# Dynamic Bandwidth Allocation For Wimax By Using Dynamic Priority Custom Queuing Algorithm

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**ABSTRACT**

The IEEE 802.16 standard, also known as WiMAX, is one of the hottest broadband wireless technologies around today. WiMAX systems are expected to deliver broadband access services to residential and enterprise customers in an economical way. There are so many bandwidth allocation mechanisms like bandwidth request and grant mechanism, priority queuing (PQ), Custom Queuing (CQ). The PQ algorithm can provide bandwidth guarantees to voice applications using priority servicing while the CQ method can achieve fairness between voice and data services using bandwidth partitions.

These Algorithms themselves cannot provide bandwidth guarantee to voice application and maintain fairness between voice and data services, while achieving high bandwidth utilization, could not fully satisfy the main QoS requirements for voice and data services. In priority queuing 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 (Starvation) .custom queuing hard threshold not only ensures that a portion of system bandwidth will be available to a specific application, but it also limits it to the same level.

Proposed DPCQ Algorithm dynamically allocates the bandwidth to the subscriber station (SS) by base station (BS) and adds a soft-threshold feature for integrated voice/data WiMAX systems. The DPCQ can thus, use the features of PQ and CQ and Soft-threshold feature to provide bandwidth guarantees to voice applications and still maintain fairness between voice and data services, while achieving high bandwidth utilization.

**Keywords**: IEEE 802.16, WiMAX, QOS, priority queuing (PQ), Custom Queuing (CQ), Base Station (BS). DPCQ

## 1. INTRODUCTION

WiMAX means Worldwide Interoperable for Microwave Access system. It provides broadband wireless access based on the IEEE802.16 standard. It plays important role in fixed broadband wireless technology [2]. IEEE802.16 will enable a single base station to support both fixed and mobile Broadband Wireless Access. It fills the gap between high data rate wireless Local Area Network and high mobility cellular Wide Area Networks. The IEEE 802.16 standard was originally approved for frequencies between 10 and 66 GHz. In order to overcome the disadvantage of the Line-of-Sight (LoS) requirement between transmitters and receivers, the IEEE 802.16a was approved in 2003 to cover frequencies between 2-11 GHz to support Non-Line-of-Sight (NLoS) links [3]. The 802.16-2004 (802.16d) standard was subsequently released primarily for fixed broadband wireless access later IEEE 802.16e is released to support mobile terminals.

## 2. IEEE 802.16 SCHEDULING MECHANISM

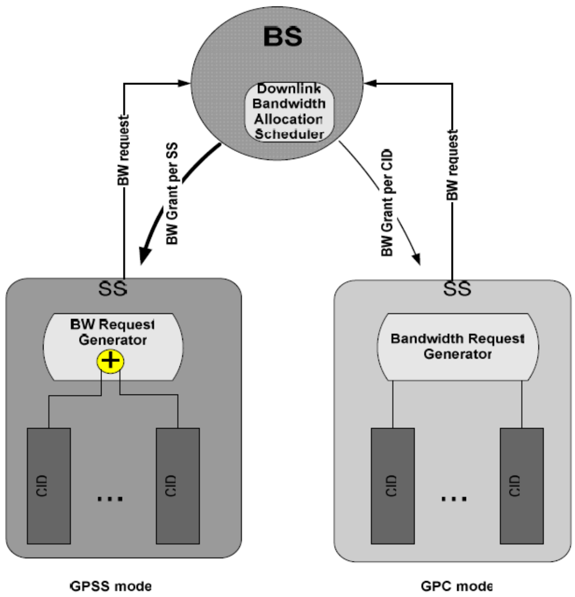
In 802.16 the MAC layer is connection-oriented [3]. Under PMP (point to multipoint) mode, the application will be established the connection with the Base Station (BS) after Subscriber Station (SS) access the net. BS will assign the connection with a unique connection ID (CID) which is associated with a level of QoS for each uplink or downlink transmission. The Base Station (BS) will manage and allocate resources in uplink transmission according to the quality of channel and QoS requirements after SS requests. To support a wide variety of applications, IEEE 802.16 defines four types of service flows, each with different QoS requirements and corresponding uplink scheduler policy:

