $B_h$
    Update $B_h$, $B_v$ and $B_c$
    End
17. If DSD=1                                              //traffic departure
    Restore bandwidth and update $B_h$ or $B_s$
    End
```

V. SIMULATION PARAMETERS AND RESULT

MATLAB is used for simulation of the proposed scheme. The different parameters used in proposed scheme are given in Table II.

TABLE II : Simulation Parameters

Parameter	Settings
FFT Size	512
Bandwidth	5 MHz
DL/UL ratio	35/12
Number of sub channels	15
Number of sub carriers	360
Frame duration	5 ms
Frame modulation	64-QAM
Total capacity	12.6 Mbps
CBR partition	15 %
VBR partition	65%
HO partition	10%
Shared partition	10%
Modulation scheme	QPSK, 16-QAM, 64-QAM
Path loss model	Erceg category-A
Transmission frequency	2.5 GHz
Path loss components	4.75
Shadowing component	8.9
BS transmitting power	43 (dBm)
BS antenna gain	15 (dB)
Receiver sensitivity	-111.1 (dBm)
Receiver antenna gain	-1.0

The traffic used in this model are categorized into five classes having associated maximum allocated rate, average sustainable traffic and minimum allocated rate. These are given in Table III.

TABLE III : Traffic Types Used

Class	Type	Max	Avg	Min
Traffic 1	UGS	64	64	64
Traffic 2	UGS	20	20	20
Traffic 3	rtPS	400	380	320
Traffic 4	rtPS	82	60	53
Traffic 4	nrtPS	130	126	110
Traffic 5	nrtPS	20000	1870	1600

For critically evaluating the performance of the proposed scheme three different scenarios are undertaken that are light traffic, medium traffic and heavy traffic. Table IV shows the amount of new and HO traffic entered in the network in these scenarios

TABLE. IV :Scenarios Undertaken

Scenario	New calls	Existing or Handover calls
Light traffic	34	16
Medium traffic	63	37
Heavy traffic	108	42

A. Light Traffic

In this case, 34 new calls and 16 HO calls occurred. This scheme is compared with scheme in [9]. The length of waiting queues of both CBR and VBR partition is taken as 2. This scheme has very low blocking probability as compared to scheme in [9]. The blocking probability of both schemes is shown in Figure 1. However all the HO traffic was admitted by both the schemes. It is shown in Figure 2. The amount of allocations to CBR, VBR and HO traffic in proposed CAC is shown in Figure3. It has admitted all the HO calls and only 6% of the new calls are blocked.

