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An Intra-Class Channel-Aware Scheduling in IEEE 802.16e

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Abstract— Scheduling mechanisms for both uplink and downlink channels in IEEE 802.16 standard are open area for research. In this paper, we propose a weighted fair priority intra class scheduling for point to multipoint mobile WiMAX system. This method takes user's battery charge level into account to determine weights of the users. Simulation results show that overall system throughput is improved.

Keywords- WiMAX, Scheduling; OFDMA; Battery level; Resource allocation.

I. INTRODUCTION

WiMAX is a very promising Broadband Wireless Access (BWA) technology that provides a high throughput [1]. The design of a scheduler able to guarantee QoS and resource allocation has recently been an area of active research.

Mobile WiMAX supports Orthogonal Frequency Division Multiple Access (OFDMA) that provides higher data rates. OFDMA allows subscribers to transmit simultaneously on different subcarriers within same symbol period.

In [2], the proposed scheduling mechanism based on the use of channel condition information is classified into two classes: Channel-Aware scheduling and Channel-Unaware scheduling. The channel unaware schedulers don't consider the channel condition parameters in making resource allocation decision. The channel is assumed error-free in these algorithms, but because of wireless environment behavior, considering channel state conditions is so important to design a radio link.

According to QoS requirements, four service classes are introduced in IEEE 802.16: Unsolicited Grant Service (UGS), real time Polling Service (rtPS), non-real time Polling Service (nrtPS) and Best Effort (BE). UGS is for real time constant bit rate applications such as T_1/E_1 AND VoIP. rtPS is designed to support real time applications that produce periodic variable size data packets such as Moving Pictures Expert Group(MPEG) VIDEO. nrtPS is designed to support delay-tolerant applications and requiring a minimum amount of bandwidth such as File Transfer Protocol (FTP). BE is appropriate to weak QoS request traffics such as HTTP.

Extended real time Polling Service (ertPS) is added in IEEE 802.16e as a new service class. It is similar nature to rtPS services, but the BS can get a default bandwidth to this service class.

The proposed scheduling rule in [3], was a hierarchical channel aware scheduling algorithm for uplink scenario. This scheduling problem was consisting of two sub problem: a RED based weighted fair priority queuing inter class scheduler and a long term proportional fair method based on mSIR for intra class scheduler. This algorithm leads to improving overall system throughput without starving lower priority service class.

In [4], an inter class scheduling for a mixture of real time, non real time and BE traffic was proposed that introduced flow metrics to make slot allocation decision.

II. SYSTEM MODEL

We consider a PMP WiMAX system with M users. The number of OFDMA subcarriers is N that to be assigned to the users. Each user m ($m \in \{1,2,\dots,M\}$)

can give N_m subcarrier(s). In this system, we assume subcarriers are not allowed to share by more than one user. We consider a frequency selective Rayleigh channel with bandwidth B that is constant over an entire TDD frame. A channel condition monitoring function gives the information about quality of links toward each MS to the BS. We assume each user perform Carrier to Interference and Noise Ratio (CINR) measurement and report it to the BS. By using these reported CINRs, it can choose the Modulation and Coding Scheme (MCS) level based on CINR threshold values.

It is assumed that n bandwidth request mechanism, each user mobile device battery level is reported as a two bit sign:

$\%0 < \mathrm{BL_m} \leq \%5 \rightarrow 00$

$\%5 < \mathrm{BL_m} \leq \%10 \rightarrow 01$

$\%10 < \mathrm{BL_m} \leq \%30 \rightarrow 10$

$\%30 < \mathrm{BL_m} \leq \%100 \rightarrow 11$

where BL_m denotes the battery level of m' th user.

I_{mn} is the subcarrier allocation indicator: if the n'th subcarrier is assigned to the m' th user then $I_{mn} = 1$, otherwise $I_{mn} = 0$. (n$\in \{1,2, \dots, N\}$)

TABLLE 1: MODULATION AND CODING SCHEME IN IEEE 802.16E

CINR (dB)	MCS level
36	5/6 64-QAM
32	3/4 64-QAM
28	2/3 64-QAM
24	1/2 16-QAM
20	1/2 16-QAM

Obviously:

$\sum_{m=1}^{M} I_{mn} = 1$

that expresses each subcarrier can only be assigned to one user.

$$R_m = \frac{B}{N}\sum_{m=1}^{M} I_{mnn} r_{mn}$$

Where R_m is the total data rate for user m and r_{mn} is number of bits that is depended on modulation and coding scheme (MCS).

Denote:

$$\frac{R_i}{W_i} = \frac{R_j}{W_j} \quad \forall i, j \in \{1,2, \dots, M\}, i \neq j$$

where W_m is normalized proportionality weight for m' th user and $\sum_{m=1}^{M} W_m = 1$.

III. PROPOSED ALGORITHM

We follow the approaches in [5] and enter the user's battery level as a new parameter to determine the weights. It is an intra class scheduling method that is proposed for nrtPS class. We follow these steps:

First step: determining N_m (number of subcarriers to be assigned to each user)

Second step: Assigning the remaining subcarriers to the users.