## 3. RELATED WORK

### 3.1 Bandwidth Request and Grant Mechanism

The 802.16 MAC protocol defines two classes of SSs which handle bandwidth requests and the granting of bandwidth differently. The first class of SSs accepts bandwidth grants for each connection called Grant per Connection (GPC) mode. The second class of SSs can accept grants for all the SS's bandwidth requests called Grant per SS (GPSS) mode. In the case of GPC mode, the SS receives grants only for specific connections and as a result must request bandwidth explicitly for each connection. It is mainly suitable for few users per SS. In addition, the GPC SS must request additional bandwidth to meet its unexpected Radio Link Control (RLC) requirements. For these reasons, GPC mode is less efficient than the GPSS mode [4] [6].

In the case of the GPSS mode, the BS grants all the connections in such a way that they belong to the SS. The GPSS SS will distribute the granted bandwidth among its connections, maintaining QoS requirements and priority agreements. It is more suitable for many connections per SS and may be useful for real time applications such as VoIP that requires a quicker response from the system [4] [6].




**Bandwidth request and grant**

**Dynamic Bandwidth Allocation (DBA)**

It is an approach for allocating bandwidth based on packet switched technology. It allocates bandwidth among multiple applications. **Scheduling** is the process of allocating bandwidth to a set of traffic. Scheduling defines the order in which packets get transmitted at the output of each queue ensuring that packets from different applications meet their QoS requirements [8]. **Scheduling algorithms** provide mechanisms for bandwidth allocation and multiplexing at the packet level.

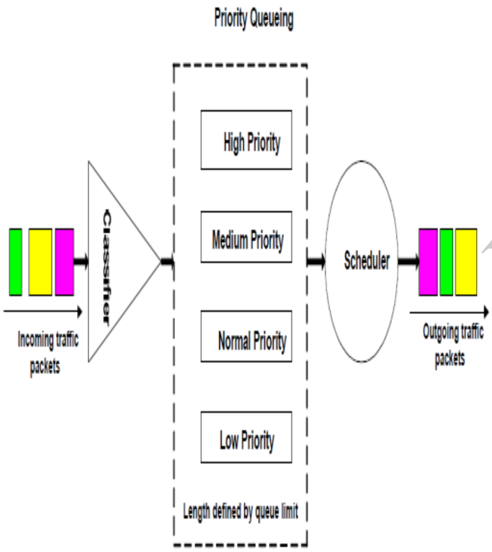
**Queuing**

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.Many mature scheduling algorithms are available for wire line networks and are not directly applicable in wireless networks because wireless networks have special problems that do not exist in wire line networks, such as a time-varying channel and location-dependent errors [9].

### 3.2. Priority Queuing

Priority Queuing is a traditional queuing technique [11]. Traffic is prioritised 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 [10]. 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

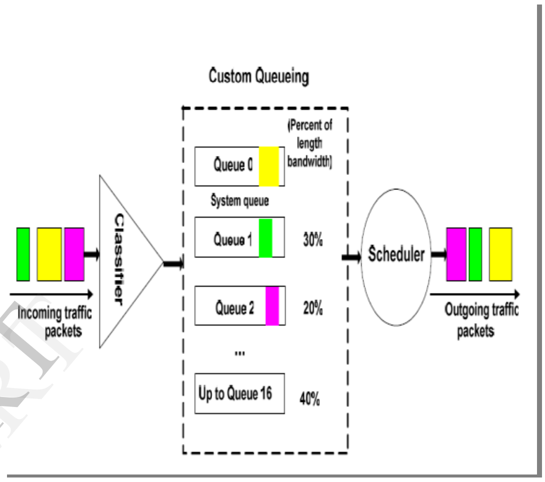
Process is repeated for the next cycle. In PQ, higher priority traffic can starve lower priority queues of bandwidth. If there is enough traffic in the higher queue, the rest of the queues will never be answered. This disadvantage is also mentioned in [7].




