

Link adaption Scheme for Multicast and Broadcast Service in IEEE 802.16 networks

Hannah KIM*, Young-il KIM*

*ETRI(Electronics and Telecommunications Research Institute),Korea

rtkim@etri.re.kr

Abstract— Multicast and Broadcast Service (MBS) is intended to efficiently use system resources by transmitting same data to multi users simultaneously. MBS is composed of either single BS or multiple BS. In single BS access, each BS transmits MBS data to user which belong to its own BS. In multiple BS access, BSs in the same geographical area composes the MBS zone to transmit the same data to multi users simultaneously. MBS users combine MBS signals which belong to same MBS zone. To enhance the spectral efficiency, link adaption has been employed in wireless communication networks. It is difficult to enable link adaption algorithm in MBS, because channel information reporting for multi users results in a large amount of uplink overhead. Therefore the conventional methods are developed in order to reduce this overhead. However the conventional methods consider single BS access. This paper presents a dynamic Modulation and Coding Scheme (MCS) for MBS zone with limited channel information. The performance of the proposed scheme is analysed in terms of throughput. The effectiveness of the proposed scheme is verified by computer simulation.

Keywords— Link adaption, Multicast, Broadcast, 802.16m, MBS zone

I. INTRODUCTION

There are interests in ways to improve the delivery of multimedia information in a wireless access network. However it is difficult to offer high quality multimedia service because of limited resource. To overcome such difficulties, Multicast and Broadcast Service (MBS) has been introduced to WiMAX standard[6]. MBS is intended to efficiently use system resources by transmitting same data to multi users simultaneously. MBS is composed of either single BS (Base Station) or multiple BS. In single BS access, each BS transmits MBS data to user which belong to its own BS. In multiple BS access, BSs in the same geographical area composes the MBS zone to transmit the same data to multi users simultaneously.

Link adaption is intended to enhance the spectral efficiency of MBS using user's feedback information. To enhance spectral efficiency, some conventional methods select MCS(Modulation and Coding Scheme) based on CQI(Channel Quality Information)information of all MBS users [1,2,3]. These methods cause large overhead in uplink because of the channel information reporting. In order to reduce this overhead, link adaptation algorithms based on limited uplink feedback have been proposed [4,5]. Cai et al.[4]

proposed link adaption algorithm which BS selects N users with the poorest channel condition to receive feedback. After receiving feedback from N users, MCS are determined. In Chen et al. [5] methods, BS selects MCS and transmission power based on NACK sent through the common feedback channel. If SINR of MBS user is less than the threshold SINR, MBS user send NACK through the common feedback channel and then BS determine MCS and power based on NACK indication.

However the conventional methods may apply only to single BS access. In multiple BS access system, link adaption algorithm considers channel condition of all MBS users which belong to same MBS zone. Therefore we proposed link adaption algorithm with reduced uplink feedback. In proposed algorithm, in order to reduce feedback, we receive uplink feedback from MBS user when channel condition changed. And we select modulation and coding scheme in multiple BS access considering all MBS users which belong to same MBS zone.

This paper is structured as follows: Section II describes MBS system model in 802.16m. In Section III, we propose link adaption algorithm with limited uplink feedback. Section IV presents simulation results. Finally we describes conclusion in Section V.

II. SYSTEM MODEL

Figure 1 illustrates an example Wimax OFDMA frame structure for a TDD[6]. Downlink transmission and uplink transmission share the same frequency but are separated in time. Especially, downlink subframe support unicast service and multicast service. Also MBS service can be supported by MBS region in the downlink subframe.

MBS is composed of either single BS or multiple. In single BS access, each BS transmits MBS data to user which belong to its own BS. In multiple BS access, BSs in the same geographical area composes the MBS zone to transmit the same data to multi users simultaneously. Figure 2 shows the overall network architecture of MBS system over multiple BS. To provide a macro-diversity gain and performance enhancement of users, several BSs in the same MBS zone transmit same signals at the same time on the same frequency. In order to be synchronized several BSs in the same MBS zone, MBS Sync controller of ASN-GW generated synchronization rules(include MCS,MBS Burst timing, MBS

Burst size and position, MBS burst PHY parameter) in Mobile WiMAX system[7]. BS or ASN-GW construct MBS burst based on synchronization rules that it received from MBS Sync controller of ASN-GW. To determine MCS in multiple BS access, we consider channel condition for all MBS users which belong to same MBS zone although not same BS.