A) number of subcarriers per each user and user's priority

In this step, we determine N_m, where:

$$N_1 : N_2 : \dots : N_M = W_1 : W_2 : \dots : W_M$$

$$\mathrm{W'_m} = \alpha_\mathrm{m}\left(\frac{\mathrm{BW_m}}{\sum_{\mathrm{m=1}}^{\mathrm{M}} \mathrm{BW_m}} + \frac{\mathrm{CINR_m}}{\sum_{\mathrm{k=1}}^{\mathrm{K}} \mathrm{CINR_m}}\right), \mathrm{m} = 1,2, \dots, \mathrm{M}$$

$$W_m = \frac{W'_m}{\sum_{m=1}^{M} W'_m} \quad, m = 1,2, \dots, M$$

where α_m is battery level factor and to be defined as:

$$\alpha_m = \begin{cases} 0.4 & , \%0 < BL \leq \%5 \\ 0.3 & , \%5 < BL \leq \%10 \\ 0. & , \%10 < BL \leq \%30 \end{cases}$$

and otherwise $\alpha_m = 0.1$. $\mathrm{BW_m}$denotes to bandwidth that m' th user requested.

then:

$N_m = \lfloor W_m N \rfloor$

Maybe it leads to $N' = N - \sum_{m=1}^{M} N_m$ unallocated subcarriers.

At the first, subcarriers allocation is performed based on the user's priority. In this step the priority metric is $|CINR_\mathrm{m}.\alpha_\mathrm{m}|$. It means the user with the better channel condition and lower battery level has higher opportunity to get service than other users.

B) remaining subcarriers allocation

In this section we introduce a new priority metric to subcarrier allocation as:

$PM_m = \alpha_m \frac{\mathrm{A_m(t)}}{\mathrm{D_m(t)}}$

where $\mathrm{A_m(t)}$ and $\mathrm{D_m(t)}$ are arrival rate in nrtPS queue and long-term throughput for user m respectively.

during frame t:

$$\mathrm{A_k(t)} = \sum_{\mathrm{d=0}}^{\mathrm{D-1}} \mathrm{a_k(t-d)}$$

$$\mathrm{D_k(t)} = \sum_{\mathrm{d=1}}^{\mathrm{D}} \mathrm{d_k\,(t-d)}$$

where $a_m(t)$ is the number of bits in a packet that transmitted by user m during frame t-1 and D denotes the sliding window length in frame duration. Also d_m is the throughput for m' the user during frame t and before subcarrier allocation it is initialized as:

$d_m(t) = 0$

Within subcarrier allocation in frame t, if user m is allocated an OFDMA subcarrier, $d_m(t)$ is updated:

$d_m(t) = d_m(t) + \mu_m(t)$

Here, $\mu_m(t)$ is the number of bits can be transmit on subcarriers that allocated to user m during frame t and it depends on the modulation and coding scheme. For example using 64 QAM 3/4 leads to transmit 6 bits.

So, according to this metric, users with higher arrival rate in previous frame, lower battery level and long-term throughput has the priority to get service. We consider:

$N_m^* = \lfloor PM_m N^* \rfloor$

It leads to fairness among all users to get resources.

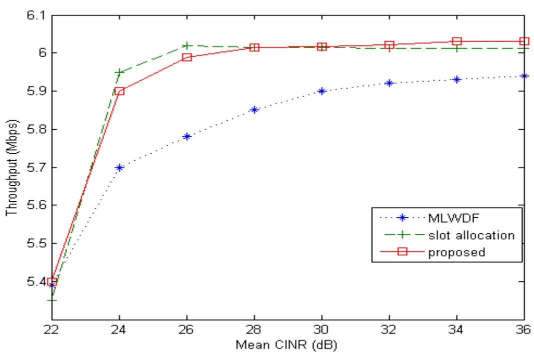

Figure 1. Throughput comparison between different algorithms

IV. SIMULATION RESULTS

The simulations are performed on MATLAB and they are shown for M=30 users and N=512 subcarriers 5 MHz bandwidth. We consider a 5ms frame where each OFDMA symbol is of duration 0.1ms. The mean battery charge level is %46.67. We assume the mean users arrival rate is 200Kbps.

Figure (1), shows the system throughput by increasing mean CINR. According to the chart, the proposed scheduling method has higher throughput than MLWDF rule between 22dB and 36dB CINR value while to compare with slot allocation algorithm in [4], system throughput relatively remains the same.

In figure (2), the normalized throughput proportions for each user are shown in two scenarios while the mean CINR is 26dB. Scenario 1, states each user normalized throughput proportions when the user's battery level (α_m) is considered and scenario 2 gives this information without considering battery charge level. According to the chart, in scenario 1 the users with the battery charge level lower than %5 (user 2, 4, 10), have a considerable increase in throughput.

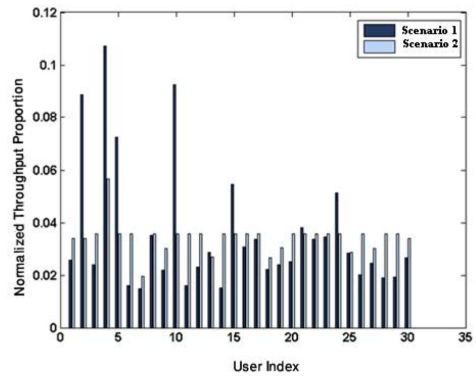

Figure 2. Each user normalized throughput

V. CONCLUSION

In this paper, we proposed an intra-class channel aware scheduling rule that determined the users proportional weights to allocate subcarriers among them with considering the effect of their battery charge level as a new parameter.

Also, according to this method, the priority of each user was depended on its channel state, battery level and previous frame arrival rate and finally long-term throughput during previous frames. It was a fair scheduling rule that lead to throughput improvement among users with low battery charge level and allow them to get service before becoming out of service. Simulation results showed this method has a good performance.

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