

Power Allocation for Broadcast and Multicast Service

Hannah KIM *, Young-il KIM*

*ETRI(Electronics and Telecommunications Research Institute) , Korea

rtkim@etri.re.kr

Abstract—Multicast and Broadcast Service (MBS) is transmission method that multiple BS in the same geographical area compose the MBS zone to transmit the same data to multi users simultaneously. MBS users combine MBS signals which belong to same MBS zone. Therefore, MBS has a much better SINR performance than unicast service. Despite its greater efficiency, it is difficult to enable power control consider channel condition of all MBS users. Users located edge of MBS zone have lower SINR performance than inner users of MBS zone. Because users in the MBS zone boundary receive MBS signals affected by interference from neighboring BS of other MBS zones. Therefore we propose power allocation scheme for MBS zone. The main purpose of power control is to minimize the transmission power thus avoiding unnecessary high power levels and eliminating neighbor MBS zone interference. The performance of the proposed scheme is analyzed in terms of throughput and transmission power. The effectiveness of the proposed scheme is verified by computer simulation.

Keywords—Muliticast , Broadcast, MBS zone, power allocation, Sector

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[1]. MBS is intended to efficiently use system resources by transmitting same data to multi users simultaneously. Multiple Base Station(BS) in the same geographical area compose the MBS zone to transmit the same MBS contents using the same multicasting channel. Therefore, MBS subscribers which belongs to a MBS zone receive all MBS signals of BS which belongs to same MBS zone.

Despite its greater efficiency, it is difficult to enable power control consider channel condition of all MBS users. Also the users near the MBS zone boundary has lower SINR performance than inner users of MBS zone. Because the users in the MBS zone boundary receive MBS signals affected by interference from other neighboring BS of other MBS zones. Therefore we proposed power control scheme for MBS zone in order to minimize transmission power of base station , thus reducing interference.

This paper is structured as follows: Section II describes MBS system model in 802.16m. In Section III, we propose power allocation algorithm with power reduction. Section IV presents simulation results. Finally we describes conclusion in Section V.

II. SYSTEM MODEL

In mobile Wimax standards, each BS belong to MBS zone which is composed of multiple BSs. To provides a macrodiversity gain and performance enhancement of users, several BSs in the same MBS zone transmit same signals at the same time on the same frequency. We assume the transmission by different BSs in the same MBS zone should be synchronized.

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

The signal to interference plus noise ratio(SINR) for each MBS user in k -th subcarrier, denoted $\text{SINR}(k)$ as ,can be expressed as[2]

$$\text{SINR}(k) = \frac{\sum_{i=0}^{N_s-1} P_{tx}^i P_{bss}^i |H^{(i)}(k)|^2}{\sigma^2 + \sum_{j=0}^{N_I-1} P_{tx}^j P_{bss}^j |H^{(j)}(k)|^2} \quad (1)$$

where N_s is the number of MBS base station in the MBS zone and N_I is the number of interferers. P_{tx}^i is the total transmit power from i -th sector and P_{bss}^i is the distance dependent path loss including shadowing and antenna gain from i -th sector. $H^{(i)}(k)$ is the channel gain for k -th subcarrier and i -th sector and σ^2 is variance of AWGN. In the unicast service, users detect interferers without signals that users belong to sector. However in the multicast service, users combine not only signal from current sector but also signal of other sector which belong to same MBS zone. Therefore, multicast has a much better SINR performance than unicast service[6].

The Mobile Wimax system contains some base station having three sectors. A multi-sectored BS comprises multiple independent transmit and receive antennas. In the case of unicast, users in differencet sectors use the same frequency and result in low edge throughput due to intercell interference. In order to reduce intercell interference, the Mobile Wimax

