Efficient Architecture for QoS Providence across WiMAX

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ABSTRACT: Wireless technology is basically used to access internet services, multimedia applications and different IP-based communications that require strict QoS requirements. Almost all developed and underdevelopment countries are connected to internet by some means but for service providers the real problem is the access of these services in rural or suburban areas where implementation cost of traditional wired infrastructure is high. To overcome this problem like IEEE 802.16 (WiMax) is the feasible solution that covers large geographical area with high-speed access. IEEE 802.16 family of standard has provided QoS parameters and services but has not specified how these parameters are satisfied. 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 queuing management & bandwidth allocation algorithm is proposed.
KEYWORDS: QoS, Admission Control, Bandwidth, Queuing, WiMAX Call Admission Control.

Introduction

In recent years, increase in demand of internet and real-time multimedia services required strict QoS for improved performance. Current high-speed wired telecommunication infrastructure is stable enough to provide internet & multimedia services. The wireless networks are growing rapidly and has increased the demand of internet services but the wireless networks has few shortcomings compared to wired infrastructure.

For the most, part far and wide used broadband technology that aims to provide high-speed data, audio, video services and an alternate of wired infrastructure with large coverage area & low deployment cost is WiMAX.

With extensive use of bandwidth hungry real-time multimedia services and application has increased the importance of QoS in wireless networks ([Tsa07]). A typical WiMAX system consists of SS (Subscriber Station) and BS (Base Station). BS is connected to core network & is responsible for communication between SS and core network. Although IEEE 802.16 family of standards have provided different QoS parameters & services but have not specified how these parameters be satisfied. ([Lin10]) IEEE 802.16e-2005 standard has defined five service types.

Call Admission Control (CAC) & Bandwidth allocation are the fundamental mechanisms for QoS providence in WiMAX.([Goy10]) CAC is the process in which base station is attempted to be connected by Subscriber Station. After receiving the request, Base Station decides whether to accept or reject connection. After the connection is set up and Subscriber Station has data to be transmitted, it sends bandwidth request to Base Station. The Base Station considers granting or rejecting the bandwidth request by using bandwidth allocation algorithms is regarded as bandwidth allocation. Any standard scheduling algorithm is so far not specified to be used and is open research area so vendors and operators can develop their own scheduling algorithms.

[Tun08]: There are two modes for Base Station and Subscriber Station to allocate bandwidth in WiMAX. First, grant per connection in which connection is granted the bandwidth after request from Subscriber Station to Base Station. Secondly, grant per subscriber station in which subscriber station is granted the bandwidth as a single slot.

In this paper our contribution is based on the extensive literature review, in-depth study of scheduling algorithms & previously proposed models regarding queuing management in bandwidth allocation and incorporation of scheduling algorithm for bandwidth allocation at Base Stations. The main objective of our conceptual model is to fully utilize the available bandwidth that is wasted or remained unused that leads to efficient use of WiMAX resources. Our conceptual model is a combination of different previously proposed models & scheduling algorithms from different research papers to guarantee QoS in WiMax. The rest of the paper is organized as follows. First, related work in section I. Then proposed a combined architecture for queuing management and bandwidth allocation mechanism in section II, section III provides our system design, section IV presents our simulation & results, section V concludes this paper and future work declared in section VI. Finally, references provided in section VII.

1. Related work

After extensive literature review, so many proposals supported quality of service in WiMAX networks that satisfy bandwidth allocation but not many solutions are provided to support bandwidth allocation and delay guarantee. ([Gha08]) A mechanism is required to maximize the system throughput and minimizing the end-to-end delay for new connection after checking the availability of the bandwidth & resources is Call Admission Control.

[Sad10] has presented a bandwidth allocation algorithm based on QoS requirements of different traffic types for real-time service classes. The proposed bandwidth allocation proposal controls the amount of bandwidth for different services by giving several priorities. [Tsa07]: The proposed algorithm collects the BW requests from each SS and compares the available resources to these BW requests; if there is enough BW to satisfy the requested BW of the SS so BW requests are accepted and BW allocated will be equal to the requested one. Otherwise, some BW requests will be rejected and the available BW is shared between different services classes by respect to the priority described previously.

