ISSN: 2229-6948(ONLINE)
DOI: 10.21917/ijct.2013.0100

BAC: BANDWIDTH BASED ADMISSION CONTROL SCHEME FOR GATEWAY RELOCATION IN IEEE 802.16e NETWORKS

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Abstract
The next generation wireless communication system aims at supporting multimedia services with different Quality of Services (QoS) and bandwidth requirements. Therefore effective management of limited resources is important to enhance network performance. Access Service Network Gateway (ASN GW) relocation is the process of changing the traffic's Anchor Point (AP) from one GW to another which is independent of Mobile Station's (MS's) Link Layer (LL) handover. The existing standards have details about the ASN relocation procedures, but do not specify when the ASN GW relocation has to be performed. As relocation is closely related to Admission Control, the proposed system combines gateway relocation and Admission Control to determine when to perform ASN GW relocation. This novel Bandwidth based Admission Control (BAC) Scheme considers the size of requests from each MS rather than taking the number of MSs as a whole. This mobility management scheme defined for WiMAX networks minimizes handover delay, packet loss, handover dropping probability, new call blocking probability and maximizes the throughput.

Keywords:
Handover, Gateway Relocation, Admission Control (AC), Dropping Probability, Blocking Probability

1. INTRODUCTION

IEEE new standard based on Broadband Wireless Access (BWA) systems, IEEE 802.16, Worldwide Interoperability for Microwave Access (WiMAX) is an air Interface for Fixed BWA Systems validated by IEEE as a Wireless Metropolitan Area Network (WMAN) Technology. WiMAX aims at providing broadband wireless- last mile access in a MAN with easy exploitation, high rapidity, high data rate, large spanning area and Quality of Service (QoS) to support all kinds of real-time applications in wireless networks. Digital Subscriber Line (DSL) can provide coverage of 3 miles whereas Wi-Fi can only cover 30 meters. Comparatively WiMAX has coverage of 50km [15] [16].

In the recent past, demands for high-speed internet access and multimedia service for residential and business customers have increased greatly. QoS can provide different priority to different users, data flows or guarantee a certain level of performance to data flows in accordance with requests from the application programs or the internet service provider policy.

In WiMAX/802.16, only the two first layers are defined. The IEEE 802.16 standards have defined specifications for both MAC (Media Access Control) layer and PHY (Physical) layer.

The OSI model separates the functions of different protocols into a series of layers. Each layer uses only the functions of the layer below and exports data to the layer above. Typically only the lower layers are implemented in hardware while the higher layers are implemented in software. The two lower most layers are the Physical (PHY) Layer and the Data Link Layer.

IEEE 802 splits the OSI Data Link Layer into two sub-layers namely Logical Link Control (LLC) and Media Access Control (MAC). The PHY layer creates the physical connection between the two communicating entities (the peer entities), while the MAC layer is responsible for the establishment and maintenance of the connection (multiple access, scheduling etc.).

IEEE 802.16 standard defines two possible network topologies - PMP (Point-to-Multipoint) topology and Mesh topology or Mesh mode [14]. The five service types defined in IEEE 802.16e-2005 standard are UGS (Unsolicited Grant Service), ertPS (Extended Real-time Polling Service), rtPS (Real-time Polling Service), nrtPS (Non Real-time Polling Service) and BE (Best Effort).

2. HANDOVER

Mobile WiMAX promises ubiquitous broadband wireless access, enabling real-time and multimedia applications. One of the main features for enabling mobility is handover.

Handover is the process of changing the physical layer connectivity of mobile node from one Access Point (AP) to another. Home Agent (HA) stores information about mobile nodes whose permanent Home Address (HA) is in the HA's network. Foreign Agent (FA) stores information about all the mobile nodes visiting its network. FAs also advertise the Care-of- Addresses (CoAs) which are used by the Mobile IP. If there is no FA in the host network, the mobile device has to take the responsibility of getting an address and advertising it.

2.1 NEED FOR HANDOVER

Handover takes place due to the following reasons.

- If the signal strength goes below the threshold for maintaining proper connection at the edge of the cell.
- BS capacity is full and more traffic is pending or to offload the capacity.
- Disturbing co-channel interference from neighboring cell or when Radio Conditions change.
- When a BS with better QoS is available or to increase the Quality of Service (QoS).
- Faster and cheaper network is available.
- Mobile Station Movement.

2.2 STAGES OF HANDOVER

A handover process can be split into three stages: handover decision, radio link transfer and channel assignment.