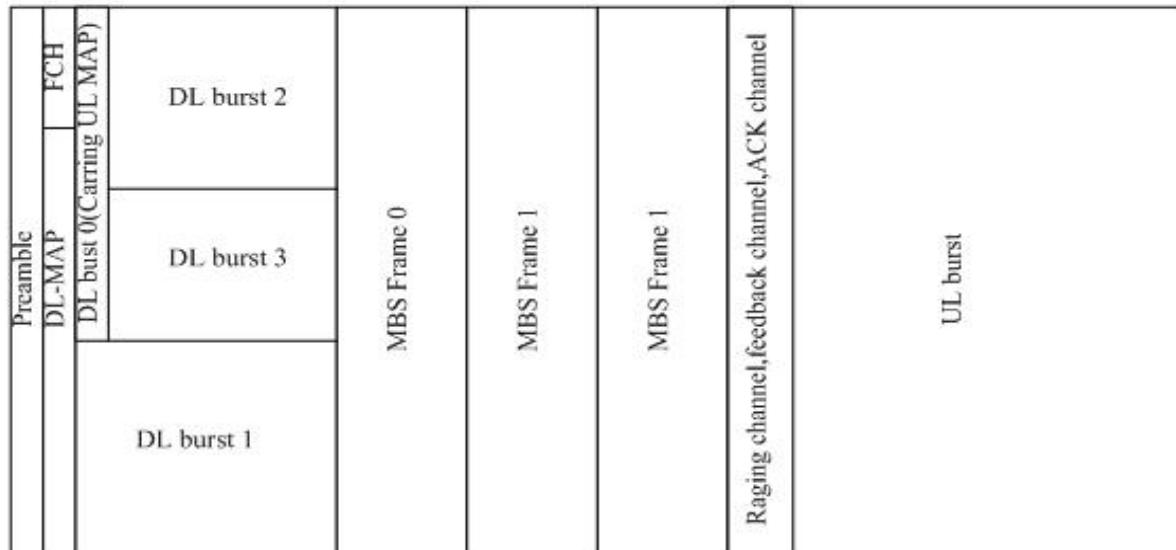


Figure 1. Wimax OFDMA frame structure

system is applied Fractional Frequency Reuse (FFR) in unicast[3]. In the case of Multicast, MBS signals affected by interference from neighboring sector of other MBS zones unlike unicast. For example, users located center of MBS zone received MBS signals from different BS which belong to same MBS zone, instead of being interfered by each other, This leads to an increase of the SINR of the inner users of MBS zone. On the other hand, users located edge of MBS zone have lower SINR performance than inner users of MBS zone. Because users in the MBS zone boundary receive MBS signals affected by interference from neighboring BS of other MBS zones. Therefore, in this paper, Sectors in a MBS zone are partitioned in two classes, namely inner sector (located inner of MBS zone) and outer sector (located edge of MBS zone). We allocate sector power divided by inner sector power and outer sector power as show in Figure 2.

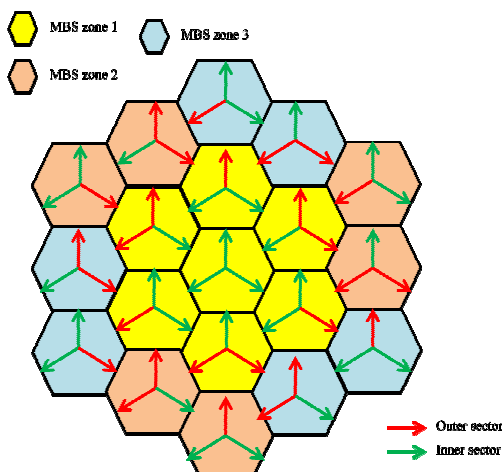


Figure 2. Inner sector and outer sector in MBS zone

III. PROPOSED POWER ALLOCATION ALGORITHM

It is difficult to enable power control consider channel condition of all MBS users because MBS transmit same data to multi users with different channel condition. Therefore the conventional method is either to allocate the fixed transmission power of BS or to select a leader channel condition among MBS users[4].

This paper propose power allocation algorithm. The main purpose of power control is to minimize the transmission power thus avoiding unnecessary high power levels and eliminating neighbor MBS zone interference. As mentioned before, the proposed algorithm consider two step when allocating power,; inner sector power and outer sector power (see figure 2)

First, as MBS user moves towards the edge of the MBS zone, the signal level from BS which belong to same MBS zone falls. This means channel condition of users near the MBS zone boundary is poorer than channel condition of users near the MBS zone center. In order to improve SINR of users near the MBS zone boundary, if transmission power of outer sector in MBS zone is increased, channel condition of users near the MBS zone boundary is good but high power signal acts as interference to other MBS zone user. On the other hand, if the transmission power of outer sector in MBS zone is too low, channel condition of users near the MBS zone boundary is poor due to interference. Therefore, we reduce power of outer sector within not affect performance to reduce interference of neighbor MBS zone.

We newly found the fact that required data rate is satisfied even if outer sector power is reduced twice than fixed power. In this proposed algorithm, we define outer sector power, P_{outer} as follows;

$$P_{\text{outer}} = \frac{1}{2} P_k \quad (2)$$

As outer sector power is reduced twice, interference from neighbor MBS zone become smaller thus we satisfy required data rate because of macrodiversity gain.

