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Source(s)	Kerstin Johnsson Intel Corp. 2200 Mission College Blvd. Santa Clara, CA 95054 voice: +1-408-653-9651 mailto: kerstin.johnsson@intel.com Kanchei (Ken) Loa, Yi-Hsueh Tsai, Yung-Ting Lee, Hua-Chiang Yin, Shiann-Tsong Sheu, Youn-Tai Lee Institute for Information Industry 8F, No. 218, Sec. 2, Dunhua S. Rd., Taipei City 106, Taiwan Voice: +886-2-27399616 Fax: +886-2-23782328 loa@iii.org.tw [add other co-authors here]
Re:	IEEE 802.16-08/007: “IEEE 802.16 Working Group Letter Ballot Recirc #28b: Announcement”
Abstract	This contribution proposes modification on SS CDMA BR ranging in the MR system
Purpose	Text proposal for 802.16j Draft Document.
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Comments on CDMA BR ranging in the MR system

Kerstin Johnsson, Ken Loa

Introduction

There is a great deal of text in 6.3.6.7 that repeats text in earlier subclauses of 6.3.6. Subclauses 6.3.6.1-6.3.6.5 cover topics in Bandwidth Request and Allocation. Subclause 6.3.6.7 covers many of the same topics but from a point of view of Relay.

In order to reduce this excessive redundancy, we have subdivided the text in 6.3.6.7 into the appropriate topics and inserted them into the relevant subclauses in 6.3.6.1-6.3.6.5.

I. Changes to text in P802.16Rev2/D0d specification

[Update 6.3.6 as follows:]

6.3.6 Bandwidth allocation and request mechanisms

~~Note that d~~During network entry and initialization every SS is assigned up to three dedicated CIDs for the purpose of sending and receiving control messages. These connection pairs are used to allow differentiated levels of QoS to be applied to the different connections carrying MAC management traffic. ~~Increasing (or decreasing) b~~ Bandwidth requirements ~~is necessary for all services~~ may vary on any connection except UGS ~~connections~~. The needs of UGS connections do not change between connection establishment and termination. Demand Assigned Multiple Access (DAMA) services are given resources on a demand assignment basis, as the need arises.

When an SS needs ~~to ask for~~ bandwidth on a connection with BE scheduling service, it sends a bandwidth request (BR) message to the BS containing the immediate requirements of the DAMA connection. Before assigning bandwidth, the BS looks up the QoS of ~~for~~ the connection which was determined during ~~established at~~ connection establishment ~~and is looked up by the BS.~~

There are numerous methods by which the SS can get the BR message to the BS. The methods are listed in 6.3.6.1 through 6.3.6.6. RSs shall use these BR methods as well; however, in some cases adjustments are made to improve relay performance. These are outlined in the relevant subclauses.

These same methods are used whether the SS/RS is attached to a BS, MR-BS, or non-transparent RS (stations can not attach to a transparent RS). However, the way in which a non-transparent RS handles BR signaling differs depending on the scheduling mode. These different BR handling methods are discussed in the next subclause.

6.3.6.1 Requests

Requests refer to the mechanism that SSs/RSs use to indicate to the ~~BS~~ scheduling station that they need an UL bandwidth allocation. In centralized scheduling mode, the scheduling station is always a BS or MR-BS. In distributed scheduling mode, the scheduling station is the nearest upstream infrastructure station that transmits MAPs (i.e. non-transparent RS or MR-BS). A ~~R~~request may come as a stand-alone BR header or it may come as a Piggy~~B~~back Request (see 6.3.2.2.2). The capability of Piggyback Request is optional.

Because the UL burst profile can change dynamically, all requests for bandwidth shall be made in terms of the number of bytes needed to carry the MAC PDU excluding PHY overhead. The BR ~~message~~ may be transmitted during any UL allocation, except during an~~y~~ initial ranging interval. An SS shall not request bandwidth for a connection if it has no PDU to transmit on that connection.

BRs may be incremental or aggregate. When the ~~BS~~ scheduling station receives an incremental BR, it shall add the quantity of bandwidth requested to its current perception of the bandwidth needs of the connection. When the ~~BS~~ scheduling station receives an aggregate BR, it shall replace its perception of the bandwidth needs of the connection with the quantity of bandwidth requested. The Type field in the BR header indicates whether the request is incremental or aggregate. Since Piggybacked BRs do not have a type field, Piggybacked BRs shall always be incremental. The self-correcting nature of the request/grant protocol requires that SSs/RSs ~~may~~ periodically use aggregate BRs as a function of the QoS of a service and of the link quality. Due to the possibility of collisions, contention-based BRs shall be aggregate requests.

Additional BR mechanisms include the focused BRs (see 6.3.6.4) and CDMA BRs (see 6.3.6.5).

Capability of incremental BRs is optional for the SS and mandatory for the BS/MR-BS/RS. Capability of aggregate BRs is mandatory for SS and BS/MR-BS/RS.

In OFDMA, the bandwidth request is to be interpreted by the ~~BS~~ scheduling station as the amount of data that the SS/RS requires for a connection after the SS/RS has sent the data that is in the current burst.

Upon network entry or re-entry after idle mode, the ~~MS~~ SS/RS shall make an aggregated bandwidth request before making an incremental bandwidth request. After HO, the MS/MRS shall make an aggregated bandwidth request before making an incremental bandwidth request.

[Insert subclauses 6.3.6.1.1 and 6.3.6.1.2 from section II in this document]

6.3.6.2 Grants

~~For~~ Although an SS~~, BRs~~ references individual connections in its BRs, ~~while each~~ the BS responds by assigning bandwidth grants ~~is addressed~~ to the SS's Basic CID, not to ~~the~~ any individual CID~~s~~. Since it is nondeterministic which request is being honored, when the SS receives a shorter transmission opportunity than expected (scheduler decision, request message lost, etc.), no explicit reason is given. In all cases, based on the latest information received from the BS and the status of the request, the SS may decide to perform backoff and request again, ~~or to~~ discard the SDU, or transmit a different SDU.

An SS may use Request IEs that are broadcast, directed at a multicast polling group it is a member of, or directed at its Basic CID. In all cases, the Request IE burst profile is used, even if the BS is capable of receiving the SS with a more efficient burst profile. To take advantage of a more efficient burst profile, the SS should transmit in an interval defined by a Data Grant IE directed at its Basic CID. Because of this, unicast polling of an SS would normally be done by allocating a Data Grant IE directed at its Basic CID. Also note that, in a Data Grant IE directed at its Basic CID, the SS may ~~make~~ transmit BRs for any of its connections.

The procedure followed by SSs is shown in Figure 57.

In relay networks with distributed scheduling, these same bandwidth grant messages and procedures are used by the SS/RS and its superordinate station regardless if that superordinate station is a BS, MR-BS, or non-transparent RS. However, MR-BSs/RSs may use additional signaling to improve relay performance (see 6.3.6.2.1). If the bandwidth request comes from an RS, the superordinate station shall address the bandwidth grant to the RS's Basic CID. The RS may schedule a MAC PDU or relay MAC PDU on the bandwidth allocation it receives.

In relay networks with centralized scheduling, these bandwidth grant messages and procedures are used between the SS/RS and the MR-BS only. However, if there are RSs along the path between the SS/RS and the MR-BS, the RSs play a role in forwarding the grant information. This is detailed in subclause 6.3.6.2.2.

[Insert subclauses 6.3.6.2.1 and 6.3.6.2.2 from section II in this document]

6.3.6.3 Polling

Polling is the process by which the BS allocates to the SSs bandwidth specifically for the purpose of making BRs. These allocations may be to individual SSs or to groups of SSs. Allocations to groups of connections and/or SSs actually define BR Contention IEs. The allocations are not in the form of an explicit message, but are contained as a series of IEs within the UL-MAP.

Note that polling is done on an SS basis. Bandwidth is always requested on a CID basis and bandwidth is allocated on an SS basis.

