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QoS Multi-users Packet Scheduling Algorithm in IEEE 802.16e System

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Abstract. IEEE 802.16e standard of wireless network defines the system structure of Quality of Service(QoS) and five service types, but it does not define fixed QoS scheduling algorithm. This paper ensures QoS features and improves the system throughput in OFDMA downlink system for the use of wireless packet scheduling algorithm. Combined with wireless communication features, Modified Deficit Round Robin algorithm(M-DRR) is proposed. The algorithm combines the channel conditions and application of hybrid automatic repeat request(HARQ) technology to Schedule wireless packet data. The simulation results show that M-DRR scheduling algorithm can improve the system throughput and provide some QoS guarantees.

Keywords: IEEE 802.16e; Quality of Service(QoS); Scheduling algorithm; M-DRR;Channel State

1. Introduction

3G era changes our daily life gradually. Broadband Wireless Access(BWA) provides ubiquitous services, convenient services and rich broadband services to meet the users' demands, so the users feel the rapid development of communication technology. The IEEE 802.16e[1] supplement the deficiencies of IEEE 802.11 in broadband and access speed. One of the important advantages of IEEE 802.16e is the wide range of data transmission with multi-users and QoS, and it supports voice, video and other multimedia services. WiMax that based on IEEE 802.16e standard applies downlink OFDMA and uplink SC-FDMA technology, and combines with the multi-antenna technology(e.g. MIMO[2]), the adaptive modulation and coding(AMC) and hybrid automatic repeat request(HARQ) sufficiently. Even if signal fading on each sub-channel is different, the system performance[3] must be improved .

Although the 802.16e standard provides the QoS, and the Media Access Control(MAC) layer provides connection-oriented delivery mechanisms and improves the service management system, the standard does not mention the realized QoS packet scheduling algorithm. Radio resource management scheduling algorithm can improve the overall system performance.

Scheduling algorithms can be divided into two different classes, such as the algorithm with independent of channel state and the algorithms based on sub-channel. The first class contains Round Robin(RR) algorithm[4], the other one contains Maximum C/I algorithm and Proportional Fair (PF)[5] scheduling algorithm. The RR algorithm requires that data is transmitted sequencely and it meets the demand of fairness. Unfortunately, The RR algorithm have some disadvantages, it does not consider the channel state, the QoS Priority and the throughput of service flow. When multi-users transport the datas, the system throughput will be decreased. In this paper, the Modifed DRR algorithm considers the situations that the channel state is changed, and the throughput of service flow is often changed, it combines with HARQ, improves the system throughput and guarantees the QoS feature.

2. QoS Mechanism in 802.16e System

2.1. Types of data delivery services in 802.16e system

The standard provides five types of data delivery services that are associated with certain predefined set of QoS-related service flow parameters at the MAC layer. They are:

- Unsolicited grant service (UGS) is designed to support real-time data streams consisting of fixed-size data packets issued at periodic intervals, such as T1/E1 and Voice over IP without silence suppression. The datas can be provided as either fixed-lenth or variable-length grants. This service eliminates overhead and latency of the Mobile users(MS) reguests, and ensure that grants are available to meet the data flow's real-time needs. The Base Station(BS) will give Data Grant Burst IEs to the MS based on the Minimum Reserved Traffic Rate of the service flow at periodic intervals. These grants' size will be sufficient to transmit the fixed-length data associated with the service flow. The main QoS parameters are Minimum Reserved Traffic Rate, Maximum Latency and Tolerated Jitter.
- The rtPS is designed to support real-time UL service flows that transport variable-size packets data at periodic intervals, such as moving pictures experts group (MPEG) video. This service offers periodic, real-time, unicast request opportunities, which meet the flow’s real-time needs and allow the MS to specify the size of the desired grant. This service requires more request overhead than UGS, but supports variable grant sizes for improving data transport efficiency. The BS will provide periodic unicast request opportunities. The main QoS parameters are Minimum Reserved Traffic Rate Maximum Sustained Traffic Rate Maximum Latency.
- Extended rtPS is a scheduling mechanism which has the efficiency of both UGS and rtPS. The ertPS is designed to support real-time service flows that generate variable-size data packets at periodic intervals, such as Voice over IP services with silence suppression. The BS will provide unicast grants in an unsolicited manner like in UGS, so it can save the latency of a Bandwidth request. However UGS allocations are fixed in size, ertPS allocations are dynamic. The BS can provide periodic Uplink(UL) Bandwidth allocations that may be used for requesting the bandwidth as well as for transmission data. By default, size of Bandwidth allocations corresponds to current value of Maximum Sustained Traffic Rate at the connection. The main QoS parameters are the Maximum Sustained Traffic Rate, the Minimum Reserved Traffic Rate and the Maximum Latency.
- The nrtPS provides unicast polls on a regular interval, which ensures that the UL service flow receives request opportunities even during network congestion. The BS typically polls nrtPS connections on an interval on the order of one second or less. The BS will provide timely unicast request opportunities,such as the non-constant rate of non-periodicservice flow that is not sensitive to delay. The main QoS parameters for this scheduling service are Minimum Reserved Traffic Rate and Maximum Sustained Traffic Rate.
- Best effort (BE) service is designed to provide efficient service for BE traffic in the UL. The features of BE is neither throughput nor delay guarantees,such as Email. BE can use contention request opportunities as well as unicast request opportunities and data transmission opportunities

