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Enhanced Packet Scheduling Scheme with Quality of Service support for WiMAX Networks

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Abstract- The Worldwide Interoperability for Microwave Access (WiMAX) is the IEEE 802.16 standard. Scheduling in WiMAX become one of the most challenging issues, since it is responsible for distributing available resources among users to meet the Quality of Service(QOS) criteria such as delay, delay jitter, fairness and throughput requirements. However, no specific scheduling mechanism has been defined to provide Quality of Service through five kinds of service class differentiation. In this paper we propose a Priority based Packet Scheduling scheme which support various services by considering the Quality of Service constraints of each class and this scheduling scheme uses a Dynamic allocating priority queue that dynamically allocates priority for each packet and then adds fairness by implementing the Weighted Fair Queuing Algorithm on these queues.

Key Words: ***Packet Scheduling; Quality of Service; Priority Queue; Weighted Fair Queuing.***

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX), has emerged as the strongest contender for Broadband wireless technology with the promises to offer guaranteed QoS to wireless users. The core of WiMAX technology is specified by the IEEE 802.16 standard that provides specifications for the Medium Access Control (MAC) and Physical (PHY) layers[1]. It spread over a metropolitan area of few kilometers and is also called WMAN (Wireless MAN). Theoretically, for fixed stations a WiMAX base station can provide broadband wireless access up to 50 kms and 5 to 15 kms for mobile stations with a maximum data transfer rate of up to 70 Mbps, whereas 802.11a can support a data-
rate of 54 Mbps up to few hundred meters. But with the rising demand for transferring huge amount of data at faster rate, WiMAX has created a remarkable amount of attention inside the networking community in the last few years. One of the key objectives of WiMAX is to support variety of applications, for example, voice, data, video, and other multimedia services which varies in its Quality of Service (QOS) requirements such as throughput, delay, and jitter. In order to support various QOS requirements, five scheduling services such as Unsolicited Grant Service (UGS), extended real-time Polling Service (ertPS), real-time Polling Service (rtPS), non-real time Polling Service (nrtPS), and Best Effort (BE) service were defined at the Medium Access Control (MAC) layer scheduler where each connection (represent user or application) in the uplink direction (from Subscriber Station/Mobile Station (SS/MS) to Base Station (BS) communication) is mapped to one of these scheduling services.[2] These scheduling services are constrained with a mandatory set of QOS parameters (maximum sustained traffic rate, minimum reserved traffic rate, maximum latency tolerance, tolerated jitter, traffic priority).

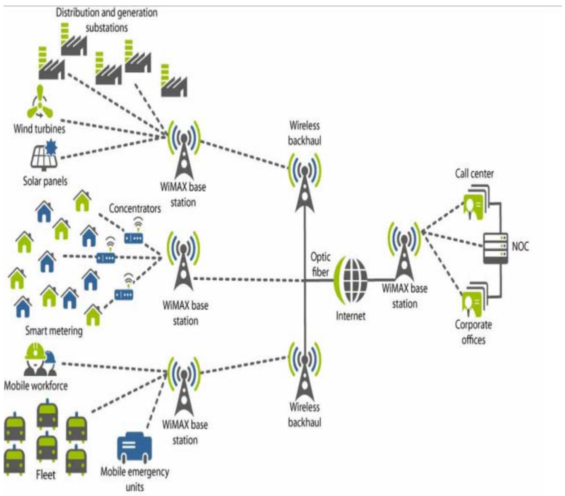

Fig.1. WiMAX Architecture

Scheduling is the process of deciding how to commit resources between a variety of possible tasks. While Packet Scheduling is the Process of assigning users' packets to appropriate shared resource to achieve some performance guarantee is called "packet-scheduling". More precisely, it has to determine which packets should be served or dropped at the packet queue and also determine the order of the packets which belongs to different application flows or users for transmitting. The process involves allocating bandwidth among the users and determining their transmission order. Scheduling algorithms for a particular network need to be selected based on the type of users in the network and their QOS requirements. QOS requirements vary depending on the type of application/user. For real-time applications such as video conferencing, voice chat and audio/video streaming, delay and delay jitter are the most important QOS requirements. Delay jitter is the inter-packet arrival time at the receiver and is required to be reasonably stable by the real-time applications. On the other hand, for non-real time applications such as file transfer protocol (FTP), throughput is the most important QOS requirement. Some applications, such as web-browsing and email do not have any QOS requirements. In a network, different types of applications, with diverse QOS requirements can co-exist. A task of a scheduling algorithm in a multi-class network is to categorize the users into one of the pre-defined classes. Each user is assigned a priority taking into account its QOS requirements. Subsequently, bandwidth is allocated according to the priority of the users as well as ensuring that fairness between the users is maintained. Fairness refers to the equal allocation of network resources among the various users operating in both good and bad channel states. In this paper, fairness is quantified using weighted fair queuing algorithm. [3]

