Dual Feedback Architecture with UL Connector for Achieving Efficient Bandwidth Allocation in WiMAX Networks

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ABSTRACT
WiMAX (Worldwide Interoperability for Microwave Access) has been developed with advantages such as high transmission rate and predefined quality of service (QoS) framework, enabling efficient and scalable networks for data, video and voice. WiMAX networks were expected to be the main Broadband Wireless Access (BWA) technology that provided several services such as data, voice, and video services including different classes of Quality of Services (QoS), which in turn were defined by IEEE 802.16 standard. Scheduling in WiMAX became one of the most challenging issues, since it was responsible for distributing available resources of the network among all users; this leaded to the demand of constructing and designing high efficient scheduling algorithms in order to improve the network utilization, to increase the network throughput, and to minimize the end-to-end delay. In this paper, we have presented Quality of Service architecture for Base Station that fully utilizes the available bandwidth that is left unused or wasted. For different service classes combined approach of UL connector is proposed. The proposed system is designed to be completely dynamic that ensures good bandwidth utilization, maintain the fairness between users and respond to the constraints of some applications (i.e. video, voice).

Key Words: WiMAX, QoS, Bandwidth scheduling.

1. INTRODUCTION
One such BWA system, the IEEE 802.16 standard, also known as WiMAX (Wireless Interoperability for Microwave Access), supports QoS architectures that include priority scheduling and queuing for bandwidth allocations designed to make the systems more efficient. One of the defining parameters of QoS measurements is proper scheduling of data packets. In any communication system, packet schedulers strive to lessen congestion and thus prioritize traffic on basis of its importance. WiMAX has undoubtedly emerged as the most promising leading technology for broadband connection in wide area networks. Its light infrastructure makes it very cheap and easy to deploy and thus WiMAX becomes an effective solution to the last mile wireless connection problem which include multipath fading, environmental factors (such as heavy rains), interference and varying SLA demands amongst a host of other problems. It is especially effective for rural areas where wired infrastructures are difficult to install. The basic WiMAX structure consists of one Base Station (BS) and one or several Subscriber Stations (SS). The communication flow from BS to SS is called downlink (DL) traffic while from SS to BS is called uplink (UL) traffic. There are two main types of architectures in WiMAX, namely Point to Multipoint (PMP) and Mesh architecture. PMP consists of a BS that serves all the SSs within its range. However communication does not take place primarily between SSs as they have to establish communication through the BS. The BS acts as a network gateway and deals only with setting up and managing the connections whenever a request is made by the SS. However, if communications between SSs have to be made, then the mesh architecture is formed. In the mesh architecture, a tree network topology is possible as the architecture allows connection over several hops. As a consequence of PMP allowing only single hop transmission and having lower signaling overhead than mesh mode, the mesh and the PMP architectures are incompatible.

1.1 Bandwidth Grant and Request
IEEE 802.16 uses two methods for bandwidth allocation: *grant per connection* and *grant persubscriber*. Through grant per connection, bandwidth is scheduled for each connection. On the other hand, bandwidth is allocated for each subscriber in grant per subscriber. The subscriber then distributes the bandwidth to its connected agents based on SLAs and service needs. SSs uses use Bandwidth Request (BR) headers to request bandwidth from the BS. Bandwidth can be negotiated for in two ways: piggybacking and contention. In piggybacking, bandwidth request is parceled with the UL data packets while in contention mode, the subscriber contends for a slot for sending bandwidth requests. Bandwidth solicited during piggyback is always incremental. In this way, the BS adds the quantity of requested bandwidth requested to its current permutations of the SS needs. Sometimes, SSs can piggyback bandwidth in an aggregate manner. In this way, the BS substitutes its current permutations of the bandwidth needs of the SS with the quantity of the bandwidth demanded. Scheduling algorithms implemented in the BS deal with both UL and DL traffic. Same scheduling algorithm can be used for both UL and DL but in some cases, separate algorithms are implemented for the UL and DL traffic. In wireless networks, the provisioning of QoS is handled at the Medium Access Control (MAC) layer as a result of the unpredictability and highly variable nature of wireless infrastructures when compared to wired networks.