In relay networks with distributed scheduling, this polling procedure may be used between any SS/RS and its scheduling station whether it is an MR-BS or non-transparent RS.

In relay network with centralized scheduling, only the MR-BS may establish a polling process with an SS or RS in the MR-cell. When the MR-BS polls an SS/RS, it shall setup the polling process so that each intermediate RS along the route from the target SS/RS is polled sequentially so that the response arrives to the MR-BS in the minimum amount of time.

6.3.6.5 Contention-based CDMA BRs for WirelessMAN-OFDMA

The WirelessMAN-OFDMA PHY supports two mandatory contention-based BR mechanisms: the SS shall either send the BR header as specified in 6.3.6.1, or use the CDMA-based mechanism as specified in the following paragraphs of this subclause.

As specified in 6.3.10.3, the OFDMA-based PHY specifies a ranging subchannel and a subset of ranging codes that shall be used for contention-based BRs. The SS, upon needing to request bandwidth, shall select, with equal probability, a ranging code from the code subset allocated to BRs. This ranging code shall be modulated onto the ranging subchannel and transmitted during a Ranging Slot randomly selected from the appropriate ranging region in a single frame.

Upon detection, the BS shall provide (an implementation dependent) UL allocation for the SS, but instead of indicating a Basic CID, the Broadcast CID shall be sent in combination with a CDMA Allocation IE, which specifies the Tx region and ranging code that were used by the SS. This allows an SS to determine whether it has been given an allocation by matching these parameters with the parameters it used. The SS shall use the allocation to transmit a BR MPDU and/or data. The SS may only omit the BR PDU when the BS indicated so in the CDMA Allocation IE (see Table 434).

If the BS does not issue the UL allocation described above, or the BR MPDU does not result in a subsequent allocation of any bandwidth, the SS shall assume that the ranging code transmission resulted in a collision and follow the contention resolution as specified in 6.3.8.

In relay networks with distributed scheduling, this contention-based CDMA BR process may be used between any SS/RS and its scheduling station (MR-BS or non-transparent RS). In relay networks with centralized scheduling, the contention-based CDMA BR process may only be implemented between an SS/RS and the MR-BS.

The MR-BS shall assign unique RS CDMA ranging codes to each RS in its MR-cell in order to reduce the overhead and latency of various processes in relay networks with centralized control (see subclause 6.3.6.5.3). RS CDMA ranging codes are assigned to the RS during its initial ranging process by sending an RS_CDMA_Codes TLV in the RNG-RSP.

[Insert 6.3.6.5.1 and 6.3.6.5.2 from section II of this document here]

[Change all Mesh subclauses to 6.3.6.7.x.x.x and insert the following as subclause as 6.3.6.6]

6.3.6.6 Relay specific bandwidth allocation procedures

Two additional bandwidth allocation procedures are introduced for relay networks in order to improve relay performance. The first is a dedicated relay channel that reduces delay in forwarding relay bursts to the MR-BS. The other is a flow control protocol that helps RSs improve their bandwidth allocation decisions.

6.3.6.6.1 Dedicated relay uplink channel allocation

After RS network entry and initialization, the RS may be assigned a dedicated uplink channel (RS_UL_DCH) by its scheduling station (i.e. the superordinate station in distributed scheduling mode; the MR-BS in centralized scheduling mode).

If the RS is not allocated a dedicated relay uplink channel, it may request one. The dedicated relay uplink channel is assigned via an RS_UL_DCH assignment IE in the RMAP and is available starting the next frame after it is received by the RS.

When a dedicated channel is established for an RS, it impacts the bandwidth requirements on all the relay uplink channels along the path to the MR-BS. In centralized scheduling, the MR-BS shall allocate a dedicated relay uplink channel for each hop along the path. If these already exist, the MR-BS shall adjust their size to accommodate the new RS. In distributed scheduling mode, the RS's superordinate station shall inform the next upstream station along the path to the MR-BS of the new bandwidth requirements so that it can make the proper adjustments to the dedicated channel between them. This process shall continue all the way to the MR-BS.

The initial (and minimum) size of a dedicated relay uplink channel shall be large enough for a management message. This size and/or allocation interval can be increased or decreased based on traffic load. The RS may calculate the traffic load periodically or in response to specific events.

When an SS adjusts its service flow requirements, it impacts the bandwidth requirements on all the dedicated relay uplink channels along the path to the MR-BS. In centralized scheduling, the MR-BS shall adjust the dedicated channel sizes along the path from the SS based on the service flow parameters contained in the signaling exchange of the DSA, DSC or DSD processes.

In distributed scheduling, the service flow adjustment is communicated to the MR-BS via DSA, DSC, or DSD messages. In response, the MR-BS may adjust the dedicated relay uplink channel of the subordinate RS that constitutes the "next hop" along the path to the ~~M~~SS by sending a new RS_UL_DCH assignment IE. This IE contains size adjustment and the CID of the updated service flow. Based on this information, the RS can determine whether the "next hop" to the MS contains yet another dedicated relay uplink channel that needs to be adjusted.

The dedicated resources for all RS UL_DCH shall be allocated consecutively before the non-dedicated RS UL bursts.

When successfully receiving an RS_UL_DCH assignment IE in the R-MAP, an RS shall send a DCH

Assignment ACK in the form of an RS UL_DCH signaling header with DCH TYPE=0001, to its scheduling station. This RS_UL_DCH signaling header shall appear in the first position of the PHY burst specified by the RS_UL_DCH assignment IE in the first frame in which the dedicated uplink resource is activated.

The RS_UL_DCH signaling header with DCH Assignment ACK contains the frame number in which the RS_UL_DCH assignment IE was received. After sending an RS_UL_DCH assignment IE to an RS, the scheduling station shall receive the RS UL_DCH signaling header with DCH Assignment ACK and finish updating resources for the dedicated uplink channel. If the scheduling station fails to receive the RS UL_DCH signaling header with DCH Assignment ACK, it shall transmit the RS_UL_DCH assignment IE again.

When the scheduling station removes a dedicated uplink channel that is assigned to a particular RS, the RS shall send an RS UL_DCH signaling header with DCH Assignment ACK utilizing any of its other uplink allocations.

[Insert 6.3.6.6.2 from section II of this document here:]

II. Changes to text in IEEE P802.16j/D3

3 Definitions

[Insert the following definition into subclause 3:]

3.126 scheduling station: In centralized scheduling mode the scheduling station is always the BS/MR-BS at the root of the PMP tree. In distributed scheduling mode, the scheduling station of a given MS/RS is the first station along the route to the MR-BS that transmits MAPs; i.e. either a non-transparent RS or the MR-BS itself.

6.3.6 Bandwidth allocation and request mechanisms

[Insert the following text after the second paragraph of 6.3.6:]

Bandwidth request methods for the RS are detailed in subclause 6.3.6.7. In addition, an RS may request a dedicated uplink resource by sending a DCH request in the form of an RS UL_DCH signaling header with DCH TYPE=0000. The MR-BS or superordinate RS may dedicate an uplink resource to the RS by sending an RS_UL_DCH assignment IE. The RS shall respond to this type of IE by transmitting a DCH Assignment ACK in the form of an RS_UL_DCH signaling header with DCH TYPE=0001.

Insert new subclause 6.3.6.7:

6.3.6.7 Relay bandwidth request and allocation mechanisms

[Insert new subclause 6.3.6.71.1:]

6.3.6.71.1 Bandwidth request handling in relay networks with Ddistributed scheduling mode

In relay systems with non-transparent RSs operating in distributed scheduling mode, each MR-BS and non-transparent RS directly handles the bandwidth requests it receives from subordinate stations. individually determines the bandwidth allocations on the links it controls (i.e. downlinks to and uplinks from its subordinate stations) and creates its own MAPs reflecting these decisions.