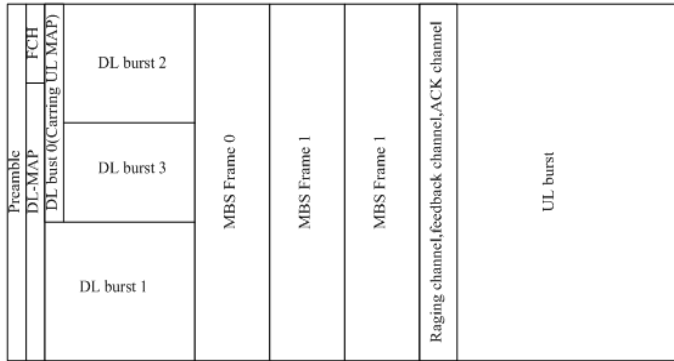


Figure 1. Wimax OFDMA frame structure

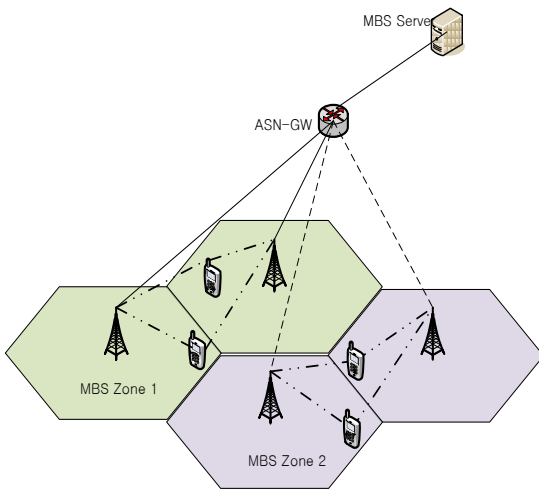


Figure 2. Network architecture of MBS system over multiple BS

It is difficult to enable link adaption algorithm from the fact that channel information reporting for multi users result in a large amount of uplink overhead. Therefore the conventional methods are developed in order to reduce this overhead. Instead of sending channel information of all MBS users, MBS users send NACK if channel condition is not good in [4] and [5]. In [5] algorithm, BS receives NACK from MBS users, if SINR is less than threshold SINR. And then the BS selects MCS based NACK indication. This algorithm sends NACK every time MBS user measures channel condition. The channel feedback increases, as the number of MBS users increase. Also this algorithm [5] applies only to single BS access. In multiple BS access system, MBS users combine not only signal from current BS but also signal of other BSs which belong to same MBS zone. Therefore, multiple BS access has

a much better SINR performance than single BS access[9]. Our investigation results reveal that channel condition of MBS user is not changed frequently in multiple BS access system. In order to reduce uplink feedback, we propose that MBS user send ACK or NACK if channel condition is changed. And we determine MCS according to the number of NACK in the same MBS zone.

III. PROPOSED ALGORITHM

We propose a link adaption algorithm with reduced uplink feedback in multiple BS access. As mentioned before, in multiple BS access, MBS users obtain macro-diversity gain by receiving MBS data from multiple BSs which belong to same MBS zone. As a result, SINR of MBS user in multiple BS access is larger and change more slowly than SINR of MBS user in single BS access. Motivated by the above investigation, we reduce uplink feedback by sending channel information when channel condition changes. And then in our proposed algorithm, we determine MCS with limited uplink feedback.

TABLE 1. Notation list

$SINR_T$	channel condition in T time
$SINR_m$	threshold SINR according to MCS level(MCS_m)
N_j^i	number of NACK for i -th BS in j -th MBS zone
N_j	summation of number of NACK for i -th BS in j -th MBS zone
γ_j	threshold in j -th MBS zone
X_j	coverage ratio
P_j	total MBS user of j -th MBS

Figure 3 is shows proposed feedback algorithm. Notations used in paper are listed in Table 1. The MBS users send NACK if MBS user's channel condition $SINR_T$ is less than threshold $SINR_m$. On the other hand, if channel condition of MBS user is larger than threshold $SINR_m$, MBS user measures channel condition regularly or irregularly without sending NACK. Next, only MBS users which send NACK in time T transmit ACK if channel condition of MBS users $SINR_{T+\alpha}$ is greater than $SINR_m$. In proposed algorithm, we transmit ACK/NACK when only channel condition is change. This implies that we can effectively reduce uplink feedback.