1.2 WiMAX QoS basics

In an ideal world it would be possible to send data over a network and gain the same performance as that achieved by a circuit switched network. However the nature of packet data means that the same channels are sued for data travelling to and from a variety of different sources and end points. Within a packet data network, there are three main parameters that are key to the performance of the network, and the WiMAX QoS. These three parameters are:

- ***Latency:*** Latency is a measure of time delay experienced in a system - in the case of a telecommunications system such as WiMAX it is the time that it takes from the initiation of sending data until it arrives at its destination. In a WiMAX system.
- ***Jitter:*** In the context of computer networks and int hei case the WiMAX system, jitter is a measure of the variability over time of the packet latency across a network. A network with constant latency has no variation and hence no jitter. However as the levels of data are constantly varying, it takes a variable amount of time for a packet to arrive at its destination. Packet jitter is expressed as an average of the deviation from the network mean latency.
- ***Packet loss:*** Packet loss is the term used to indicate the loss of data packets during transmission over a network. Packet loss may occur for a variety of reasons but normally occurs as a result of high network latency or overloading of switches or routers that are unable to process or route all the incoming data.

Network performance parameters and their characteristics maintained by QoS.

Network Performance Parameters	**Characteristics**
Latency	Delivery delay of a packet from source to Destination
Jitter	Variation in latency
Reliability	The percentage of traffic that should be successfully delivered from source to destination to maintain the service quality
Data Transmission Rate	The amount of data that should be carried from source to destination in a given period of time to maintain the service quality

2. Uplink Bandwidth Request-Allocation Mechanisms

There are five types of service class to support the various type of traffic

1. Unsolicited Grant Service (UGS)
2. Real time Polling Service (RtPS)
3. Extended Real Time Polling Service (Ertps)
4. Non real time Polling Service (NrtPS)
5. Best Effort (BE).

1. Unsolicited Grant Service

The UGS generates fixed size data packets at a designated time interval. It is designed to support real time data flows with periodic fixed size data packets, e.g., VoIP or Asynchronous
Transmission Mode Cambridge Fast Ring (ATM CFR).

2. Real Time Polling Service

The RtPS, similarly to UGS, generates fixed size data packets at a designated time interval. For RtPS flows however, periodic variable size data packets are always scheduled to be transferred by using for example the Movie Producer Expert Group (MPEG) media format.

3. Extended Real Time Polling Service

This service exists for real time traffic with variable data rate such as VoIP with silence suppression over the WiMAX network. Although for ErtPS, service mechanism and its associated bandwidth request/grant for OFDM and OFDMA is specified in IEEE 802.16-2004 standards, this standard specification however do not include methods of scheduling traffics to meet QoS requirements. There is no specification for packet scheduling mechanism for UL and DL flows that provide required QoS for most service applications. This area is in fact left open for vendors to implement based on the needs imposed by their specific service requirements.

4. Non Real Time Polling Service

For NrtPS flows with regular variable size burst are transferred via e.g. File Transfer Protocol
(FTP), Hyper Text Transfer Protocol (HTTP) or ATM Guaranteed Frame Rate (ATM GFR). The services supported are in most cases delay tolerant and transmission of minimum data rates is allowed.

5. Best Effort

Services for this class may be handled when the network is relatively free of other services. It can always be scheduled for time when spaces are available for data transmission. For BE traffic, no minimum service level is required. Examples of this type of traffic include User Datagram Protocol (UDP) and ATM Unspecified Bit Rate (ATM UBR).

Service Class	Applications	WiMAX QoS Class Details	QOS Specifications
Unsolicited Grant Service (UGS)	VoIP	UGS is used for real-time services such as Voice over IP for applications where WiMAX is used to replace fixed lines such as E1 and T1.	-Jitter tolerance -Maximum latency tolerance -Maximum sustained traffic rate
Real-time Packet Services (rtPS)	MPEG, video and aud io streams, Streaming Audio/Video	This WiMAX QoS class is used for real-time services including video streaming. It is also used for enterprise access services where guaranteed E1/T1 rates are needed but with the possibility of higher bursts if network capacity is available. This WiMAX QoS class offers a variable bit rate but with guaranteed minimums for data rate and delay.	-Traffic priority -Maximum latency tolerance -Maximum reserved rate -Maximum sustained rate
Extended real time Packet Services (ertPS)	VoIP (VoIP with Activity Detection)	This WiMAX QoS class is referred to as the Enhanced Real Time Variable Rate or Extended Real Time Packet Services. This class is used for applications where variable packet sizes are used - often where silence suppression is implemented in VoIP. One typical system is Skype.	-Traffic priority -Jitter tolerance -Maximum latency tolerance -Maximum reserved rate -Maximum sustained rate -VoIP with silence suppression
Non-real time Packet Services (nrtPS)	FTP	This WiMAX QoS class is used for services where a guaranteed bit rate is required but the latency is not critical. It might be used for various forms of file transfer.	-Traffic priority -Maximum reserved rate -Maximum sustained rate
Best Effort (BE)	Data transfer, web browsing	This WiMAX QoS is that used for Internet services such as email and browsing. Data packets are carried as space becomes available. Delays may be incurred and jitter is not a problem.	-Traffic priority -Maximum sustained rate