- Handover decision involves making a decision to choose the point of attachment to execute a handover and the time/ duration of connection.
- Radio link transfer is the task of establishing links with the new BS.
- Channel assignment deals with allocation of resources.

Fig.1 shows the hybrid mobility management scheme comprising of two layers in Mobile WiMAX networks. The first is ASN Anchored mobility or Link layer mobility. In ASN Anchored mobility handover, the mobile APs before and after handover are attached to ASN itself and are not relocated as a part of handover. ASN performs FA functionality.

The second mobility management in WiMAX is the Connectivity Service Network (CSN) located at the IP layer. HA is being located in CSN. CSN will be actively involved in handling mobility. During this process CSN AP remains unchanged whereas ASN AP in NAP is relocated to different ASN-GW.

In the figure, as shown below, CSN acts as the HA and ASN acts as the FA. Each ASN or ASN-GW is connected to CSN. A GW is an internetworking medium that is capable of connecting two different Networking protocols.

For Flow 1, Intra ASN handover takes place i.e. the process of handover happens between BSs of the same ASN GW. Here handover delay will be very less and the MS is called as the serving MS of first GW.

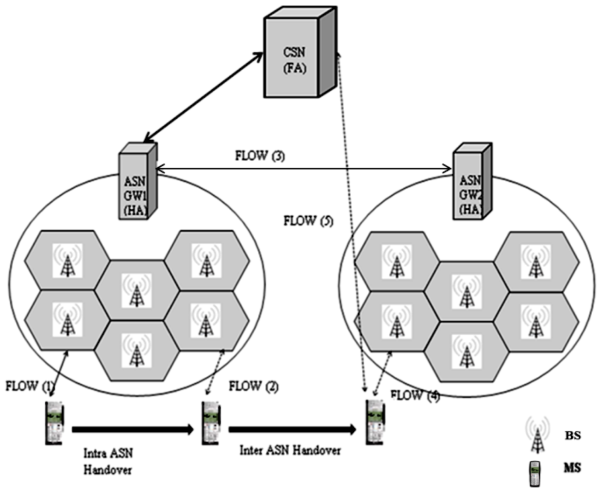

Fig.1. ASN and CSN Anchored mobility

As the MS moves, in Flow 3 the traffic will be forwarded from the same GW i.e. ASN GW-1. It overloads the GW and the GW cannot accommodate any new MSs. The new MSs have to be blocked and the handover MSs should be dropped. In this case the MS is said to be Anchored MS of the ASN GW-1 (as it is moving away from ASN GW-1) and handover MS for the ASN GW-2.

In flow 1, 2 and 3, only the ASN-Anchored mobility takes place. But in case of flow 4, the traffic will be tunnelled to ASN GW-2 as the MS is currently in the second GW. This step is known as the ASN GW relocation. This is to eliminate the system load in the ASN GW-1. Once relocation is performed, the MS will not be served by the ASN GW-1. This increases the new call blocking and handover call dropping probabilities.

3. ADMISSION CONTROL

Admission Control (AC) is a resource management technique, which guarantees QoS and reduces network congestion by limiting the maximum amount of traffic in the network.

In WiMAX, if the MS connects to the BS which is under another ASN, the MS performs ASN Anchored Mobility. This is because, if both ASN Anchored mobility and CSN Anchored mobility are performed simultaneously, the handover delay will be high. Although the aforementioned techniques can reduce the load of the old serving ASN GW, the load of the new serving ASN GW is increased. Therefore, only the Anchored MS needs to perform ASN GW relocation to reduce the load of the Anchored ASN GW.

In wireless and mobile networks, the AC algorithms are much more complicated due to the movement of MSs. An MS being served in the current network might move to another network.

The connection of the MS might be dropped, if the required resources in the target network are not available. It is generally agreed that keeping an on-going connection unbroken is more important than admitting a new MS. Therefore, a handover MS is given higher priority to access the network resources. For this purpose, the overall resources are partitioned and some resources are preserved for the handover MSs only. This is called priority-based AC.

4. RELATED WORK

The two-tiered mobility management defined in WiMAX is similar to that of Hierarchical MIP (HMIP) [1]. In HMIP, the multiple levels of FA hierarchy reduce the handover latency and localize the MIP signalling traffic.

In [2], the authors design a dynamical HMIP scheme for MIP networks. Each MS dynamically determines the hierarchy of FAs according to the call-to-mobility ratio. The MIP registration update is only performed when a threshold is reached. Therefore, the signalling overhead incurred by MIP can be reduced significantly.

