Performance Analysis of Multicast Service Using MBS Region in Mobile WiMAX System

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Abstract— **In this paper, we look at the IEEE 802.16m based MBS and its problem of waste of resource. And we also look at new ways of MBS which have been introduced to overcome the disadvantage of waste of resource. Especially, we closely look at one of the new methods which dynamically configure the MBS region. And then, we show how many base stations are needed to obtain the same performance as the one which is provided by IEEE 802.16 through simulation. And we also show how the resource utilization is changed according to the number of MBS users in a MBS region.**

Keywords— **MBS, MCBCS, E-MBS, E-MCBCS, MBS zone**

I. Introduction

The Mobile WiMAX (IEEE 802.16e and IEEE802.16m) standard defines the multicast and broadcast service (MBS) that simultaneously transmits service contents to multiple users using shared radio resource. The Mobile WiMAX supports two types of MBS in single frequency network environment, one is single-BS MBS and the other is multi-BS MBS. In the single-BS MBS, one base station (here after BS) participates in the MBS, but in the case of multi-BS MBS, more than two BSs are participates in the MBS. In this paper, we consider only the multi-BS MBS.

The region covered by a multi-BS MBS is called MBS zone. And the BSs which belong to the same MBS zone are called member BSs. The member BSs use the same time and frequency resources to transmit MBS traffic to users. So the multi-BS MBS improves the reliability of the signal being received by the macro-diversity effects, even if the MBS users stay in the border of the cell. In addition, when users move between cells belonging to the same MBS zone, there is no need to re-create the MBS connection. Therefore, even if during the handover, the user can seamlessly receive MBS traffic.

However, in the case of multi-BS MBS, the member BSs should always allocate radio resources for the transmission of MBS traffic. Therefore, if users are concentrated in a narrow region within the MBS zone, the radio resources are wasted. In Mobile WiMAX MBS, the radio resource waste problem is due to the fixed configuration of MBS zone without taking into account the mobility of the user.

To solve this problem, there have been several previous studies. One of such studies is to dynamically make MBS zone to reduce the amount of radio resource used in the MBS. We will call this scheme dynamic MBS zone. In the study of dynamic MBS zone, the MBS control server dynamically manages the MBS zone based on the channel quality information which is measured and sent by user terminal [1]. But the problem of this method is that the user may go outside of the current MBS zone when the user performs handover. In other words, the MBS can be stopped whenever the user goes outside the MBS zone. The study [1] show that how often the MBS user leaves the MBS zone dynamically configured due to handover. However, the previous study did not show and compare the throughput performance between the proposed MBS scheme and the mobile WiMAX MBS scheme. Other previous studies [2, 3, 4] is a study on how to efficiently allocate the radio resource to reduce the latency of handover between MBS zones.

In this paper, we will show throughput performance of the study [2] mentioned above. First, we compare the MBS traffic throughput between the approach suggested in the study [1] and the MBS scheme by Mobile WiMAX. The purpose of the comparing the MBS traffic throughput between those two MBS scheme is to show how many member BSs are needed to get the same throughput as the Mobile WiMAX in the study [1]. Finally, we will show how the resource utilization is changed according to the number of MBS users in the study [1].

In Chapter 2 of this paper, we will look at the differences between the dynamic MBS scheme proposed by [1] and IEEE 802.16-based MBS. In Chapter 3, we will perform simulation to compare the performance of the two MBS schemes, by the study [1] and by the IEEE 802.16-based MBS. and the results are compared with each other. Finally, in Chapter 4, we will summarize our work.

II. The Comparison Between the Two MBS Schemes

In this chapter, we will look at two types of MBS schemes more closely. One is proposed by the Mobile WiMAX standard and the other is proposed by the study [1]. For convenience, we will call the former scheme static MBS and the latter scheme dynamic MBS respectively.

A. The Mobile WiMAX MBS (IEEE 802.16m)

Figure 1 (a) shows the network configuration of static MBS scheme specified in the Mobile WiMAX standard. The MBS zone is a group of BSs which use the same MBS ID and Flow ID (FID) for a MBS connection. And the MBS service can be synchronized in symbol level using among those BSs to allow macro diversity [1]. For the synchronization of symbol level, the member BSs consisting of the MBS zone use the same time and frequency to transfer the traffic to users. This allows the users to be seamlessly receive the MBS traffic, even if the users move between cells belonging to the same MBS zone. In addition, the reliability of received signal is improved, even if the users are stay in a boundary of cell.