3. RELATED WORKS

The design objectives of the optimal bandwidth request allocation algorithm for real-time service are as follows. It should estimate the required bandwidth timely and accurately. It should neither waste bandwidth nor suffer from lack of bandwidth. It should satisfy delay requirement and minimize jitter. Mathew Andrews.et.Al [3] tells about the Quality of Service support for the multiple real-time data users, using a wireless channel. It concerned about the scheduling algorithms how exploiting asynchronous variations of channel quality that can be used to enhance the channel capacity (i.e., enhancement the number of users with the desired (QoS). This Quality of Service (QoS) is considered in a specific combination of the data rate and packet delay constraints of real-time data users, which are the requirements in obtaining high-speed data networks. This is the way to handle the issue regarding efficient data scheduling for supporting QoS for real-time data. This problem can be considered as a multi-user variable channel scheduling issue. The channel capacities of different users can be vary in time in an asynchronous manner, the QoS of the users can be efficiently improved over scheduling schemes that cannot be considered channel conditions into account. Dong-Hoon Song.et.Al [4] focused on a new structure of QoS provided. This new QoS supports the real time traffic with high priority to an acceptable level for low priority traffic. There are two new mobile interfaces for wireless broadband specified as 802.16e and 802.20. 2 to 6 GHz licensed bands mobility will be added in the 802.16e while 802.20 aims for operation in licensed bands below 3.5GHz. Scheduling algorithm and admission control policies for IEEE 802.16 broadband wireless access standard are introduced. The proposed solution which is practical and compatible to the IEEE 802.16 standard provides QoS support to different traffic classes. It includes QoS support for all types of traffic classes as defined by the standard. The relationship between traffic characteristics and its QoS requirements and the network performance has been showed. QoS support in terms of bandwidth request and allocation for all type of traffic classes are discussed. William Hrudey[5] focuses on WiMAX is a communication technology for wirelessly delivering high-speed Internet service to large geographical areas. It is a part of a "fourth generation," or 4G, of wireless-communication technology, WiMaX far surpasses the 30-metre (100-foot) wireless range of a conventional Wi-Fi Local Area Network (LAN), offering a metropolitan area network with a signal radius of about 50 km (30 miles). WiMaX offers data-transfer rates of up to 75 Mbit/s, which is superior to conventional cable-modem and DSL connections. Matthew Andrews [6] propose an efficient way to support quality of service of multiple real-time data users sharing a wireless channel. We show how scheduling algorithms exploiting asynchronous variations of channel quality can be used to maximize the channel capacity (i.e., maximize the number of users that can be supported with the desired QoS). that it is possible to support real-time data users over a shared wireless link, as in CDMA/HDR. An efficient throughput optimal scheduling algorithm, utilizing asynchronous channel quality variations, can be used to: Maximize the number of users that can be supported with the desired QoS, Provide QoS differentiation between different users and Provide minimum throughput guarantees and flow isolation. Kitti Wongthavarawatn [7] provides QoS support to different traffic classes. To the best of our knowledge this is the first such algorithm. The simulation studies show that the proposed solution includes QoS support for all types of traffic classes as defined by the standard. We have shown the relationship between traffic characteristics and its QoS requirements and the network performance.The simulation studies show that the proposed solution provides QoS support in terms of bandwidth and delay bounds for all types of traffic classes as defined by the standard.