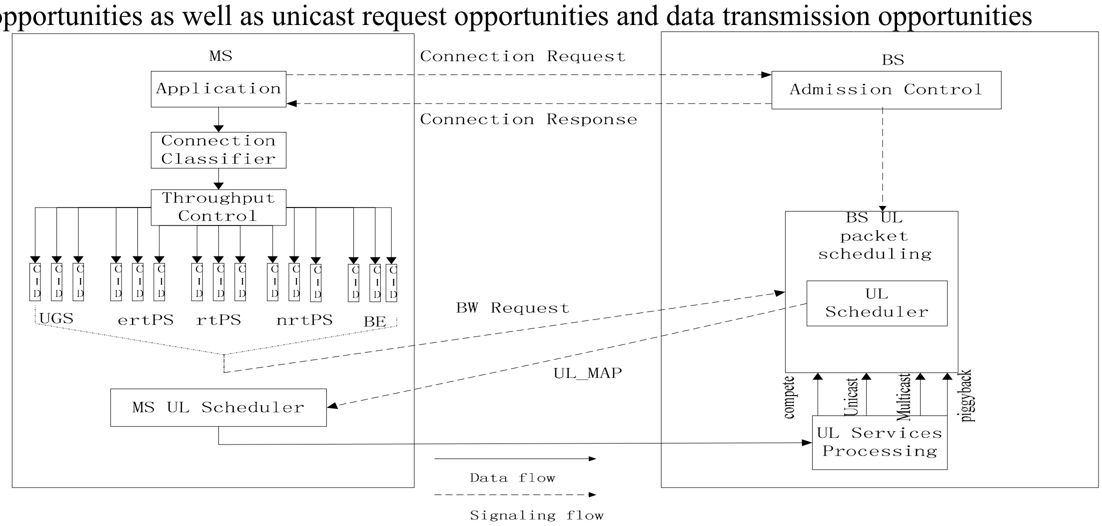

Fig. 1: QoS scheduling architecture

2.2. QoS Architecture at MAC Layer of 802.16e System

The system is shown in Figure 1.Because The MAC is connection-oriented, MS need to send the access request to the BS when MS signaling and data services establish a connection with BS. The MS signaling contains QoS requirements. The connection will be accepted if it can pass the certain criteria in the admission control module of the BS. After the judgement, MS will receive the response from BS. Traffic flows will be divided into different types of services after MSs are allowed to connect with BS. The classifier can divide all different packet datas into the certain class service flows that be identified through Connection identifier(CID) by the QoS constraints at convergence sublayer. MS UL service scheduler allocate bandwidth according to different scheduling classes at common part sublayer. For example: UGS does not need the bandwidth request, but BS will grant fixed bandwidth: rtPS, nrtPS and BE have different bandwidth request types that may be competitive, unicast, multicast and piggback request. ertPS is a scheduling mechanism which has the efficiency of both UGS and rtPS. After the scheduler of BS receives bandwidth request, it will send UL_MAP, and then MS can receive UL_MAP, So UL scheduler of MS will transport datas in allocated time slot.

3. Scheduling Algorithm

Scheduling that is the effective mean of sharing resources to solve multiple service flows' competions is one of the core resource management in the 802.16e system. Packet scheduling can be achieved with a fast link management, according to certain rules to select which packet to send.

