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MAC Scheduling Algorithm for IEEE 802.16e standards to improve QoS throughput

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Abstract: Scheduling is the main process of the MAC layer that helps assure QoS to various service classes. The scheduler works as a distributor to allocate the resources among Mobile Stations (MS). Our proposed algorithm works much better than others in throughput, delay and packet loss rate for real-time services.. The goal of designing a cross layer scheduling algorithm is to provide best possible end to end performance. The result shows that maximize the throughput when satisfying the QoS requirements of different services classes.

Keywords: Cross-Layer, IEEE 802.16, QoS, Scheduling, Wimax, NS2.

I. INTRODUCTION

The rapid growth in demand for high speed and high quality multimedia communications is creating opportunities and challenges for next-generation wired and wireless network designs. Multimedia communications provides quality of service (QoS) requirements for different applications including voice, data and real time, or streaming video or audio. Providing QoS-guaranteed services is necessary for future wireless networks, including cellular networks, mobile *ad hoc* networks, and wireless sensor networks, e.g., IEEE 802.16, IEEE 802.11, and IEEE 802.15 standard wireless networks. Such networks are envisioned to support multimedia services with different QoS requirements. However, the previously useful standards define only QoS architecture and signaling, but do not specify the scheduling algorithm that will ultimately provide QoS support. The wireless network topology under consideration have multiple subscriber stations (SS) are connected to the base station (BS) or relay station over wireless channels, where multiple connections (sessions, flows) can be supported by each SS. This kind of star topology is not only applicable to cellular networks but is also used to describe the connections between each relay station and multiple SS in mobile *ad hoc* networks and wireless sensor networks. All connections communicate with the BS using time division multiplexing or time-division multiple access (TDM or TDMA). We have focus on the downlink here, although our results can be extended to the uplink as well. The IEEE 802.16 MAC is connection oriented. Upon entering the network, each SS creates one or more connections over which their data packets are transmitted to and from the BS. Each packet has to be associated with a connection at MAC level. Each connection has a unique 16-bit connection identifier (CID) in downlink as well as in uplink direction. The MAC PDU is data unit used to transfer data between MAC layers of BS and SS.

IEEE 802.16e**:** This extension, known as "Mobile WiMAX", adds mobility support for the technology. The extension preserves the technical aspects of "Fixed WiMAX" while adding support for mobile broadband wireless access. The standard specifies the use of OFDMA technology with support for 2000-FFT, 1000-FFT, 512-FFT and 128-FFT system profiles. The OFDMA technology allows signals to be divided into many sub-channels to increase resistance to multi-path interference. The specification in the standard supports mobile device speeds up to 100 km/h[1]. The IEEE 802.16 standard supports four different flow classes for QoS and the MAC supports an request-grant mechanism for data transmission in uplink direction.

These flows are associated with packets at MAC level. Each connection has a unique flow type associated with it. The IEEE 802.16 standard does not define any slot allocation criterion or scheduling algorithm for any type of service.

II. Scheduling Algorithm

Our aim is based on service flows in IEEE802.16e, each with different QoS constraints. For the best guaranteeing of QoS requirements, we introduce a cross layer algorithm by employing a priority function at MAC layer and a slot allocation policy at physical layer. By the priority function at the MAC layer, the priority order of service flows or equally connections is specified and is updated dynamically depending on wireless channel quality, QoS satisfaction and service priority across layers. The slot allocation policy at physical layer specifies the appropriate slots to be allocated for each service flow based on the priority order. IEEE 802.16 MAC layer adopts a connection oriented architecture in which a connection must be established before data communications. Each connection is assigned a unique identifier (connection IDI) and it is associated with a service flow which defines the desired QoS level of the connection. In a standard scheduling framework, data packets arriving at the BS are classified into connections which are then classified into service flows. Packets of same service flow are placed in a queue and then further classified based on their service priorities of the connection. For packets in multiple queues with different service requirements, a packet scheduler is employed to decide the service order of the packets from the queues. If properly designed a scheduling algorithm may provide the desired service guarantees.

III. Implementation of Cross Layer Scheduling Algorithm Included [2]

Assign higher priority queue

Allocate the Bandwidth request opportunities which should be scheduled in next frame

Periodically check the request or response for the service flow

Check the bandwidth minimum availability

Resources should be periodically distributed among the service flow according to the request and response.

The algorithm is executed at the BS at the beginning of every frame thereby priority is assigned to each SS. The cross layer algorithm proposed in[2] implies three drawbacks. The modified cross-layer scheduling algorithm improves those drawbacks in the following ways and efficiently manages the bandwidth allocation:

Required slots are allocated to higher priority packets and not only to one packet

- Multiple packets are in same priority, the one with earliest arrived has been picked up to decrease the delay
- Fragmentation is done for service types to make use of the available slots except the ertPS connection in WiMAX frame based on SNR, the type of modulation is assign in **Table 1**

Table 1 MCS and receiver SNR

S/N	Modulation	Coding rate	SNR(db)
1	QPSK	1/2	5.0
		3/4	8.0
2	16-QAM	1/2	10.5
		3/4	14.0
3	64Q	1/2	16.0
		2/3	18.0
		3/4	20.0

Four different buffers were used, each for one service flow. Each buffer has length t and each packet received in the uplink session is stored in the i) identification, ii) SNR, iii) arrival time and iv) packet size. The responsibility of the scheduler is to visit each buffer during the downlink subframe and to schedule the packets based on the proposed algorithm [1].