**The illustration of priority queuing**

### 3.3. Custom Queuing

Custom Queuing eliminates the potential PQ problem by reserving a proportion of bandwidth for each specified class of traffic [5]. CQ is aimed at dividing bandwidth fairly among different applications. To show the principle of the bandwidth allocation algorithm using strict Custom Queuing, we divide the system bandwidth into two parts with the hard-threshold in an integrated voice/data network. The service providers determine partition requirements based on market demands for specific traffic classes. For example, in a call centre, the service provider might assign approximately 70% bandwidth for voice conversations since there will be more demand for voice traffic and 30% for data transmission since there is bound to be less data traffic. The voice users can only use the allocated voice bandwidth while the file users can only use the allocated data bandwidth. In other words, the hard-threshold not only ensures that a portion of system bandwidth will be available to a specific application, but it also limits it to the same level.



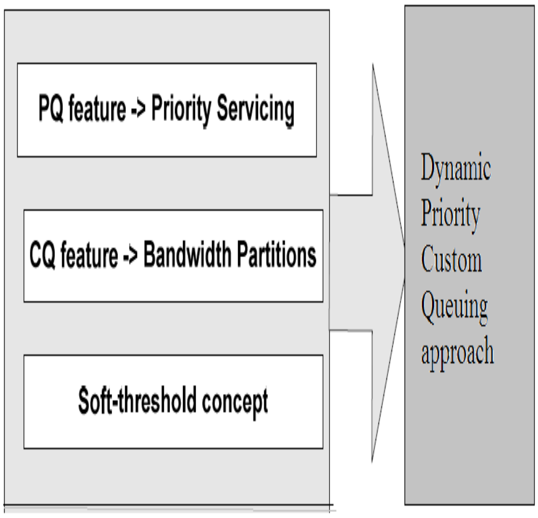

**The illustration of custom queuing**



## 4. PROPOSED ALGORITHM :

### ( DYNAMIC PRIORITY CUSTOM QUEUING ALGORITHM)

DPCQ brings the features of the PQ and CQ, but adds a threshold feature. The PQ algorithm can provide bandwidth guarantees to voice applications using priority servicing while the CQ method can achieve fairness between voice and data services using bandwidth partitions. The DPCQ can thus, use the features of PQ and CQ and its own threshold feature to provide bandwidth guarantees to voice applications and still maintain fairness between voice and data services, while achieving high bandwidth utilization.




**The development of proposed algorithm**

The partition for voice and data traffic is not fixed, and can be varied according to user specifications. The proposed algorithm can also be applied to other traffic partitions. However, in the DPCQ approach, a threshold zone is set. Figure shows the scheduling of a downlink sub frame.

**Thresholds in the scheduling downlink frame**

In the proposed DPCQ approach, to ensure voice quality, the voice traffic is given a higher priority than data traffic. Voice traffic will be checked and served first. However, it is bandwidth limited with a soft-threshold. Data traffic is given a lower priority compared to voice traffic, but it also has a bandwidth guarantee with a soft-threshold. If voice demand increases, DPCQ can protect the data application.

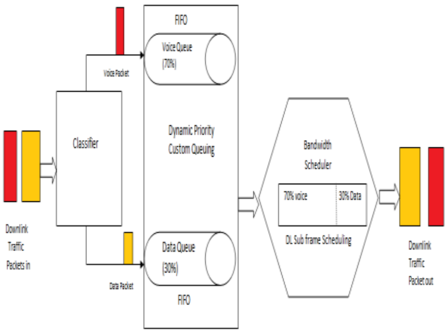
We define voice traffic as a real-time Polling Service (rtPS) and data traffic as a non-real-time Polling Service (nrtPS). In the DPCQ approach, the fixed available system bandwidth is divided into two parts using a soft-threshold instead of hard-threshold (CQ). The users have a better chance to access the medium because they can expect spare bandwidth from the other zone. In other words, the soft-threshold not only ensures that a defined portion of system bandwidth will be available to a specific application, but also allows the access of additional unused bandwidth in the other zone. In the soft-threshold bandwidth algorithm, different kinds of users are allocated bandwidth in a predefined proportion. However, if users in one zone require more bandwidth than the capacity of the zone, it is then possible to get available bandwidth from another zone if the other zone has spare bandwidth to re-allocate. If the reserved bandwidth is used, then no re-allocation will be done.