Various priority-based AC algorithms have been proposed in [3-11]. The two commonly used priority-based AC algorithms are Cut-off Priority algorithm [4 - 6] and New Call Bounding algorithm. These schemes involve high system load, handover latency and blocking probability of new MS and dropping probability of new MS.

In [12] [13] a dynamic bandwidth allocation algorithm for WiMAX called Efficient Bandwidth Management (EBM) is proposed. In EBM, the bandwidth will be increased in the upcoming frames when the allocated bandwidth is not sufficient to transfer the data. On the other hand, if the allocated bandwidth is more, then the bandwidth will be decreased in the upcoming frames so that other services can use this excess bandwidth. This bandwidth increase or decrease is proportional to the remaining data in the queue. EBM increases the throughput of real time traffic as the bandwidth is handled efficiently.

An efficient bandwidth management scheme, named WiMAX Dynamic Channel Allocation Scheme (WDCAS) is proposed in [14]. This scheme uses a cognitive radio for dynamic channel allocation to improve bandwidth utilization while satisfying the QoS requirements. A queuing model based on maximum entropy principle for performance analysis is introduced and closed-form expressions for state and blocking probabilities are obtained.

By controlling the amount of bandwidth allocated to an application or user, the network administrator can prevent a small number of applications or users from consuming all the available bandwidth [15] [16]. Partition-based link bandwidth architecture was targeted at improving the capacity utilization and the flow acceptance or the total traffic accepted [17] [18]. The data packets transmitted by a user appliance (e.g. MS) will be forwarded to AP through WLAN first and then to BS through 802.16 air interface.

To establish a connection with QoS requirement, the Resource Reservation Protocol (RSVP) can be adopted to reserve the desired bandwidth in the WLAN through the assistance of AP [19][20].

In mobile (wireless) networks, one major concern about QoS is call dropping, where a handoff call is dropped due to insufficient wireless resources. Previous research on this issue suggested reserving a certain amount of bandwidth for handoff calls. While such reservation schemes can reduce call dropping rate, it is at the cost of low bandwidth efficiency.

A new approach that combines dynamic channel allocation and Call Admission Control for bandwidth management is proposed in [21].

Bandwidth sharing for real time and non - real time handoff calls is discussed in [22], where bandwidth is reserved in more than one cell is not necessary, if the mobile node’s future location is predicted properly [23].

A layer-2 handover scheme based on mobile WiMAX causes many handover failures in mobile WiMAX based wireless mesh networks because it does not consider the characteristics of wireless mesh networks [24].

A new methodology using data latency for characterizing handover performance that enables the detection of issues during handover by projecting data latency pattern is discussed in [25].

In the context of micro and macro-mobility capabilities defined by IEEE 802.16e/WiMAX standards, a simulation campaign was undertaken to identify the sets of configuration parameters having a major impact on the handover process for the IEEE 802.16e MS [26].

In Mobile WiMAX, MS scans the neighbouring BSs before performing handover. The MS may perform the association further, i.e., initial ranging, with neighbouring BSs during scanning to obtain ranging parameters and/or service availability information for a potential handover to a BS and/or the selection of target BSs. The scanning with association scheme may introduce additional latency for handover [27].

An appropriate Call Admission Control (CAC) and a resource management scheme that significantly reduces unnecessary handovers, is proposed in [28].

A Serving BS (SBS)-controlled fast Target BS (TBS) selection scheme for Mobile WiMAX networks is given in [29]. Orientation Matching (OM) between the geographical position of each NBS and the MS' direction of motion, both with respect to the SBS and the Signal Strengths of the different neighboring Base Stations (NBS) as received by the MS, the SBS selects the TBS out of the shortlisted NBSs. An enhanced handover target cell selection algorithm for WiMAX network based on the effective capacity estimation and neighbour advertisement, which effectively avoids the Ping-Pong effect and handover synchronization effect, is discussed in [30].

A Co-Channel Interference (CCI) cancellation method at the mobile user side, based on a realistic cell-edge scenario is discussed in [31]. The standards only define the ASN GW relocation procedures without specifying when the ASN GW relocation should be performed. It incorporates traditional Admission Control (AC) and Wiener Process (WP)-based prediction algorithms to determine when to carry out ASN GW relocation.

ASN Anchored Mobility refers to the procedures associated with the movement of MS between BSs, which may belong to the same or different ASN GWs [32].