Second, if users are located inner sector, macrodiversity is high because user is close sectors of same MBS zone thus interference from neighbor MBS zone is lower than users located edge of MBS zone. Therefore we allocate low power to inner sector while maintaining macrodiversity. We define inner sector power as follows;

$$P_{\text{inner}} = \min(P_{\text{max}}, \quad (3)$$

$$P_{\text{required SINR}} + (\gamma_{\text{required SINR}} - \gamma_{\text{M h n u m S N R o f M B S z o n e}}))$$

where $P_{\text{required SINR}}$ is the minimum power that satisfy coverage of each MCS level, $\gamma_{\text{required SINR}}$ is required SINR for the MCS level and $\gamma_{\text{M h n u m S N R o f M B S z o n e}}$ is the minimum SINR of all MBS users in same MBS zone. Although inner sector power is only satisfied own coverage area, we consider channel condition of users in others sector because inner sector power give other sector macrodiversity.

Consequently, the overall procedure is described as shown in Table 1. In the next section, the simulation results reveal that the power reduction by the proposed algorithm is significant.

Table 1. The procedure of the proposed algorithm

If (sector= outer sector of MBS zone)	
	$P_{\text{outer}} = \frac{1}{2} P_k$
Else (sector= inner sector of MBS zone)	
	$P_{\text{inner}} = \min(P_{\text{max}}, P_{\text{required SINR}} + (\gamma_{\text{required SINR}} - \gamma_{\text{M h n u m S N R o f M B S z o n e}}))$
End if	

IV. SIMULATION RESULTS

For the performance evaluation, we assumed some parameters according 802.16m Evaluation Methodology[3]. Table 2 shows parameters that have been used in this simulation. We set the maximum transmission power, P_{max} to 46dBm. MBS zones are composed of 7BSs and 4BSs zones in a wrap around scenario, as shown in Fig 3.

For the performance comparison, we consider equal power allocation algorithm where each sector transmits an equal amount of power to all users.

In order to find minimum power of outer sector, we fix P_{inner} ($P_{\text{inner}} = P_{\text{max}}$) and we set P_{outer} to $= 1/4 P_{\text{max}}, 1/3 P_{\text{max}}, 1/2 P_{\text{max}}, 2/3 P_{\text{max}}$. Figure 4 compares the average sector throughput of proposed algorithm and equal power allocation algorithm. As show in Figure 4, the proposed algorithm with $2/3 P_{\text{max}}, 1/2 P_{\text{max}}$ shows the same the average sector throughput without any performance degradation. This is because interference from neighbor MBS zone decreases as power of outer sector P_{outer} decreases. However, the proposed algorithm with $1/4 P_{\text{max}}, 1/3 P_{\text{max}}$ has a lower throughput than equal power allocation algorithm. From this results, we set $P_{\text{outer}} = 1/2 P_{\text{max}}$ while maintaining same performance with minimum power.

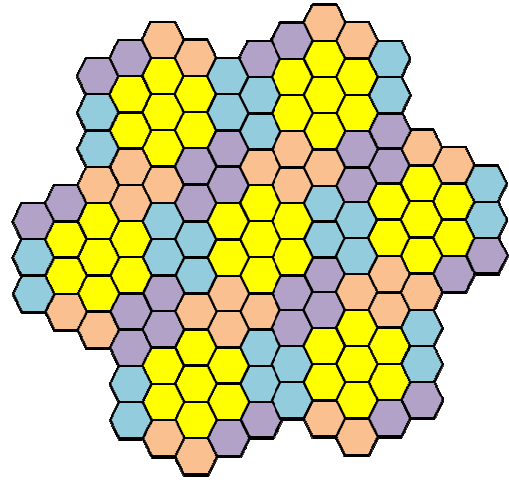


Figure 3. MBS zone

Table2. 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 Pedistrian 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(60%), 60(30%), 120(10%) [km/h]
FFT size	1024
nominal bandwidth	10
carrier frequency	2.5
OFDMA symbol	102.857
CP ratio	1/8
Frame duration	5

Table 3. MCS set and Minimum required SINR for IEEE 802.16m

MCS level	Modulation and code rate	$\gamma_{\text{required SINR}}$ (dB)
0	QPSK 1/2	- 0.2
1	QPSK 3/4	3.2
3	16QAM 1/2	5.2
4	16QAM 3/4	9.4