The MBS is offered in the downlink only. Each MBS zone is identified by the unique MBS zone ID. The member BSs broadcast the MBS zone ID. The MBS ID and FID represents a MBS service flow. And those IDs may be different in a different MBS zone. The MBS ID and FID are assigned to MBS user when he/she requests MBS service connection to one of the member BSs. A member BS can belong to multiple MBS zones serving different MBSs. In figure 1, the MBS network consists of 2 MBS zone, MBS zone A and MBS zone B.

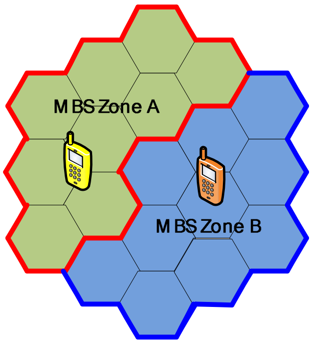

Figure 1. The MBS network configuration by static MBS scheme

In the case of the above static MBS scheme, the member BSs consisting of MBS zone is decided before MBS initiation by a MBS user. In IEEE 802.16m, The MBS user informs the one of the member BSs of the request of MBS transmission by AAI_REG_REQ message. And the BS responds with AAI_REG_RSP message which contains the information of available MBS type in the MBS zone. And then, the user or the BS responding to the user request initiates DSA (Dynamic Service Addition) procedure to make MBS connection between the user and the BS. The user obtain some information required to receive MBS traffic such as MBS ID, FID, MBS zone ID and MBS carrier information through the DSA procedure. Now the user is ready to receive the MBS traffic. And the BS periodically advertise the MBS configuration information through AAI-E-MBS-CFG. The user must update the information required to continuously receive the MBS traffic when the user moves across cell boundary. The AAI-E-MBS-CFG message includes MBS zone ID of serving and neighboring BS, MBS MAP time offset, MBS MAP resource allocation, MBS ID and FID mapping between serving MBS zone and neighboring MBS zone for the same contents.

The static MBS scheme has a waste of resources, depending on the number and location of MBS users. As a worst case example, if there is one MBS user at one member BS among the 9 member BSs consisting of a certain MBS zone, the radio resource of the other 8 member BSs are wasted. In this situation, the service transition from the MBS to unicast service can be one solution to save the radio resource. But during service transition from MBS to unicast service, the service should be interrupted, which causes the degradation of the MBS quality. And the single-BS MBS can be another solution to save radio resource. But in this scheme, the signal quality of MBS users staying at the cell boundary becomes worse as we already mentioned before.

B. The dynamic MBS scheme

In the previous section, we looked over the static MBS scheme. In this section, we examine the dynamic MBS scheme. It is also a way to provides the user with MBS. But this method uses the radio resource more efficiently even if the MBS user distribution is concentrated in a very limited area within the MBS zone and the number of the MBS users are very small.

Figure 2 shows the configuration of MBS network for the dynamic MBS scheme. There are 2 MBS zones, MBS zone A and MBS zone B in the figure. The cells of the same color are member BSs consisting of same MBS zone. And the cells of different color means different MBS zone. The white cell represents an BSs (or cells) that does not transmit the MBS traffic nor the MBS-related control information. And the MBS is supported at the cells which are inside the blue-line boundary.

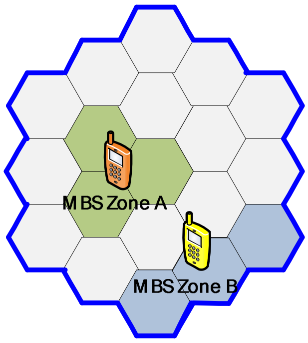

Figure 2. The MBS network configuration by dynamic MBS scheme

In case of the dynamic MBS scheme, the member BSs consisting of MBS zone is decided according to the change of channel quality. The MBS users or BSs always monitors the channel quality. If the channel condition is changed, the member BSs can be also changed. More specifically, the new selection of member BSs by measuring the channel quality are performed whenever each MBS user perform handover and a certain amount of time is elapsed after configuring a MBS zone. In [1], the RSSI (Received Signal Strength Indicator) is used as the metrics for the channel quality.

If a user informs BS of the request for MBS transmission by sending AAI_REG_REQ message, the BS responds AAI_REG_RSP to notify whether the MBS is available or not. If MBS is possible, the user measures the RSSI value of signal received from neighbor BSs through the cell scan procedure and choose the candidate BSs as many as predefined. And the user reports the information of selected candidate BSs to MBS control server. The MBS control server selects the member BSs to participate in the requested MBS among the candidates BSs. The channel quality measured by the user is the primary criteria to select the member BS. Next, the MBS control server sends request for the establishment of MBS traffic path to the each of the BSs which are newly selected as the member of the MBS zone. And it also gives them MBS parameters such as MBS ID, FID, MBS zone ID and MBS carrier information, etc. Now, the new member BSs can receive MBS traffic from MBS content server and transmit it to the user.