**4.1. Downlink Bandwidth Scheduler Using DPCQ**

The downlink bandwidth scheduler is responsible for the whole downlink bandwidth scheduling from BS to SSs. The BS uses the proposed DPCQ algorithm for downlink bandwidth allocation for different classes of service in this scenario.

**4.1.1The Concept of the Downlink Bandwidth Scheduler**

The DPCQ scheduler in integrated voice/data WiMAX networks is illustrated in Figure Classifier is responsible for the association of incoming downlink traffic with connections. The Classifier sorts the incoming packets to relative FIFO queues. If the incoming packet in a connection is labelled as voice traffic, it will be put in the voice queue. Otherwise it will be put in the data queue. A Bandwidth Scheduler is responsible for the whole downlink scheduling from BS to SSs as described above. The BS uses the DPCQ algorithm for downlink bandwidth scheduling. Based on the assumed partitions, the DPCQ scheduler allocates bandwidth to voice traffic first with a soft-threshold by pre-empting 70 percent of the overall downlink bandwidth. On the other hand, the DPCQ scheduler also protects data traffic with the same soft-threshold by reserving 30 percent of the overall downlink bandwidth when the total incoming voice traffic becomes more than the soft-threshold.




**DPCQ scheduler in integrated voice/data WiMAX network**

### 4.1.2 Analysis of Traffic Scenarios for DPCQ Scheduler

Assuming the voice/data partitions as indicated, the number of voice users that would consume 100%($V_{max}$ ) and 70%($V_{thres}$ ) of the bandwidth is first determined. The number of file users which would occupy 100 %($F_{max}$) and 30%($F_{thres}$) of the bandwidth is also determined.

It is assumed that the requested number ($V_{req}$ and $F_{req}$) of both voice and file users is randomly generated from uniform distribution. The assumed range is from 0 to its maximum ($V_{max}$ or $F_{max}$). For voice users, the maximum number of voice requests ($V_{max}$) is the system bandwidth divided by the voice data rate while the maximum number of file requests ($F_{max}$) is the system bandwidth divided by the file data rate for file users. The following illustrates the various possibilities of the proposed bandwidth allocation algorithm.

### 4.1.3 DPCQ Algorithm

While Voicequeue() do
If $V_{req} > V_{thres}$ then do
  Checking data traffic queue then
    If $F_{req} > F_{thres}$ then do
Some voice and data requests are rejected
    Else if $F_{req} = F_{thres}$ then do
  Some voice requests are rejectes
    Else if $F_{req} < F_{thres}$ then do
  Voice requests get some available
    bandwidth from data zone
Else if $V_{req} = V_{thres}$ then do
  Checking data traffic queue then
    If $F_{req} > F_{thres}$ then do
  Some data requests are rejected
    Else if $F_{req} = F_{thres}$ then do
  No request is rejected
    Else if $F_{req} < F_{thres}$ then do
  No request is rejected
Else if $V_{req} < V_{thres}$ then do
  Checking data traffic queue then
    If $F_{req} > F_{thres}$ then do
  File requests get some available
    bandwidth from the voice zone
    Else if $F_{req} = F_{thres}$ then do
  No request is rejected
    Else if $F_{req} < F_{thres}$ then do
  No request is rejected

The various possible scenarios that could arise are described as follows:

When the voice requests are more than the voice threshold and the file requests are more than the file threshold, traffic congestion happens in both zones. Therefore, some voice requests and some file requests are rejected. When the voice requests are more than the voice threshold and the file requests are equal to the file threshold, traffic congestion happens in the voice zone. Therefore, some voice requests are rejected. When the voice requests are more than the voice threshold and the file requests are less than the file threshold, voice traffic gets some spare bandwidth from the data zone. When the voice requests are equal to the voice threshold and the file requests are more than the file threshold, traffic congestion happens in the data zone. Some file requests are rejected. When the voice requests are equal to the voice threshold and the file requests are equal to the file threshold, both zones are fully utilized. No request is rejected. When the voice requests are equal to the voice threshold and the file requests are less than the file threshold, no request is rejected. When the voice requests are less than the voice threshold and the file requests are more than the file threshold, data traffic gets some spare bandwidth from the voice zone. When the voice requests are less than the voice threshold and the file requests are equal to the file threshold, no request is rejected. When the