4. EXISTING SYSTEM

Dual feed back architecture consisting of two feedback loops of packet arrival rate and service rate (Figure1). Existing system using an efficient uplink bandwidth request- allocation algorithm for real-time services in Mobile WiMAX networks based on IEEE 802.16e. In order to minimize bandwidth wastage without degrading Q uality of Service (QoS). It is introduced a notion of target delay and dual feedback architecture. The existing algorithm calculates the amount of bandwidth request such that the delay is regulated around the desired level to minimize delay violation and delay jitter for real-time services. Also, it can increase utilization of wireless channel by making use of dual feedback, where the bandwidth request is adjusted based on the information about the backlogged amount of traffic in the queue and the rate mismatch between packet arrival and service rates. Due to the target delay and dual feedback, the existing scheme can control delay and allocate bandwidth efficiently while satisfying QoS requirement. The stability of the existing algorithm is analyzed from a control-theoretic viewpoint and a simple design guideline is derived based on this analysis.

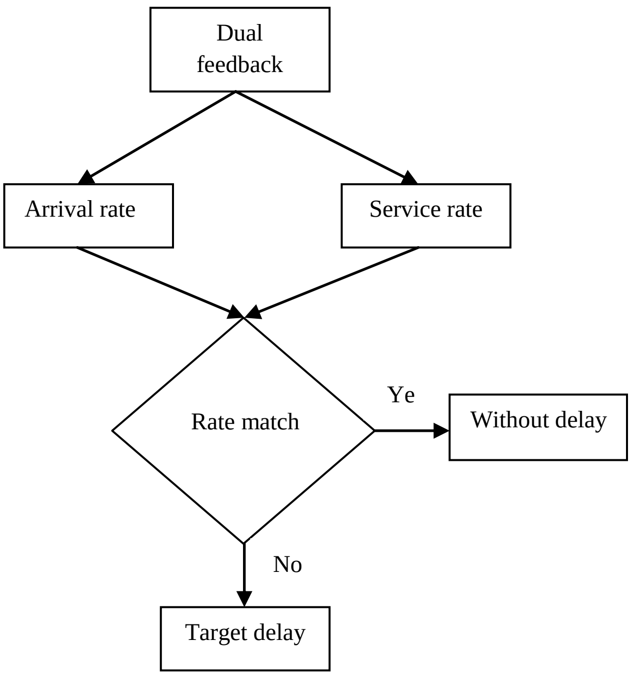


Figure 1: Dual Feedback Architecture (Existing System)

5. PROPOSED SYSTEM

The design objectives of the proposed system for real-time service are as follows:

- To consider random and dynamic subscribers for every SS.
- For minimizing bandwidth wastage without QoS loss.
- To calculate amount of bandwidth request by regulating the delay around the desired level.

Our approach tends to minimize bandwidth wastage without violating delay requirement. It estimates the required bandwidth timely and accurately. It should neither waste bandwidth nor suffer from lack of bandwidth and satisfy delay requirement and minimize jitter. The proposed system strikes a balance between utilization and QoS, i.e., it increases efficiency of bandwidth allocation without violating QoS requirements. This proposed system provides a control knob for the delay. By setting the target delay appropriately, it can control delay to the desired level while minimizing delay jitter. Although this system is developed for the ertPS scheduling class, it can be applied to the rtPS class without any significant changes. Moreover, it can be extended to a generalized uplink bandwidth request mechanism for real-time service under centralized scheduling framework. Figure 2 represents the Dual Feedback Architecture with UL Connector.

