

Cross Layer Multiserve Scheduling for Mobile WiMAX

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ABSTRACT: In Mobile WiMAX system, it is important to allocate resources appropriately for efficient application of resources among a variety of real-time and non-real-time services. We consider a cross-layer scheme for the downlink multiuser Orthogonal Frequency Division Multiple Access (OFDMA) for mobile WiMAX based on IEEE802.16e. We propose an intelligent Medium Access Control that adapts with physical layer in response to the different QoS requirements of the service flows in the system. Since Mobile WiMAX supports five kinds of services classes, it is important to gross QoS constraints of each class into consideration. Our scheme pleases the maximum delay requirements for real time service flows as well as minimum reserved data rate for non-real-time service flows sessions while maintaining a high resource utilization of the system.

KEYWORDS: WiMAX, Cross-layer, OFDMA, QoS

I. INTRODUCTION

Mobile WiMAX (Worldwide Interoperability for Microwave Access), based on IEEE 802.16, is providing broadband wireless access with high speed, large coverage and a variety of services. Since Mobile WiMAX system provides various real-time and non-real-time services, appropriate resource allocation schemes are required to support QoS (Quality of Service) of each service efficiently.

There are several researches for packet scheduling algorithms to support various services in OFDMA system and proposed efficient packet scheduling schemes to assign resources for real-time and non-real-time packets together in OFDMA system; these schemes are needed to be modified to apply Mobile WiMAX system which provides multiple service classes. Proposed a multiclass scheduler structure in OFDMA system. This scheduler has separated class buffer which prioritized with urgency of each classes and as long as the higher class buffer has packets, the lower class will never be serviced. It also suggest the joint algorithm to solve the problem, this algorithm does not considers QoS characteristics of each class.

In this paper, we propose a packet scheduling scheme to support multiple services efficiently with considering the QoS characteristics of each class. Proposed scheme selects a service class first with considering characteristics of each class and then choose an appropriate user in selected class.

II. RELATED WORK

In this division gives a literature review of various scheduling schemes and their outcomes.

Jun Shen et al proposed various scheduling algorithms for the various traffics in mobile WiMAX. These Scheduling algorithms do not clearly consider all the required QoS parameters.

Khaled et al designed various scenarios using the QualNet simulation package to evaluate the performance of WiMAX in delivering traffic under different operational conditions for a point to multi point configuration. The results showed how different factors such as load and mobility might affect the performance of WiMAX in a single cell environment.

R.Murali Prasad et al propose to design an adaptive power efficient packet scheduling algorithm that provides a minimum fair allocation of the channel bandwidth for each packet flow and additionally minimizes the power

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consumption. By simulation results, it is clear that proposed scheduler achieves better channel utilization while minimizing the delay and power consumption.

Eunyoung Lee et al proves properly chosen scheduling algorithm can provide high service standards to support the QoS required for different type of traffics and users.

Mohd Ali et al proposed Modified Priority Algorithm to improve the throughput and fairness of the BE. The other service classes are not mentioned in this paper.

VikramMehta etal gives an idea about WiMAX Quality of Service (QoS) parameters, including guaranteed throughput, delay, jitter and packet loss.

III. WiMAX SERVICE CLASSES

The 5 kinds of QoS class which supported in WiMAX system. They are UGS, rtPS, ertPS, nrtPS, BE. UGS, rtPS, ertPS are used to support real-time services. nrtPS is for non-real-time services which has minimum reserved rate requirement and BE is to service best effort services which has no QoS requirements.

1. Unsolicited Grant Service (UGS)

In this service class the real time applications generating fixed-size packets on a periodic basis are mapped. An example of these applications is the VoIP call; voice data flow generates periodic and fixed-size packets. Once the BS grants bandwidth for a connection belonging to this service class, the SS maintain this allocation for the lifetime of the connection. The SS can use the UGS connection to require bandwidth for other types of service using the poll-me bit of the grant management sub header. In this way SS activating the polling process allows for bandwidth optimization and in this way there is no waste of bandwidth to send a request.

2. Real-time Polling Service (rtPS)

In the real-time polling service class real-time applications which send variable-size packets on a periodic basis are mapped; an example of this service is the MPEG video. In this case, the SS verifying the existence of this connection; if false, can create a new connection for this service and then request bandwidth for it. The bandwidth request, for this service class, can be made with unicast polling mechanisms, that is, the BS grants the SS a lot of bandwidth in which the SS can send its request. Another way to request bandwidth is to insert the request in a data PDU; this is for optimized bandwidth management. This process is called a piggybacking request.

3. Extended Real Time Polling Service (ertPS)

The ertPS is a scheduling service added recently by the mobile WiMAX amendments; it is intended to support real-time uplink service flows transporting periodically variable size data packets such as Voice over IP (VoIP) traffic with silence suppression. The ertPS combines the advantages of both the UGS and the rtPS services. The BS provides unicast grants in an unsolicited manner as in UGS but the allocations are dynamic as in rtPS.

