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RESEARCH ARTICLE

Ensuring QOS in WiMAX Networks

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Abstract— Quality of service (QoS) is a key metric for bandwidth demanding applications in WiMAX (IEEE 802.16 standard) networks. It is achieved through Bandwidth Reservation for each application. Existing solution use Priority based Scheduling Algorithm to ensure the QoS guaranteed services. Although it allows the Subscriber Station (SS) to adjust the reserved bandwidth via bandwidth requests in each frame, it cannot avoid the risk of failing to satisfy the QoS requirements. So earlier bandwidth recycling was developed to recycle the unused bandwidth, once it occurs. Besides the naive priority based scheduling algorithm, it uses three additional algorithms to improve the recycling effectiveness and thereby ensuring QOS. These various scheduling algorithms have brought some issues in terms of implementation complexity. So we propose to use a simple algorithm that could be implemented for uplink and downlink scheduling at the Base Station (BS) as well as for the uplink scheduling at the SS. The algorithm is based on a strict priority scheduling in which the highest service class will be served first. The simulation results show that our proposed algorithm improves the overall network throughput.

I. INTRODUCTION

QoS refers to the ability (or probability) of the network to provide a desired level of service for selected traffic on the network. The demand for multimedia traffic with various QoS requirements such as bandwidth and latency has been the main reason why the IEEE802.16 standard and its derivative, known as WiMAX provide support for QoS. The main advantages of WiMAX when compared to other access network technologies are the longer range and more sophisticated support for the Quality of Service (QoS) at the MAC level. An important principle of WiMAX is that it is connection oriented. It means that an SS(Subscriber station) must register to the base station before it can start to send or receive data. During the registration process, an SS can negotiate the initial QoS requirements with the BS(Base station). The basic approach for providing the QoS guarantees in the WiMAX network is that the BS does the scheduling for both the uplink and downlink directions. In this paper, a novel scheduling algorithm that guarantees the QoS of various service classes of WiMAX is proposed. We propose to allocate slots based on the QoS requirements and bandwidth request sizes. Furthermore, for each service class we propose a policy to allocate slots so that the BS can perform polling. The algorithm allocates the resources to each service classes in terms of slots. The number of slots needed is calculated based on the minimum and the maximum bandwidth requirements of each connection depending on its service class. The algorithm takes into account the polling interval for uplink scheduling and the packet size for the downlink scheduling in calculating the needed slots. Each service class uses different priority scheme to determine the priority of a connection within a class, either using packet waiting.

II. PROPOSED SCHEME

We propose a simple algorithm that could be implemented for uplink and downlink scheduling at the BS as well as for the uplink scheduling at the SS. The WiMAX scheduling should comprise three major stages:

1. Allocation of the minimum number of slots: At this stage, the task of the BS is to calculate the minimum number of slots for each connection to ensure the basic QoS requirements.

2. Allocation of unused slots: At this stage, the BS has to assign free slots to some connections to avoid nonwork Conserving behavior.

3. Order of slots: At this stage, the BS has to select the order of slots to improve the provisioning of the QoS guarantees.

The scheduling solution we propose concerns only the scheduler at the BS that allocates resources in the WiMAX network

Each SS is free to choose the scheduling discipline at its Wi MAX output interface because it will control how the resources, which are allocated by the BS, will be shared between local applications and/or sub connections.

A) Allocating the minimum number of slots

Suppose Bi is the bandwidth requirement of the connection. Also, suppose that stands for the slot size, i.e. the number of bytes a connection can send in one slot. It is worth noting that the slot size Si depends on an SS since the latter can use different modulations to transmit data. Based on the introduced above parameters, one can calculate the number of slots within each frame by using the following expression: Ni =[Bi / SiFPS]where FPS stands for the number of frames the WiMAX BS sends per one second. In practice, to calculate the number of slots for the WiMAX connections we also have to take their types, or classes, and the request sizes into account. There are four distinct service classes defined by the 802.16 specification:

