An Efficient Connection Admission Control Mechanism For IEEE 802.16 Networks

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Abstract- **The main function of connection admission control (CAC) is to resolve whether or not to accept a new connection. The decision is made based on the aspects whether the Quality of Service (QoS) of new connection is satisfied and whether the QoS of ongoing connections is influenced after new connection is accepted. There has been no architecture that clearly describes a CAC for IEEE 802.16 networks. In this paper, we wish to design an efficient admission control mechanism for IEEE 802.16 networks to solve the above issues. Our CAC is based on the estimation of bandwidth utilization of each traffic class, with the constraint that the delay requirement of real-time flows should be satisfied. The current available bandwidth is estimated for all the nodes and for the new incoming flows, it estimates the requested bandwidth and decides to admit this new flow or not. By simulation results we show that our proposed approach reduces the blocking probability, there by increasing the throughput for all classes of traffic.**

Keywords- Quality of Service (QoS), Connection Admission control (CSC), Bandwidth based CAC, IEEE 802.16, MAC protocol.

I. Introduction

A. WIMAX Networks

WiMAX (Worldwide interoperability for Microwave access) or IEEE 802.16 is regarded as a standard for metropolitan area networks (MANs) [1]. It is one among the most reliable wireless access technologies for upcoming generation all-IP networks. In reality, this access technology enables obtaining high bit rate and reaching large areas with a single Base Station (BS), and because of this it provides to operators the option of supplying connectivity to end users in an economical way [2]. It is a reliable choice to offer last-mile access in wireless metropolitan area network (WMAN) together with the merits of low cost, high speed, rapid and easy deployment, such that a large number of applications can be applied also in the areas where the installation of wired infrastructure is cost-effective or technically achievable [3]. In consequence to the characteristics of WiMax, it can be widely employed in several related fields, comprising of mobile service, mobile commerce, mobile entertainment, mobile learning and mobile healthcare [4]. Fixed subscriber stations (SSs) and mobile subscriber stations (MSSs) remain in contact with BSs by means of air interfaces [1]. Even though the deployment and the utilization of this standard have begun, the exploitation of WiMAX networks is still restricted to certain situations. Research works on WiMAX access networks is still taking place, because several topics have yet to be described to permit and optimize the utilization of this technology in upcoming generation networks [2].Traffic on 4G networks namely WiMAX is heterogeneous with random mix of real and non-real time traffic with applications needing widely varying and miscellaneous QoS guarantee [5].

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B. Connection Admission Control (CAC)

IEEE 802.16 achieves QoS guarantee between Base Station (BS) and Subscriber Station (SS) by using connection admission control (CAC), packet scheduling, dynamic sub-carrier assignment etc, in order to keep up multimedia services. In ensuring QoS, CAC is the first stage. Also the selection of scheduling and resource allocation algorithms is controlled by the choice of CAC algorithms [7].

To resolve whether or not to accept a new connection, is the main function of CAC. The decision is made owing to two aspects

i. Whether the QoS of new connection is satisfied,
ii. Whether the QoS of ongoing connections is influenced after new connection is accepted [7].

The basic idea in CAC is to consider information from other cells in the network along with local information. The confined cell, where the new call has been requested, interacts with a set of cells called cluster that will take part in the admission process. In general, the schemes vary from each other in accordance with how the cluster is constructed, the nature of information exchanged and how this information is used. Making the choice of admission control in a decentralized manner, will be the primary idea [8].

i. CAC schemes

Call admission control schemes can be divided into following categories,

Local schemes- It uses local information alone (e.g. local cell load) when taking the admission decision.

Collaborative schemes- It involves more than one cell in the admission process. The cells exchange information about the ongoing sessions and about their capabilities to support these sessions [8].

Bandwidth based CAC (BW-CAC)- It admits flows as long as there is enough bandwidth to satisfy the incoming request, but it does not consider the deadline constraints of the connections. The BW-CAC receives all the DSA/DSC/DSD requests and updates the available bandwidth after admitting new connection or deleting an outgoing connection or honoring bandwidth change request of a connection [9].

QoS based CAC (QoS-CAC)- It services the UGS connection queue first, followed by RTPS and then by

NRTPS queues. Thus, it provides highest priority to UGS connections requests followed by RTPS and NRTPS connection requests. There is no need for Admission Control to Best-Effort connections since it does not require any guarantees [9].

ii. Issues in CAC

The presented admission control strategies can handle the resource management in homogeneous wireless networks only but not the issues in heterogeneous wireless environment. In mobile communication environment, the mobility of the terminals makes the resource allocation, a difficult task at what time the resources are always insufficient. This contradicting situation can be handled by efficient call admission control policies which optimize the resource utilization [8].