[Goy10] has presented a study on centralized scheduling for Unsolicited Grant Service and Real-time Polling Service. Author has discussed routing algorithms and proposed two new routing algorithms. Author has also proposed a mechanism to meet quality of service for discussed classes. As data rate can be changed in real-time polling service and extra bandwidth can be requested so performance increases in delay & drop of packets.

[Uki09] has proposed a new predictive CAC and resource reservation scheme that predicts the instantaneous new incoming call's QoS requirement using adaptive filtering approach based on the past knowledge gained as well as the QoS trend of the already admitted calls. The proposed prediction algorithm finds out the condition of the network in terms of stability and loading and passed that message to source reservation block. Resource reservation block takes the decision of the admission or rejection of the new call based on the congestion notification sent by the PCAC block and the available resource available.

[Kal09] has proposed Token bucket based CAC scheme. The function of the admission controller in our CAC scheme is described as follows. Whenever base Station receives a connection request it first checks for availability of required bandwidth. If no, it will reject the connection, else it will verify whether the delay guarantees given to the admitted rtPS connections as well to the current requested connection (rtPS) are satisfied. From the numerical results author has conclude that the proposed CAC scheme could be the better choice for admission control in Mobile WiMAX in terms of NCBP and HCDP.

[Gha08] has presented an analytical analysis of three types of connections for service classes that supports different types of application & connection to assess call admission control. The presented analysis is a combination of new connection appearance and intended the results obtained for delay by Markov chain.

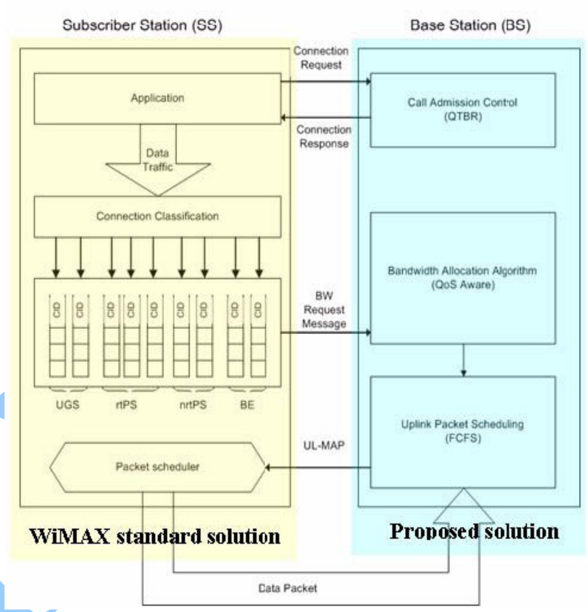

Figure 1: QoS Model for WiMAX (Tung, 2008)

[Tun08] has proposed termination probability of channel utilization for Call Admission Control mechanism that blocks & drops under traffic loads [Tsa07]. To support quality of service author has claimed that the proposed model support different traffic types. The existing model has not included the Queuing mechanism for bandwidth allocation. As more and more SS join to communicate, the bandwidth requirements will increase accordingly. Also, the location of BS is stationary but the location of SS may vary dynamically. Therefore, in the absence of proper queuing mechanism and bandwidth allocation, the BS will become overloaded nevertheless.

[Gho07] has proposed scheduling algorithm in whish assumed that all nodes are half duplex and cannot transmit and receive at same time. Author has illustrated five algorithms and has recommended the SFS algorithm. Author has justified his claim by simulation results.

2. Proposed model

In our proposed conceptual architecture, idea is to fully utilize the available bandwidth that is wasted or remained unused by different services classes which varies as per their requirements. All services approaches to BS for connection establishment as it is connected to the core network & CAC is responsible for connection establishment, depending upon the available recourses connection is accepted or rejected. Thus CAC restricts the access to network in order to provide QoS to already established connections.

In PMP mode BS has to treat lots of requests for bandwidth allocation to avoid dead lock situation and provide QoS to SS, we have proposed a conceptual queuing managements architecture with addition of bandwidth allocation algorithm at base station. In our proposed architecture, when a connection request is forwarded to Base Station the CAC policy checks whether it has resources available to fulfill the requirements. After connection is established the Subscriber Station sends a bandwidth request to Base Station. Base Station than allocates the bandwidth and manages the queue to pass on by using Weighted Fair Queuing (WFQ). Packets are first classified into various service classes and then assigned a queue. There after the bandwidth allocation algorithm in [Sad10] specify amount of resource to each service on priority basis.