II. Scheduling Services In Wimax

A. UGS: This service class provides a fixed periodic bandwidth allocation. Once the connection is setup, there is no need to send any other requests. This service is designed for constant bit rate real-time traffic.
Example: VoIP

B. rtPS: This service class is for variable bit rate real-time traffic such as MPEG compressed video. Unlike UGS, rtPS bandwidth requirements vary and so the BS needs to regularly poll each MS to determine what allocation need to be made. The QoS parameters are similar to the UGS but minimum reserved traffic rate and maximum sustained traffic rate need to be specified separately.
Examples: Video Conferencing, Audio Streaming, Telemedicine, E-Learning

C. nrtPS: This service class is for non-real-time Variable bit rate traffic with no delay guarantee. Only minimum rate is guaranteed. Example: FTP protocol traffic is an application using services class and document sharing is another example.

D. BE: This service provides efficient service for Best effort traffic. No service guarantee, some connections may starve for long period of time.
Example: E-Mail, Web Browsing

QoS Category	Applications	QoS Specifications
UGS Unsolicited Grant Service	VoIP	-Maximum Sustained Rate -Maximum Latency Tolerance -Jitter Tolerance
rtPS Real-Time Polling Service	Streaming Audio or Video	-Minimum Reserved Rate -Maximum Sustained Rate -Maximum Latency Tolerance -Traffic Priority
nrtPS Non-Real-Time Polling Service	File Transfer Protocol (FTP)	-Minimum Reserved Rate -Maximum Sustained Rate -Traffic Priority
BE Best-Effort Service	Data Transfer, Browsing, Web etc.	-Maximum Sustained Rate -Traffic Priority

Fig.2 Scheduling Services

III. Review Of Existing Packet Scheduling Scheme

Packet Scheduling (PS) for IEEE 802.16 and WiMAX has been studied by many groups in the wireless research community. In the Existing packet scheduling scheme the scheduler first uses an Ad-Hoc scheduling scheme, where all service requests in each service class are separately scheduled using different queuing disciplines. Then in the second level of scheduling, the scheduler uses a novel queuing discipline called Dynamic Allocating Priority Queue (DAPQ) to dynamically allocate bandwidth to each class based on the history of its traffic arrival rate. The existing study dealt with the packet scheduling scheme involving a dynamic priority queuing but here the bandwidth is not utilized in an efficient way.[3]

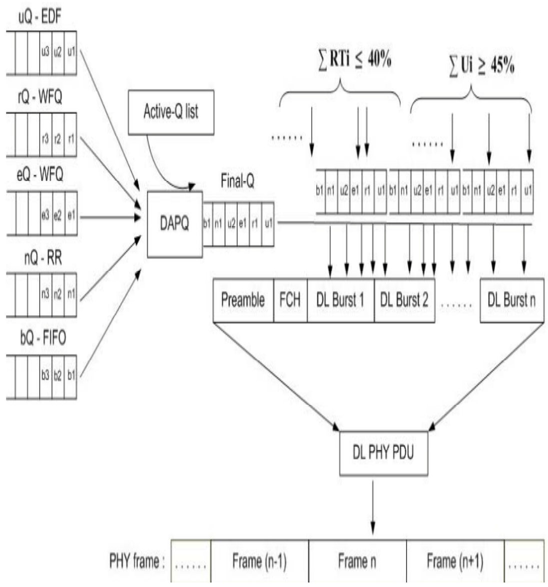

Fig.3 2-Tier Architecture provided in the Existing Scheduling Scheme

Techniques used in existing study are:

A. Queuing:

Queuing is the way in which traffic packets are queued in order while they wait for processing by the scheduler. The scheduler decides which queue and which packets from that queue should be transmitted. The order in which the scheduler selects the packets to process can affect network performance. This will be shown in the following sections. By modifying the queuing algorithm being used, system bandwidth can be shared fairly and efficiently between different applications, users and computers.

B. Priority queue:

Priority Queuing is a traditional queuing technique. Traffic is prioritized with a priority-queue-list. Packets are classified based on user-specified criteria and placed into one of the four output queues – high, medium, normal, and low – in terms of the assigned priority. When traffic packets arrive, different traffic packets are classified into high, medium, normal and low priority queues. When the scheduler is ready to allocate bandwidth to traffic, it searches the high queue for a request. If there is one, it gets answered. If not, the medium queue is then checked. If there is a request, it is answered. If not, the normal queue, and finally the low priority queues are checked consequently. The process is repeated for the next cycle. In PQ, higher priority traffic can starve lower priority queues of bandwidth. If there is enough traffic in the higher queue, the rest of the queues will never be answered.