4. Non-real-time Polling Service (nrtPS)

This service class is suitable for non-real-time applications such as FTP traffic. The services mapped on this class generate variable size packets on a regular basis. Like the previous class, to request bandwidth for this service the SS can use piggybacking and polling mechanisms. In this case unicast and broadcast polling can be used, the difference being that broadcast polling can cause collisions and the collision can be resolved by an exponential back off process.

5. Best Effort (BE)

The Best Effort data service can map data flows without QoS constraints. To request bandwidth for this class, the SS can use all the previously described mechanisms, but normally the BS scheduler neglects the BE connections. In fact a BE connection receives the remaining amount of bandwidth after the BS serves all of the most important service classes

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IV. PROPOSED SCHEDULING METHODS

In this paper, we propose a multiclass scheduler to meet the QoS requirements of each service class in Mobile WiMAX system. Proposed scheme is progressed in 3 steps as follow.

In the first step, scheduler chooses an appropriate service class based on QoS requirements of each class. Once a service class is selected, scheduler chooses a user which has the highest priority based on QoS requirements and channel information in the selected service class. Finally the scheduler assigns channels on the selected user.

1. Service class selection

The scheduler selects an appropriate service class in every scheduling instance. Basically it refers to the class parameter and selects the class which satisfies the predefined conditions. Each class parameter reflects the QoS requirements of each class. Since real-time classes such as UGS, rtPS, ertPS are delay sensitive classes, it uses urgency metric U as the class parameter. Each class's class parameter U is determined by the maximum allowable delay of each class and the biggest HOL waiting time among the packets in each class queue as following descriptions (1) – (4).

$$U_{UGS} = MD_{UGS} - \max (WT (j \in UGS)) \quad (1)$$

$$U_{rtPS} = MD_{rtPS} - \max (WT (j \in rtPS)) \quad (2)$$

$$U_{ertPS} = MD_{ertPS} - \max (WT (j \in ertPS)) \quad (3)$$

$$U = \min (U_{UGS}, U_{rtPS}, U_{ertPS}) \quad (4)$$

Where MD_{class} is the maximum allowable delay time of the class and $WT (j \in Class)$ is the HOL waiting time of user j in the class. For example, MD_{UGS} means the maximum allowable delay time of UGS class and $WT (j \in rtPS)$ means the HOL waiting time of user j in rtPS class queue. Each class parameter U_{class} for real time classes represents the urgency level of each class and the smaller value means the larger urgency level. We expressed the largest urgent level as U which is the smallest value among the class parameter U_{class} of each class. Since non real-time class such as nrtPS has minimum reserved rate requirement, it uses class parameter R which is determined by ratio of average transmitted data rate to minimum reserved rate as (5).

$$R = \max (AR (j \in nrtPS) / MR) \quad (5)$$

Where MR is the minimum reserved rate of nrtPS class and $AR(j)$ is the average transmitted data rate of user j . Since BE class does not have QoS requirements, it basically selected when there is available resources after finish other class's allocation. In this scheme we considered one more condition that if queue length of user j of BE class exceed the maximum queue length then BE class can be selected. We express the biggest value of the ratio of queue length of user j to maximum queue length as the class parameter Q .

$$Q = \max (QL (j \in BE) / MQL) \quad (6)$$

Where $QL(j)$ is the queue length of user j and MQL is the maximum queue length. In this scheme we also defined χ as the threshold for urgency level of real-time classes. nrtPS and BE class can be selected only when the U is bigger than threshold χ . This threshold value will be determined by other information such as number of users and maximum allowable delay of real-time classes. Class selection conditions are based on the QoS requirements of each class.

2. User Selection

After select an appropriate class in step 1, scheduler finally selects a user which has the highest priority in selected class. User priority of each class is calculated as following (7) – (11).

- UGS

$$SM = \operatorname{argmax}_j (C (j) / AC (j) * WT (j) / MD_{UGS}) \quad (7)$$

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- rtPS $SM = \text{argmax}_j(C(j)/AC(j)*WT(j)/MD_{rtPS})$ (8)
- ertPS $SM = \text{argmax}_j(C(j)/AC(j)*WT(j)/MD_{ertPS})$ (9)
- nrtPS $SM = \text{argmax}_j(C(j)/AC(j)*MR/AR(j))$ (10)
- BE $SM = \text{argmax}_j(C(j)/AR(j))$ (11)

Where j is user index, C(j) is current channel condition of user j and AC(j) is average channel condition of user j. Priorities of real-time classes are based on the MLWDF algorithm which is well known QoS guarantee scheduler that considers both maximum allowable delay and channel condition. User priority of nrtPS class is determined by channel condition and ratio of minimum reserved rate to average transmitted rate to meet the QoS requirement of nrtPS class. BE class does not have QoS requirements. Instead fairness among users is important issue for BE class. In this scheme we used PF algorithm which provides maximum throughput and fairness among users.