The following subclauses specify bandwidth request and allocation procedures for the relay link (i.e. between an RS and its superordinate RS or MR-BS) in relay systems with non-transparent RSs operating in distributed scheduling mode.

[Insert new subclause 6.3.6.7.1.1:]

6.3.6.7.1.1 Bandwidth request handling and transmission

An non-transparent RS may receive bandwidth requests from its subordinate stations in via the MAC signaling header, the grant management subheader or the CDMA bandwidth request code. Of these, only the grant management subheader may be encrypted.

Depending on whether the RS is capable of decrypting MAC PDUs, there are two ways to handle the grant management subheader. RSs capable of decrypting MAC PDUs shall handle all bandwidth requests locally; while RSs incapable of decrypting MAC PDUs shall handle all bandwidth requests locally except for the grant management subheader. For this type of RS, the encrypted grant management subheader is forwarded to and decrypted by the MR-BS and forwarded returned to the RS using an MR_PBBR-INFO message.

When AES-CCM is used as the encryption algorithm, the MR-BS shall set the PN_Flag = 1 and indicate the packet number in the MR_PBBR-INFO message. The packet number is taken from the encrypted MAC PDU that contains the grant management subheader. When other encryption algorithms are used, the PN_Flag and Packet Number shall be set to zero.

When the RS receives an MR_PBBR-INFO message with PN_Flag = 1, it checks the packet number to see if any ~~standalone (i.e.~~ aggregate~~)~~ bandwidth requests arrived after that packet since these would supersede the bandwidth request information in the MR_PBBR-INFO. If the MR_PBBR-INFO is not superseded or the PN_Flag = 0, the RS shall add the quantity of bandwidth requested in the MR_PPBR-INFO to its current perception of the bandwidth needs of the connection.

Although some RSs can not decrypt MAC PDUs, all RSs can detect the presence of a grant management subheader by checking the type field of the GMH. When an RS detects a grant management subheader but can not decrypt the MAC PDU, it may decide to allocate a small amount of bandwidth to the associated connection as a temporary measure.

The MR-BS may also disable piggybacked bandwidth requests for stations attached to an RS incapable of MAC PDU decryption. This is done by sending the appropriate Capabilities for Construction and Transmission of MAC PDUs TLV in an SBC-RSP message or Request/Transmission Policy TLV in a DSA-REQ/ RSP message.

To forward traffic upstream, an RS may request uplink bandwidth via a stand-alone bandwidth request header or piggyback the request on the relay MAC PDUs. ~~If it is a stand-alone bandwidth request header, it may come as a response to a poll (see 6.3.6.7.1.3) or as a result of a contention-based CDMA bandwidth request process (see 6.3.6.7.1.4). Because the uplink profile can change, all requests shall be made in terms of the number of bytes needed to carry the corresponding MAC PDU or relay MAC PDU.~~ An RS may combine the bandwidth requests that arrive from subordinate stations together with the bandwidth needs of queued packets into one bandwidth request header per QoS class. When resources are available, the superordinate station will allocate bandwidth using the RS's Basic CID.

~~An RS can transmit an aggregate or incremental bandwidth request. When the upstream station receives an incremental bandwidth request, it shall add the quantity of bandwidth requested to its current perception of the bandwidth needs of the connection. When the upstream station receives an aggregate bandwidth request, it shall replace its perception of the bandwidth needs of the connection with the quantity of bandwidth requested. The Type field in the bandwidth request header indicates whether the request is incremental or aggregate. Since piggybacked bandwidth request do not have a type field, they shall always be incremental.~~

The RS should transmit a BW request header soon after it receives a BW request header from one of its subordinate stations (timed to yield an uplink allocation sequential to the arrival of those packets) instead of waiting for the actual packets to arrive in order to reduce delay in relaying traffic (see Figure 60a).

~~***Insert new subclause 6.3.6.7.1.1.1:***~~

~~6.3.6.7.1.1.1 Bandwidth requests~~

~~On the relay link, the contention-based CDMA bandwidth request process and its associated ranging codes are the same as those used on the access link detailed in 6.3.6.5. Alternatively, the MR-BS may assign unique RS CDMA ranging codes to each RS in its MR-cell for the purpose of requesting bandwidth from a superordinate station. RS CDMA ranging codes are assigned to the RS during its initial ranging process by sending an RS_CDMA_Codes TLV in the RNG-RSP.~~

~~The ranging code shall be modulated onto the ranging subchannels and transmitted during the appropriate relay uplink allocation. Upon detection of a ranging code which is not a unique one assigned to an RS, the RS's superordinate station shall provide a relay uplink allocation using a CDMA_Allocation_IE specifying the transmit region and ranging code used by the RS. Once the RS determines it has been given an allocation by matching the transmit region and code it used against those specified by the CDMA_Allocation_IE, it shall use the allocation to transmit a bandwidth request header and/or data. Upon detection of a unique RS CDMA code,~~

~~the RS's superordinate station shall provide a relay uplink allocation without a CDMA_Allocation_IE. If the superordinate station does not issue a relay uplink allocation or if the bandwidth request header does not result in a bandwidth allocation, the RS shall assume that the code is lost and retry sending the code again. The RS should send a bandwidth request CDMA ranging code as soon as it receives one from a downstream station instead of waiting for the actual packets to arrive (see Figure 60b).~~

~~***Insert new subclause 6.3.6.7.1.2:***~~

6.3.6.~~7.1.~~2.1 Bandwidth grant~~s~~ handling in relay networks with distributed scheduling

~~RS bandwidth requests may reference specific connections, while each bandwidth grant an RS receives from its superordinate station is addressed to the RS Basic CID. The RS may schedule a MAC PDU or relay MAC PDU on the bandwidth allocations it receives from its superordinate station.~~

In an MR system with RSs operating in distributed scheduling mode, the MR-BS and non-transparent RSs in the MR-cell each create and broadcast their own MAPs for their subordinate stations. If these subordinate stations are themselves non-transparent RSs that create and broadcast MAPs, the MR-BS/RS ~~or an RS~~ may send them ~~its subordinate RSs~~ uplink scheduling information ahead of time via an RS-SCH management message. This message indicates when a given uplink bandwidth allocation will be granted to the subordinate RS (i.e. in how many frames), the size of the allocation, and which CID it is intended for. The actual bandwidth grant is issued to the subordinate RS using a Data Grant IE in an upcoming UL-MAP. In the case of periodic bandwidth grants, the scheduling information need only be sent once (see Figure 60c).

When an RS receives an RS-SCH management message with uplink scheduling information from its superordinate station (MR-BS or RS), it shall look up the "next hop" of the given CID. Based on this scheduling information and the "next hop" of the CID, the RS can determine the appropriate bandwidth allocations and associated RS UL allocation frame offset on the uplinks it controls. The RS sends its own RS-SCH management messages to its subordinate RSs to inform them of the bandwidth allocation decisions it makes.