An inter-Frequency Assignment (FA) handover algorithm that reduces handover latency and message overhead is proposed in [33].

Location-aware scanning includes scanning and network re-entry. It reduces interruption of data transmission during handover by decreasing both the scanning delay and the number of the neighbour BSs to be scanned. Handover interruption time and the amount of signalling during handover are reduced in [34]. The MS finds its position using GPS and selects the target BS based on the distance.

Another scanning mechanism that uses GPS (Global Positioning System) as location-aid and yields less scanning time by reducing the number of BSs scanned is proposed in [35].

A Pre-Coordination Mechanism (PCM) for supporting fast handover in WiMAX networks is designed in [36]. The distance between the BS and the MSS is measured and the time of handover occurrence is predicted, thus pre-allocating available resources for handover usages.

In the scheme proposed in [37], the MS scans for Target BS (TBS) selection until it gets better signal quality by using location based mobility pattern table for WiMAX networks.

A Mobile Station (MS) - controlled fast MAC-layer handover (HO) scheme based on the Received Signal Strength (RSS) from any Base Station (BS) to reduce the HO latency in Mobile WiMAX is proposed in [38].

A MIH based Velocity Optimized Seamless Handover Mechanism (VOSHM) for WiMAX networks described in [39] shows how the handover probability value is affected by the velocity of the mobile node.

A new handoff procedure is proposed in [40] that interleaves handoff procedure of layer 3 with that of layer 2. The message passing scheme mechanism of IEEE 802.16e and fast MIPv6 is analysed along with the correlation between these two schemes are examined to minimize the control flow.

An efficient Adaptive Load-balancing Association handoff approach (namely ALA) that consists of two phases: the Adaptive Association Handoff phase (AAH) and the Predictive-direction-based load balancing phase (PDLB), to overcome problems associated with scanning is proposed in [41].

5. NEW CALL BOUNDING ALGORITHM (NCB) WITH ASN GW RELOCATION

The algorithm involves the following steps.

1) A New or Handover MS requests to connect with the ASN GW at time 't'.
2) If New MS arrives, the ASN GW compares the number of current Serving and Anchored MS with the threshold value. If it is less than that of threshold value, then the New MSs are served. If both are equal, then it checks for any Anchored MS (the MS which is anticipated to move out of currently serving Gateway) in the system.
3) If any Anchored MS is found in the system then the ASN relocation is performed and the MS is removed from current ASN and the New call is accepted. Else the call is blocked.
4) For Handover MS, the number of MSs in the current ASN GW is calculated and if it is less than the maximum number of MS in one ASN GW, then the Handover MS is accepted. Else it is dropped.

Considering that the system load is heavy, the Anchored MSs are forced to perform ASN GW relocation to accommodate new MSs. An Anchored MS is requested to perform ASN GW relocation only when no more resources are available for new coming users.

When a new MS arrives and if there is no resource for newly arrived MS, it will request an Anchored MS to perform ASN GW relocation, if the Anchored MSs are available in the system. The resources will be counted twice as it is required by two ASN GWs. Hence there is a larger probability of call dropping. Handover latency and the service quality will also be low. Accepting/ rejecting based on the number of users do not hold good. Since each user has different requirements (size of the requests vary), considering the number of users as the threshold leads to misconceptions in the system performance.

6. BANDWIDTH BASED ADMISSION CONTROL (BAC) SCHEME

The New Call Bounding Algorithm which was discussed earlier includes threshold values for the number of MSs entering the network. Motivated by aforementioned issues, the proposed method considers the available bandwidth to permit any MS into the network.

N_S (t) - Number of serving MSs in one ASN GW at time t

N_A (t) - Number of Anchored MSs in one ASN GW at time t

N_H (t) - Number of Handover MSs in one ASN GW at time t

B_{TOTAL} - Total Bandwidth in a GW

B_{THRESH} - Threshold Bandwidth

B_{REQ_S} / B_{REQ_A} - Bandwidth requested by Serviced and Anchored MS respectively