According to the order of the queue, RR algorithm polls users to allocate bandwidth.After the process of selection completed and the assigns time of system arrives, the system will schedule the service flows.If the process does not complete the required tasks, the scheduler will suspend the implementation of the process, and this process will be arranged at the end of the queue and wait for the next scheduling. Meanwhile, the scheduler will schedule the next process to assure all processes in a given timeframe. This algorithm avoids a "starvation" phenomenon. But its disadvantage is that every rotation only send a packet queue. Because the length of each packet is not fixed,the Sub-head of the queue gets more services than the short packet queue. It will lead to a certain degree of unfairness. When more users connect with the network, the system throughput will decrease. In addition, there is no distinction between different priority traffic and it can not provide delay guarantees.

Weighted Round Robin (WRR) algorithm[6] and Deficit Round Robin (DRR) algorithm[7] are proposed according to the RR algorithm.

WRR algorithm gives a weight to each queue which means the number of sending packets when the queue polled. Each queue must maintain a counter that is initialized to the weights. Each time you send a packet, the counter will minus one. If the counter is not zero, the queue that be polled will always send the packet. From the above, we can see that it can achieve a certain priority if the weight value is set in reason. However, WRR algorithm may bring poor fairness due to the variable length packet as same as RR algorithm. In addition the delay can not be guaranteed.

DRR algorithm sets a fixed amount of bandwidth for each queue, and establishs a counter.At the first time,the initial value of the counter is the size of fixed bandwidth of the queue. This algorithm is still the rotation of each queue, if the packet length is less than the value of the corresponding counter, the length packet data of the queue is sent. On the contrary, the scheduler can not give services to this queue, and must update the queue counter value that is the sum of the bandwidth of the fixed value and the current residual value, and then the scheduler polls the next queue.

Either RR or WRR and DRR algorithms do not take into account the characteristics of wireless communication:

- Channel error rate and sudden
- Location of the MS affects channel capacity, error conditions and the time to support real-time.
- The scarce bandwidth resources

4. M-DRR Algorithm is Proposed for the 802.16e System

The inconsistencies in the sub-carrier channel conditions of the service flow are considered sufficiently. In order to improve the fairness and the throughput, M-DRR algorithm uses HARQ technology in the 802.16e system. The introduction of M-DRR algorithm that shows in Figure 2 are as follows :

If one queue has no packet data, then it will be kicked out from the active queues. If the packet data of one queue arrives, then the queue will add to the active queues. The order will accord to the priority of QoS.

The parameter values of each queue must be initialized. At the first time, the residual bandwidth (BWRes,J) is the system's total bandwidth (BWTotal,J). After each rotation, BWRes,J must be updated. Such as BWRes,J+1=BWRes,J - BWJ.

Each activity queue is rotated in accordance with the priority order. Taking into account the wireless channel state and the size of the data, the queues are adjusted by combination with HARQ technology. The queues are scheduled as the follow conditions:

- Modulation encoding fixed, low CINR of the users location, the quality of the channel is poor. In the case of a large volume of data, use the small HARQ packet, a number of packets to transmit, to ensure that even in the case of the bad link, resulting in some wrong HARQ packages (because the packet is small) does not affect the data transmission.
- Modulation encoding fixed, low CINR of the users location, the quality of the channel is general, in the case of a small amount of data business, also use the small HARQ packet to transport.
- Modulation encoding fixed, high CINR of the users location, the quality of the channel is good, In the case of a large volume of data, have to use the HARQ large package, relatively fewer packets to transmit, because the quality of the channel is good, there will not be packet errors. The use of the HARQ large package is helpful to improve the amount of data at the serve flow.
- Modulation encoding fixed, high CINR of the users location, the quality of the channel is good. In the case of a small amount of data , it will be enough to use the small HARQ packet to transport.

If there is no event queue or BWRes,J = 0 ,this rotation is completed.MS will frame and the scheduling packet data will be sent. If there is event queue or BWRes,J >0, and then schedule the other users' queue.