~~***Insert new subclause 6.3.6.7.1.2.1:***~~

~~6.3.6.7.1.2.1 Polling~~

~~MR-BSs and RSs can allocate bandwidth to one or more subordinateRSs for the purpose of transmitting a bandwidth request header. This polling process on the relay link is the same as that defined for the access link in 6.3.6.3.~~

~~If the RS is regularly polled, it can transmit a bandwidth request header on the relay uplink to its superordinate station as soon as it detects impending uplink traffic thereby reducing relaying delay (see Figure 60d).~~

~~An MR-BS or RS may inform a subordinate RS of an upcoming polling via an RS-SCH management message (see Figure 60e).~~

~~***Insert new subclause 6.3.6.7.1.2.2:***~~

~~6.3.6.7.1.2.2 Dedicated relay uplink channel allocation~~

~~After RS network entry and initialization, the RS may be assigned a dedicated uplink channel (RS_UL_DCH) by its superordinate station. If the RS is not allocated a dedicated relay uplink channel, it may request one. The dedicated relay uplink channel is assigned via an RS_UL_DCH assignment IE in the RMAP and is available starting the next frame after it is received by the RS.~~

~~The initial (and minimum) size of a dedicated relay uplink channel shall be large enough for a management message. This size and/or allocation interval can be increased or decreased based on traffic load. The RS may calculate the traffic load periodically or in response to specific events.~~

~~When an MS adjusts its service flow requirements, it impacts the bandwidth requirements on all the dedicated relay uplink channels along the path to the MR-BS. This service flow adjustment is communicated to the MR-BS via DSA, DSC, or DSD messages. In response, the MR-BS may adjust the dedicated relay uplink channel of the subordinate RS that constitutes the "next hop" along the path to the MS by sending a new RS_UL_DCH assignment IE. This IE contains size adjustment and the CID of the updated service flow. Based on this information, the RS can determine whether the "next hop" to the MS contains yet another dedicated relay uplink channel that needs to be adjusted.~~

~~The dedicated resources for all RS UL_DCH shall be allocated consecutively before the non-dedicated RS UL bursts.~~

~~When successfully receiving an RS_UL_DCH assignment IE in the R-MAP, an RS shall send a DCH Assignment ACK in the form of an RS UL_DCH signaling header with DCH TYPE=0001, to its superordinate MR-BS/RS. This RS_UL_DCH signaling header shall appear in the first position of the PHY burst specified by the RS_UL_DCH assignment IE in the first frame in which the dedicated uplink resource is activated.~~

~~The RS_UL_DCH signaling header with DCH Assignment ACK contains the frame number in which the RS_UL_DCH assignment IE was received. If the superordinate MR-BS/RS fails to receive the RS UL_DCH signaling header with DCH Assignment ACK, it shall transmit the RS_UL_DCH assignment IE again.~~

~~When an MR-BS or RS removes a dedicated uplink channel that is assigned to a particular RS, the RS shall send an RS UL_DCH signaling header with DCH Assignment ACK utilizing any of its other uplink allocations.~~

~~***Insert new subclause 6.3.6.7.1.3:***~~

6.3.6.6.2.~~7.1.3~~ Downlink flow control for relay networks with distributed scheduling

When RSs operating in distributed scheduling mode are employed in an MR network, the MR-BS may configure individual RSs to send flow control messages to regulate the flow of DL traffic. The MR-BS shall configure DL flow control within the MR-Cell using the REG-REQ/RSP message. Within these messages the MR-BS shall indicate whether DL flow control is enabled or not.

When flow control is enabled within an MR-cell, flow control is performed independently on traffic destined for each RS in the MR-cell. Flow control of the traffic destined for an RS is performed on the link between the RS and its superordinate station. In this case the superordinate station is the transmitter and the RS is the receiver. In addition, when the path between the RS and MR-BS has more than two hops, flow control of the traffic destined for an RS shall be performed between its superordinate RS and the MR-BS. In this case the MR-BS is the transmitter and the superordinate RS is the receiver.

The DL flow control protocol shall operate in one of two states. The first state is called uncontrolled state. In uncontrolled state, the transmitter may send traffic without restriction. The second state is called controlled state. In controlled state, the receiver grants credit to the transmitter specifying the amount of DL traffic that it can safely accept from the transmitter. When flow control is first enabled, it shall begin in the uncontrolled state between all transmitters and receivers in the MR-Cell.

When DL flow control is enabled within an RS, the RS shall monitor the flow of DL traffic in order to determine whether it is necessary to control the flow of DL traffic coming into it. When an RS determines that it is necessary to control the flow of DL traffic, it shall send a DL Flow Control Header (see subclause 6.3.2.1.2.2.2.5) to its superordinate station indicating the amount of credit that it is granting the superordinate station. This header shall be sent using the subordinate RS's Basic CID. The credit shall be specified as the number of bytes of DL traffic that the RS can safely receive. This message indicates to the superordinate that flow control is transitioning into the controlled state.

When an RS receives a DL_Flow_Control Header from its subordinate RS it performs one of the following actions:

- If the CID specified in the DL_Flow_Control Header is the Basic CID of its immediate subordinate station, the RS examines the credit field in the header. If the credit field contains a value other than 0b11111111 it limits the amount of data that it transmits to the subordinate RS to the amount of bytes specified in the credit field. If the credit field contains a value of 0b11111111 the RS turns off flow control for traffic destined for the subordinate RS which sent the DL_Flow_Control Header
- If the CID specified in the DL_Flow_Control Header is not the Basic CID of its immediate subordinate RS, the RS which received the DL_Flow_Control Header forwards it without modification to its superordinate station. This forwards the DL_Flow_Control Header all the way to the MR-BS. In response, the MR-BS may adjust the flow of packets to the RS specified by the basic CID.

When the MR-BS receives a DL_Flow_Control Header it examines the credit field in the header. If the credit field contains a value other than 0b11111111 the MR-BS limits the amount of data that it transmits to the RS whose Basic CID was specified in the header to the number of bytes specified in the credit field. If the credit field contains a value of 0b11111111 the MR-BS shall change the state of flow control to the uncontrolled state for the RS whose Basic CID was specified in the header.

When the MR-cell topology contains paths that are longer than 2 hops, it is possible for the receiver of a DL Flow Control Header to be an RS. When such an RS receives a DL Flow Control Header from its subordinate it may in turn send a DL Flow Control Header to the MR-BS, using the Basic CID of the subordinate RS which has requested flow control. The superordinate RS may indicate the same credit value or a different credit value depending on its internal state. It may also decide not to send a DL Flow Control Header to the MR-BS.

When flow control is in the controlled state, the receiver which initiated flow control shall send DL Flow Control Headers updating the number of bytes of DL traffic that it can safely receive. When the receiver determines that flow control is no longer necessary, it shall send a DL_Flow_Control Header with a credit value of 0b11111111, indicating the transition to uncontrolled state. Upon receiving a DL_Flow_Control Header with a credit value of 0b11111111, the transmitter may go back to sending DL traffic to the receiver in an unrestricted manner.

Figure 60f shows a sample topology that is used to illustrate the flow control process.

Figure 60g illustrates an example flow of DL Flow control message flows. This example assumes the topology in Figure 60f. In this example, RS1 determines that it is congested and sends a DL_Flow_Control Header to RS3 using its Basic CID and indicating that it can accept no more than 500 bytes of data. RS3 limits the amount of data that it send to RS1 to 500 bytes, but decides that it has enough room in its buffers that it need not ask the MR-BS to control the flow of data to RS1. At some later point in time, RS1 has cleared its buffers and sends another DL_Flow_Control Header to RS3 indicating that flow control is off. RS3 resumes sending data to RS1 without flow control.

Figure 60h illustrates a second example flow of DL Flow control message flows. This example also assumes the topology in Figure 60f. In this example, RS1 determines that it is congested and sends a DL Flow Control Header to RS3 using its Basic CID and indicating that it can accept no more than 500 bytes of data. RS3 limits the amount of data that it sends to RS1 to 500 bytes. At some later point in time, RS3 determines that the amount of data destined for RS1 has exceeded an acceptable limit and sends a DL_Flow_Control-Header to the MR-BS. It sends this header on the Basic CID of RS1, in order to indicate to the MR-BS that it should limit the flow of packets to RS1. In this example, RS3 indicates to the MR-BS that it can receive no more than 1000 bytes of data destined for RS1. When the MR-BS receives the DL_Flow_Control Header it limits the amount of data destined for RS1 that it sends to 1000 bytes. It does not limit the amount of data that it sends to RS2 even though this data flows through RS3. At some later point in time, RS1 has cleared its buffers and sends another

DL Flow Control Header to RS3 indicating that flow control is off. RS3 resumes sending data to RS1 without flow control. RS3 also sends a DL_Flow_Control Header to the MR-BS indicating the flow control for RS1 is turned off. The MR-BS resumes sending data destined for RS1 without flow control.

