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Modified Priority Algorithm for Mobile WiMAX Uplink Scheduler

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Abstract: In this note, we propose a modified priority algorithm for the uplink scheduler of Mobile WiMAX. The proposed algorithm guarantees the delay property of the real-time traffic by imposing a threshold to the bandwidth request messages of the non real-time Polling Service (nrtPS). Each service class is serviced exhaustively (until empty) to overcome on the starving of lower priority service class which is the Best Effort (BE). The threshold value can be adjusted according to the load demand of the networks. Simulation results, found at the end of this study show that the proposed algorithm is fairer and delivers higher throughput of the BE service class.

Key words: Mobile WiMAX, modified priority algorithm, QoS, scheduling algorithm, threshold, uplink scheduler

INTRODUCTION

The tasks of the Mobile WiMAX uplink scheduler have the reputation to users as being rather complex. The complexities are seen in that the scheduler must be able to support different types of application (Belghith and Nuaymi, 2008) as well as to distribute the available bandwidth of different classes, (Chakchai *et al*., 2009) while satisfying the Quality of Service (QoS) requirements.
The uplink scheduler can be classified into two categories: the intra-class scheduling and inter-class scheduling (Chakchai *et al*., 2009). The intra-class scheduling is responsible for allocating the resources within the same class whereas the inter-class scheduling will allot the resources to different classes of services.

To guarantee the QoS of different service classes, a priority-based scheme is applied for the inter-class scheduling in a Mobile WiMAX scheduler. Unsolicited Grant Service (UGS) is set to have the highest precedence followed by the extended real-time Polling Service (ertPS), Real-Time Polling Service (rtPS), nrtPS and BE. The direct negative effect of the priority-based algorithm (Settembre *et al*., 2006) is that, it may starve the connections of lower priority service classes (BE) which cause the throughput to be lower. Thus, to mitigate with this problem, Deficit Fair Priority Queueing (DFPQ) with a counter is introduced to maintain the maximum allowable bandwidth for each service class (Po *et al*., 2009). However, determining the correct value of the counter is crucial and if not configured properly, the delay and throughput of the service classes traffic might suffer. In this note we propose a modified priority algorithm aimed at improving the throughput and fairness of the lower priority classes.

Mobile WiMAX architecture: A point-to-multipoint network is considered in this note. The BS communicates with several Mobile Stations (MS) within a cell. Connections between the Base Station (BS) and an MS are structured in frames and identified by a Connection Identifier (CID). A CID can represent an individual or a group of applications. The transmission of data from MS to BS is called uplink (UL) whereas downlink (DL) is indicated by the transmission from BS to MS. The BS should perform the connection admission to find out if the QoS requirements of the requested bandwidth can be supported based on the current resource available (Nuaymi, 2007). If the service is granted with the bandwidth, the BS will generate a new CID and Service Flow Identifier and notify the MS.

Please note that for an uplink transmission, packets are queued at the MSs and the uplink scheduler works on a request-grant basis. Each MS will send a bandwidth request message to the BS. Subsequently, after receiving the bandwidth request messages, the messages are then classified according to the service classes and QoS

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Table 1: Traffic parameters

Application	Parameter
Video conference (Yi *et al*., 2009; Hua and Lars, 2007)	Frame size: • Lognormal distribution • Average : 4.9 bytes • Standard deviation: 0.75 bytes Inter-arrival time • Normal distribution • Mean: 33 msec • Standard deviation : 10 msec
File Transfer Protocol	Inter request time : • Constant distribution (30 sec) File size : • Constant distribution • 10000 bytes
Web browsing	Page interarrival time: • Exponential (exp) distribution (30 sec) Page properties: Object size: exp 1000 bytes Object per page: exp 4