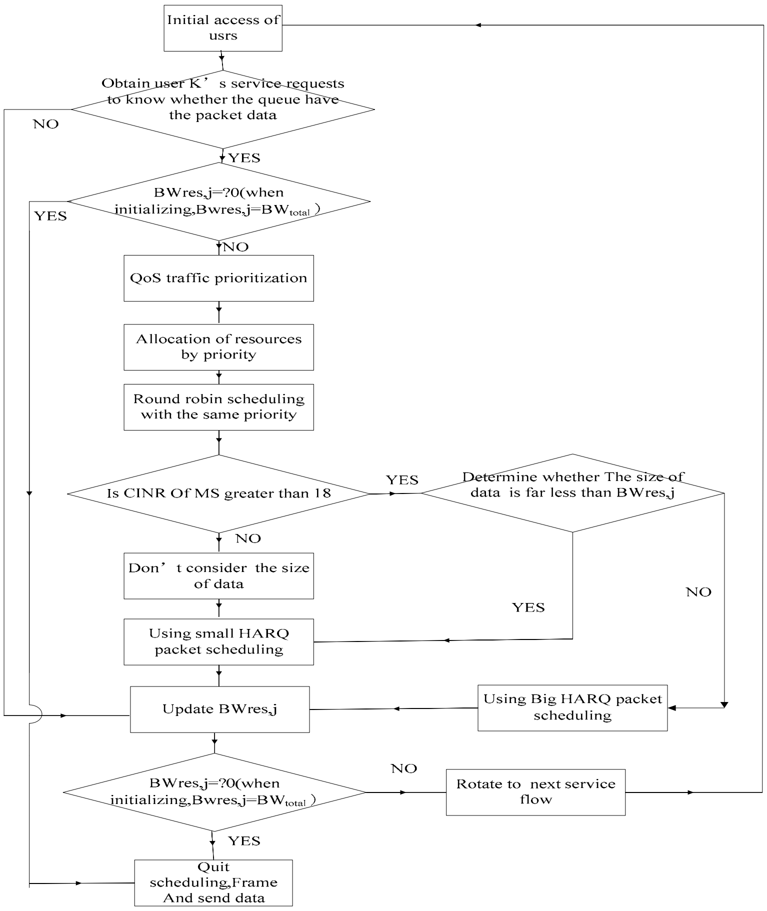

Fig.2. M-DRR algorithm flowcharts

5. Simulation Results and Analysis

Examine the applied scenario of multiple MS, the BW is 7MHz, and then the system use 64-QAM 2 / 3 of the modulation. In this situation, there are 192 available sub-carrier. So all the throughput of system is

7.83mbps in the OPNET. It means the throughput of the MAC layer, which is equal to BS side statistics, it is equal to the sum of data packets（bits) sent by all the BS which are received by MAC layer , the ratio of the receiver time. In this simulation, the MSs do the FTP, and the number of the MS is from 2 to 16, and then the quality of the users channel start to be worse form the eighth users, which some users suddenly a large amount of data traffic suddenly a small case. The M-DRR and DRR algorithm do the same experiment, regulate the emulative data throughput, and inspect the packet scheduling algorithm how to influent the network performance respectively. Draw a conclusion from the performance of M-DRR and DRR algorithm. Figure 3 shows the throughput of MAC layer of the M-DRR algorithm and the DRR algorithm, when numbers of MS in the corresponding network. In the case of the increase of the network users, seen form the indicator of the system throughput, M-DRR algorithm is better than the DRR algorithm.

6. Conclusion

The traditional scheduling algorithm can not be applied in the wireless communication system because of the wireless network’s variability and instability. In this paper the M-DRR scheduling algorithm that based on multi-users scenario considers the actual business case, it ensures fairness and the QoS features to improve the system throughput.

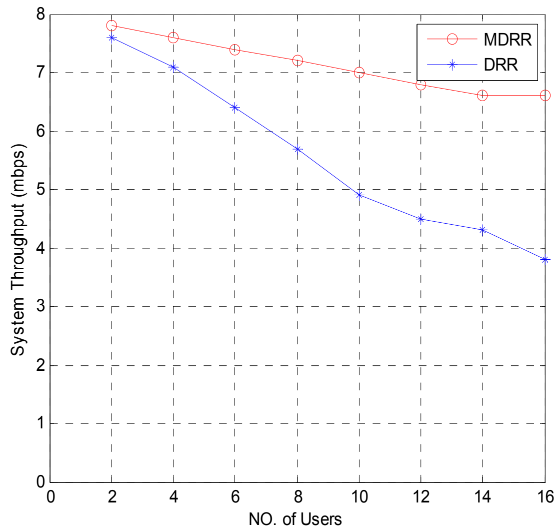

Fig.3. Multi-user throughput when comparing two algorithms

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