Insert new subclause 6.3.6.7.2:

6.3.6.71.2 Bandwidth request handling in relay networks with Ccentralized Sscheduling mode

In systems with RSs operating in centralized scheduling mode, the MR-BS shall determine the bandwidth allocations (i.e. MAPs) for all links (access and relay) in its MR-cell. This has no impact on transparent RSs since they do not transmit MAPs; however, it impacts non-transparent RSs since they must receive the MAPs from the MR-BS for the links to/from their subordinate stations before they can transmit them.

Thus, before a station can transmit a packet to the MR-BS, that station's bandwidth request must first reach the MR-BS, which then creates bandwidth allocations on the links along the path from the station to the MR-BS. The following subclauses discuss centralized bandwidth request and allocation with transparent and/or non-transparent RSs operating in centralized scheduling mode. A transparent RS does not transmit MAPs. A non-transparent RS transmits MAPs; however, in a centralized scheme these MAPs are determined by the MR-BS.

Insert new subclause 6.3.6.7.2.1:

6.3.6.7.2.1 Bandwidth request handling and transmission

Since the MR-BS creates all MAPs in the MR-cell, an SS/RS's bandwidth request must first reach the MR-BS before allocations can be created for the data along the path to the MR-BS. In centralized mode As a result, RSs shall forward all bandwidth request headers and bandwidth request CDMA ranging code information they receive from subordinate stations to the MR-BS. The RS shall not combine bandwidth request amounts from different sources since the MR-BS must know the details of each bandwidth request in order to assign uplink bandwidth along the proper route.

Bandwidth requests from the RS for its relay uplink may be stand-alone bandwidth request headers or piggybacked on other MAC PDUs. All requests shall be made in terms of the number of bytes needed to carry the MAC header and payload (not including the PHY overhead). The bandwidth request header may be transmitted during any relay uplink allocation, except during initial ranging.

If the RS has available uplink bandwidth, it shall simply forward the bandwidth request information to its superordinate station. Otherwise, the RS shall request uplink bandwidth from the MR-BS using CDMA ranging codes or dedicated RS CDMA ranging codes (see 6.3.6.5.27.2.3).

If the RS needs bandwidth for a MAC management message on its access/relay downlink to a subordinate station, the RS shall either send an RS CDMA ranging code dedicated for that purpose or an RS BR header. In response, the MR-BS shall allocate bandwidth for a management message in the DL-MAP it sends to the RS for broadcast on the access link and notify the RS of this resource by inserting the appropriate IE in the R-MAP.

Insert new subclause 6.3.6.7.2.1.1:

6.3.6.5.1.7.2.1.1 Contention-based CDMA bandwidth requestBRs in relay networks with centralized scheduling

The MR-BS may assign unique RS CDMA ranging codes to each RS in its MR-cell in order to reduce the overhead and latency of various processes in relay networks with centralized control (see subclause 6.3.6.7.2.3).

One such code may be reserved for the purpose of requesting bandwidth along the path from a specific RS to the MR-BS on which to forward a bandwidth request header; another may be reserved for the MR-Code-REP. RS CDMA ranging codes are assigned to the RS during its initial ranging process by sending an RS_CDMA_Codes TLV in the RNG-RSP.

In relay networks with centralized scheduling, When the RS needs to request uplink bandwidth, it an RS shall transmit the appropriate dedicated RS CDMA ranging code to its superordinate station when it needs to contend for bandwidth. Each intermediate RS along the path to the MR-BS shall relay this code in the uplink direction. When the MR-BS receives an RS CDMA ranging code, it shall look up which RS sent the code (there is a one-to-one mapping between RS CDMA ranging codes and RSs in the MR-cell) and create the appropriate bandwidth allocations on the relay links along the path from the RS to the MR-BS. This requires that each RS inform the MR-BS of its processing time.

When a non-transparent RS with unique BSID receives one or more bandwidth request CDMA ranging codes in a frame from its subordinate SSs, it shall forward an MR Code-REP header using its RS basic CID to the MR-BS. The MR Code-REP header shall indicate the number of bandwidth request CDMA ranging codes the RS received. Upon receiving an MR Code-REP header from a non-transparent RS, the MR-BS shall insert CDMA Allocation IEs with certain fields zeroed out into the UL-MAP that it assigns to that RS to broadcast on the access link. These CDMA_Allocation_IEs will have zeros in the fields for Frame Number Index, Ranging Code, Ranging Symbol, and Ranging Subchannel. When a non-transparent RS receives its assigned UL-MAP (see 6.3.28) from the MR-BS containing CDMA_Allocation_IEs with zeroed out fields, the RS shall fill in these fields with the appropriate ranging code and transmit region information and then broadcast this updated UL-MAP on the access link in accordance with the timing specified in subclause 6.3.30.1.

When a transparent RS receives overhears a one or more bandwidth request CDMA ranging codes from a subordinate station, it shall forward an MR-Code-REP message to the MR-BS. The MR-Code-REP contains the CDMA ranging code that was sent by the SS as well as its transmit region and channel adjustment information. If the transparent RS receives more than one bandwidth request CDMA ranging code from its subordinate SSs within one frame, it shall forward as many codes as possible (along with their transmit regions and channel adjustment information) within the MR Code-REP message based on the available uplink bandwidth. If there is not enough bandwidth for all code information, the RS shall indicate in the MR Code-REP message the number size of remaining codes to be reported. Based on this number, the MR-BS can allocate uplink bandwidth for the remaining code information. Using the code and transmit region information the MR-BS shall generate the appropriate CDMA_Allocation_IEs that prompt the SSs to forward their bandwidth request headers on the access uplink. If management messages are relayed on the uplink, the MR-BS shall insert an UL_Burst_Receive_IE in front of the CDMA_Allocation_IE in the UL-MAP. The UL_Burst_Receive_IE shall contain either the RS basic CID of the assigned RS or the multicast management CID. The MR-BS shall also create bandwidth allocations along the relay path from the assigned RS for the purpose of forwarding these SS bandwidth request headers to the MR-BS (see Figure X 60a).

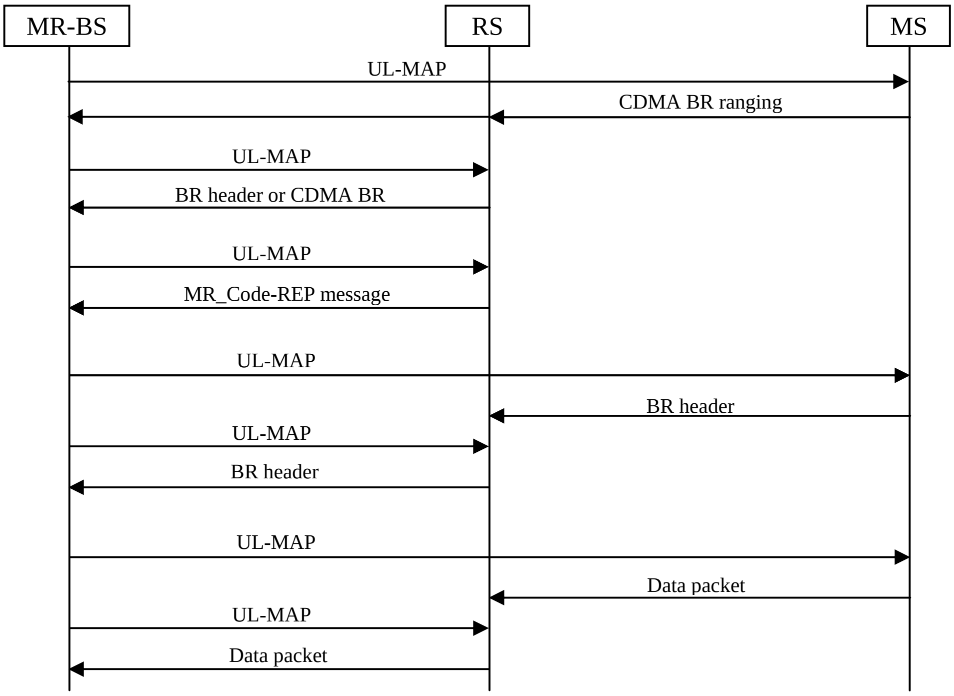

Figure X—BW request/allocation signaling for transparent RS

Insert new subclause 6.3.6.7.2.2:

6.3.6.7.2.2 Bandwidth grants handling in relay networks with centralized scheduling

In relay networks with centralized scheduling, the MR-BS determines bandwidth allocations on all links in the MR-cell. Thus, only the MR-BS creates MAPs. However, if the MR-cell contains non-transparent RSs, the MR-BS shall send the MAPs to these RSs for broadcasting to their subordinate stations.