Parameters that can be associated with service flows are minimum reserved rate, traffic priority, tolerated jitter, maximum traffic burst, maximum sustained rate, scheduling service and maximum latency. However, BS have right to create optional service class. Whereas, service class shows a specific set of QoS parameters. IEEE 802.16 WiMAX standard has define some of the following scheduling services[3]:

A. Unsolicited Grant Service (UGS)

UGS is used to enable support for real time services which has data packets of fixed size on periodic basis. Specifically used for VoIP, E1 and T1 links. This service type has fixed size data grants on periodic basis that reduces the latency and overhead on SS's Requests.

B. Real time Polling Service (rtPS)

It is used to enable support for real time services which has data packet of variable size on periodic basis. Specifically used for MPEG video where, applications run on real time but due to ups and down on frame ratio, data rates varies. This QoS service class offers more overhead as compare to UGS, this happens due to variable data rates.

C. Extended real time Polling Service (ertPS)

ertPS is a scheduling service mechanism that was introduced by using the efficiency of both rtPS and UGS. ertPS is specifically designed for real time traffic that operates on variable data rate. Such as VoIP with silence suppression.

D. Non real time Polling Service (nrtPS)

It provides unicast polling service on regular intervals, which means, this service class receives data packets even if the network is in congestion mode. Usually this polling mechanism repeats on the interval of one or less second .

E. Best Effort(BE)

BE is used to provide services on the basis of best effort mechanism. Contention mechanism process has to be set for this service to work properly, as it is based on best effort, due to this, it might get less opportunities as compared to others. So a policy should be set by using which it gets proper contention opportunities.

Performance Evaluation depends on three parameter:

Throughput: To calculate throughput the size of each packet was added. The total time was calculated by the difference between the time that the first packet started and the time that the last packet reached the destination. The throughput is found out by calculating number of bytes received per simulation time of any network simulated[2].

Throughput= Received Bytes /Per Simulation Time

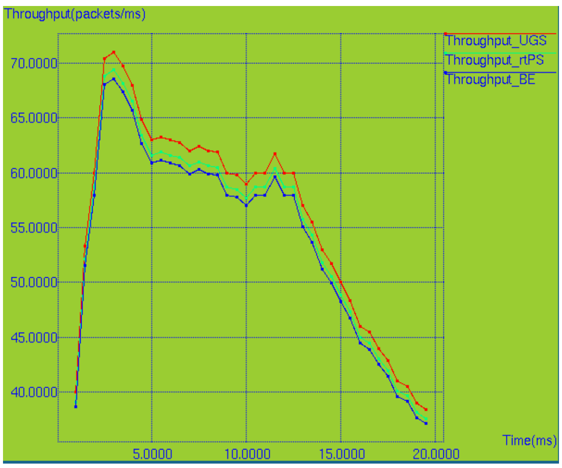

Figure 1.Throuhput with time for all three service flow

Packet Loss: Packet loss is the sum of all the packets which do not reach the destination over the sum of packets which leaves the destination [2].

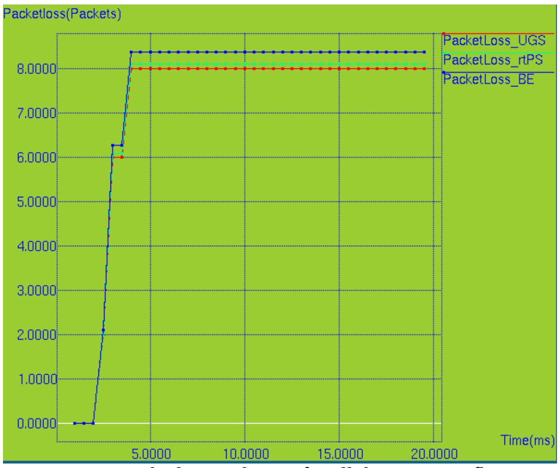

Figure 2.packetloss with time for all three service flow

Average Delay: The time taken by the packets to start from the source and reach the destination and traverse back to source is the delay produced by packet[2].

Delay=Bytes Received – Bytes Sending

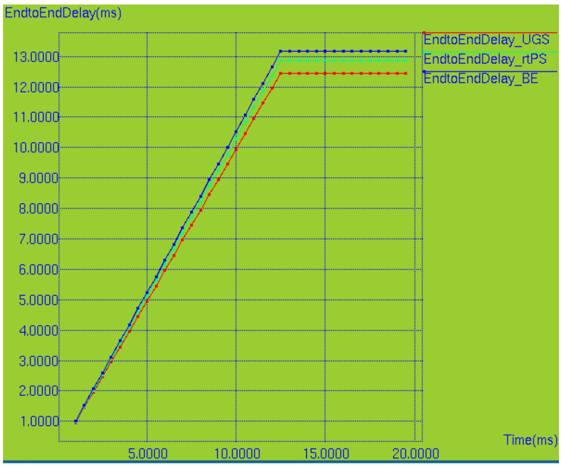

Figure 3.Average Delay with time for all three service flow

Table 2 Aggregate parameters for all services flow

Algorithm	UGS	rtPS	BE
Throughput(Mbps)	307	293	302
Packet Loss(%)	0.032	0.035	0.0343
Average Delay(ms)	0.035	0.0410	0.0359

Three service flow aggregate variation is comparatively shown in above table 2. The delay for UGS service flow and rtPS service flow is shown in above table. The packet loss for UGS service flow and rtPS service flow is close to each other. From Table 2, it is proved that UGS service flow has higher throughput, lowest delay and lowest packet loss. This makes UGS traffic a most suitable service flow for VOIP traffic.

IV. Conclusion

In this paper, we have introduced a cross layer scheduling algorithm at the medium access control (MAC) layer for multiple connections with QoS requirements. In this study, static IEEE 802.16 network is considered. To validate the proposed algorithm a Wimax simulation platform based on NS- 2 has been implemented. The proposed algorithm not only meets all the QoS requirements of the service classes but also maximize throughput, low delay and packet loss rate, while promises the fairness among all the other service class.

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