Table 2: Simulation parameters

Parameter	Value
PHY profile	OFDMA
Bandwidth	10 MHz
Base frequency	2.5 GHz
TTG (Transmit-receive transition gap)	106 µs
RTG (Receive-transmit transition gap)	60 µs
OFDMA symbol duration	100.8 µs
Frame preamble	1 symbol
Duplexing mode	TDD
FFT size	1024
Frame duration	5 ms
Subframe ratio (DL/UL)	1:1
MRTR rtPS	10000 b/s
MRTR nrtPS	50000 b/s
MRTR BE	40000 b/s
Polling time (rtPS)	2 msec
Polling time (nrtPS)	10 msec

parameters in the scheduler for the bandwidth allocation process to take place. An Information Element (IE) is created in the UL-MAP to show the control region and new resource assignments that MSs should transmit. The UL-MAP is placed at the beginning of the DL subframe of each frame and broadcast. Each MS listens to the broadcast MAP message for their CID and decodes the UL-MAP IE so the packets are sent in accordance to the slots allocated. To ease the interpretation of the uplink scheduler at the BS, we assume that each MS carries single service flow (to eliminate the effect of packet scheduling at MSs) which is then mapped to a queue. Each service flow is fixed to a minimum reserved traffic rate (MRTR) for rtPS and nrtPS and the BE is given the available capacity after considering all the service classes. The IEEE 802.16e standard enables the optimization of each MS's data rate by allowing the BS to set the Modulation Coding Scheme (MCS) with regards to the channel condition. Thus, to account for the adaptive MCS, each service flow is translated into the coding rate and

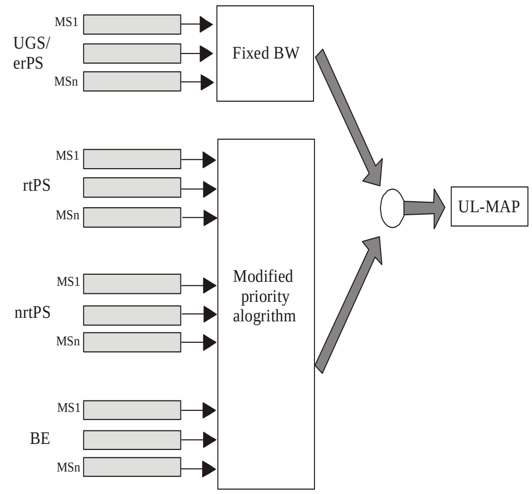

Fig. 1: The architecture of the uplink scheduler

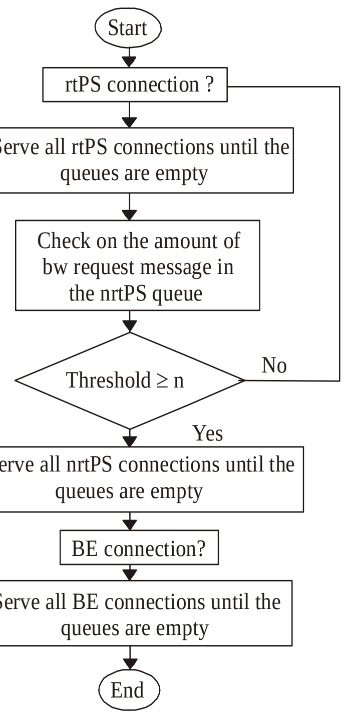

Fig. 2: Modified priority algorithm flowchart

bits per symbol for each modulation. Table 1 and 2 summarize the traffic parameters and simulation parameters used in the simulation respectively.

Modified priority algorithm: The architecture of the uplink scheduler in this note is shown in Fig. 1. The approach aims at adjusting the threshold value which represents the number of bandwidth request message in the nrtPS service class. The scheduling scheme starts with the scheduler visits to rtPS. The rtPS is serviced until no more bandwidth request message is available. Before continuing the service to nrtPS, the scheduler will check on the amount of bandwidth request available in the nrtPS service class. If the amount of bandwidth request exceeds the threshold assigned, then the scheduler will carry out the service to nrtPS and subsequently the BE. On the other hand, the scheduler will return to service rtPS if the amount of the bandwidth request is less than the threshold assigned. Fig. 2 shows the flow chart of the proposed algorithm.

In order to select the suitable value for the threshold, we have performed the simulation rigorously, by varying the threshold value. Through this, we observe that the optimal value of the threshold is equal to 10 and the smallest is 1. If there is a high load demand of the real-time traffic, the threshold value can be set high to guarantee the delay property of the real-time traffic. However, this will cause low throughput of the BE service class. Thus, it is important to select the best value of the threshold that can guarantee the QoS of each service class.

