DPRA Scheduling Algorithm for Uplinks in IEEE 802.16 Wireless Systems

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ABSTRACT
In order to support different types of multimedia applications, the IEEE 802.16 standard defines different service classes with their associated Quality of Service (QoS) parameters. The scheduling algorithm is the crucial point in QoS provisioning over such broadband wireless access (BWA) network and it is important that the scheduling algorithm have a multi-dimensional objective of satisfying QoS requirements of the users, maximizing system utilization and ensuring fairness among users. In this paper, a dynamic priority resource-allocation (DPRA) scheme is proposed for uplinks in IEEE 802.16 wireless communication systems. The DPRA scheme dynamically gives priority values to four types of service traffic based on their urgency degrees and allocates system radio resources according to their priority values. It can maximize the system throughput and satisfy differentiated quality-of-service (QoS) requirements. Simulation results show that the proposed DPRA scheme performs very close to the optimal method, which is by exhaustive search in system throughput, and it outperforms the conventional efficient and fair scheduling (EFS) algorithm in the performance measures such as system throughput, delay, packet loss.

Keywords – IEEE802.16, Scheduling algorithms, Quality of Service

1. INTRODUCTION
The increasing interest in wireless broadband communications is a consequence of both rapid growth and the rising importance of wireless communications and multimedia services to end users. In rural areas, broadband wireless access (BWA) represents an economically viable solution to provide last mile access to the Internet, thanks to the easy deployment and low cost of its ”light” architecture. Standard activities for BWA are being developed within IEEE project 802, Working Group 16, often referred to as 802.16. The IEEE 802.16 standard is also known in the trade press as Worldwide Interoperability for Microwave Access (WiMAX) [1]. Orthogonal frequency-division multiplexing has been proposed as a promising technique for future multimedia wireless communication systems due to its ability to mitigate frequency-selective fading and intersymbol interference (ISI) and its flexibility for adaptive modulation on each subcarrier. Orthogonal frequency-division multiple access (OFDMA) has been adopted for IEEE 802.16 broadband wireless access systems.

The medium access control (MAC) signaling has been well defined in the IEEE 802.16 specifications [1], resource management and scheduling still remain as open issues. Since the wireless channel condition varies with time, adaptive resource allocation has been viewed as one of the key technologies to provide efficient utilization of the limited system resource in multiuser wireless communication systems. Furthermore, for a system with multimedia traffic provisioning, diverse quality of service (QoS) requirements should be taken into account when developing an efficient resource-allocation algorithm. Therefore, an effective resource-allocation scheme is required to exploit frequency diversity, multiuser diversity, time diversity, and QoS requirement diversity so that the overall system resource can efficiently be utilized and the QoS requirement can be guaranteed.

Many papers considered the downlink resource allocation [3]–[5], but a few papers investigated the uplink resource allocation. Resource allocation of both downlink and uplink is primarily performed by the base station (BS). Das and Mandyam [6] considered the uplink transmission of the OFDMA system and developed an efficient algorithm for the subcarrier and bit allocation of each user. The algorithm includes the power distribution over the selected set of subcarriers for every user so that the total used power is minimized. Furthermore, the channel state information (CSI) on the sub channels of each subscriber station (SS) is assumed to be periodically reported. Then, the optimization problem using a utility function was formulated, and a practical algorithm was provided to obtain a near-optimal solution. Singh and Sharma [10] also developed an efficient and fair scheduling (EFS) algorithm for each time slot in IEEE 802.16 OFDMA/time-division duplex systems.

The EFS algorithm is designed with a fixed priority scheme that gives priorities to service traffic according to their QoS requirements. Chen and Chang proposed a dynamic uplink channel-allocation strategy for selecting a better channel for each SS, depending on the SS’s signal-to-noise ratio value [11]. However, the QoS requirements and power constraint are not considered. Furthermore, an efficient uplink resource allocation for power saving in IEEE 802.16 OFDMA systems was proposed in [12]. It adaptively adjusts the modulation and coding scheme to minimize the required transmission power while guaranteeing the BER. However, multiple services and their differentiated QoS requirements are not taken in account.

In this paper, we propose a dynamic priority resource allocation (DPRA) scheme for IEEE 802.16 uplink communication systems. The goal of the proposed DPRA scheme is to maximize the system throughput while satisfying various QoS requirements of multimedia traffic.