Comparison between the previous scheme [9] and proposed scheme against bandwidth usage for total number of service flows is shown in Figure 4. The bandwidth usage pattern is almost identical for both the schemes.

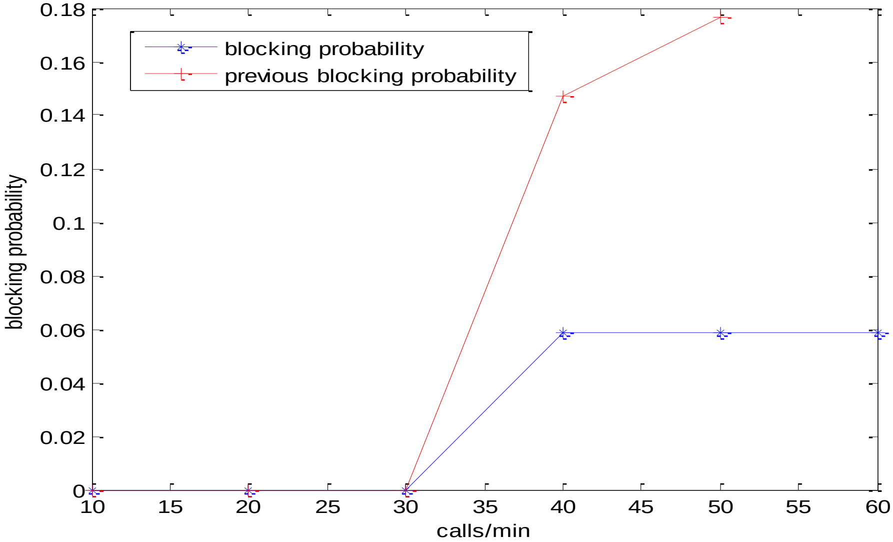

Figure 1 Blocking Probability in Light Traffic

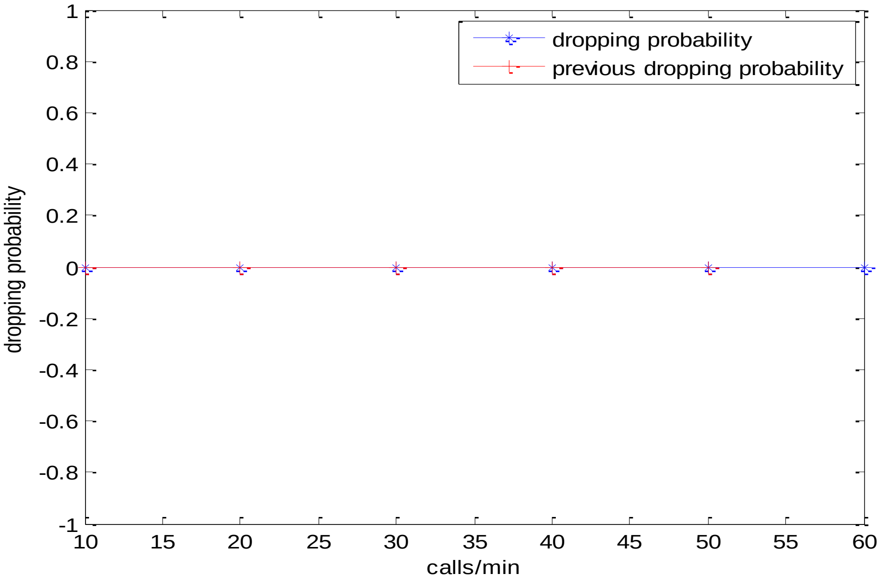

Figure 2 Dropping Probability in Light Traffic

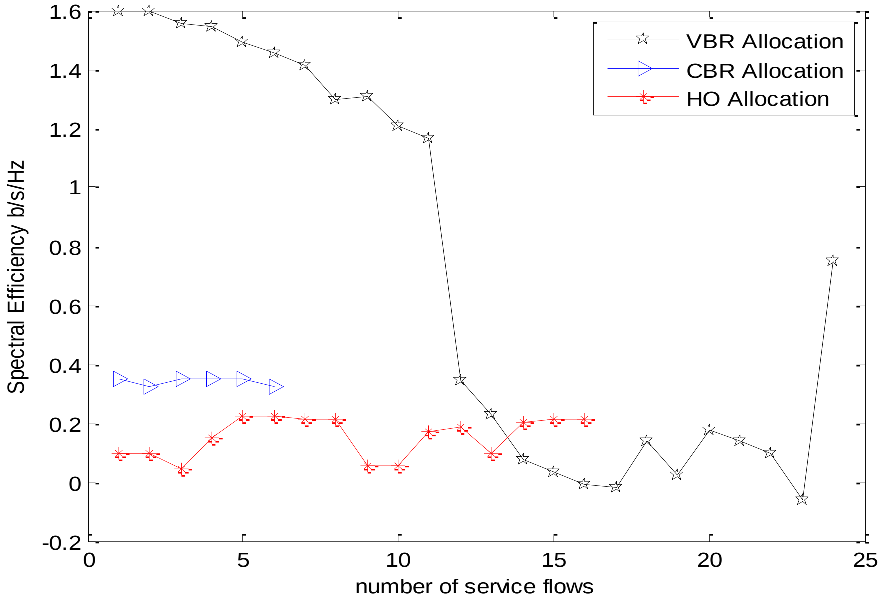

Figure 3 Spectral Efficiency of Proposed CAC in Light Traffic

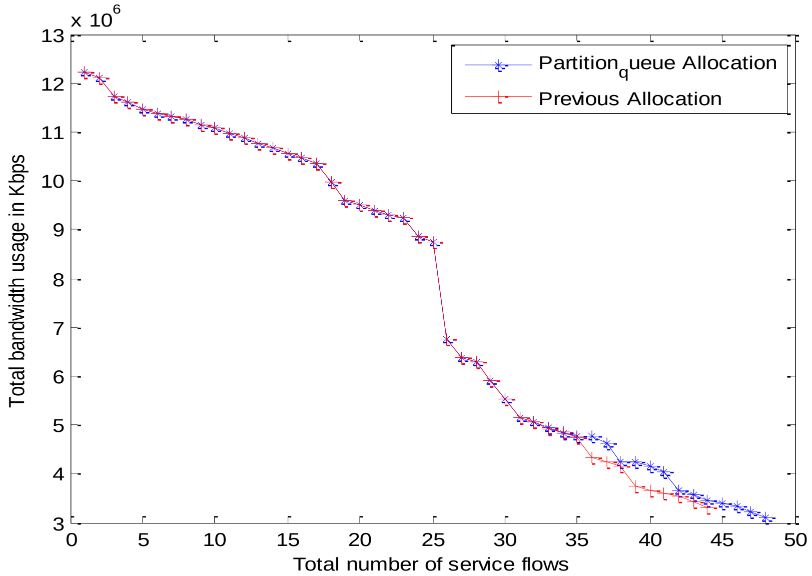

Figure 4 Bandwidth Usage in Light Traffic

B. Medium Traffic

In this scenario a total of 100 calls are deployed: 63 new calls and 37 HO calls. The blocking probability of proposed scheme and previous scheme is shown in Figure 5. Proposed scheme gives much lower blocking probability. While proposed scheme has admitted all HO traffic, previous scheme has dropped about 6% HO calls. Figure 6 depicts dropping probability of both schemes. Figure 7 shows the amount accepted service flows of proposed scheme. As it can be seen from Figure 8, the proposed scheme and the previous scheme performs equally well in bandwidth usage [9].