The CAC mechanism deals with the advent of a new call in the connection-oriented systems and decides whether the system accept a new connection or not. CAC should verify that the new call does not affect the QoS of present connections and also the system can offer the QoS requirements of the new call before taking a decision. The ongoing calls of present cell might be handed over to another cell because of user mobility. Due to the network overload or aggressive channel conditions, the receiving cell might have scarce resources. Consequently, it may start dropping calls or decline handoff attempts if the arrival rate of new or handoff calls exceeds the capability of a cell [10].

In IEEE 802.16 networks, there has been no clear structure described for CAC. Although a few authors have recommended implicit conventional bandwidth based CAC, such simple CAC cannot guarantee QoS to application services. Consequently such ancient CAC may make the execution uncooperative as well as inappropriate for application using diverse services of 802.16 [9].

II. RELATED WORK

Ke Yu et al [7] have proposed a statistical CAC mechanism for IEEE 802.16 network. In order to avoid the QoS degradation, their proposed CAC mechanism considers the traffic variability and overflow. Furthermore, a model of traffic and air interface capacity is provided to make their CAC mechanism easy to be implemented. They also proposed a performance analysis model based on Markov chains.

Ramesh Babu H.S et al [8] have proposed an optimal call admission control algorithm to reduce call blocking probability in Next generation wireless network (NGWN) and provided optimal QoS to the mobile users. In their proposed algorithm they have considered three classes of traffic having different QoS requirements which are complementary in nature with respect to their QoS requirements are considered.

Sarat Chandra and Anirudha Sahoo [9] have presented an efficient CAC algorithm which not only provides bandwidth guarantee, but also ensures QoS guarantees to connections as per their service types.

Prasun Chowdhury et al [11] have focused on the integration of Call Admission Control (CAC) and Uplink Packet Scheduling (UPS) mechanism to identify quantitative measurement of some QoS parameters like delay, loss rate, throughput, connection acceptance probabilities and bandwidth utilization of the system. Reservation based Prioritized CAC with degradation (RPCAC- Deg) and Non Reservation based Prioritized
CAC with degradation (NRP-CAC-Deg) schemes along with the two delay models maintaining delay guarantee have been evaluated by their integrated Markov Chain model.

Anas Majeed et al [12] have described a problem in the mesh network Relay station that how to serve the mobile stations (MSs) which are out of the Relay station coverage. They also proposed a solution for mobile stations out of the coverage of the WIMAX Relay stations mesh Network. Therefore they defined Ad-hoc network as a solution by using its admission control scheme and apply it on the mobiles inside and outside the Relay station coverage.

III. EFFICIENT ADMISSION CONTROL MECHANISM

A. System Model and Overview

We consider a wireless metropolitan area mesh network in which the infrastructure/backbone is built using IEEE 802.16 technology. The mesh network consists of fixed wireless mesh routers and end mobile clients. The wireless mesh routers form a multi-hop wireless backbone to relay traffic to and from mobile clients. An IEEE 802.16 cell consists of a base station and one or more mobile stations based on point-to-multipoint (PMP) network topology. Wireless mesh routers also serve as base stations to mobile stations within their coverage area.

We describe an IEEE 802.16-based wireless mesh network as a set of nodes N = {1, ...,N} that includes all the mobile clients and mesh routers and a set of wireless links L = {1, ...,L} that includes all the backhaul links as well as the links between mobile stations and base stations. Assume the bandwidth requirement for the new arrival is REQbw. Each node and each link along the chosen route must have at least MIAbw units of bandwidth available for the new connection.

Our CAC is based on the estimation of bandwidth utilization of each traffic class, with the constraint that the delay requirement of real-time flows should be satisfied. The principle of our CAC algorithm is:

i. First, system calculates the current available bandwidth.
ii. Second, for new incoming flows, system estimates the bandwidth it will take and the system will decide to grant this new flow or not.

B. Available Bandwidth Estimation

The area within transmission range is defined as the direct range, and the area between transmission range and interference range is defined as the indirect range. The total numbers of these two areas denotes the number of

competitive nodes. Therefore; each node maintains two tables, the Direct Range Members (DRM) and Indirect Range Members (IRM) tables. DRM is found from the first hop nodes and IRM may be found from two or more hops nodes or hidden nodes. A node wishing to transmit data should consider both its local bandwidth and the bandwidth of all interference range nodes. In our proposed system, each node sends out a special signal with double power at a predefined interval, and collects all the signals from its neighboring nodes and updates its DRM and IRM tables.
The local bandwidth and neighboring nodes' bandwidth are determined as below.
Since bandwidth is shared among neighboring nodes, a node listens to the channel and estimates bandwidth based on the ratio of idle and busy times for a predefined interval.
The local bandwidth LBW is estimated as follows:

