Synchronization Method of Broadcast Messages for Beamforming Performance in Mobile WiMAX Networks

Sung-Man Kim, *Member, KIMICS*

***Abstract*— We report that broadcast messages in Mobile WiMAX networks should be synchronized throughout all the base stations to gain the benefit of beamforming technique. A simple synchronization implementation of broadcast messages in Mobile WiMAX networks is presented. Using this technique, the interference between broadcast messages and beamformed messages can be reduced.**

***Index Terms*— Mobile WiMAX, beamforming, synchronization, broadcast messages**

I. INTRODUCTION

MOBILE WiMAX (Worldwide Interoperability for Microwave Access) is one of the next generation wireless telecommunication technologies, which is based on the IEEE 802.16 standard [1]. In Mobile WiMAX networks, lots of multiple antenna techniques have been considered to enhance the system performance [2]. Among them, beamforming technology has been considered as a promising technique to increase cell coverage and achievable data rate [3]. Beamforming is an energy focusing technique toward a certain user achieved by choosing appropriate weights for each antenna element with a certain criterion [4]. One of the widely used beamforming technology is channel inversion and regularization technique [5]. The beamforming technology reduces interference from the other signal sources and increase signal to interference and noise ratio.

However, beamforming function cannot be used for broadcast messages because broadcast messages should be delivered to all the users in a cell. Therefore, broadcast messages are transmitted without beamforming processing. The broadcast messages in the current Mobile WiMAX networks are transmitted at different time depending on each base station (BS) since there is no regulation in IEEE 802.16 standard about the synchronization of broadcast messages among BSs. Therefore, broadcast message transmitted by a BS can be interfered by beamformed messages transmitted by an adjacent BS, as illustrated in Fig. 1 (c). If all BSs transmit broadcast messages or beamformed messages at the same time, the interference between broadcast messages and beamformed messages can be reduced, as illustrated in Fig. 1 (a) and Fig. 1 (b). Our simulation result shows that data throughput decreases by about 12 % due to interference if one BS sends a beamformed message while neighboring BSs are transmitting broadcast messages.

To solve the problem, we propose a simple synchronization method of broadcast messages over all BSs for proper beamforming performance in Mobile WiMAX networks [6].

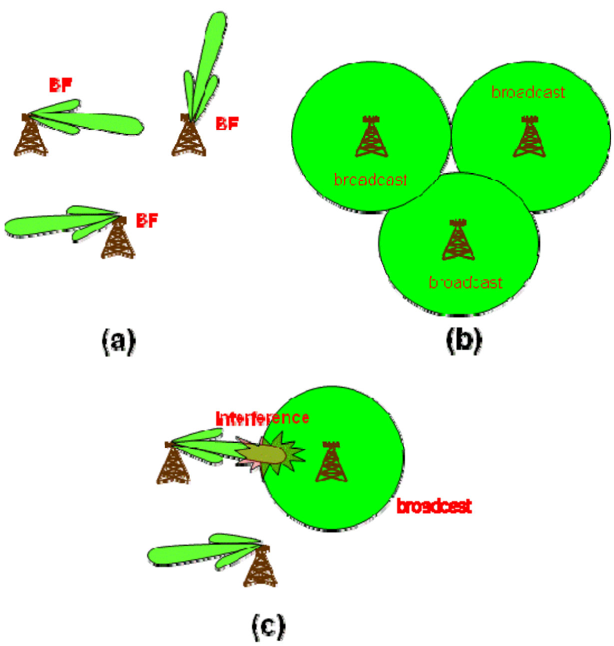

Fig. 1. The requirement of synchronization of broadcast messages for beamforming function. (a) When all BSs transmit beamformed messages. (b) When all BSs transmit broadcast messages. (c) If a BS transmits broadcast messages while other BSs are transmitting beamformed messages, it can cause interference between the beamformed messages and the broadcast messages.

Manuscript received April 27, 2010; revised May 4, 2010; accepted May 17, 2010.

Sung-Man Kim is with the Department of Electronics Engineering, Kyungsung University, Busan, 608-736, Korea (Email: sungman@ks.ac.kr)

II. BROADCAST MESSAGES

MAC (medium access control layer) management messages used in Mobile WiMAX networks are listed in IEEE 802.16 standard [7]. Out of the MAC management messages, the currently used broadcast messages are listed in Table I.

In Table I, UCD is UL (uplink) channel descriptor message transmitted by BSs at a constant periodic interval (about 1~2 second depending on implementation), which defines the characteristics of an UL physical channel. DCD is DL (downlink) channel descriptor message transmitted by the BSs at a constant periodic interval (about 1~2 second depending on implementation), which defines the characteristics of a DL physical channel. MOB_TRF-IND is a traffic indication message which indicates whether there has been traffic to each mobile station (MS) in sleep mode. MOB_TRF-IND is transmitted to MSs in sleep mode during listening windows. Time interval of listening windows is dependent on power saving class [7] and it may not be a constant value. And, the number of MSs in sleep mode is different in each cell.