When an MR-BS allocates bandwidth to forward a packet to/from a given station, it shall allocate bandwidth on all links (relay and access) that make up the path to/from that station taking into account the processing delay and link qualities at each RS along the path as well as the multihop frame structure. To create this continuous forwarding of a packet, the MR-BS shall allocate bandwidth on consecutive links along a path taking into consideration the the intermediate station's processing time. Each RS informs the MR-BS of its minimum forwarding delay capability using the SBC-REQ message during the RS's network entry process.

Insert new subclause 6.3.6.7.2.2.1:

6.3.6.7.2.2.1 Polling

The MR-BS may periodically allocate bandwidth to RSs for the purpose of forwarding bandwidth request information (i.e. bandwidth request headers or bandwidth request CDMA code information). In centralized mode, when the MR-BS decides to poll a particular RS, it shall setup the polling process so that each intermediate RS along the route from the target RS is polled sequentially so that the response arrives to the MRBS in the minimum amount of time.

Insert new subclause 6.3.6.7.2.2.2:

~~6.3.6.7.2.2.2 Dedicated relay uplink channel allocation~~

~~After RS network entry and initialization, the RS may be assigned a dedicated uplink channel (RS UL_DCH) by the MR-BS. If the path from an RS to the MR-BS includes intermediate RSs, the MR-BS shall allocate a dedicated relay uplink channel for each hop along the path. If these already exist, the MR-BS shall adjust their size to accommodate the new RS. If the MR-BS does not allocate a dedicated uplink channel to an RS, the RS may request one.~~

~~The initial (and minimum) size of a dedicated relay uplink channel shall be large enough for a management message. The MR-BS may increase or decrease the size and/or allocation interval based on traffic requirements. The RS may compute its traffic requirements periodically or in response to specific events.~~

~~In centralized mode, only the MR-BS may assign and update a dedicated relay uplink channel. This is done via an RS_UL_DCH assignment IE in the R-MAP and is available starting in the next frame after it is received by the RS.~~

~~When an MS adjusts its service flow requirements, it impacts the bandwidth requirements on all the dedicated relay uplink channels along the path to the MR-BS. To maintain the appropriate size of each dedicated relay uplink channel, the MR-BS shall adjust channel sizes based on the service flow parameters contained in the signaling exchange of the DSA, DSC or DSD processes.~~

~~The dedicated resources for all RS UL_DCH shall be allocated consecutively before the non-dedicated RS~~

~~UL bursts.~~

~~When successfully receiving an RS_UL_DCH assignment IE, an RS shall send a DCH Assignment ACK in the form of an RS UL_DCH signaling header with DCH TYPE=0001 to the MR-BS. The RS UL_DCH signaling header shall appear in the first position within the PHY burst of the first frame in which the dedicated uplink resource specified by the RS_UL_DCH assignment IE is activated. The frame number in the RS UL_DCH signaling header with DCH Assignment ACK is the one in which the RS_UL_DCH assignment IE was received.~~

~~After sending an RS_UL_DCH assignment IE to an RS, an MR-BS shall receive the RS UL_DCH signaling header with DCH Assignment ACK and finish updating resources for the dedicated uplink channel. If the MR-BS does not receive an RS UL_DCH signaling header with DCH Assignment ACK, the RS_UL_DCH assignment IE shall be sent again.~~

~~If the dedicated uplink resource specified by an RS_UL_DCH assignment IE, is smaller than the allocation required to send an RS UL_DCH signaling header with DCH Asignment ACK, an RS may send this headerin other uplink allocations.~~

~~***Insert new subclause 6.3.6.7.2.3:***~~

6.3.6.5.2~~7.2.3~~ Unique RS CDMA code allocation

The MR-BS shall assign unique CDMA ranging codes to each RS in its MR-cell so that it can immediately determine the purpose and the originator of the code. Some codes allow the RS to quickly inform the MR-BS that it is engaged in a ranging process with one of its downstream stations and receive bandwidth from the MR-BS on which to continue or complete the process. Other codes allow the RS to quickly inform the MR-BS that allocations are needed along the route from the RS to the MR-BS on which to forward a specific type of message.

The RS may be assigned several unique CDMA ranging codes in RNG-RSP for communicating the following requests to the MR-BS:

1) RS needs BW on its access downlink (to SS) on which to send a RNG-RSP message. In this case, the RS

does not send an RS BR header to the MR-BS.

2) RS needs BW on the relay uplinks along the path to the MR-BS on which to send an MR Code-REP message, which contains the attributes of one CDMA ranging code and all adjustment information.

3) RS needs BW on its relay downlink (i.e. to its subordinate RS) on which to send a RNG-RSP message. In this case, the RS does not send RS BR header to the MR-BS.

4) RS needs BW on the relay uplinks along the path to the MR-BS on which to forward a 6-byte header

5) RS needs BW on the relay uplinks on which to forward an HARQ error report.

III. Final text of 6.3.6 once sections I and II are merged

{Note: in this section, text not underlined is already in P802.16Rev2/D0d, underlined text is to be inserted by 16j}

[Update 6.3.6 as follows:]

6.3.6 Bandwidth allocation and request mechanisms

~~Note that d~~During network entry and initialization every SS is assigned up to three dedicated CIDs for the purpose of sending and receiving control messages. These connection pairs are used to allow differentiated levels of QoS to be applied to the different connections carrying MAC management traffic. ~~Increasing (or decreasing) b~~ Bandwidth requirements ~~is necessary for all services~~ may vary on any connection except UGS ~~connections~~. The needs of UGS connections do not change between connection establishment and termination. Demand Assigned Multiple Access (DAMA) services are given resources on a demand assignment basis, as the need arises.

When an SS needs ~~to ask for~~ bandwidth on a connection with BE scheduling service, it sends a bandwidth request (BR) message to the BS containing the immediate requirements of the DAMA connection. Before assigning bandwidth, the BS looks up the QoS of ~~for~~ the connection which was determined during ~~established at~~ connection establishment ~~and is looked up by the BS.~~

There are numerous methods by which the SS can get the BR message to the BS. The methods are listed in 6.3.6.1 through 6.3.6.6. RSs shall use these BR methods as well; however, in some cases adjustments are made to improve relay performance. These are outlined in the relevant subclauses.

These same methods are used whether the SS/RS is attached to a BS, MR-BS, or non-transparent RS (stations can not attach to a transparent RS). However, the way in which a non-transparent RS handles BR signaling differs depending on the scheduling mode. These different BR handling methods are discussed in the next subclause.

6.3.6.1 Requests

Requests refer to the mechanism that SSs/RSs use to indicate to the ~~BS~~ scheduling station that they need an UL bandwidth allocation. In centralized scheduling mode, the scheduling station is always a BS or MR-BS. In distributed scheduling mode, the scheduling station is the nearest upstream infrastructure station that transmits MAPs (i.e. non-transparent RS or MR-BS). A ~~R~~request may come as a stand-alone BR header or it may come as a Piggy~~B~~back Request (see 6.3.2.2.2). The capability of Piggyback Request is optional.