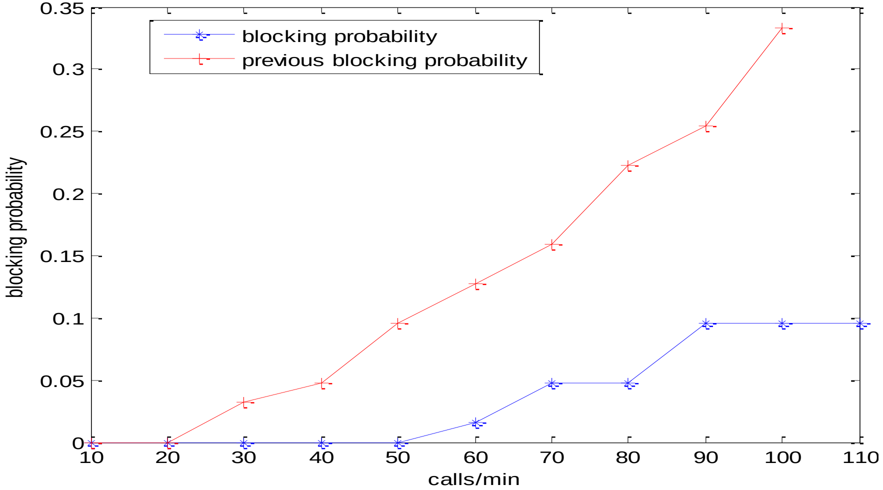

Figure 5 Blocking Probability in Medium Traffic

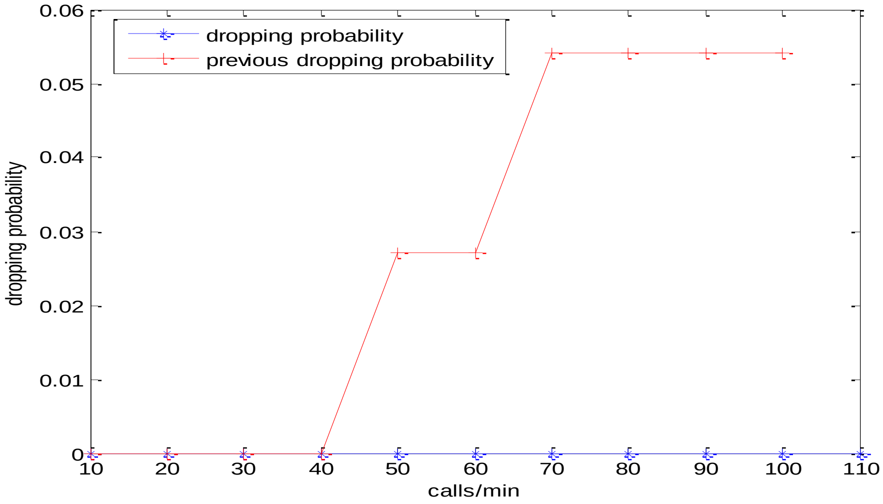

Figure 6 Dropping Probability in Medium Traffic

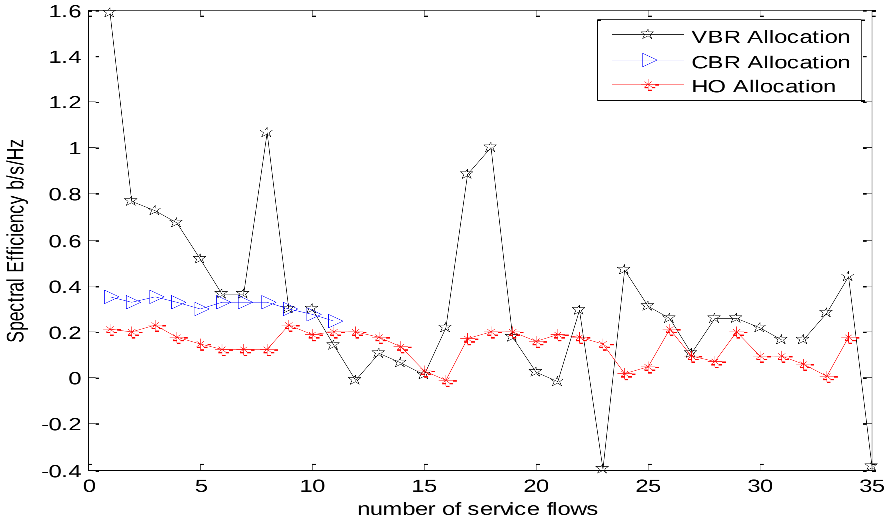

Figure 7 Spectral Efficiency of Proposed Scheme in Medium Traffic

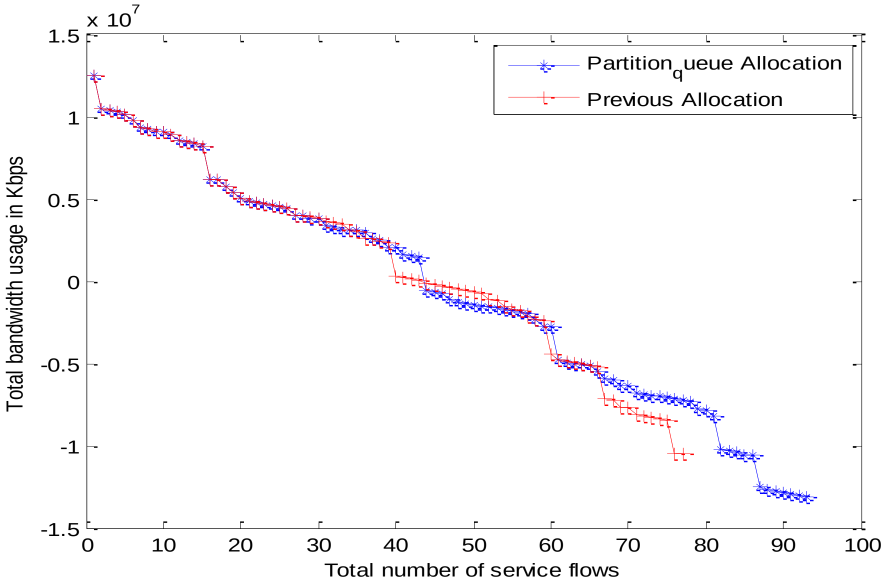

Figure 8 Total Bandwidth Usage in Medium Traffic

C. *Heavy Traffic*

108 new service flows and 42 HO service flows are considered. Figure 9 depicts the blocking probability of both schemes. Blocking of calls is far much reduced in proposed scheme. Figure 10 depicts dropping probability of both schemes which concludes that the dropping probability is also lower in proposed scheme. The blocking and dropping probabilities are evaluated 20 calls per minute. The amount of admitted traffic in terms of CBR, VBR and HO traffic is shown as spectral efficiency of proposed scheme in Figure 11. Comparison of bandwidth usage of both schemes is shown in Figure 12. Proposed scheme utilizes bandwidth far better than previous scheme.