MOB_NBR-ADV is neighbor advertisement message at a periodic interval (about 2 second depending on implementation). This message is to identify the network and define the characteristics of neighbor BSs to potential MSs seeking initial network entry or handover. MOB_PAG-ADV is BS broadcast paging message during the BS paging interval. This message is related to idle mode and its time interval is dependent on idle mode window. And also, the amount of this message is different in each cell. SII-ADV is service identity information message at a periodic interval (around 5 second depending on implementation). This message is to broadcast a list of network service provider identifiers.

As explained above, some broadcast messages have a period while some broadcast messages do not; the time interval of some broadcast messages depend on sleep or idle mode window. In sleep or idle mode, the time interval of listening window is doubled at each attempt. Thus, even in sleep or idle mode window, there is a common divisor time for transmit time (~ 300 ms for sleep mode and ~ 1200 ms for idle mode) and the transmit time can be synchronized.

Because the amount of broadcast messages is different depending on each cell, perfect synchronization of broadcast messages is theoretically impossible. Nevertheless, we can make a rule to increase the possibility of synchronization of broadcast messages and reduce the interference between broadcast messages and beamformed messges.

TABLE I
BROADCAST MESSAGES IN MOBILE WIMAX

Broadcast Messages	Description	Period
UCD	UL channel descriptor	Fixed value
DCD	DL channel descriptor	Fixed value
MOB_TRF-IND	Traffic indication message	Depends on sleep-mode window
MOB_NBR-ADV	Neighbor advertisement message	Fixed value
MOB_PAG-ADV	BS broadcast paging message	Depends on idle-mode window
SII-ADV	Service Identity broadcast	Fixed value

III. SYNCHRONIZATION ALGORITHM AND DISCUSSION

To synchronize the broadcast messages throughout all BSs, we propose a new algorithm, as illustrated in Fig. 2. In the proposed algorithm, we assumed that every BS has precise clock information via GPS (global positioning system) or network synchronization protocol such as IEEE 1588 [8].

The first step is numbering the frame according to the clock information so that every BS has the synchronized frame number. The second step is defining start time, period, and time interval for each broadcast message identically so that each type of broadcast message can be transmitted at the same time throughout all BSs.

The third step is the most complicated step in the algorithm. Since there are several kinds of broadcast messages that have different time intervals and periods, in some cases, several broadcast messages happen to be scheduled to transmit in the same frame. However, if there is not enough room for the broadcast messages, some broadcast messages supposed to transmit in the $[N]_{th}$ frame is delayed to the next frame ($[N+1]_{th}$ frame). In this case, the next transmit time of the broadcast messages should be the $[N+period]_{th}$ frame, not the $[N+1+ period]_{th}$ frame which is the current implementation.

Fig. 3 shows the importance of the third step. The reason of defining the third step is that the occurrence of the irregular broadcast messages, MOB_TRF-IND and MOB_PAG-ADV, is different depending on each cell. It is dependent on the sleep/idle mode windows and the number and status of MSs in each cell. Thus, the purpose of the third step is to increase the possibility of synchronization of broadcast messages throughout all BSs even when occurrence of the broadcast messages, MOB_TRF-IND and MOB_PAG-ADV, is not identical. If the third step is not applied, as illustrated in Fig. 3 (a), broadcast messages in BS1 and BS2 will not be synchronized. However, if the third step is applied, as illustrated in Fig. 3 (b), the broadcast messages will be synchronized.

Using the algorithm steps, the broadcast messages can be synchronized throughout all BSs. However, the interference between broadcast messages and beamformed messages cannot be eliminated totally because the amount of broadcast messages is not identical in each cell.

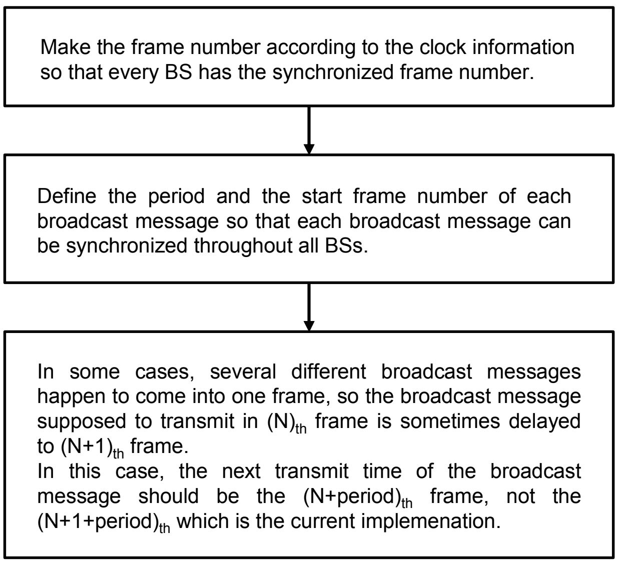

Fig. 2. Algorithm for synchronization of broadcast messages in Mobile WiMAX.

