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Re:	IEEE802.16j-07/019:" Call for Technical Comments Regarding IEEE Project 802.16j"
Abstract	This contribution proposes a practical design for the synchronous multicast and broadcast service (MBS) transmission to achieve macro diversity in the MR networks.
Purpose	Discuss and adopt proposed text by TG16j
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Synchronous MBS Transmission for Macro Diversity in MR Networks

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Introduction

This contribution proposes a practical design for the synchronous multicast and broadcast service (MBS) transmission to achieve macro diversity in the WiMAX MR networks.

All the related RS(s) defined in [1] are expected to be synchronized to achieve the macro diversity in the MBS transmission. Previous work in [2] reveals MBS transmission synchronization may be achieved by previously transmitting data on the relay link to all the RS(s) while informing the RS(s) how long they should wait. The waiting time is the difference between the delay of the longest relay path from MR-BS to any Access RS in the MR-cell and the delay from MR-BS to the specific Access RS with the transit delay through any RS being pre-determined and fixed by the "RS Downlink Processing Delay" reported by the RS to the MR-BS during RS network entry.. The processing delay is reported to MR-BS via SBC-REQ. However, there are several issues regarding this synchronization method:

- The current solution enforces a strict time for forwarding at each intermediate RS (based on the DR reported by the RS). It unnecessarily constrains the flexibility of scheduling at the intermediate RSs and can cause a decrease in the MR-cell's capacity to handle other delay-constrained traffic when compared to the case if intermediate RSs were allowed to forward anytime before their MBS data forwarding deadlines. To allow MBS data synchronization, the basic requirement is only that all RS's within the MR-cell receive the MBS data to be sent over the access link in time for the access RSs to transmit the MBS data successfully in the same (assigned) frame.
- The current solution assumes that all types of MBS traffic being relayed should be treated equally
- There is no mechanism defined to help the MR-BS to identify situations when the transit delay allowances at intermediate RSs needs to be adjusted or should be adjusted to improve relaying performance.
- As defined in [2], when a RS enters or exits the network (or due to other change at RS), the wait time can change and the MR-BS sends unsolicited SBC-RSP to all RS with the modified wait time. Since there is no acknowledgment of SBC-RSP message, MR-BS has no information on whether any RS has received the SBC-RSP message and when the wait time will be changed at the RS. This can cause synchronization problem that can not be corrected until next wait time change.

An alternative solution is proposed to provide the synchronized delivery of MBS data in a MBS zone. The proposed solution supports MBS data synchronization by directing all RSs to transmit MBS data at a specific frame over the access link. The delivery of MBS data to each RS is ensured by using a delay-constrained QoS definition for each relaying connection (multicast or unicast) along the relay paths instead of a fixed transmission time at each intermediate RS. The QoS approach is consistent with mechanisms already provided by 802.16e. In addition, modification to current baseline is included to address some of the issues listed above (such as unacknowledged SBC-RSP)

Proposed Solution

In this contribution, an adaptive method is introduced to provide synchronized transmission of MBS data in a MBS zone. The following section provides a detailed description of this method.

As defined in IEEE802.16j-06/026r4[3], each RS still reports its delay to MR-BS. MR-BS determines cumulative delay based on information received from RS and scheduling information such as the availability of relay zone. When MBS data is scheduled, the transmission time of the MBS data on the access links is determined by a centralized MBS scheduler that is outside the scope of this standard, but the maximum transit delays through all RSs in the paths to all access RSs serving MSs receiving the MBS data are determined by the MR-BS controlling the MR-cell. Therefore, the MR-BS is responsible for achieving successful delivery of the MBS data to all required access RSs within its MR-cell by the appropriate configuration of delay-constrained QoS along all required relay paths so that all access RSs will receive the MBS data before the required transmission time on the access links. The synchronization among multiple MR-BSs is outside the scope of this standard.

To synchronize data transmission for all RSs and MR-BSs in a MBS zone, the MR-BS is required to pre-transmit MBS data to each RS involved in MBS service. When pre-transmitting MBS data to each RS, MR-BS attaches a frame number to the relay MAC PDU which contains MBS data block to be transmitted at a frame over access link. This frame number indicates the target transmission frame of the MBS data. RS is required to transmit the MBS data block at the target transmission frame to MSs over the access link. In addition, the MBS data block is relayed by each intermediate RS to its subordinated RSs in a timely manner to allow synchronized transmission at access link. The relaying of MBS data block is constrained by QoS parameters (such as Maximum latency, etc) for the MBS service flow at each RS. The initial QoS parameters for relaying MBS data block at each intermediate RS are determined by MR-BS during MBS connection set up and are sent to each RS through DSA/DSC messaging.