B_{REM} - Remaining Bandwidth

B_t - Total Bandwidth used at time 't'

```
Bt = 0
if a new or handover MS arrives then
   if (B_REM ≥ B_THRESH & B_REQ_S < B_THRESH ) then
      Ns(t)= Ns(t)+1
      Bt + = B_REQ_S
        B_REM - = B_REQ_S
   else if (B_REQ_S = B_THRESH) then
        if (N_A(t) > 0) then
           N_A(t) = N_A(t) - 1
           N_s(t)= N_s(t)+1
           Bt  = Bt - B_REQ_A + B_REQ_S
           B_REM = B_REM + B_REQ_A - B_REQ_S
        else
           BW = ∑_{i=1}^{n} B_FREE
           If (BW  ≥ BTHRESH)) then
              N_s(t)= Ns(t)+1
              Bt + = BREQ_S
              B_REM - = B_REQ_S
           else
              The MS is blocked or dropped.
            end if
        end if
   end if
 end if
```

Fig.2. Bandwidth based Admission Control Scheme

Considering the number of users alone is not adequate. The requests may demand different amounts of bandwidth. In Bandwidth based Admission Control (BAC) Scheme, a Threshold Bandwidth (B_{THRESH}) is set for each GW. If the Requested Bandwidth (B_{REQ}) of the new call or handover call is less than the Threshold Bandwidth (B_{THRESH}) in one particular Gateway, that call is accepted. Else it will be dropped. B_{REM} is the difference between the Total Bandwidth (B_{TOTAL}) of a GW and sum of bandwidths allocated to MSs currently serviced by that GW. The algorithm is given in Fig.2.

The steps involved in BAC algorithm are listed below.

1) A New or Handover MS requests to connect with the ASN GW at time 't'.
2) If the amount of bandwidth requested by the MSs (New or Handover) is less than the threshold bandwidth and the remaining bandwidth is greater than or equal to the threshold bandwidth, the call is accepted. The remaining bandwidth and the amount of bandwidth used at time 't' are updated.

3) Else if the amount of bandwidth requested by the MSs is equal to the threshold bandwidth and if there are any Anchored MSs, then the Anchored MSs are moved and the New call is accepted. The amount of remaining bandwidth is increased.
4) Else free or shared bandwidths of the neighbouring BSs, say B_{FREE} is taken. This BW can be allocated to a new MS. If the collected BW yields a BW ≥ B_{THRESH}, then the call can be accepted.
5) Else the call is dropped or blocked based on New or Handover call.

7. PERFORMANCE ANALYSIS

When comparing to the existing New Call Bounding Algorithm, the proposed Bandwidth based Admission Control Scheme (BAC), yields better results. The following graphs show the performance of both the systems. Simulation parameters are listed in the table below (Table.1).

Table.1. Simulation Parameter

Parameters	Value
MAC protocol	802.16
Bandwidth	2 Mbps
Threshold Bandwidth (BAC)	0.5 Mbps
Packet size	1024 bits
Data Rate	512 kbps
Routing protocol	NOAH
Transmission Range	250 - 400 m
Queue Length	50
Queue Type	Queue/DropTail/PriQueue
Simulation time	80.0
Capacity (NCB)	100

PLR is less for BAC when compared to NCB algorithm. As bandwidth at time 't' is taken into consideration, packet loss is reduced to a greater extent (Fig.3).

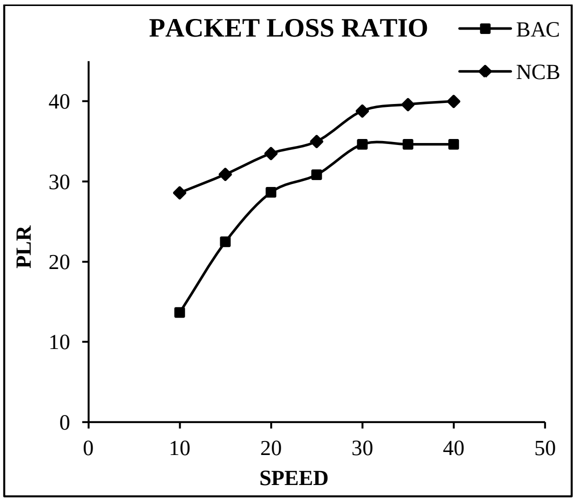

Fig.3. Packet Loss Ratio (PLR)

In Fig.4, delay is shown. The handover delay of BAC is considerable. The Handover and New call MSs are accepted based on remaining bandwidth, yielding less delay.