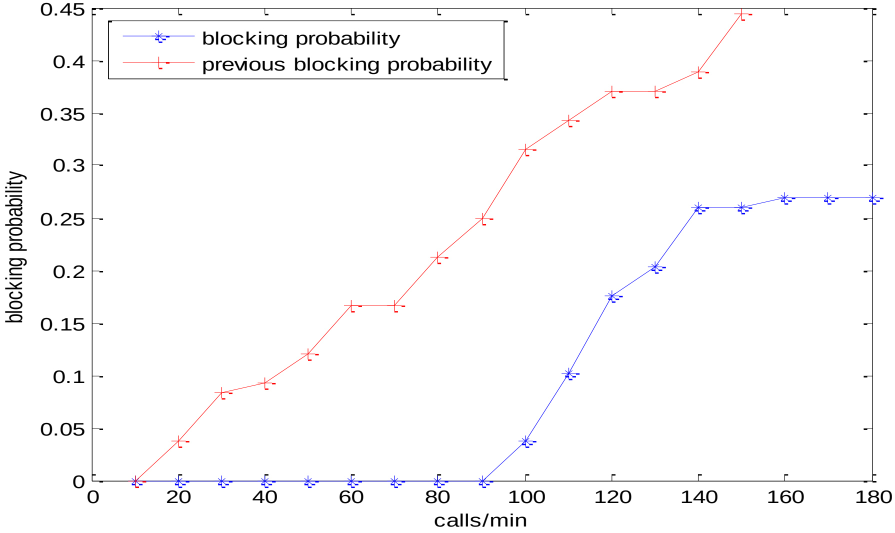

Figure 9 Blocking Probability in Heavy Traffic

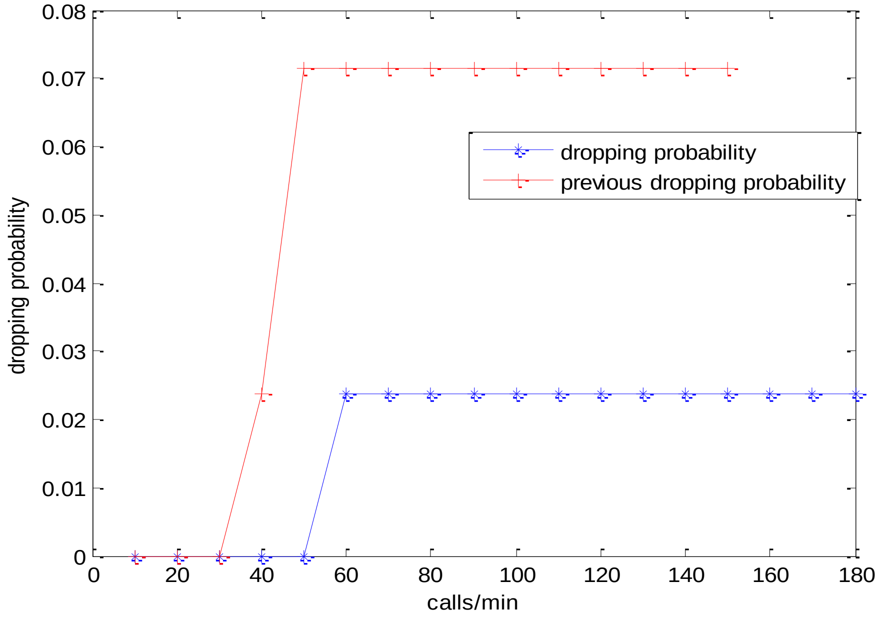

Figure 10 Dropping Probability in Heavy Traffic

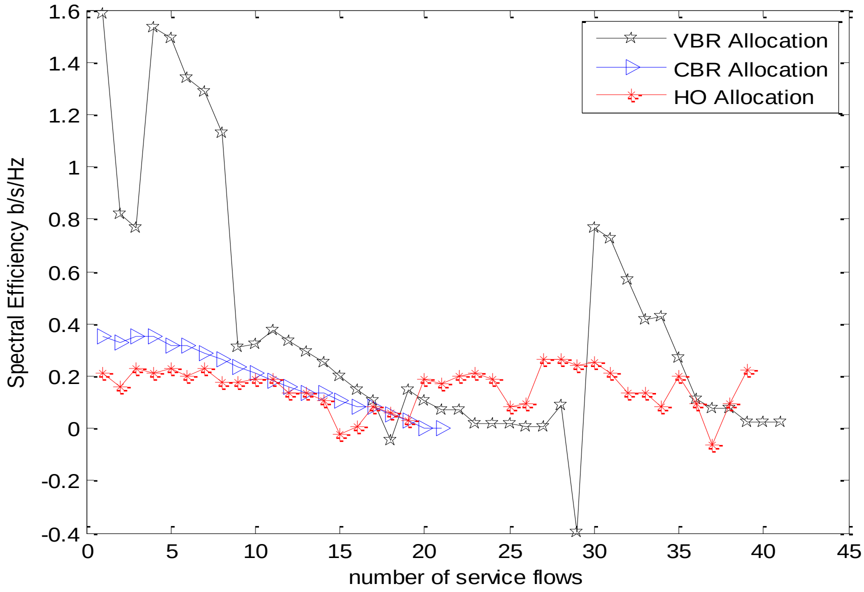

Figure 11 Spectral Efficiency of Proposed Scheme in Heavy Traffic

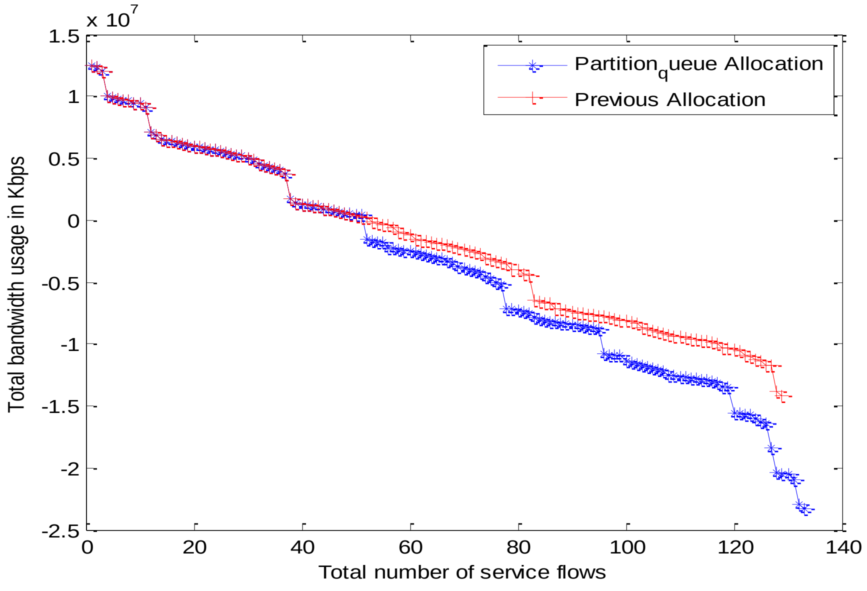

Figure 12 Bandwidth Usage in Heavy Traffic

For evaluating the performance of proposed scheme against queue length in CBR and VBR portion a total of 200 service flows are undertaken. Queue length is taken as 2 in first case and 6 in other. We cannot keep on increasing the queue length as it will enhance the waiting time of calls. The performance is measured in terms of blocking probability. Figure 13 shows the blocking probability of proposed scheme when queue length is 2 and Figure 14 when queue length is 6.