Four types of service traffic for users are taken into account, including unsolicited grant service (UGS), rtPS, nrtPS, and best effort (BE) service. A priority value for every service type of each user is defined and adaptively adjusted frame by frame according to its urgency related with individual QoS requirements and buffer condition. Then, the BS will dynamically allocate the uplink subchannel, modulation order, and power to each SS according to its priority value and the CSI. Furthermore, to meet the uplink frame structures defined in IEEE 802.16 specifications and reduce the computational complexity and the transmission overhead, a consistent allocation mechanism is designed in the proposed DPRA scheme. Simulation results show that the proposed DPRA scheme performs close to the optimal method, which is by exhaustive search, in system throughput. Furthermore, it outperforms the EFS conventional algorithm [10] in system throughput and rtPS packet dropping rate. In addition, the DPRA scheme can take much less computational complexity than the optimal method and the EFS algorithm.

IEEE 802.16 defines the following four service types, and each of them has different QoS requirements.

1) *UGS:* The UGS supports real-time traffic that periodically generates fixed-size data packets. Thus, the BS generally allocates a fixed amount of bandwidth for this type of service.

2) *rtPS:* It is designed to support real-time service, which generates variable-size data packets. It is a delay-sensitive traffic so that the delay requirement is an important QoS issue. The amount of bandwidth granted for this type of service needs to be dynamically determined according to its priority based on the QoS requirements and traffic models.

3) *nrtPS:* It is designed to support delay-tolerant data streams while a minimum data transmission rate is required. Furthermore, the bandwidth granted for nrtPS needs to be dynamically determined according to its priority based on the QoS requirement and the buffer condition.

4) BE: The BE service is designed to support data streams that have no QoS requirement. It will be transmitted when system resource is available. Thus, the bandwidth left after serving the UGS, rtPS, and nrtPS traffic is allocated for the BE service.

The remainder of the paper is organized as following: section 2 analyses the existing Fair scheduling algorithms, their merits and demerits. Section 3 analysis the proposed Dynamic Priority Resource Allocation algorithm. The section 4 presents simulation comparisons of scheduling algorithms and finally, we conclude and give perspectives of future works.

2. FAIR SCHEDULING SCHEMES IN WiMax

The objective of scheduling schemes is to provide fairness and quality of service among all users in the session, also reduces the packet loss and delay in wireless environment.

The basic FQ scheme refers Weighted Fair Queuing (WFQ). WFQ [3] is a variation of Fair Queue algorithm proposed for reasonable and sufficient QoS mechanism in wireless error free network. The underlying idea of Fair Queue is to serve sessions with some prespecified service shares. WFQ allots a set of weights to each class queue. The weights sets may be the time-sharing mechanism. Such a mechanism prevents the low priority queues from starving. But in wireless network, error free channel is not possible, because error will be introduced during the transmission of packets between base station and mobile nodes.

During the transmission of packets through wireless link, some of the packets are errored. In order to overcome that problem P.Agarwal [6] introduced an algorithm as Server Based Fairness Approach (SBFA). The basic idea of SBFA is to supplement the bandwidth of session which have received reduced throughput due to poor quality of wireless channel. Scheduler keeps track of the amount of fixed bandwidth in compensation server, at working SBFA; allocate the fixed bandwidth to errored packets from compensation server.

The above disscussed Fair Queuing algorithms works based on static weight distribution along with error networks. But none of them consider about the high priority packets, it will *introduce Static-Weight delay* problem in wireless environment.

3.PRIORITY SCHEDULING SCHEMES IN WLANs

The most well-known priority algorithms are classified as Static Priority Queue (SPQ), Probabilistic Priority (PP), Earlier Deadline First (EDF) and Rotating Priority Queue (RPQ). Priority queue differentiating the incoming packets based on source and destination address, packet type, sequence number. At working, higher priority packets are processed earlier than the lower priority packets. SPQ[4] uses static configuration and does not automatically adapt the network resources. For example, consider two queues are Q1< A B C > and Q2 < D E F >. Each queue having three packets and corresponding priority assigned to this packets are Q1 < 3 4 6 > and Q2 < 2 1 5 >. Scheduler transmit the packets in the order of Q <C6 F5 B4 A3 D2 E1 >.
The proposed DPRA scheme performs subchannel selection, modulation order, and power-allocation assignment for uplink users. The DPRA scheme is also designed with a *consistent allocation mechanism*. Once a subchannel with a modulation order and power is assigned to a selected user at a certain slot, the next consecutive slots at the same subchannel will consistently be given to the selected user until its required transmission of bits completes.