If a RS receives a relay MBS MAC PDU after its target transmission frame or a RS is not able to process the MAC PDU at its transmission time, the RS should ignore the MBS MAC PDU and send a Access Link Transmission Status feedback to MR-BS. Included in the feedback, the RS should inform MR-BS the number of addition frames that MR-BS should pre-transmit the MAC PDU to meet the target transmission time. In addition, the RS may also optionally send a Access LinkTransmission Status feedback when a MBS MAC PDU arrives at the RS earlier than Early Arrival Report Threshold. The Early Arrival Report Threshold can be configured to RS through SBC-RSP message.

When MR-BS receives feedbacks from one or more RSs, it should re-adjust the pre-transmission time with respect to the target transmission time to ensure all RS successfully transmits MBS data synchronously. Similarly, when a RS enters or exits the network, MR-BS should re-adjust the pre-transmission time based on RS reporting or the processing of Access Link Transmission feedbacks received that may be triggered by the RS entry or exit event..

Figure 1 shows an example message for this method. The MBS scheduler shown in Figure 1 is for illustration purpose only. Its functionality and physical location is outside the scope of this standard and not discussed in this contribution.
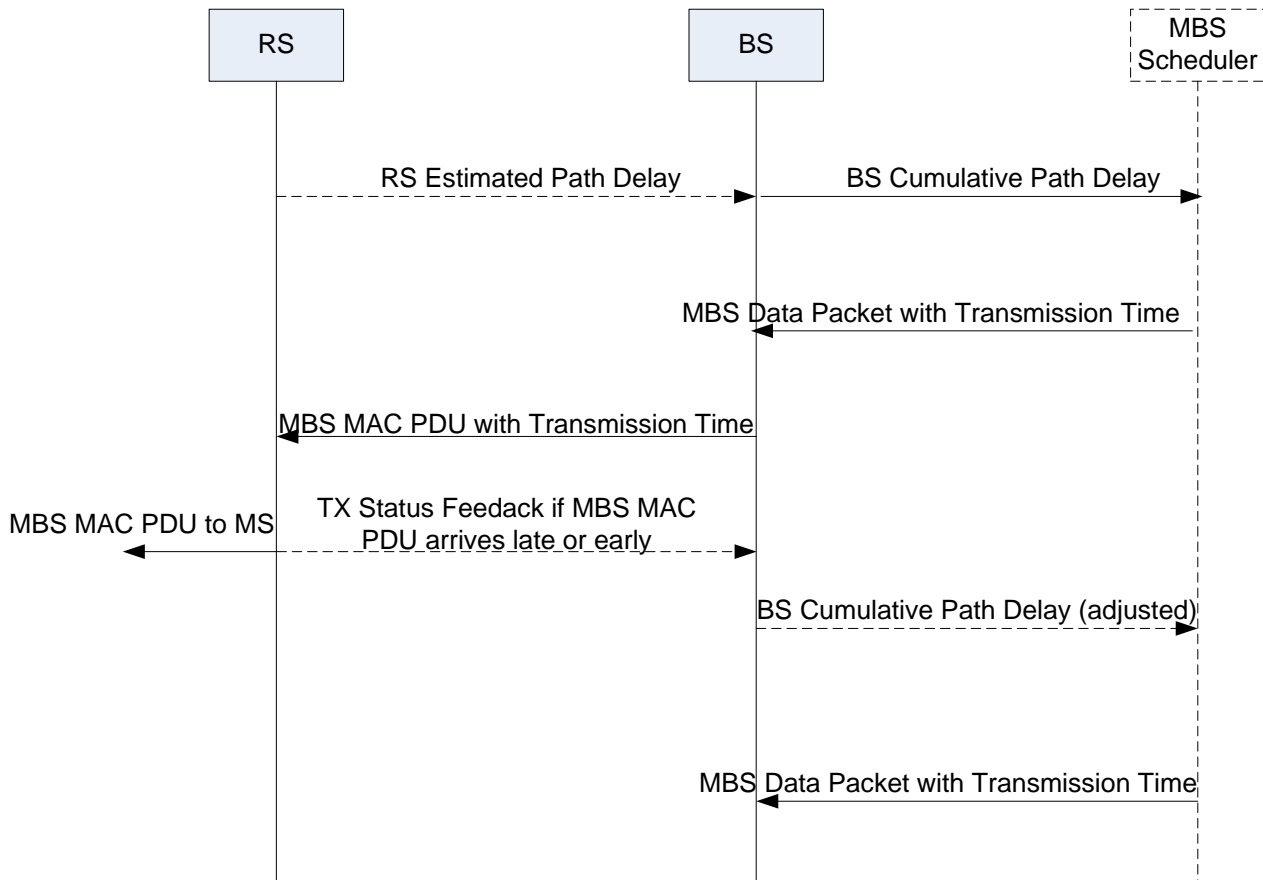
Figure 1 MBS Data Synchronization

Using this method, the MR-BS can adapt to the changes of delay at each RS in a timely manner. When the cumulative delay changes, there is no need to inform each RS of the change. Instead, the RS only needs to transmit the MAC PDU based on the target transmission time specified.