The serving BS to which the user are connected initiates DSA procedure to make MBS connection between the user and the serving BS. The serving BS may be a new member BS or the one which is already in the MBS service. The next step is DSA procedure which is mentioned in the static MBS scheme. And the DSA procedure of dynamic MBS scheme is the exactly same as the one of the static MBS scheme.

In the dynamic MBS scheme, the MBS control server predefines the number of member BSs. In addition, the member BSs are chosen by the channel quality between a MBS user and the neighbor BSs of the user. So the member BSs may not be geographically adjacent. Therefore, the geographical shape of the MBS zone in the dynamic MBS scheme may be much dynamic compared with the shape of the MBS zone in the static MBS scheme. As a result, the service interruption may occur more frequently due to handover. This can be a serious problem of the dynamic MBS scheme. The study [1] showed that the probability of the service interruption due to handover was below 15%, 10%, and 10% according to the user speed of 3Km/h, 30Km/h, 120Km/h respectively.

III. SIMULATION RESULTS

In this chapter, we perform system level simulation (SLS) for the dynamic MBS scheme. The SLS is to show that the throughput change of the dynamic MBS scheme according to the number of member BSs and the MBS users. In addition, it is to find that the least number of member BSs for the dynamic MBS zone while the its throughput is almost the same as the one of the static MBS scheme.

The SLS follows EMD (Evaluation Methodology Document) for IEEE 802.16m [5]. The EMD defines the data throughput of a user as the ratio of the number of information bits that the user successfully received divided by the total simulation time. In this paper, we define the MBS throughput as the ratio of the number of MBS information bits that the user successfully received divided by the total simulation time.

A. The Conditions of Simulation

The table I shows the simulation parameters used in this study. And below is the order of throughput calculation according to the EMD.

- Tone SINR (Signal Interference and Noise Ratio)
- Tone RBIR (Received Bit Information Rate)
- Effective RBIR
- Effective SINR
- BLER (BLock Error Rate)
- Data rate

Transmit mode was SISO (Single Input Single Output) and AWGN channel is used to calculate the tone SINR and BLER, respectively. And we refer to QualNet4.0 model library in order to decide handover parameters like the threshold of handover trigger, handover margin [6].

TABLE 1. SIMULATION PARAMETERS

	Simulation Parameters		
	term	**value**	**note**
Simulation Time	# of drops	20	-
	# of frames	240,000	-
Channel Resource	Frame type	TDD	802.16m
	Frame length	5msec	
	Bandwidth	10MHz	-
	Cyclic prefix	1/8	-
	# of FFT / symbol	1024/47	-
	Modulation	QPSK	-
	permutation	PUSC	
	# of cell(BS)	19	Wrap around
	# of member BSs	7	Static MBS
		3 ~ 7	Dynamic MBS
User	# of users	1~20	Random walk
	User speed	3, 30, 120	Km/h

B. The Analysis of Simulation Results

Figure 3 shows the throughput ratio of the dynamic MBS scheme and the static MBS scheme. The considered number of member BSs of the dynamic MBS scheme are 1~7 cells. The considered user speeds are 3Km/h, 30Km/h and 120Km/h.

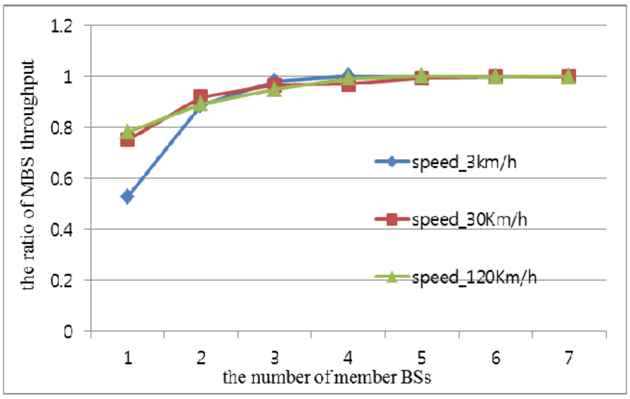

Figure 3. The ratio of MBS throughput according to the number of member BSs for dynamic MBS scheme

In the figure 3, the x-axis represents the number of the member BSs which consist of dynamic MBS zone. And the y-axis is the ratio of the throughput of the static and dynamic MBS scheme. The throughput ratio is calculated by dividing the throughput of dynamic MBS scheme by the throughput of static MBS scheme. The static MBS zone always consists of 7 member BSs. On the other hand, the number of member BSs of the dynamic MBS zone change from 1 to 7 cells. And we assume that there is only one user is using the MBS.