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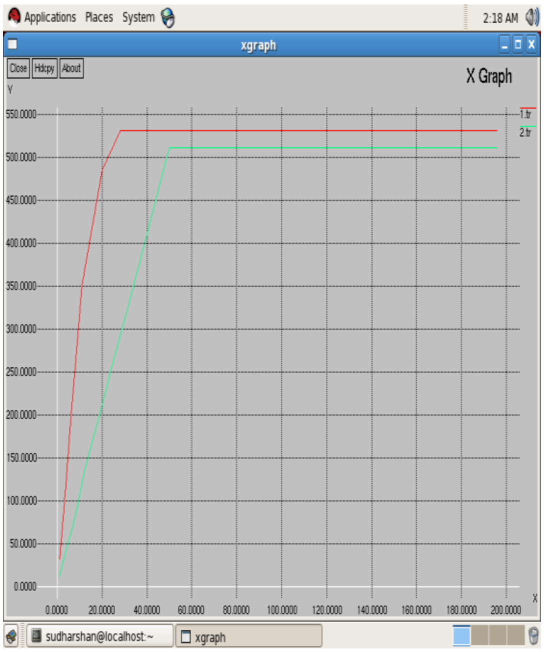
voice requests are less than the voice threshold and the file requests are less than the file threshold, no request is rejected. The bandwidth allocation algorithm using DPCQ is summarized in Table 1 in accordance with the algorithm. The DPCQ scheduler can achieve better system performance once unbalanced traffic occurs. This means that when the voice requests are more than the voice threshold and the file requests are less than the file threshold, voice traffic gets some spare bandwidth from the allocated data bandwidth When the voice requests are less than the voice threshold and the file requests are more than the file threshold, data traffic will get some spare bandwidth from the allocated voice bandwidth.

| | | File Request | | |
|---|---|---|---|---|
| | | $F_{req}>F_{thres}$ | $F_{req}=F_{thres}$ | $F_{req}<F_{thres}$ |
| Voice Request | $V_{req}>V_{thres}$ | Some voice request and some data requests are rejected. | Some voice requests are rejected. | Voice requests get some available bandwidth from the data zone. |
| | $V_{req}=V_{thres}$ | Some data requests are rejected. | No request is rejected. | No request is rejected. |
| | $V_{req}<V_{thres}$ | File requests get some available bandwidth from the voice zone. | No request is rejected. | No request is rejected. |

**Table1: bandwidth allocation algorithm using DPCQ**



## 5. Results:-




The PQ method could provide bandwidth guarantees to voice applications but 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. The CQ method could achieve fairness between voice and data services but the voice users can only use the allocated voice bandwidth while the file users can only use the allocated data bandwidth. It is concluded that the PQ method could provide bandwidth guarantees to voice applications and that the CQ method could achieve fairness between voice and data services. The PQ and CQ algorithms by themselves cannot provide bandwidth guarantee to voice application and maintain fairness between voice and data services, while achieving high bandwidth utilization. PQ and CQ could not fully satisfy the main QoS requirements for voice and data services. This paper proposes an adaptive bandwidth allocation algorithm based on PQ and CQ and adds a soft-threshold feature for integrated voice/data WiMAX systems. The proposed bandwidth allocation algorithm uses a Dynamic Priority Custom Queuing Algorithm approach to provide bandwidth guarantees for voice applications and maintain fairness between voice services and data services, while achieving high bandwidth utilization. From the graph we observe that the existing method can not utilizes the high bandwidth, but the proposed method DPCQ algorithm utilizes the high bandwidth.

## 6. Conclusion

DPCQ Algorithm dynamically allocates the bandwidth to the subscriber station (SS) by base station (BS) and adds a soft-threshold feature for integrated voice/data WiMAX systems. The DPCQ can thus, use the features of PQ and CQ and Soft-threshold feature to provide bandwidth guarantees to voice applications and still maintain fairness between voice and data services, while achieving high bandwidth utilization show better performance regarding system utilization when compared to the traditional CQ algorithm. The proposed algorithm also shows that it can achieve high throughput and high system bandwidth utilization.

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