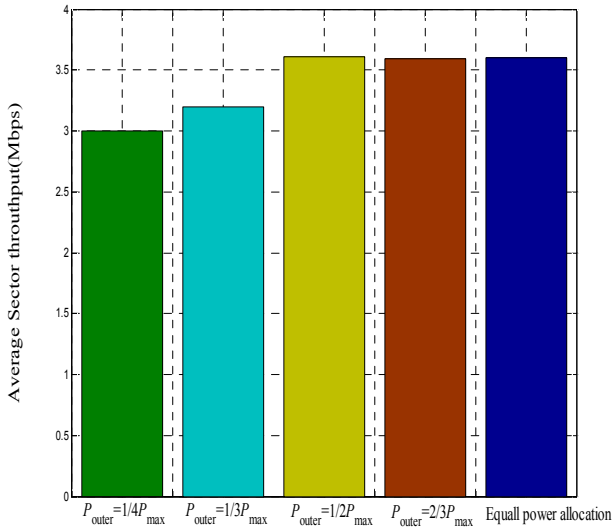


Figure 4. Average sector throughput of equal power allocation algorithm and proposed algorithm
 $(P_{\text{inner}} = P_{\text{max}}, P_{\text{outer}} = 1/4 P_{\text{max}}, P_{\text{outer}} = 1/3 P_{\text{max}}, P_{\text{outer}} = 1/2 P_{\text{max}}, P_{\text{outer}} = 2/3 P_{\text{max}})$

Figure 5 and Figure 6 compare average sector throughput and average sector power of proposed algorithm and equal power allocation algorithm with MCS level=0 (see table 3). We determine $P_{\text{required SINR}}$ and $\gamma_{\text{required SINR}}$ (see table 3) through simulation. As shown in Figure 5, the proposed algorithm shows the same average sector throughput. However, Figure 6 shows that the proposed algorithm achieves significantly reduced power compared to the equal power allocation algorithm. For example, the proposed algorithm requires 63.3% power of the equal power allocation algorithm.

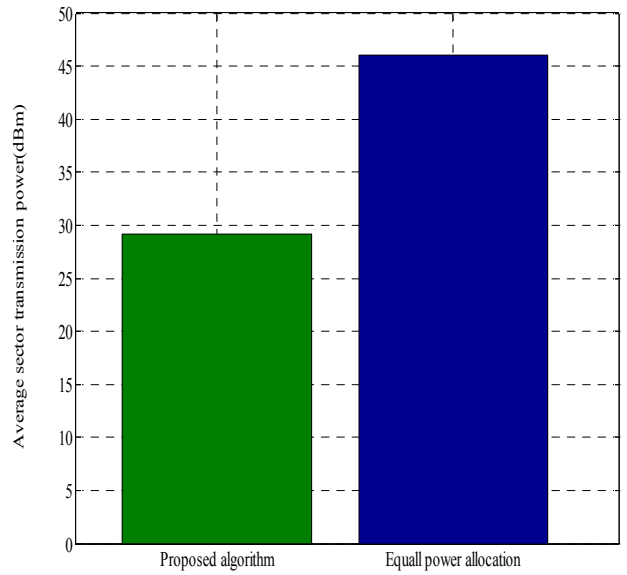


Figure 6. Average sector transmission power of equal power allocation algorithm and proposed algorithm (MCS level=0)

Figure 7 and Figure 8 compare average sector throughput and average sector power of the proposed algorithm and equal power allocation algorithm with various MCS levels. In Figure 7 and Figure 8, we note that the proposed algorithm requires much less power compared to the equal power allocation algorithm. For example, the proposed algorithm with MCS level=3 requires 73.5% power of the equal power allocation algorithm while maintaining the same sector throughput.

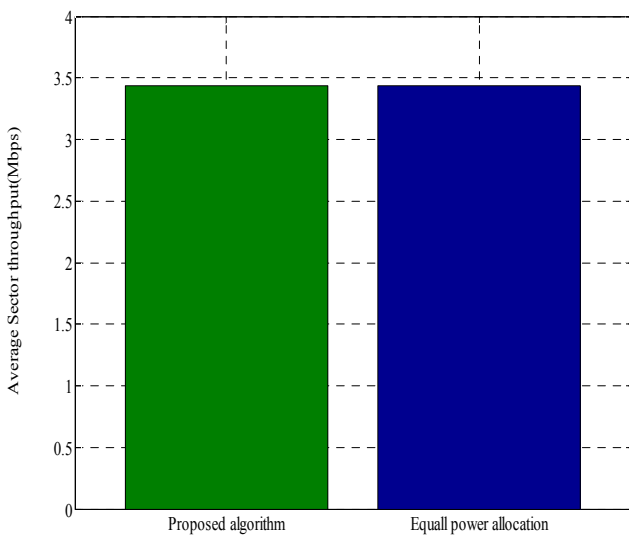


Figure 5. Average sector throughput of equal power allocation algorithm and proposed algorithm (MCS level=0)