$$L_{BW} = C_{BW} X \frac{idle_t}{\text{int}_t} \qquad (1)$$

where C_{BW} denotes the channel capacity, $idle_t$ denotes the idle time in a predefined interval int_t.,
The neighboring nodes bandwidth is given by NMBW which is collected from the neighboring nodes.
So the residual bandwidth R_{BW} is calculated as

$$BW_{res} = NM_{BW} - L_{BW} \qquad (2)$$

C. Estimating Requested Bandwidth

Let Nand F_L be the session duration and frame length respectively. Let the traffic arrival rate be TR_i,(bps) and packet size is b_i bits. When a traffic flow wants to establish a connection with BS, it sends parameters TR_i, and b_i to the BS and waits for the responses from BS. An extra parameter, delay requirement $Dreq_i$, will be sent by rtPS flows. In order to meet delay requirement of rtPS packets, packets generated at time t must start to send after k_i-1 frames after t, where

$$k_i = \frac{Dreq_i}{F_L} \qquad (4)$$

If data rate is bigger than TR_i, these b_i bits can be shared by k_i-1 frames before deadline.
Therefore, our estimation of the data volume in a time frame is:

$$(TR_i * F_L) + \frac{Dreq_i}{k_i - 1} \qquad (5)$$

And, the expected bandwidth of the flow is estimated as

$$TR_i + \frac{Dreq_i}{(k_i - 1) * F_L} \qquad (6)$$

Let N_{rtPS} be the number of rtPS connections, BW_{req} be the bandwidth required by all rtPS connections, we can know that BW_{req} can be calculated as

$$BW_{req} = \sum_{i}^{N_{rtPS}} (TR_i + \frac{Dreq_i}{(k_i - 1) * F_L} \qquad (7)$$

D. Call Admission Control

In order to avoid starvation of some traffic classes, we set a threshold of bandwidth used for each class. They are: TUGS,
T_{rtPS}, T_{nrtPS} and T_{BE},
$T_{UGS} + T_{rtPS} + T_{nrtPS} + T_{BE} \leq BW_{Tot}$,

where BW_{Tot} is the total bandwidth. When the bandwidth occupied by a class is over its threshold, this class will have lower priority to the bandwidth resource.
For rtPS flow, (3) is used to estimate its bandwidth; for the other three flows, TR_i, the token rate, will be used to estimate bandwidth. Our CAC algorithm is as follows:

Algorithm

i. Calculate the residual bandwidth BW_{res} and requested bandwidth BWreq using (2) and (7), respectively.
ii. If BWreq< BWres, then
Accept the new flow
Else
iii. If BW (nrtPS) > ThnrtPS and BW (BE) > ThBE
Allocate less time slots
Go to step-2.
iv. Else if BW (rtPS) > Th_{rtPS} and BW (UGS) >Th_{UGS} then
Degrade Tr_i of UGS and rtPS.
Else
v. Reject new flow.
End if.
End if.
End if.

In the above algorithm, step-5 refers to the ―Stealing bandwidth from upper class".Stealing bandwidth from upper class may be an issue. Stealing bandwidth from BE and nrtPS flows is relatively simple. We can easily decrease the bandwidth used by them because of they are not real-time flows. To steal bandwidth from the other two real-time classes, we will choose some connections of these two classes and degrade their TR_i, e.g. make TR_i to be C • TR_i, where 0 < C < 1.

IV. SIMULATION RESULTS

A. Simulation Model And Parameters

To simulate the proposed scheme, network simulator (NS2) [13] is used. The proposed scheme has been implemented over IEEE 802.16 MAC protocol. In the simulation, clients (SS) and the base station (BS) are deployed in a 1000 meter x 1000 meter region for 50 seconds simulation time. All nodes have the same transmission range of 250 meters. In the simulation, the video traffic (VBR) and CBR traffic are used.

The simulation settings and parameters are summarized in table 1.

Area Size	1000 X 1000
Mac	802.16
Nodes	50
Radio Range	250m
Simulation Time	50 sec
Traffic Source	VBR
Physical Layer	OFDM
Packet Size	1500 bytes
Frame Duration	0.005
Rate	1Mb
OFDM Bandwidth	10 MHz

B. Performance Metrics

We compare our efficient CAC (ECAC) method with the Modified Complete Sharing algorithm with CAC (MCS-CAC) [7]. We mainly evaluate the performance according to the following metrics

Blocking Probability- It is the ratio of number of requests rejected to the total number of requests.

Average End-to-End Delay-The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Throughput-It is the bandwidth received measured in Mb/s.