Because the UL burst profile can change dynamically, all requests for bandwidth shall be made in terms of the number of bytes needed to carry the MAC PDU excluding PHY overhead. The BR ~~message~~ may be transmitted during any UL allocation, except during an~~y~~ initial ranging interval. An SS shall not request bandwidth for a connection if it has no PDU to transmit on that connection.

BRs may be incremental or aggregate. When the ~~BS~~ scheduling station receives an incremental BR, it shall add the quantity of bandwidth requested to its current perception of the bandwidth needs of the connection. When the ~~BS~~ scheduling station receives an aggregate BR, it shall replace its perception of the bandwidth needs of the connection with the quantity of bandwidth requested. The Type field in the BR header indicates whether the request is incremental or aggregate. Since Piggybacked BRs do not have a type field, Piggybacked BRs shall always be incremental. The self-correcting nature of the request/grant protocol requires that SSs/RSs ~~may~~ periodically use aggregate BRs as a function of the QoS of a service and of the link quality. Due to the possibility of collisions, contention-based BRs shall be aggregate requests.

Additional BR mechanisms include the focused BRs (see 6.3.6.4) and CDMA BRs (see 6.3.6.5).

Capability of incremental BRs is optional for the SS and mandatory for the BS/MR-BS/RS. Capability of aggregate BRs is mandatory for SS and BS/MR-BS/RS.

In OFDMA, the bandwidth request is to be interpreted by the ~~BS~~ scheduling station as the amount of data that the SS/RS requires for a connection after the SS/RS has sent the data that is in the current burst.

Upon network entry or re-entry after idle mode, the ~~MS~~ SS/RS shall make an aggregated bandwidth request before making an incremental bandwidth request. After HO, the MS/MRS shall make an aggregated bandwidth request before making an incremental bandwidth request.

[Insert new subclause 6.3.6.1.1:]

6.3.6.1.1 Bandwidth request handling in relay networks with distributed scheduling

In relay systems operating in distributed scheduling mode, each MR-BS and non-transparent RS directly handles the bandwidth requests it receives from subordinate stations.

A non-transparent RS may receive bandwidth requests from its subordinate stations via the MAC signaling header, the grant management subheader or the CDMA bandwidth request code. Of these, only the grant management subheader may be encrypted.

Depending on whether the RS is capable of decrypting MAC PDUs, there are two ways to handle the grant management subheader. RSs capable of decrypting MAC PDUs shall handle all bandwidth requests locally; while RSs incapable of decrypting MAC PDUs shall handle all bandwidth requests locally except for the grant management subheader. For this type of RS, the encrypted grant management subheader is forwarded to and decrypted by the MR-BS and returned to the RS using an MR_PBBR-INFO message.

When AES-CCM is used as the encryption algorithm, the MR-BS shall set the PN_Flag = 1 and indicate the packet number in the MR_PBBR-INFO message. The packet number is taken from the encrypted MAC PDU that contains the grant management subheader. When other encryption algorithms are used, the PN_Flag and Packet Number shall be set to zero.

When the RS receives an MR_PBBR-INFO message with PN_Flag = 1, it checks the packet number to see if any aggregate bandwidth requests arrived after that packet since these would supersede the bandwidth request information in the MR_PBBR-INFO. If the MR_PBBR-INFO is not superseded or the PN_Flag = 0, the RS shall add the quantity of bandwidth requested in the MR_PPBR-INFO to its current perception of the bandwidth needs of the connection.

Although some RSs can not decrypt MAC PDUs, all RSs can detect the presence of a grant management subheader by checking the type field of the GMH. When an RS detects a grant management subheader but can not decrypt the MAC PDU, it may decide to allocate a small amount of bandwidth to the associated connection as a temporary measure.

The MR-BS may also disable piggybacked bandwidth requests for stations attached to an RS incapable of MAC PDU decryption. This is done by sending the appropriate Capabilities for Construction and Transmission of MAC PDUs TLV in an SBC-RSP message or Request/Transmission Policy TLV in a DSA-REQ/ RSP message.

To forward traffic upstream, an RS may request uplink bandwidth via a stand-alone bandwidth request header or piggyback the request on the relay MAC PDUs. An RS may combine the bandwidth requests that arrive from subordinate stations together with the bandwidth needs of queued packets into one bandwidth request header per QoS class. When resources are available, the superordinate station will allocate bandwidth using the RS's Basic CID.

The RS should transmit a BW request header soon after it receives a BW request header from one of its subordinate stations (timed to yield an uplink allocation sequential to the arrival of those packets) instead of waiting for the actual packets to arrive in order to reduce delay in relaying traffic (see Figure 60a).

[Insert new subclause 6.3.6.1.2:]

6.3.6.1.2 Bandwidth request handling in relay networks with centralized scheduling

In systems with RSs operating in centralized scheduling mode, the MR-BS shall determine the bandwidth allocations (i.e. MAPs) for all links in its MR-cell. This has no impact on transparent RSs since they do not transmit MAPs; however, it impacts non-transparent RSs since they must receive the MAPs from the MR-BS for the links to/from their subordinate stations before they can transmit them.

Since the MR-BS creates all MAPs in the MR-cell, an SS/RS's bandwidth request must first reach the MR-BS before allocations can be created for the data along the path to the MR-BS. As a result, RSs shall forward all bandwidth request headers and bandwidth request CDMA ranging code information they receive from subordinate stations to the MR-BS. The RS shall not combine bandwidth request amounts from different sources since the MR-BS must know the details of each bandwidth request in order to assign uplink bandwidth along the proper route.

If the RS has available uplink bandwidth, it shall simply forward the bandwidth request information to its superordinate station. Otherwise, the RS shall request uplink bandwidth from the MR-BS using CDMA ranging codes or dedicated RS CDMA ranging codes (see 6.3.6.5.2).

If the RS needs bandwidth for a MAC management message on its access/relay downlink to a subordinate station, the RS shall either send an RS CDMA ranging code dedicated for that purpose or an RS BR header. In response, the MR-BS shall allocate bandwidth for a management message in the DL-MAP it sends to the RS for broadcast on the access link and notify the RS of this resource by inserting the appropriate IE in the R-MAP.

6.3.6.2 Grants

~~For~~ Although an SS~~, BRs~~ references individual connections in its BRs, ~~while each~~ the BS responds by assigning bandwidth grants ~~is addressed~~ to the SS's Basic CID, not to ~~the~~ any individual CID~~s~~. Since it is nondeterministic which request is being honored, when the SS receives a shorter transmission opportunity than expected (scheduler decision, request message lost, etc.), no explicit reason is given. In all cases, based on the latest information received from the BS and the status of the request, the SS may decide to perform backoff and request again, ~~or to~~ discard the SDU, or transmit a different SDU.

An SS may use Request IEs that are broadcast, directed at a multicast polling group it is a member of, or directed at its Basic CID. In all cases, the Request IE burst profile is used, even if the BS is capable of receiving the SS with a more efficient burst profile. To take advantage of a more efficient burst profile, the SS should transmit in an interval defined by a Data Grant IE directed at its Basic CID. Because of this, unicast polling of an SS would normally be done by allocating a Data Grant IE directed at its Basic CID. Also note that, in a Data Grant IE directed at its Basic CID, the SS may ~~make~~ transmit BRs for any of its connections.

The procedure followed by SSs is shown in Figure 57.

In relay networks with distributed scheduling, these same bandwidth grant messages and procedures are used by the SS/RS and its superordinate station regardless if that superordinate station is a BS, MR-BS, or non-transparent RS. However, MR-BSs/RSs may use additional signaling to improve relay performance (see 6.3.6.2.1). If the bandwidth request comes from an RS, the superordinate station shall address the bandwidth grant to the RS's Basic CID. The RS may schedule a MAC PDU or relay MAC PDU on the bandwidth allocation it receives.