Notice that the allocation for each user in a frame by the DPRA scheme takes execution only one time rather than symbol by symbol [7]. Consequently, the DPRA scheme can not only meet the uplink frame structure defined in IEEE 802.16 [1] but also reduce the computational complexity and fulfill the QoS requirement. The DPRA scheme is a heuristic algorithm that contains six steps of functions to solve the optimization problem given in (15)–(18). At the beginning, the assignment vector x and allocated power $p_{k,n}$ are initialized to be zero, which means that all resources are free.

The six steps involved in the DPRA scheme periodically given by, Step *1—User–Subchannel Selection:* The DPRA scheme selects users from the set of backlogged users Ω according to the priority values. *Step 2—Highest Modulation Order Assignment:* Once an optimal pair of user and subchannel is selected, the highest modulation order assignment and its associated power allocation are performed.*Step 3—Allocation Slot Calculation:* The number of bits that user can transmit on subchannel in the first assigned slot. *Step4—Power Rechecking:*If user can possibly simultaneously transmit on the same slots of more than one subchannel. Since we only check the transmission power on subchannel. the power constraint should be rechecked if it is still satisfied. If the power constraint is violated, the number of slots allocated to user will be decreased until the power constraint is fulfilled. *Step 5—Maximum Available Slot Finding:* the total number of available bits that the system can allocate to user from subchannel. If it is smaller than the actual number of required bits. *Step 6—Remapping:*To fulfill the slot allocation constraint, the slots that have been allocated to other users had better shift to the neighboring available slots. This process of shifting is called “remapping.” The DPRA scheme will continuously be executed until there are no free subchannels or no backlogged users. Note that the DPRA scheme is a kind of greedy algorithm, which can find a near-optimal solution for the optimization equations given in (15)–(18) [14]. Furthermore, the functions in Steps 3–6 are the consistent allocation customized for IEEE 802.16 systems.

4. SIMULATION RESULTS AND DISSCUSSION

We have used Network Simulator(NS-2) in our evaluation.The NS2 is a discrete event driven simulator developed at UC Berkeley.It suitable for designing new protocols,combining different protocols and traffic evaluation.It is an object oriented simulation written in C++ with an OTcl interpreter as a frontend.

In this section, we employ simulation to validate the analysis and to demonstrate the performance of the proposed DPRA scheme interms of packet loss, Fair Rate and packet delay QoS metric. The analysis done by varying the number of users for every particular interval of time.

Fig.1,2 shows the End to end Delay, Packet loss performance of EFQ and DPRA schemes in wireless environment. The delay performance of EFQ varying ununiformly(very delay variation) due to fixed weight distribution of resources to all users, causes the static weight delay problem. The DPRA have lower packet delay and loss compared to WFQ due to differentiation property and dynamically allocate the resources to all users based on demands request. Fig. 3 shows the fair data rate response of EFQ and DPRA algorithms in WiMax enviroment. DPRA provide good data rate compared to EFQ algorithm. Therefore, we can conclude that the proposed DPRA scheme can reach throughput maximization and QoS satisfaction with a lower computational complexity and transmission overhead. The DPRA scheme would be suitable for real applications.