We proceed to compare the performance of the proposed algorithm with reference to (Settembre *et al*., 2006; Po *et al*., 2009). We have chosen the work in (Settembre *et al*., 2006; Po *et al*., 2009), provided that our proposed algorithm falls into the category of priority-based algorithms. DFPQ is also a priority-based algorithm in which the highest priority class is fixed with a larger quantum value than the lower priority class. Only the rtPS, nrtPS and BE are involved in the evaluation because the UGS and ertPS are granted with a fixed bandwidth. Ten MSs are configured to the web-browsing and FTP using BE and nrtPS respectively. An increasing number of MSs performing video conferencing which is associated with the rtPS service class is adopted for the purpose of expanding the load. A threshold value of 1 is selected to have higher throughput of the BE service class.

RESULTS

Figure 3 compares the average throughput for the BE service class. The comparison shows that our proposed algorithm delivers the highest throughput for the BE when the MS approaches 20. The Red-based DFPQ (Po *et al*., 2009) delivers the lowest average throughput when MS approaches 30 because rtPS is given higher transmission opportunities when the number of bandwidth request messages of rtPS increases. This is shown in Fig. 4. The BS is only capable of estimating the uplink traffic through the bandwidth request messages sent from the MS and the MRTR assigned for each service class. Thus, setting the counter of the BE service class to a fixed quantum value still does not improve the amount of throughput delivered.

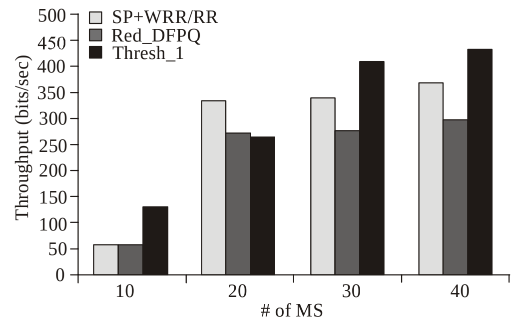

Fig. 3: Throughput of the BE service class

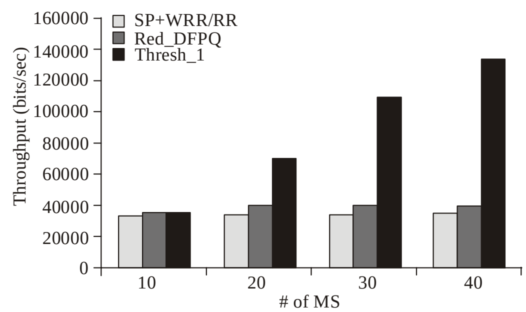

Fig. 4: Throughput of the rtPS service class

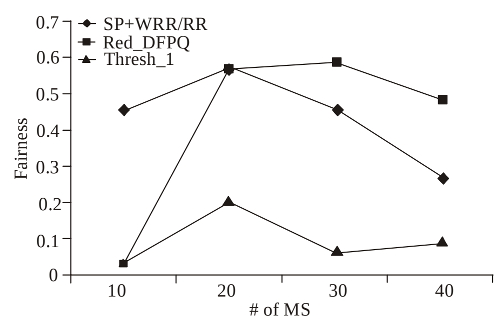

Fig. 5: Fairness

The combination of Strict Priority algorithm and Round Robin (BE) (Settembre *et al*., 2006) reduces the throughput because the scheduler needs to satisfy the higher priority class before the BE is serviced. The fairness between rtPS and BE is calculated as (Yi *et al*., 2009):

$$Fairness = \left| \frac{Th_{rtPS}}{S_{rtPS}} - \frac{Th_{BE}}{S_{BE}} \right| \tag{1}$$

where S_{rtPS} and Th_{rtPS} are the total traffic and corresponding throughput of rtPS, whilst S_{BE} and Th_{BE} are those of the BE. Fig. 5 has supplied the evidence that our proposed algorithm is fairer than (Settembre *et al*., 2006; Po *et al*., 2009).

CONCLUSION

A modified priority algorithm for an uplink scheduler in Mobile WiMAX is proposed to improve the throughput and fairness of the BE. Results from the simulation show that the algorithm outperforms the algorithm in (Settembre *et al*., 2006) by 44% and (Po *et al.*, 2009) by 58% and has been observed to be fairer. Furthermore, the algorithm boasts off simplicity, where it does not require complex analytical implementations. Nevertheless, it is able to guarantee the QoS requirements of the BE service class.

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