Each BS classifies channel information of MBS user. For example if BS receive NACK, BSs are set as $N_j^i = N_j^i + 1$. In contrast, if BS receive ACK, BSs are set as $N_j^i = N_j^i - 1$. And then each BS transmits N_j^i to MBS sync controller of ASN-GW in order to determine MCS. MCS level is determined by coverage, where the coverage is defined percentage of MBS users who successfully received the MBS data. In the proposed algorithm, we select MCS level consider coverage of MBS zone.

First, ASN-GW classifies the number of NACK N_j^i received by multiple BS. The total channel state for j -th MBS zone is the summation of number of NACK for i -th BS as follows:

$$N_j = \sum_{i=1}^K N_j^i \quad (1)$$

In other words, N_j is the number of MBS users who not received MBS data. Then we define threshold to satisfy coverage as follows:

$$\gamma_j = (100 - X_j) * 0.01 * P_j \quad (2)$$

where X_j is coverage ratio and P_j is total MBS user of j -th MBS.

Second, to determine MCS level, we compare N_j and γ_j . The initial parameters are set as $m=0$, $MCS_m = MCS_0$ and $SINR_m = SINR_0$. If N_j is less than γ_j , we change MCS level from MCS_m to MCS_{m+1} . This result means that coverage of MBS zone is enough to upgrade MCS level. In contrast, if N_j is greater than γ_j , we change MCS level from MCS_m to MCS_{m-1} . In this case, we decrease the MCS level to satisfy coverage ratio. The details of proposed link adaption algorithm are described as shown in Table 2. In the next section, the simulation results reveal that proposed algorithm reduce uplink feedback without any performance degradation.

TABLE 2. The procedure of the proposed link adaption algorithm

Step 1:	$m=0$ (modulation level), MCS_0 , $SINR_0$
Step 2:	IF (receive NACK) $N_j^i = N_j^i + 1$ (i -th BS in j -th MBS zone) ELSE (receive ACK) $N_j^i = N_j^i - 1$ END IF
Step 3:	Each BS transmits N_j^i to MBS synch controller of ASN-GW
Step 4:	$N_j = \sum_{i=1}^K N_j^i$ (K =the number of BSs which belong to same MBS zone)
Step 5:	FOR $j = 1, \dots, L$ DO (L = the number of MBS zone) IF ($N_j < \gamma_j$) $MCS_m = MCS_{m+1}$ (upgrade MCS) $SINR_m = SINR_{m+1}$ ELSE $MCS_m = MCS_{m-1}$ (downgrade MCS) $SINR_m = SINR_{m-1}$ END IF END FOR

IV. SIMULATION RESULTS

For the performance evaluation, we assumed some parameters according 802.16m Evaluation Methodology[8]. Table 3 shows parameters that have been used in this simulation. MBS zones are composed of 7BSs and 4BSs zones in a wrap around scenario, as shown in Fig 4. For the performance comparison, we consider NACK based algorithm [5] where all MBS users transmit NACK if channel condition of MBS user is lower than threshold SINR. Let us define the average feedback number of MBS user as the average number of MBS users that transmit uplink feedback in one frame.