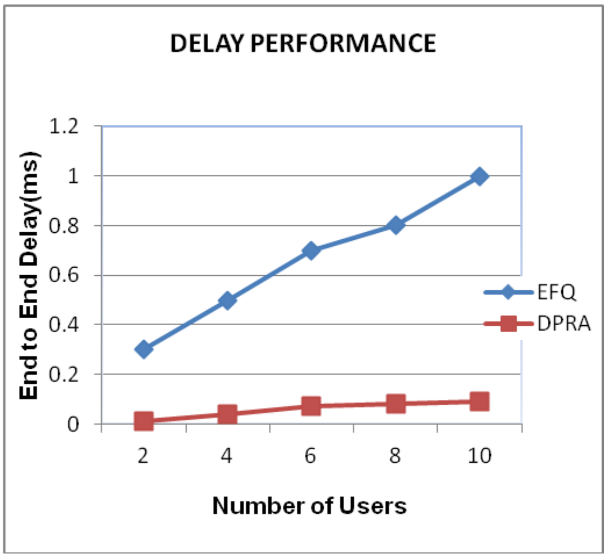

Fig 1. End-to-End- Delay Performance

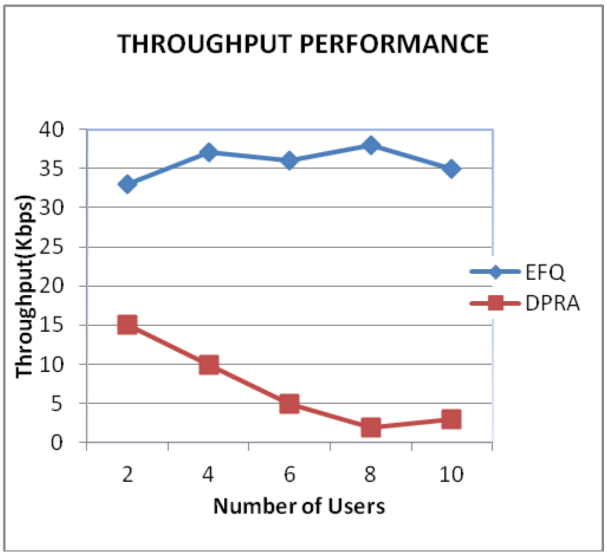

Fig 2. Thrpughput Performance

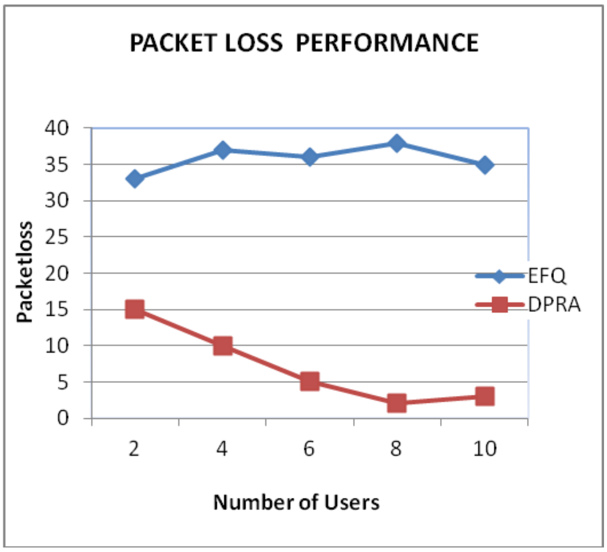

Fig 3. Packet Loss Performance

5. CONCLUSION AND FUTURE WORK

In this paper, we discuss about detailed survey of existing scheduling schemes and their issues in WiMax scenario. The fair queuing works based on pre-assigned weights, priority queuing depends on order of priority dynamically allocate the resources to all users. From the simulation results, we demonstrate that the proposed algorithm satisfies the Quality of Service (QoS) flows and guarantee the delay for higher priority classes and has achieved better overall performance than those of all other existing scheduling schemes. The performance increment of throughput and packet loss is considered for next stage improvements on DPRA packet scheduling scheme.

In our future work, we plan to study the performance of these schemes under other network scenarios by varying the network size, number of connections, speed of mobile nodes etc..

6.REFERENCES

[1] Wan-Seon Lim, Young- Joo Suh, Achieving Per-Station Fairness in IEEE 802.11 Wireless LANs,IEEE-2010.

[2] Eun-Chan Park, Dong-Young Kim, Chong-Ho Choi, Jungmin, Improving Quality of Service and Assuring Fairness in WLAN Access Networks, IEEE Transactions on mobile computing, VOL.6, No.4, APR-2007.

[3] Mong-Fong Homg, Wei-Tsong Lee, Kuan-Rong Lee, Yau-Hwang Kuo, An adaptive approach to weighted fair queue with QoS enhanced on IP network, in: Proceedings of IEEE Region 10 International Conference on Electrical and Electronic Technology, vol. 1, 19–22 August 2001, pp. 181–186.