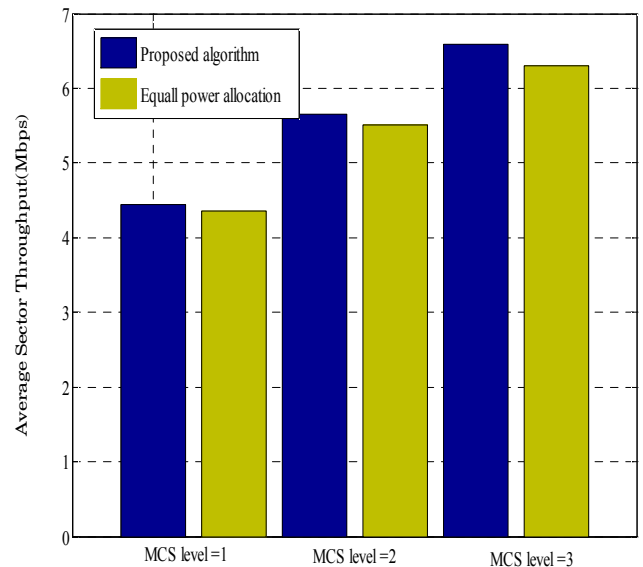


Figure 7. Average sector throughput of equal power allocation algorithm and proposed algorithm (MCS level=1,2,3)

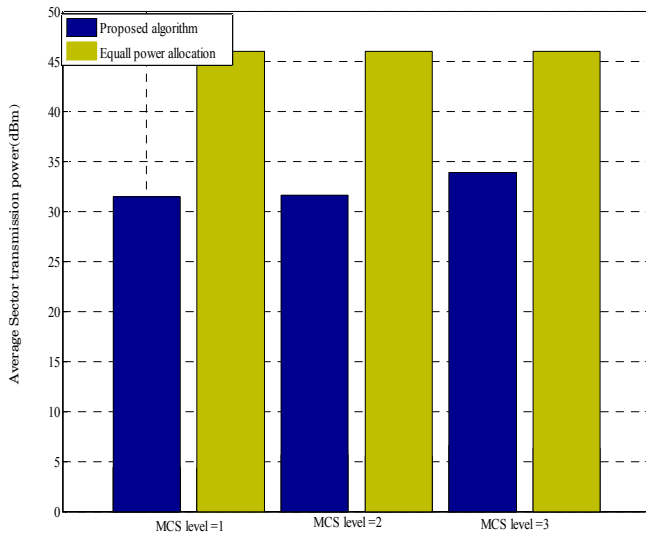


Figure 8. Average sector transmission power of equal power allocation algorithm and proposed algorithm(MCS level=1,2,3)

V. CONCLUSION

We newly found the fact proposed algorithm achieves rather reduced power compared to equal power allocation algorithm for Multicast and Broadcast in 802.16m system. We allocate power of MBS zone divided by inner sector power and outer sector power. We properly allocate outer sector power of MBS zone, so we maximize macrodiversity by reducing interference between MBS zones. In addition, we control inner sector power in order to avoid unnecessary high power levels. Although proposed algorithm demonstrate through simulation, we will study numerical analyze of proposed algorithm for further study.

ACKNOWLEDGMENT

This research is supported by Korea Communications Commission under 10912-03001[The development of IMT-Advanced mobile IPTV core technology].

REFERENCES

- [1] *IEEE Standard for Local and Metropolitan Area Network Part 16: Air Interface For Broadband Wireless Access Systems Amendment 3:Advanced Air Interface*, IEEE Std 802.16m, Mar, 2011.
- [2] Seong Young Seo, Suk Chan Kim and Young Il Kim, "MS aided MBS enhancement algorithm," *Information and Communication Technology Convergence (ICTC), 2010 International Conference on*, pp.101-102, Nov. 2010
- [3] Assaad, M., "Optimal Fractional Frequency Reused in Multicellular OFDMA System," *Vehicular Technology Conference, 2008. VTC 2008-Fall. IEEE 68th*, Sept. 2008.
- [4] Hojoong Kwon and Byeong Gi Lee, "Cooperative Power Allocation for Broadcast/Multicast Service in Cellular OFDM Systems," *IEEE Transactions on Communications*, Vol. 57, No 10, OCT 2009
- [5] *IEEE 802.16m Evaluation Methodology Document(EMD)*, Jan, 2009
- [6] Vladeta Vasilije Milenkovic, Nikola Milos Sekulovic, Mihajlo Caslav Stefanovic, and Mile Branko Petrovic, "Effect of Microdiversity and Macrodiversity on Average Bit Error Probability in Gamma-Shadowed Rician Fading Channels," *ETRI Journal*, vol.32, no.3, pp.464-467, June 2010.