The main objective of using bandwidth allocation algorithm after queue management is fully utilize the bandwidth as if one service class has requested bandwidth that is currently not available the available bandwidth is passed on to the next service class. With this combined approach of queue management & bandwidth allocation algorithm the bandwidth is allocated as per requirements with support of reuse of remaining bandwidth. Then connection request/application approaches to uplink packet scheduler at BS.

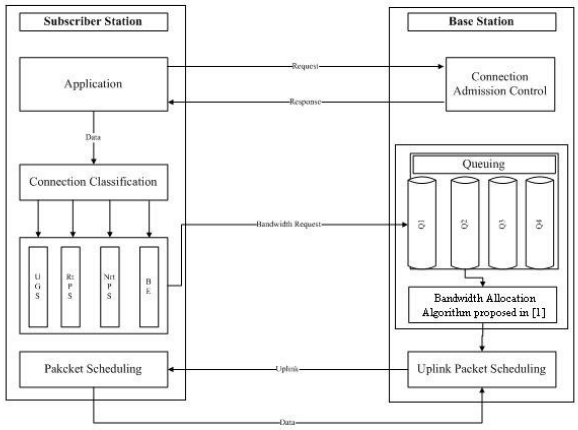

Figure 2: Proposed Architecture for Bandwidth Allocation and Queuing Management

3. System design

In this paper we proposed a conceptual model based on the extensive literature review, in-depth study of scheduling algorithms & previously proposed models regarding queuing management in bandwidth allocation and incorporation of bandwidth allocation algorithm for bandwidth allocation at Base Stations. The main objective of our conceptual model is to fully utilize the available bandwidth that is wasted or remained unused. Bandwidth is basically allocated at Base Station in GPC mode and each connection is treated separately, Subscriber Stations has to follow the directions of Base Station.

In our conceptual architecture we proposed Weighted Fair Queue (WFQ) technique to reserve the bandwidth for the new connection request with set bandwidth method. As current open connections are utilizing there required & allocated bandwidths. The new bandwidth request is hold in queue and in the mean time the bandwidth allocation algorithm proposed in [Sad10] checks whether it has the bandwidth available for the service or not. If available bandwidth is allocated else the available bandwidth is provided to the next service on priority basis. In our model service provider and subscribers can be allocated bandwidth as fixed or dynamic as required.

UGS is designed so that it supports real-time data streams. In UGS service flow require no compromise due to high priority. These services are the voice applications that always require maximum bandwidth. Delay can be tolerated in ertPS that is a real-time application with variable data rate and supports video type applications. ([Goy10]) Inconsistent real time data packets of streams are designed for real time polling service multimedia traffic. Applications like http and FTP requires delay tolerant mechanism of data stream which is supported by NrtPS.

In our proposed model for delivery of quality of service we have prioritize different service classes as first UGS, secondly ErtPS, third rtPS, fourth nrtPS & fifth BE. The priority mechanism works such that higher priority served first than the remaining resources allocated to the reaming classes but in our model if higher priority class has requested resource that is currently not available than the algorithm allocate that recourse to the next service class.

Proposed Bandwidth Allocation Algorithm in [Sad10]

```
For i=1:M
if Bavail ≥ Breq
Ballock= Breqk , k=1,2,3,4,5
else
Bremaind = Bavail – Breq1 – Bresv
Balloc1=Breq1
    if Breq2≤ Bresv
    Balloc2=Bresv
     if Bremaind ≥ Breq3
        Balloc3=Breq3
        if (Bremaind- breq3) ≥ Breq4
        Balloc4= Breq4
        Balloc5= Bremaind-Balloc3-Balloc4
        else
        Balloc4=Bremaind - Breq3
        Balloc5=0
    else
    Balloc3=Bremaind
    Balloc4=0
    Balloc5=0
     else
        if (Breq2-Bresv) ≥ Bremaind
        Balloc2=Bremaind+Bresv
        Balloc3=0
```

```
            Balloc4=0
            Balloc5=0
            else
      Balloc2=Breq2
      if (Bremaind-Breq2) ≥Breq3
      Balloc3=Breq3
             if (Bremaind-Breq2-Breq3) ≥Breq4
            Balloc4=Breq4
            Balloc5= Bremaind-Breq2-Breq3-Breq4
            else
            Balloc4= Bremaind-Breq2-Breq3
            Balloc5=0
      else
      Balloc3=Bremaind-Breq2
      Balloc4=0
      Balloc5=0
end
end
end
end
end
```