It is proposed that the support of this method and the method currently specified in the baseline document be optional implementation selections for both MR-BS and RS, meaning that to be standards-compliant, an implementation need only provide support for one of the two methods.

Specified Text Changes

[Insert new section 6.3.2.2.8 in 6.3.2.2]

6.3.2.2.8 Relay MAC Subheader

Relay MAC Subheaders shall only be included in Relay MAC PDU with Relay MAC PDU header.

6.3.2.2.8.1 MBS Subheader

MBS subheader is a per-PDU subheader and may be included in all MAC PDUs for a MBS transport connection if Multi-BS MBS service is specified for the connection. When MBS subheader is used, MBS subheader shall be inserted into MAC PDU immediately following Relay MAC PDU header.

MBS subheader is shown in Table xxx:

Syntax	Size	Notes
MBS Subheader{		
Frame Number	8bits	Indicates the frame which RS shall transmit the MAC PDU to MS
}		

Table XXX   MBS Subheader

[Modify section 6.3.2.1.2.2.1, Table7i, insert a new Feedback Type]

6.3.2.1.2.2.1 Feedback header

Feedback Type (binary)	Feedback Contents	Description
1110	Early/Late Indication (1bit) Arrival Delta (8 bits) CID (16bits)	This feedback header is sent by RS to MR-BS to provide access link transmission status for data. The feedback is used when MR-BS provides a target transmission time of the MAC PDU and the RS detect any abnormality in transmitting the MAC PDU. The RS may report missed transmission due to late arrival of a MAC PDU or abnormal early arrival of a MAC PDU in respect to transmission time. Early/Late Indication: 0: Early Indication 1: Late Indication Arrival Delta: Number of frames RS received frames early or late based on Early/Late Indication. For Late indication, this value is the difference in frame number between the target transmission time and frame in which the MAC PDU arrives at the RS. For Early indication, this value is the difference between the transit delay of the MAC PDU through the RS and the early detection threshold as set by the "Relay Data Early Arrival Report Threshold " TLV in the SBC-RSP. CID: CID of transport connection between RS and MR-BS
1110-1111	Reserved for future use	-

[Insert following text in the end of section 6.3.2.3.23:]

6.3.2.3.23 SS and RS basic capability request (SBC-REQ) message

MBS Data Synchronization Mode Support (11.8.3.7.25)
RS Downlink Processing Delay For MBS (11.8.3.7.27)

[Insert following text in the end of section 6.3.2.3.24:]

6.3.2.3.24 SS and RS basic capability response (SBC-RSP) message

MBS Data Synchronization Mode Support(11.8.3.7.25)
Relay Data Early Arrival Report Threshold (11.8.3.7.26)

[Modify text in 6.3.23.3:]

6.3.23.3 MBS in MR network

For MR networks, MBS transmission within an MBS zone shall be synchronized. In Multi-MR-BS-MBS case, MR-BSs should be synchronized in network level as described in section 6.3.23.2.

To facilitate MBS transmission synchronization, ~~If there is only one RS connecting with the MR-BS,~~ an~~that~~ RS shall report its processing delay (in units of a frame), D_R, to the MR-BS as a capability parameter in the SBC-REQ message. When an MBS transmission is necessary, the MR-BS shall first send the MBS data over the relay downlink as a pre-transmission.~~, and then after D_R frames, the MR-BS and RS shall synchronously transmit this MBS data over the access link.~~

When MBS data synchronization with pre-defined relative transmission time is selected, if there is only one RS connecting with the MR-BS, the MR-BS shall first send the MBS data over the relay downlink as a pre-transmission., and then after D_R frames, the MR-BS and RS shall synchronously transmit this MBS data over the access link. If there are multiple RSs in the MBS zone at various hop counts from the MR-BS and/or with different processing delays, each RS shall report its processing delay, D_R, to the MR-BS as a capability parameter in the SBC-REQ message. The MR-BS shall determine the maximum cumulative delay, D_M, of all RSs in the MBS zone based on their positions in the tree and their individual processing delays. The MR-BS shall then calculate the required waiting time, Wi, for each RS based on the value of D_M and each RS's cumulative delay and notify each RS of its waiting time via an SBC-RSP message. If the MR-BS detects that the waiting time has changed for a particular RS, it may send an unsolicited SBC-RSP message to that RS to update its waiting time. When RS receives a unsolicited SBC-RSP message with updated waiting time, it shall sends an ACK header to MR-BS as an acknowledgement for the unsolicited SBC-RSP message. The MR-BS may retransmit SBC-RSP message with the updated waiting time if it does not receive ACK header before the expiration of T49 timer. When an MBS transmission is necessary, the MR-BS shall forward the MBS data over the relay downlink as
a pre-transmission D_M frames before transmitting this MBS data over the access link. Each RS in the MBS zone shall forward the MBS data it receives over the relay downlink. Finally, once the MR-BS has waited D_M frames and each RS has waited its specified waiting time, W_i, the MR-BS and RSs shall synchronously transmit the MBS data over the access link.