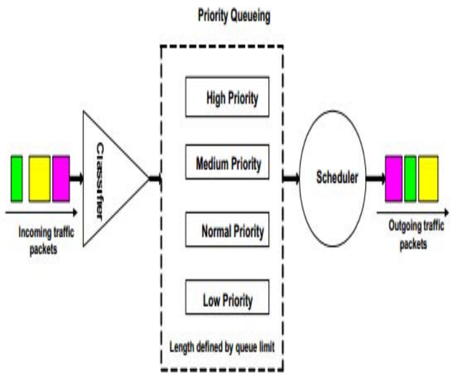

Fig.4 Priority Queuing

C. Dynamically allocating Priority Queuing:

DAPQ is to dynamically allocate bandwidth to each class based on the history of its traffic arrival rate. Many proposed scheduling schemes use the normal PQ. In PQ, bandwidth allocation is per flow and it follows strict priority, from highest to lowest, which means for IEEE 802.16 service classes, will have the following order: UGS, rtPS, nrtPS and BE. The problem with PQ is that the highest priority will get allocated bandwidth, and if the flow continues for a long time, the lower priorities such as BE could go through bandwidth starvation. The Existing study proposes DAPQ as a solution for this problem. [4]

IV. PROPOSED SCHEDULING SCHEME

In this study, we propose a Packet Scheduling (PS) Scheme which we call "Enhanced 2-Tier Ad-Hoc Scheduling Scheme" (E2T-AHSS) which supports all types of service flows, and makes a bandwidth allocation technique that is dynamic and fair, and utilizes the total bandwidth in an efficient way. The motivation for this study is to have an in-depth analysis of the QoS differentiation, and to establish parameters to quantify the differentiation based on Fairness and Utilization measurements

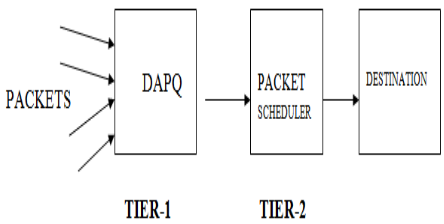

Fig.5 Enhanced 2-Tier Architecture

The scheduler first uses an Ad-Hoc scheduling scheme, where all service requests in each service class are separately scheduled using different queuing disciplines. Then in the second level of scheduling, the scheduler uses a novel queuing discipline called Dynamic Allocating Priority Queue (DAPQ) [5] to dynamically allocate bandwidth to each class based on the history of its traffic arrival rate. And then we use weighted fair queuing algorithm for allocating priority through which we can allocate resources.

A. Our Enhancement:

1) Fairness:

In our scheduling scheme, Fairness is provided by reducing the starvation. i.e., all the classes are allocated with processes and also starvation will be minimal. To achieve this parameter we have included an algorithm called "weighted fair queuing".

2) Utilization:

Utilization is achieved in our scheduling scheme by allocating/ sharing the available bandwidth among all the available requests.

B. Weighted Fair Queuing Algorithm

Weighted Fair Queuing Algorithm [5] as per our implementation takes the expiry time and waiting time, packet size and queue length as the inputs. It then calculates the priority for each queue by comparing the expiry time and waiting time. Further, the requests are arranged in descending order of priorities.

Input: expiry time, waiting time, packet size, Queue Length, service type for i=1 to n

i. Compare expiry time and waiting time at priority index 'a'
ii. Compare packet size & queue length which arrives at priority index 'b'
iii. Compare 'a' and 'b' and assign priority.
iv. Arrange requests in descending order of priorities.

V. RESULTS

In our project, as we have mentioned earlier we have enhanced the fairness and utilization factors. As a part of this we reduced the delay between successive transmissions. As we have allocated bandwidths dynamically as per the request of service classes, appropriate bandwidths are allocated and the service flows are scheduled in lesser time reducing the delay and increasing the throughput. This delay reduction between rounds can be observed in the fig.[vi], fig.[vii] that are generated by us.

Chart-1: Delay Base Chart-1

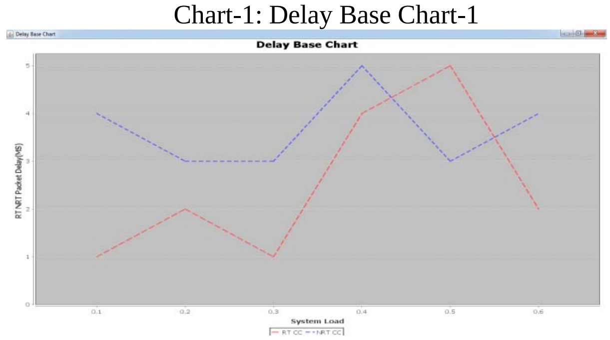

Chart-2: Delay Base Chart-2

VI. Conclusion

In this paper, we have developed a Packet Scheduling Scheme for the WiMAX networks. Our proposed Packet scheduling scheme supports the quality of service by achieving fairness and utilization using a dynamic allocation priority queue and a weighted fair queuing algorithm. Further motivation is to develop a packet scheduling scheme with the ability to distinguish the Inter-Class versus Intra-Class QoS requests, and to deliver QoS support at both levels.

Acknowledgement

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