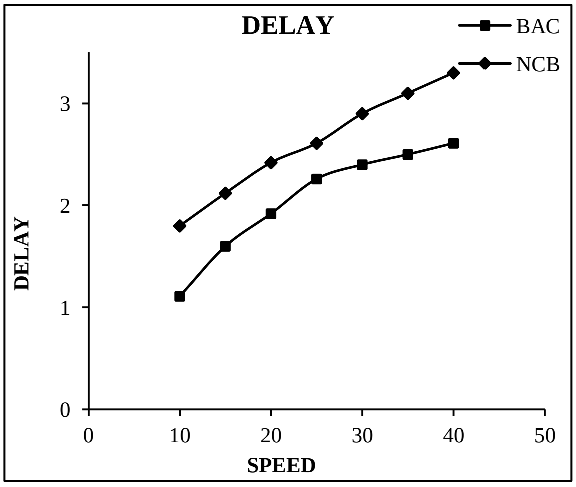

Fig.4. Delay

In Fig.5, throughputs of both the algorithms are shown. Since the movement of MSs are reduced, throughput of the proposed system is high.

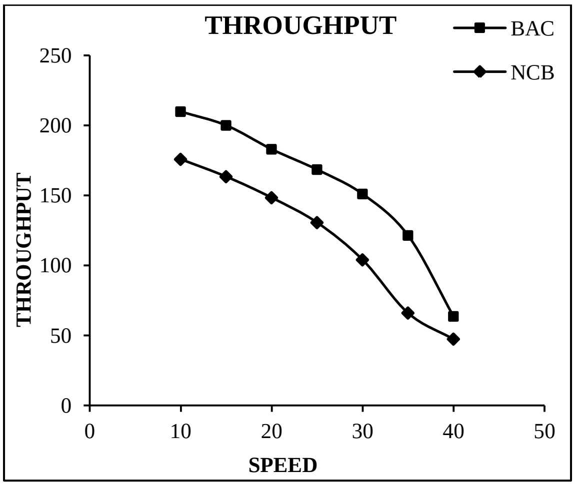

Fig.5. Throughput

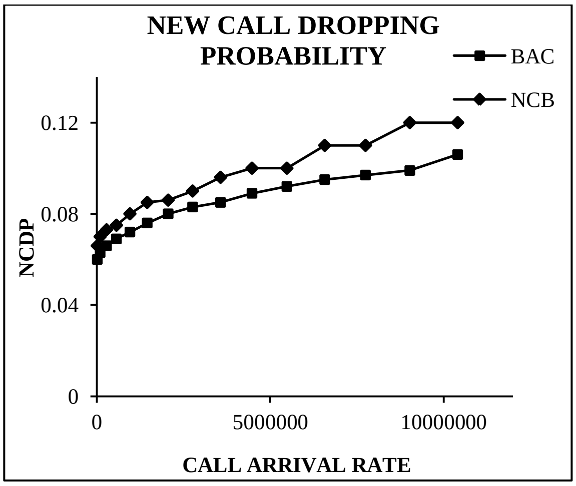

Fig.6. New Call Blocking Probability

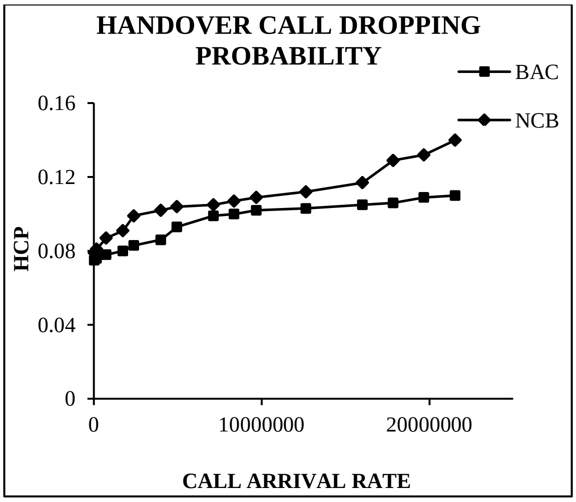

Fig.7. Handover Call Dropping Probability

The Fig.6 and Fig.7 show the New Call Blocking Probability and Handover Call Dropping Probability. The proposed system yields better results. New calls are accepted immediately if the requested bandwidth is less than the remaining bandwidth. The Handover calls are accepted only if the total bandwidth at time 't' is less than the threshold.

8. CONCLUSION

The proposed Bandwidth based Admission Control (BAC) Scheme performs better. As the bandwidth requirements of the MSs are considered rather than the number of MSs, both the Handover MSs and Anchored MSs are handled efficiently. Handover delay is minimized. The blocking probability of new MSs and the dropping probability of Handover MSs are also reduced, thus improving the average serving rate. In the future, the system can be implemented for heterogeneous networks and the performance can be analyzed.

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