[Insert following text in the end of 6.3.23.3:]

When the capability of MBS data synchronization with target transmission time is selected, MR-BS should

determine target transmission frame over access link for each MBS data burst based on maximum cumulative delay, D_M and other MR-BS information. If ARQ is enabled over a relay link, MR-BS may select target transmission frame to accommodate delay due to ARQ retransmission on the relay link.MR-BS shall include frame number of the target transmission frame with each relay MBS MAC PDU using MBS subheader. The RS shall remove relay MAC header and subheaders and transmit the MBS data to MS over access link at target transmission frame. The intermediate RS shall relay MBS data to its subordinate RSs based on the constraints of QoS parameters for the RS's relay connection for the MBS data. During MBS connection setup for an MS, if a relay path with suitable characteristics, such as per-hop QoS configuration, is not available to an Access RS, the MR-BS may initiate the creation of a new relay path to the Access RS with the required characteristics, such as per-hop QoS configuration, using DSA messages. The QoS parameters of any of the constituent per-hop connections on an existing relay path to an Access RS may be changed by the MR-BS via DSC messages.

If a RS fails to transmit a MBS data burst at its target transmission frame, the RS shall inform MR-BS of the failure by sending Access Link Transmission Status feedback header (Feedback type 1110). The RS shall include the duration of late arrival for this MBS data burst in unit of frames. In addition, a RS may provide early arrival information to MR-BS by sending Access Link Transmission Status feedback header if the RS determines a MBS data burst has arrived earlier than Relay Data Early Arrival Report Threshold to its target transmission frame. With early arrival detection, the RS shall include the number of frames exceeding the threshold that the MBS data burst has waited to be transmitted. When Relay Data Early Arrival Report Threshold is set to 0, the early arrival reporting is disabled.

[Modify section 10.1,add the following at the end of table 42:]

10.1 Global values

System	Name	Time Reference	Minimum value	Default value	Maximum value
MR-BS	T49	Waiting for ACK header from RSs within MR-cell after sending unsolicited SBC-RSP to update waiting time	TBD	TBD	TBD

[Insert new section in 11.8.3.7.27:]

11.8.3.7.27 RS Downlink Processing Delay For MBS

This TLV is used to report the time delay for a RS to forward MBS data burst to its subordinate RS when MBS data synchronization with target transmission time is supported. RS downlink processing delay is defined as the minimum time duration a RS requires to transmit the MBS data upon receiving of the data without any queuing delay.

Type	Length	Value	Scope
TBA	1	RS Downlink Processing Delay For MBS(unit: frame)	SBC-REQ

[Insert new section 11.8.3.7.25:]

11.8.3.7.25 MBS Data Synchronization Mode Support

This TLV indicates the capability of MBS data synchronization method is supported by the MR-BS and RS. A bit value of 0 indicates "not supported" while 1 indicates it is supported.

Type	Length	Value	Scope
xxx	1	Bit#0: MBS Data Synchronization with pre-defined relative transmission time (6.3.23.3) Bit#1: MBS data synchronization with target transmission time (6.3.23.3) Bit#2-7: Reserved, shall be set to zero	SBC-REQ SBC-RSP

[Insert new section11.8.3.7.26:]

11.8.3.7.26 Relay Data Early Arrival Report Threshold

When MBS data synchronization with target transmission time is supported, this TLV defines the threshold used by RS to determine when to send Access Link Transmission Status feedback header when one or more MAC PDUs arrives at the RS too early. When the threshold is included, the RS shall send Access Link Transmission Status feedback header to MR-BS when one or more MAC PDU arrives at the RS earlier than the threshold to the target transmission time. When the threshold is set to 0 or if this TLV is not included, RS shall disable the early arrival reporting.

Type	Length	Value	Scope
xxx	1	In frames. When set to 0, the RS shall not send any Access Link Transmission Status feedback header to MR-BS.	SBC-RSP

Reference:

[1] IEEE 802.16e-2005.
[2] IEEE C802.16j-07/005, "A proposal for synchronous MBS transmission in MR".
[3] IEEE 802.16j-06/026r4