The performance results are presented in the next section.

V. Results

A. Based on Traffic class

In our initial experiment we vary the classes: UGS, rtPS, nrtPS andBE, as 1, 2, 3 and 4

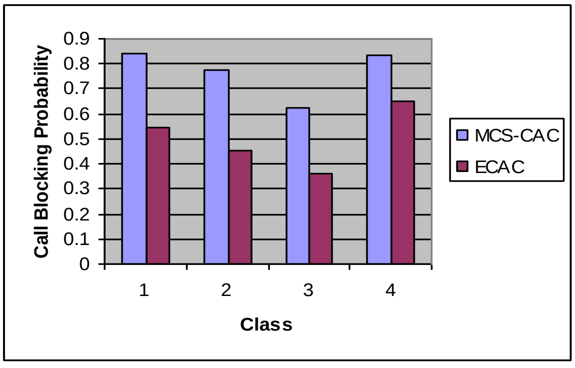

Fig: 1 Class Vs Blocking Probability

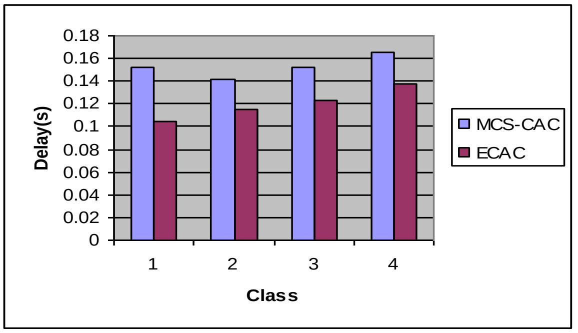

Fig: 2 Class Vs Delay

Fig: 1 shows that the blocking probability is more for MCS-CAC when compared with our proposed ECAC scheme. From Fig: 2 it is clear that the delay for our proposed ECAC scheme is less when compared with the MCS-CAC scheme.

B. Based on number of Users

In our second experiment we vary the number of users as 2, 4, 6 and 8.

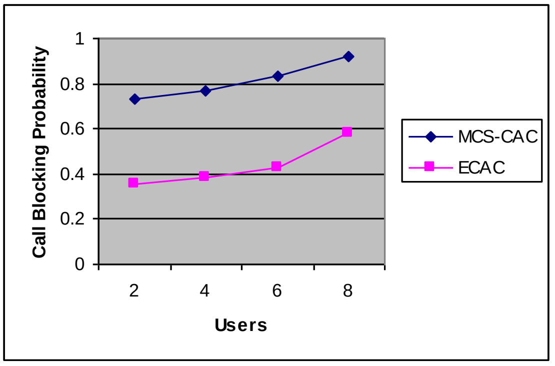

Fig: 3 Users Vs Blocking Probability

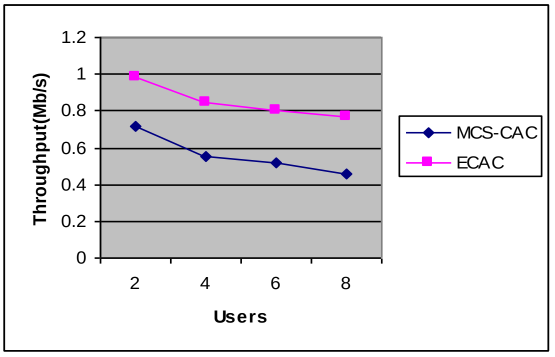

Fig: 4 Users Vs Throughput

Fig: 3 show that the blocking probability is more for MCS-CAC when compared with our proposed ECAC scheme. From Fig: 4 it is clear that the throughput for our proposed ECAC scheme is high when compared with the MCS-CAC scheme.

VI. Conclusion

There has been no architecture that clearly describes a CAC for IEEE 802.16 networks. Though some authors have suggested implicit conventional bandwidth based CAC, such simple CAC cannot guarantee QoS to application services.

In this paper, we have designed an efficient admission control mechanism for IEEE 802.16 networks to solve the above issues. Our CAC is based on the estimation of bandwidth utilization of each traffic class, with the constraint that the delay requirement of real-time flows should be satisfied. First the current available bandwidth is estimated for all the nodes based on the local and neighborhood bandwidth information. Then for the new incoming flows, the requested bandwidth is estimated for each class of service. Admission is made for the flows whose requested bandwidth is less than the available bandwidth. In order to admit a real time flow with additional bandwidth requirement, the QoS of best effort traffic is degraded by rate limiting its bandwidth. By simulation results we have shown that our proposed approach reduces the blocking probability, there by increasing the throughput for all classes of traffic.

VII. References

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