4. Simulation & results

For the validation of our proposed model we simulated a simple WiMAX network in ns-2 simulator. The network topology of simulation scenario consist of one BS & 5 fix nodes (SS).In our proposed model DSDV routing protocol is used over an available bandwidth of 2.5 Mbps, for channel simplicity we utilized wireless mode with addition of bandwidth allocation algorithm and queue mechanism over MAC 802.16.

First we simulated a standard network with fixed five nodes. In this scenario only one service is started with BS during communication over a channel in which Priority Queue mechanism is implemented in which UGS has maximum priority & BE with minimum.

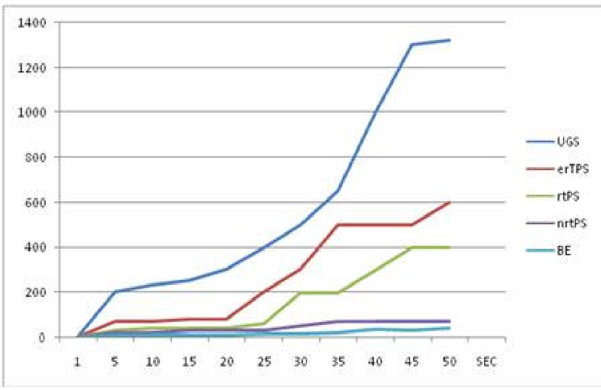

Figure 3: Throughput achieved by each service type in a typical WiMAX scenario

Figure 3 shows the results of throughput achieved by each service class in standard scenario. A 2.5 Mbps available bandwidth link is examined in ns-2. As the traffic starts the UGS throughput reaches to over 1 Mbps, ertPS reaches over half Mbps, rtPS reaches 400 Kbps, nrtPS reaches 70 Kbps and BE reaches 40 Kbps. These results shows that nrtPS and BE have large drop of bandwidth, Thus verified that high priority services consume maximum bandwidth and available bandwidth is not completely used. Then we simulated a new scenario using Weighted Fair Queuing.

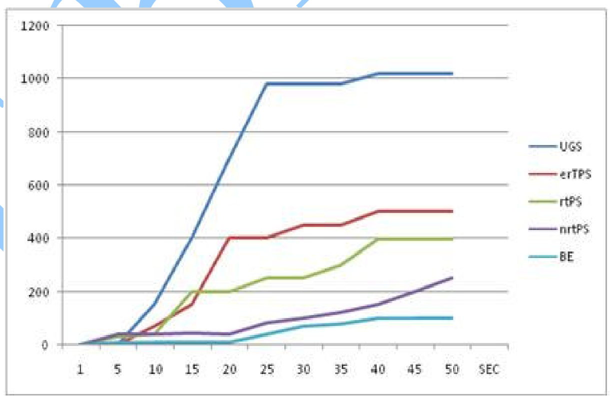

Figure 4: Throughput achieved by each service type using queuing mechanism

In the next scenario, the Weighted Fair Queuing is applied to each service class. The value for each service class is fixed according to Table 1.

Table 1: Reserved Bandwidth for each Service Class

Service Class	Bandwidth Allocation (%)
UGS	40
ertPS	20
rtPS	20
nrtPS	15
BE	5

Figure 4 present the throughput achieved by each service class using Weighted Fair Queuing mechanism. All service classes reached their fixed allocated bandwidths. UGS reaches 1 Mbps, ertPS reaches 500 Kbps, rtPS reaches 400 Kbps, nrtPS reaches 250 Kbps and BE reaches 100 Kbps. The simulation result showed that available bandwidth is almost fully utilized and low priority service also got their allocated share.

In the next scenario, the Weighted Fair Queuing mechanism is applied along with the bandwidth allocation algorithm proposed in [Sad10] to each service class. Figure 5 shows the simulation results of the proposed architecture. A slight change observed in the response time due to addition of bandwidth allocation algorithm but available bandwidth is fully utilized and all the service classes have got there allocated share.