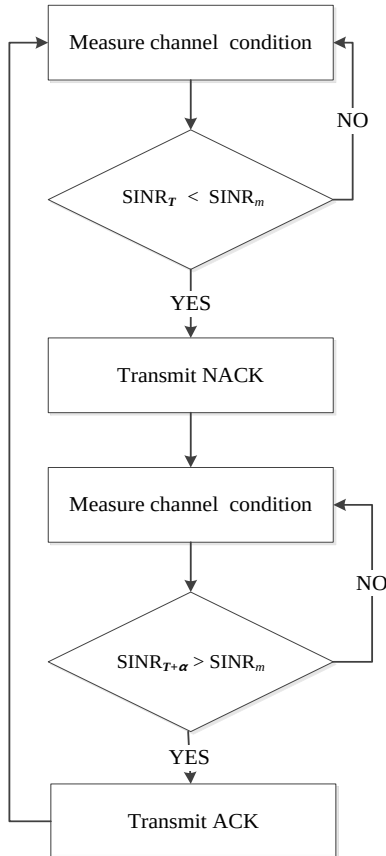


Figure 3. Proposed feedback algorithm

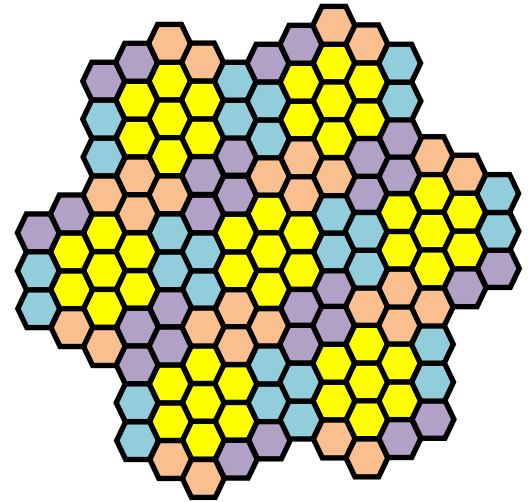


Figure 4. MBS zone

TABLE 3. Simulation parameter

Description	Value
Inter Site Distance(ISD)	1000m
Number of tiers	2
Number of sectors per BS	3
Number of cells	19
Number of users	full buffer : 30
Pathloss type	Urban Macro
Multipath type	ITU-R Pedestrian B Vehicular A
Shadow modelling	WINNER Channel Model II
Shadowing standard deviation	8dB
Antenna structure	1×1 (SISO)
frame structure	IEEE 802.16m
link to system level modelling	RBIR
frequency reuse	1
scheduling type	round robin
AMS speed	3 [km/h]
FFT size	1024
nominal bandwidth	10
carrier frequency	2.5
OFDMA symbol	102.857
CP ratio	1/8
Frame duration	5

In order to compare average feedback number of MBS user, we set same SINR threshold in proposed algorithm feedback and NACK- based algorithm [5]. Table 4 shows average feedback number of MBS user according to $SINR_m$. The proposed algorithm shows reduced feedback compared NACK-based algorithm. For example proposed algorithm 17% feedback of the NACK based algorithm. Also feedback reduction of the proposed algorithm becomes more significant in high $SINR_m$. The proposed algorithm reduced uplink feedback by transmitting NACK or ACK when channel condition of MBS users is changed.

TABLE 4. Average number of feedback MBS users

$SINR_m$	Proposed algorithm	NACK based algorithm [5]
-12.8dB	0.17	0.97
-6.6 dB	1.96	17.88
-0.2 dB	7.7	101.17

Figure 5 and Table 5 compare average sector throughput and average number of feedback MBS users of proposed algorithm and NACK-based algorithm[5] with $X_j = 95\%$. We note that proposed algorithm requires much less uplink feedback compared to NACK-based algorithm[5] in Table 4. For example, with $X_j = 95\%$, proposed algorithm requires 37% uplink feedback of the NACK-based algorithm[5] while maintaining same sector throughput .

TABLE 5. Average feedback number of MBS user

Coverage ratio	Proposed algorithm	NACK-based algorithm [5]
95%	0.48	0.85

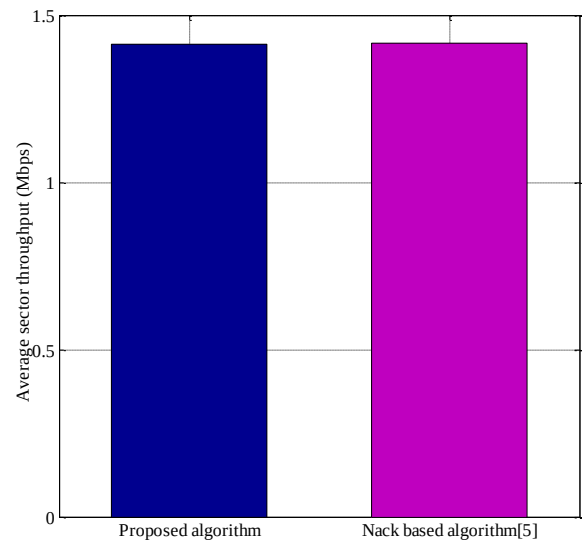


Figure 5. Average sector throughput of NACK-based algorithm and proposed algorithm

V. CONCLUSION

We newly found the fact proposed algorithm achieves rather reduced uplink feedback compared to NACK-based algorithm for Multicast and Broadcast in 802.16m system. We send ACK or NACK when channel condition of MBS users is changed significantly. And then we properly select MCS level based on total number of NACK in multi-access BS system. As a result, we achieve the significantly reduced uplink feedback while maintaining same sector throughput. We will study power control of proposed algorithm for further study.

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