3. Channel allocation

In this step, scheduler allocates a channel for selected user. In this time scheduler chooses the best channel for the selected user and calculates the channel capacity to allocate the amount of calculated bits to the channel. Mobile WIMAX supports fragmentation and concatenation for efficient packet transmission. If the size of packet is bigger than the frame, it will be fragmented into several frames. Otherwise several packets are put into the same frame.

V. SIMULATION RESULTS AND DISCUSSION

The simulations are carried out under various scenarios. The first class selection result given below.

First Sceneries: In first scenarios, we are considering the eight nodes where three nodes are rtps remaining will be one UGS, one ertps, nrtps, and BE. It is implied that when delay is more the percentage of loss is less.

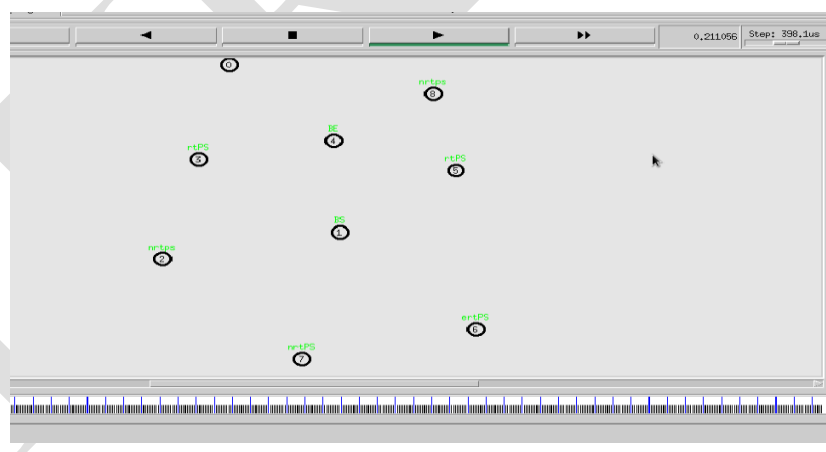


Fig.1 Snapshot of Node Formation

The fig.1 shows the service class selection mechanism, it contains one base station and different service class nodes.

Second Sceneries: In second scenarios three nodes are the ertps remaining will be a UGS, rtps, and nrtps and BE. Number ertps is more compared to other nodes so the delay is more the percentage of loss is less.

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Third Sceneries: Here nrtps is more remaining nodes are one. So the delay is higher than the percentage of loss. So the loss is less in these scenerios.

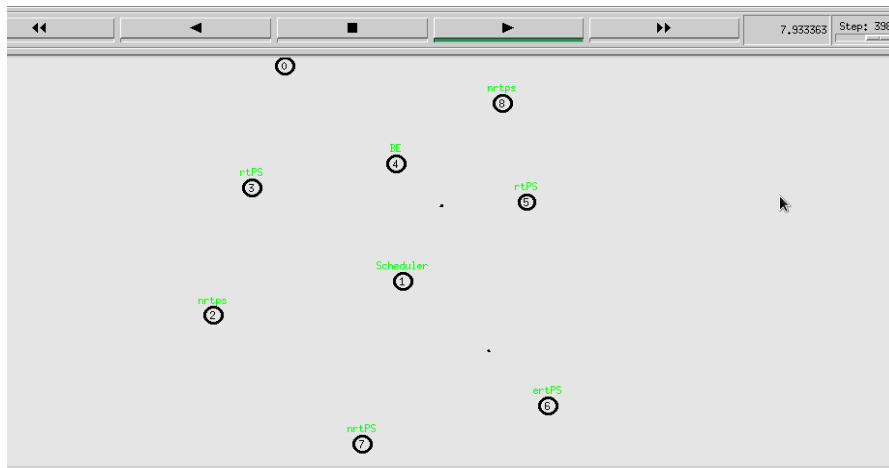


Fig.2 Snapshot of channel allocation

The fig.2 shows the scheduling mechanism, the scheduler chooses a proper service class based on QoS requirements. After select proper class scheduler chooses the user based on priority. Next step the scheduler consigns channel on selected user for transmission.

VI. CONCLUSION

In this paper, we have proposed a cross layer multiservice scheduling algorithm for mobile WiMAX, studied and compared the QoS performance of three scenarios via Class selection, user selection, channel selection in mobile WiMAX environment. A cross layer scheduling algorithm to provide QoS for mobile WiMAX is used. For that a mobile WiMAX environment is created using NS2. From the simulation results its clear that the modified cross-layer improves the utilization of WiMAX network compared to original algorithm. Thus the modified cross layer algorithm may be considered as one of the best WiMAX scheduling algorithms because it is simple and it takes into account the channel conditions and relative priority between the different scheduling services effectively under various scenarios.

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