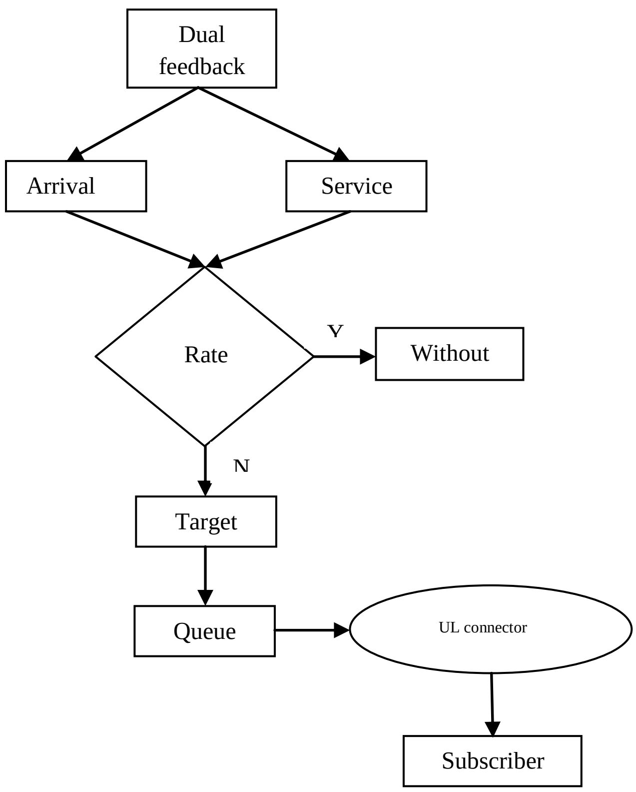
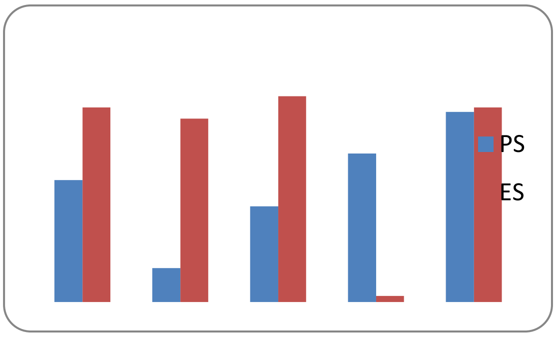


Figure 2: Dual Feedback Architecture with UL Connector (Proposed System)

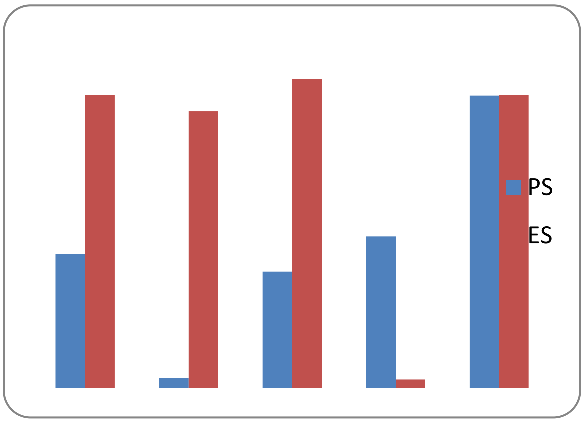
6. EXPERIMENTAL RESULTS

The plots given below state the 5 Iteration simulation results. The noise considered is Gaussian Noise. The Uplink Bandwidth Request-Allocation Mechanisms are taken in X axis and Packet Throughput is taken in Y axis. Dual feedback architecture is mentioned as ES (Existing System) and Dual Feedback Architecture with UL Connector is mentioned as PS (Proposed System).

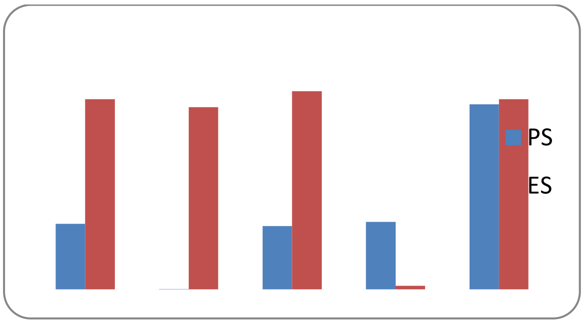
6.1 Max Avg WAITING TIME FOR 5 USERS



6.2 Max Avg WAITING TIME FOR 10 USERS



6.3 Max Avg WAITING TIME FOR 20 USERS



7. CONCLUSION

This paper presents a conceptual architecture to fully utilize the available bandwidth that is wasted or remained unused that leads to efficient use of WiMAX resources. The proposed QoS scheduling scheme is compared with an existing QoS scheduling scheme. For different service classes combined approach of UL connector & bandwidth allocation algorithm is proposed. The objective of UL connector to achieve the optimal usage of resources, to assure the QoS guarantees, to maximize goodput and to minimize power consumption while ensuring system scalability compare their performances in terms of delays, throughput and packet loss. This proposed method controls the periodicity of sending unicast polling to the real-time and non-real-time service classes, in accordance with the quality of service requirements of the applications.

8. REFERENCES

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