- Unsolicited Grant Service (UGS),
- Real time Polling Service (rtPS),

non real time Polling Service (nrtPS) and Best Effort (BE).UGS is designated for fixed size data with periodic intervals. The rtPS class is similar to UGS but for variable rate traffic, such as MPEG video data. The sensitive to delay and jitter. The 802.16e specification has added another class, extended real time Polling Service (ertPS). The purpose of this class is to combine efficiency of the UGS and PS classes. The difference between the UGS class is that whereas UGS allocations are fixed, ertPS allocations are dynamic. Depending on the service class the number of slots for each connection is calculated differently. The UGS class does not send the bandwidth requests and cannot participate in the contention. Thus, we always have to allocate the necessary number of slots based on the bandwidth requirement In the case of the rtPS class we allocate slots based on the bandwidth requirements and the request size Ri If the request size equals zero, then we allocate one slot. We cannot allocate zero slots because the rtPS connection cannot participate in the contention. If a connection is allocated at least one slot, then it has a possibility to send the bandwidth request, thus asking BS to allocate more slots. If the request size is bigger than zero, then we calculate the minimum and maximum number of slots based on the minimum and maximum bandwidth requirements. The purpose of the ertPS class is to combine efficiency of the UGS and rtPS classes. The typical application that will use this class is VoIP with the silence suppression. ertPS is allowed to send the bandwidth requests. Since the request size equals zero during a silence period, the BS can allocate one slot thus enabling an SS to ask for more bandwidth when the active phase of the speech starts. The logic behind allocating slots for the nrtPS class is quite similar to the rtPS class. The only difference is that if the request size equals zero, then we do not allocate any slots at all. Unlike the rtPS class, nrtPS connections can participate in the contention. By not allocating slots when the request size equals zero, we preserve some slots that later can be allotted for those nodes that really need them. Since the BE class does not have any requirements at all, we do not reserve any slots for the connections that belong to this class. However, the maximum number of slots allocated for the BE connection should not exceed the amount of data specified in the bandwidth request.

B) Allocating free slots

If there are unused slots, it makes sense to allocate them to other connections. The reason is that the frame has the fixed size. If we do not allocate unused slots to some connections, then the WiMAX BS will have the non-work conserving behaviour. Having analysed the service classes, it is possible to arrive at the conclusion that it makes sense to allocate unused slots to the rtPS, nrtPS, and BE connections. There is no need to allocate slots to the UGS or ertPS connections since it is not likely that the constant rate applications will increase their transmission rates.Suppose, A is a set with connections for which free slots should be assigned; Depending on the class of connections kept in A , slightly different resource allocation can be achieved. At one extreme point, A may contain connections of the rtPS, nrtPS, and BE classes. At another extreme point, A may contain connections belonging to one specific class. In other words, first free slots are allocated for the rtPS connections, then for the nrtPS connections, and finally for the BE connections. The implementation we have at the moment first allocates free slots for the rtPS and nrtPS connection, and then what remains is distributed between the BE connections.

c) Order of slots

When the BS calculates the number of slots for every connection, it can specify an order of slots. The simplest solution is to put all the slots consecutively. However, a better approach is to interleave the slots to decrease the maximum jitter and delay values. In this paper, we present a sample algorithm we use at the moment. In the first step, the algorithm calculates the ideal distance between slots for every connection. Then, based on these distances, the algorithm takes all the connections one by one and tries to assign slots to the proper positions. The algorithm starts to place slots for the UGS connections and then for the ertPS and rtP connections. If the chosen slot is already assigned to another connection, then the closest free slot is chosen. The remaining slots can just be filled with the slots for the nrtPS and BE connections because they do not have any delay or jitter requirements. By this we can make this stage a little bit faster.

III. PERFORMANCE

To check whether delay intolerant service classes like UGS, ertPS and rtPS connections are satisfied in terms of their delay requirements, the delay plots will be used. For delay tolerant services like nrtPS and BE classes, their throughput will be plotted to check whether they have received their minimum bandwidth guarantee and not being deprived of the bandwidth, respectively. Let consider the scheduler is evaluated on its effectiveness on ensuring QoS requirements of various service classes especially the impact on the QoS of lower priority service classes when the highest priority service class that is (UGS) load is increased. We can see that the average delay for UGS in both downlink and uplink cases is constant which means that it is not affected by the load increase. This should be the case as the UGS is guaranteed to be provided with data grants at fixed interval by the scheduler. The delay for ertPS cases also shows quite a constant value although it is a little bit higher than the UGS case since the former has less stringent delay requirements than the latter. The delay of uplink rtPS shows some slight increment with the UGS load increase but it is still lower than the required one. The downlink rtPS however, shows quite a constant and lower value compared to the uplink case. This is because for the downlink, there is no bandwidth request involved and the scheduler provides the required bandwidth to the connection whenever there are packets in the queue. In the uplink, the connection only receives periodic data grants at a certain interval, hence the higher average delay but still does not exceed its requirements.

IV. CONCLUSION

In this paper, we have presented a scheduling solution for the 802.16 BS to ensure the QoS requirements of SSs in the uplink and downlink directions. Our solution takes into account parameters, such as the minimum/maximum bandwidth requirements, class type, slot size, and the bandwidth request size. The proposed algorithm makes scheduling decision based on the priority of the service classes involved and allocates resources in terms of needed the slots depends on the bandwidth requirements of each connection and the algorithm ensures that the granted resources do not exceed the maximum requirement of the each connection to prevent lower service classes from being starved. The proposed algorithm also complies with the standard as it does not introduce any new signaling mechanism.

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