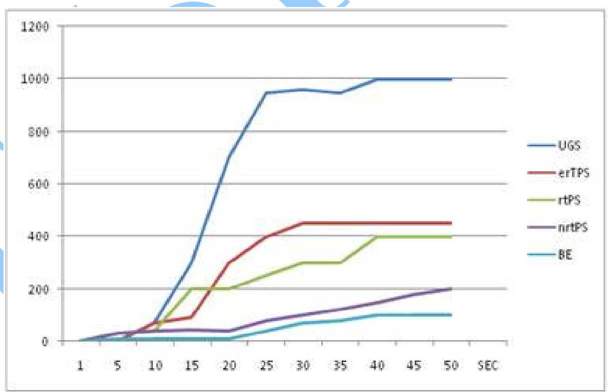

Figure 5: Throughput achieved by each service type using queuing mechanism and bandwidth allocation algorithm

5. Conclusion

This paper presented a conceptual architecture to fully utilize the available bandwidth that is wasted or remained unused that leads to efficient use of WiMAX resources. The results of the simulations showed that using queuing mechanism along with bandwidth allocation algorithm fully utilize the available bandwidth efficiently.

6. Future work

We have provided a conceptual model that is justified by simulation. In future our focus will be on connection blocking & dropping states to minimize connection requests.

References

[Bro06] **G. Brown -** *WiMax & QOS*. Webinar, 2006.

[Gha08] **S. Ghazal -** *Performance Analysis of UGS, rtPS, nrtPS Admission Control in WiMAX Networks*. Communications, 2008. ICC '08. IEEE International Conference (pp. 2696 - 2701). Beijing: IEEE, 2008.

[Gho07] **G. Ghosh -** *Admission Control and Interference-Aware Scheduling in Multi-hop WiMAX Networks*. Mobile Adhoc and Sensor Systems, 2007. MASS 2007. IEEE Internatonal Conference (p. 1). Pisa: IEEE, 2007.

[Goy10] **P. Goyal -** *A scheduling and Call Admission Control algorithm for WiMax mesh network with strict QoS guarantee*. Communication Systems and Networks (COMSNETS), 2010 Second International Conference (p. 1). Bangalore: IEEE, 2010.

[Kal09] **S. Kalikivayi -** *Bandwidth and Delay Guaranteed Call Admission Control Scheme for QOS Provisioning in IEEE 802.16e Mobile WiMAX*. Global Telecommunications

Conference, 2008. IEEE GLOBECOM 2008. IEEE (p. 1). New Orleans, LO: IEEE, 2009.

[Kuo06] **G. S. Kuo -** *Cross-layer Design of Optimal Contention Period for IEEE 802.16 BWA Systems*. Communications, 2006. ICC '06. IEEE International Conference (pp. 1807 - 1812). Istanbul: IEEE, 2006.

[Lin08] **J.-C. Lin -** *Performance Evaluation for Scheduling Algorithms in WiMAX Network*. Advanced Information Networking and Applications - Workshops, 2008. AINAW 2008. 22nd International Conference (pp. 68 - 74). Okinawa: IEEE, 2008.

[Lin10] **C. P. Lin -** *An efficient bandwidth allocation algorithm for real-time VBR stream transmission under IEEE 802.16 wireless networks*. Journal of Network and Computer Applications , 33 (4), 467-476, 2010.

[Sad10] **A. Saddoud -** *Admission control scheme and bandwidth allocation for mobile WiMAX networks*. Informatics and Systems (INFOS), 2010 The 7th International Conference (p. 1). Cairo: IEEE, 2010.

[Tsa07] **K. Tsang -** *Admission Control Scheme for Mobile WiMAX Networks*. Consumer Electronics, 2007. ISCE 2007. IEEE International Symposium (pp. 1 - 5). Irving, TX: IEEE, 2007.

[Tsu08] **H. E. Tung -** *QoS for Mobile WiMAX Networks: Call Admission Control and Bandwidth Allocation*. Consumer Communications and Networking Conference,CCNC 2008. 5th IEEE (pp. 576 - 580). Las Vegas, NV: IEEE, 2008.

[Uki09] **A. Ukil -** *QoS aware predictive Call Admission Control and resource reservation in next generation wireless networks*. Computers and Devices for Communication, 2009. CODEC 2009. 4th International Conference (p. 1). Kolkata: IEEE, 2009.