In the figure 3, the throughput is below 80% if the number of member BSs of the dynamic MBS scheme is 1. Especially, in the case of user speed 3Km/h, the throughput ratio of the dynamic MBS scheme compared to the static MBS scheme is about 53%. If the number of member BSs are 2, the throughput ratio is 88% ~ 92% according to the user speed. And if the number of member BSs are 3, the throughput ratio is 95%~98%. Finally, if the number of member BSs are over 4, the throughput of the dynamic MBS scheme is almost equal to the one of the static MBS scheme. Therefore, if the dynamic MBS zone consist of 3 member BSs, it can obtain at least 95%

throughput of the static MBS scheme and reduce the amount of the radio resource required for MBS by about the half of the static MBS scheme.

Below figure 4 shows how the throughput is changed according to the increment of the user number in the dynamic MBS scheme.

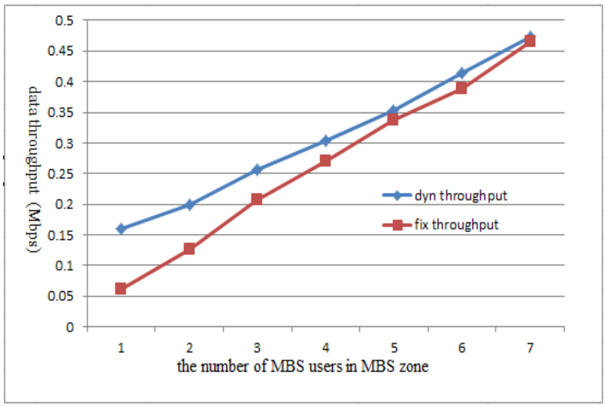

Figure 4. The ratio of MBS throughput according to the number of MBS user number

In figure 4, the data throughput is the number of received bits divided by the amount of used resource to receive the data bits during simulation time. The blue line shows the data throughput of the dynamic MBS scheme. And the red line shows the data throughput of the static MBS scheme.

In case of a single MBS user, the data throughput of the dynamic MBS scheme is about 0.16 Mbps, but the data throughput of the static MBS scheme is about 0.06 Mbps. The ratio of these two MBS scheme is about 2.67. In the case of 2 MBS users, the data throughput of the dynamic MBS scheme is about 2 Mbps, but the data throughput of the static MBS scheme is about 1.3Mbps. The ratio of the data throughput of the two MBS scheme is about 1.58. In the case when the number of MBS user is 3, 4, 5, 6, 7, the ratio of the data throughput is 1.24, 1.12, 1.04, 1.06 and1.01, respectively.

The gap between the data throughput of the dynamic MBS scheme and the data throughput of the static MBS scheme is reduced as the number of MBS user is increased. When the number of MBS user is 7, the data throughput of the dynamic MBS scheme is almost same as the one of the static MBS scheme. This is because the number of member BSs consisting of the dynamic MBS zone is the same as the number of member BSs consisting of the static MBS zone. In the simulation, the users are dropped randomly. Therefore, the users can be evenly distributed in the MBS zone. As a result, the member BSs also may be chosen from very wide area. Below table 2 shows the detail results of the simulation.

TABLE 2. DATA THROUGHPUT

user #	# used resoruce (dyn)	#received bits (dyn MBS)	the ratio	#used rsc (static)	#received bits (static)	the ratio
1	311043	49974.1956	0.160666517	840000	5170.93794	0.061558785
2	513059	102065.2794	0.19893478	840000	10545.10758	0.125536995
3	659876	169238.0844	0.256469525	840000	17405.95122	0.207213705
4	714921	217478.772	0.304199726	840000	22646.7927	0.269604675
5	759322	268097.5962	0.353074975	840000	28284.71688	0.33672282
6	762210	315510.0984	0.413941169	840000	32552.2575	0.387526875
7	796944	376475.1354	0.472398481	840000	39123.3087	0.465753675

IV. CONCLUSIONS

In this paper, we looked over two types of MBS schemes. The first one is static MBS scheme which has a problem of the waste of radio resource. The second one is the dynamic MBS scheme to overcome the problem of the static MBS scheme.

We did simulation to know that how many member BSs for the dynamic MBS scheme are needed to maintain almost the same performance as the static MBS scheme. And we also showed how the resource utilization is changed according to the number of MBS users in the dynamic MBS scheme.

In the simulation we knew that the 3 or 4 member BSs is enough to obtain 95%~98% throughput of static MBS scheme. And also, if the number of MBS users are below 7, the dynamic MBS scheme shows the better throughput performance than the static MBS scheme. But if the number of MBS user is over 7, the gap of the data throughput between the dynamic MBS scheme and the static MBS scheme is very little.

As a result, the dynamic MBS scheme can be a solution to provide the MBS to users while preventing the waste of resource by the static MBS scheme.

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