[4] T.S. Eugene Ng, I. Stoica, H. Zhang, Packet fair queuing algorithms for wireless networks with location-dependent errors, in: Proceedings of INFOCOM98, March 1998, pp. 1103–1111.

[5] Y. Wang, S.R. Ye, Y.C. Tseng, A fair scheduling algorithm with traffic classification in wireless networks, in: International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS), 2004, pp. 502–509.

[6] Y. Wang, Y. Tseng, W. Chen, K. Tsai, MR-FQ: a fair scheduling algorithm for wireless networks with variable transmission rates, ITRE 2005 27–30 (June) (2005) 250–254.

[7] *IEEE Standard for Local and Metropolitan Area Networks—Part 16: Air Interface for Fixed Broadband Wireless Access Systems*, IEEE Std. 802.16-2004, Oct. 2004.

[8] C. Y. Wong, R. S. Cheng, K. B. Letaief, and R. D. Murch, "Multiuser OFDM with adaptive subcarrier, bit, and power allocation," *IEEE J. Sel. Areas Commun.*, vol. 17, no. 10, pp. 1747–1758, Oct. 1999.

[9] Y. J. Zhang and K. B. Letaief, "Multiuser adaptive subcarrier-and-bit allocation with adaptive cell selection for OFDM systems," *IEEE Trans. Wireless Commun.*, vol. 3, no. 5, pp. 1566–1575, Sep. 2004.

[10] M. Ergen, S. Coleri, and P. Varaiya, "QoS aware adaptive resource allocation techniques for fair scheduling in OFDMA based broadband wireless access system," *IEEE Trans. Broadcast.*, vol. 49, no. 4, pp. 362–370, Dec. 2003.

[11] N. Xu, Y. Wang, and P. Zhang, "Multiuser scheduling in downlink MIMO/OFDMA system with transmit preprocessing," in *Proc. Asia- Pacific Conf. Commun.*, Aug. 2006, pp. 1–5.

[12] H. Yaghoobi, "Scalable OFDMA physical layer in IEEE 802.16Wireless-MAN," *Intel Technol. J.*, vol. 8, no. 3, pp. 201–212, Aug. 2004.

[13] "Feasibility study for OFDM for UTRAN enhancement," *3rd Generation Partnership Project*. Tech. Rep., 2004-06.

[14] *Universal Mobile Telecommunication System, Selection Procedures for the Choice of Radio Transmission Technologies of the UMTS*, UMTS Std. 30.03, 1998.

[15] CISCO Tech. Notes, *Voice over IP—per call bandwidth consumption*.Document ID 7934.

[16] IEEE 802.16m-08/004r2, *IEEE 802.16m Evaluation Methodology Document*, Jul. 3, 2008.

[17] H. Wang, C. Shen, K.G. Shin, Adaptive-weighted packet scheduling for premium service, IEEE International Conference on Communications, vol. 6, 2001, pp. 1846–1850.

[18] Mong-Fong Homg, Wei-Tsong Lee, Kuan-Rong Lee, Yau-Hwang Kuo, An adaptive approach to weighted fair queue with QoS enhanced on IP network, in: Proceedings of IEEE Region 10 International Conference on Electrical and Electronic Technology, vol. 1, 19–22 August 2001, pp. 181–186.

[19] R.L. Cruz, A calculus for network delay. I. Network elements in isolation, Information Theory, IEEE Transactions, vol. 37(1), January 1991, pp. 114–131.

[20] Y. Wang, L. Fan, D. He, R. Tafazolli, ARPQ: A Novel Scheduling Algorithm for NEMO-based Vehicular Networks, submitted to Journal of Selected Areas on Communications, the special issue for vehicular networks.

[21] H.-L. Chao, W. Liao, Fair scheduling with QoS support in wireless ad hoc networks, IEEE Transactions on Wireless Communications 3 (6) (2004).

[22] H.-L. Chao, W. Liao, Fair scheduling in mobile ad hoc networks with channel errors, IEEE Transactions on Wireless Communications 4 (3) (2005).

[23] L. Wang, Y.-K. Kwok, W.-C. Lau, V.K.N. Lau, Efficient packet scheduling using channel adaptive fair queueing in distributed mobile computing systems, Springer Mobile Networks and Applications 9 (4) (2004).