IV. CONCLUSIONS

We reported an interference problem between broadcast messages and beamformed messages in Mobile WiMAX networks. To solve this problem, we proposed a simple synchronization technique of broadcast messages thoughout all BSs. Using the proposed synchronization algorithm of the broadcast messages, the interference between beamformed messages and broadcast messages can be reduced. This technique will help to enhance the performance of beamforming technology in Mobile WiMAX networks.

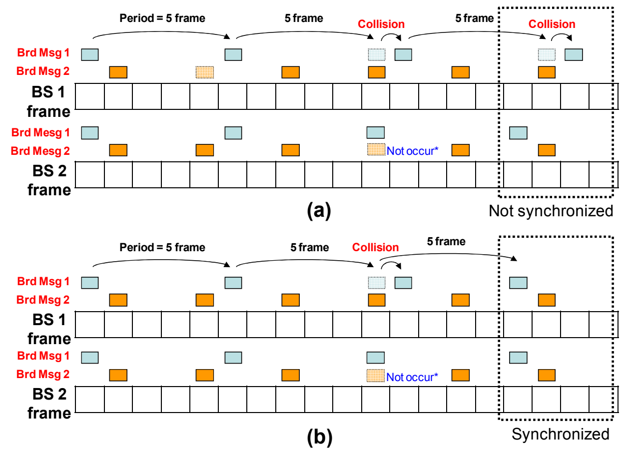

Fig. 3. An example of synchronization of broadcast messages using the third step. (a) When the third step of synchronization algorithm is not applied. (b) When the third step of synchronization algorithm is applied. Broadcast Message 1 (Brd Msg 1) means regular broadcast messages such as DCD or UCD, while Broadcast Message 2 (Brd Msg 2) means irregular broadcast messages such as MOB_TRF-IND and MOB_PAG-ADV. *The Broadcast Message 2, MOB_TRF-IND and MOB_PAG-ADV, sometimes do not occur depending on status of MSs in each cell.

ACKNOWLEDGMENT

This research was supported by Kyungsung University Research Grants in 2010.

REFERENCES

[1] Sung-Man Kim, "A Study on the Output Power Optimization of Mobile WiMAX Base Station", *Journal of Korea Information and Communications Society*, vol.35, no.4, pp.341-349, April 2010.
[2] Sam P. Alex and Louay M. A. Jalloul, "Performance Evaluation of MIMO in IEEE 8021.16e/WiMAX", *IEEE Journal of Selected Topics in Signal Processing*, vol. 2, no. 2, pp. 181–190, April 2008.
[3] Md. Z. Alam, Charles C. Patra, Colin Patra, and M A. Sobhan, "An Efficient Beamforming Technique in WiMAX", *Advanced International Conference on Telecommunications 2009, pp.* 351-356, May 2009.
[4] Jeffrey G. Andrew, Arunabha Ghosh, and Rias Muhamed, *Fundamentals of WiMAX: Understanding Broadband Wireless Networking*, Prentice Hall, ISBN 0-13-222552-2, 2007.
[5] Christian B. Peel, Bertrand M. Hochwald, and A. Lee Swindlehurst, "A vector-perturbation technique for near-capacity multiantenna multiuse communication–Part I: channel inversion and regularization", *IEEE Trans. Commun.*, vol. 53, no. 1, pp 195-202. Jan. 2005.
[6] Sung-Man Kim, "A Study on the Synchronization Algorithm of Broadcast Messages in Mobile WiMAX systems for Proper Beamforming Performance", *Korea Information and Communications Society Annual Summer Meeting*, paper 8E-22, June 2010.
[7] *IEEE Standard 802.16e-2005*, Chapter 6, Feb. 2006.
[8] *IEEE Standard 1588-2002*, Nov. 2002.

Sung-Man Kim received the B.S., M.S., and Ph.D. degrees in electrical engineering from Korea Advanced Institute of Science and Technology (KAIST), Daejon, Korea, in 1999, 2001, and 2006, respectively. His main interests during the Ph.D. course include optical fiber communication.

From 2006 to 2009, he was a senior engineer in the network R&D center, Samsung electronics, Suwon, Korea, where he engaged in the research and development of Mobile WiMAX. Since 2009, he has been a faculty member in the department of electronics engineering, Kyungsung University, Busan, Korea. His research interests include optical fiber communications, mobile communications, and wireless optical communications.