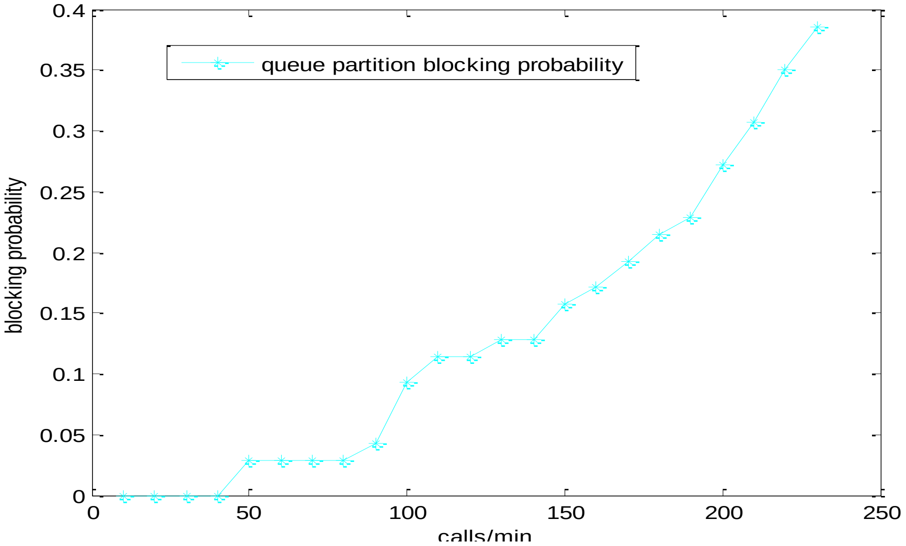

Figure 13 Blocking Probability when Queue Length is 2

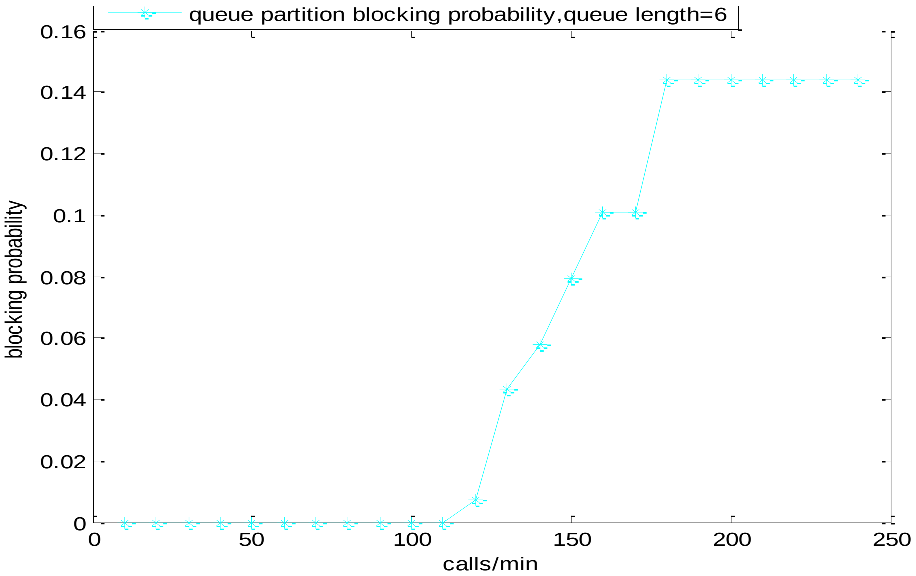

Figure 14 Blocking Probability when Queue Length is 6

VI. CONCLUSIONS

In this paper a new CAC partition-base scheme based on queuing model is proposed. The waiting queues are implemented in CBR and VBR portions whereas Fuzzy logic is implemented in HO portion. The performance of proposed scheme is compared with FZ-CAC scheme [9]. The proposed scheme lowers the blocking probability as the new calls are allowed to wait instead of complete denial of service. When the length of waiting queue is increased it further lowers the blocking probability. We cannot increase the length of queues more as waiting cause lower QoS. The proposed scheme also provides lower dropping probability thus makes this scheme efficient in providing QoS for mobility in service flows.

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