In relay networks with centralized scheduling, these bandwidth grant messages and procedures are used between the SS/RS and the MR-BS only. However, if there are RSs along the path between the SS/RS and the MR-BS, the RSs play a role in forwarding the grant information. This is detailed in subclause 6.3.6.2.2.

[Insert new subclause 6.3.6.2.1:]

6.3.6.2.1 Bandwidth grant handling in relay networks with distributed scheduling

In an MR system with RSs operating in distributed scheduling mode, the MR-BS and non-transparent RSs in the MR-cell each create and broadcast their own MAPs for their subordinate stations. If these subordinate stations are themselves non-transparent RSs that create and broadcast MAPs, the MR-BS/RS may send them uplink scheduling information ahead of time via an RS-SCH management message. This message indicates when a given uplink bandwidth allocation will be granted to the subordinate RS (i.e. in how many frames), the size of the allocation, and which CID it is intended for. The actual bandwidth grant is issued to the subordinate RS using a Data Grant IE in an upcoming UL-MAP. In the case of periodic bandwidth grants, the scheduling information need only be sent once (see Figure 60c).

When an RS receives an RS-SCH management message with uplink scheduling information from its superordinate station (MR-BS or RS), it shall look up the "next hop" of the given CID. Based on this scheduling information and the "next hop" of the CID, the RS can determine the appropriate bandwidth allocations and associated RS UL allocation frame offset on the uplinks it controls. The RS sends its own RS-SCH management messages to its subordinate RSs to inform them of the bandwidth allocation decisions it makes.

[Insert new subclause 6.3.6.2.2:]

6.3.6.2.2 Bandwidth grant handling in relay networks with centralized scheduling

In relay networks with centralized scheduling, the MR-BS determines bandwidth allocations on all links in the MR-cell. Thus, only the MR-BS creates MAPs. However, if the MR-cell contains non-transparent RSs, the MR-BS shall send the MAPs to these RSs for broadcasting to their subordinate stations.

When an MR-BS allocates bandwidth to forward a packet to/from a given station, it shall allocate bandwidth on all links (relay and access) that make up the path to/from that station taking into account the processing delay and link qualities at each RS along the path as well as the multihop frame structure. To create this continuous forwarding of a packet, the MR-BS shall allocate bandwidth on consecutive links along a path taking into consideration the intermediate station's processing time. Each RS informs the MR-BS of its minimum forwarding delay capability using the SBC-REQ message during the RS's network entry process.

6.3.6.3 Polling

Polling is the process by which the BS allocates to the SSs bandwidth specifically for the purpose of making BRs. These allocations may be to individual SSs or to groups of SSs. Allocations to groups of connections and/or SSs actually define BR Contention IEs. The allocations are not in the form of an explicit message, but are contained as a series of IEs within the UL-MAP.

Note that polling is done on an SS basis. Bandwidth is always requested on a CID basis and bandwidth is allocated on an SS basis.

In relay networks with distributed scheduling, this polling procedure may be used between any SS/RS and its scheduling station whether it is an MR-BS or non-transparent RS.

In relay network with centralized scheduling, only the MR-BS may establish a polling process with an SS or RS in the MR-cell. When the MR-BS polls an SS/RS, it shall setup the polling process so that each intermediate RS along the route from the target SS/RS is polled sequentially so that the response arrives to the MR-BS in the minimum amount of time.

6.3.6.5 Contention-based CDMA BRs for WirelessMAN-OFDMA

The WirelessMAN-OFDMA PHY supports two mandatory contention-based BR mechanisms: the SS shall either send the BR header as specified in 6.3.6.1, or use the CDMA-based mechanism as specified in the following paragraphs of this subclause.

As specified in 6.3.10.3, the OFDMA-based PHY specifies a ranging subchannel and a subset of ranging codes that shall be used for contention-based BRs. The SS, upon needing to request bandwidth, shall select, with equal probability, a ranging code from the code subset allocated to BRs. This ranging code shall be modulated onto the ranging subchannel and transmitted during a Ranging Slot randomly selected from the appropriate ranging region in a single frame.

Upon detection, the BS shall provide (an implementation dependent) UL allocation for the SS, but instead of indicating a Basic CID, the Broadcast CID shall be sent in combination with a CDMA Allocation IE, which specifies the Tx region and ranging code that were used by the SS. This allows an SS to determine whether it has been given an allocation by matching these parameters with the parameters it used. The SS shall use the allocation to transmit a BR MPDU and/or data. The SS may only omit the BR PDU when the BS indicated so in the CDMA Allocation IE (see Table 434).

If the BS does not issue the UL allocation described above, or the BR MPDU does not result in a subsequent allocation of any bandwidth, the SS shall assume that the ranging code transmission resulted in a collision and follow the contention resolution as specified in 6.3.8.

In relay networks with distributed scheduling, this contention-based CDMA BR process may be used between any SS/RS and its scheduling station (MR-BS or non-transparent RS). In relay networks with centralized scheduling, the contention-based CDMA BR process may only be implemented between an SS/RS and the MR-BS.

The MR-BS shall assign unique RS CDMA ranging codes to each RS in its MR-cell in order to reduce the overhead and latency of various processes in relay networks with centralized control (see subclause 6.3.6.5.3). RS CDMA ranging codes are assigned to the RS during its initial ranging process by sending an RS_CDMA_Codes TLV in the RNG-RSP.

[Insert new subclause 6.3.6.5.1:]

6.3.6.5.1 Contention-based CDMA BRs in relay networks with centralized scheduling

In relay networks with centralized scheduling, an RS shall transmit the appropriate dedicated RS CDMA ranging code to its superordinate station when it needs to contend for bandwidth. Each intermediate RS along the path to the MR-BS shall relay this code in the uplink direction. When the MR-BS receives an RS CDMA ranging code, it shall look up which RS sent the code (there is a one-to-one mapping between RS CDMA ranging codes and RSs in the MR-cell) and create the appropriate bandwidth allocations on the relay links along the path from the RS to the MR-BS. This requires that each RS inform the MR-BS of its processing time.

When a non-transparent RS with unique BSID receives one or more bandwidth request CDMA ranging codes in a frame from its subordinate SSs, it shall forward an MR Code-REP header using its RS basic CID to the MR-BS. The MR Code-REP header shall indicate the number of bandwidth request CDMA ranging codes the RS received. Upon receiving an MR Code-REP header from a non-transparent RS, the MR-BS shall insert CDMA Allocation IEs with certain fields zeroed out into the UL-MAP that it assigns to that RS to broadcast on the access link. These CDMA_Allocation_IEs will have zeros in the fields for Frame Number Index, Ranging Code, Ranging Symbol, and Ranging Subchannel. When a non-transparent RS receives its assigned UL-MAP (see 6.3.28) from the MR-BS containing CDMA_Allocation_IEs with zeroed out fields, the RS shall fill in these fields with the appropriate ranging code and transmit region information and then broadcast this updated UL-MAP on the access link in accordance with the timing specified in subclause 6.3.30.1.

When a transparent RS overhears one or more bandwidth request CDMA ranging codes from its subordinate SSs within one frame, it shall forward as many codes as possible along with their transmit regions and channel adjustment information within the MR Code-REP message based on the available uplink bandwidth. If there is not enough bandwidth for all code information, the RS shall indicate in the MR Code-REP message the size of remaining codes to be reported. Based on this number, the MR-BS can allocate uplink bandwidth for the remaining code information. Using the code and transmit region information the MR-BS shall generate the appropriate CDMA_Allocation_IEs that prompt the SSs to forward their bandwidth request headers on the access uplink. If management messages are relayed on the uplink, the MR-BS shall insert an UL_Burst_Receive_IE in front of the CDMA_Allocation_IE in the UL-MAP. The UL_Burst_Receive_IE shall contain either the RS basic CID of the assigned RS or the multicast management CID. The MR-BS shall also create bandwidth allocations along the relay path from the assigned RS for the purpose of forwarding these SS bandwidth request headers to the MR-BS (see Figure X).

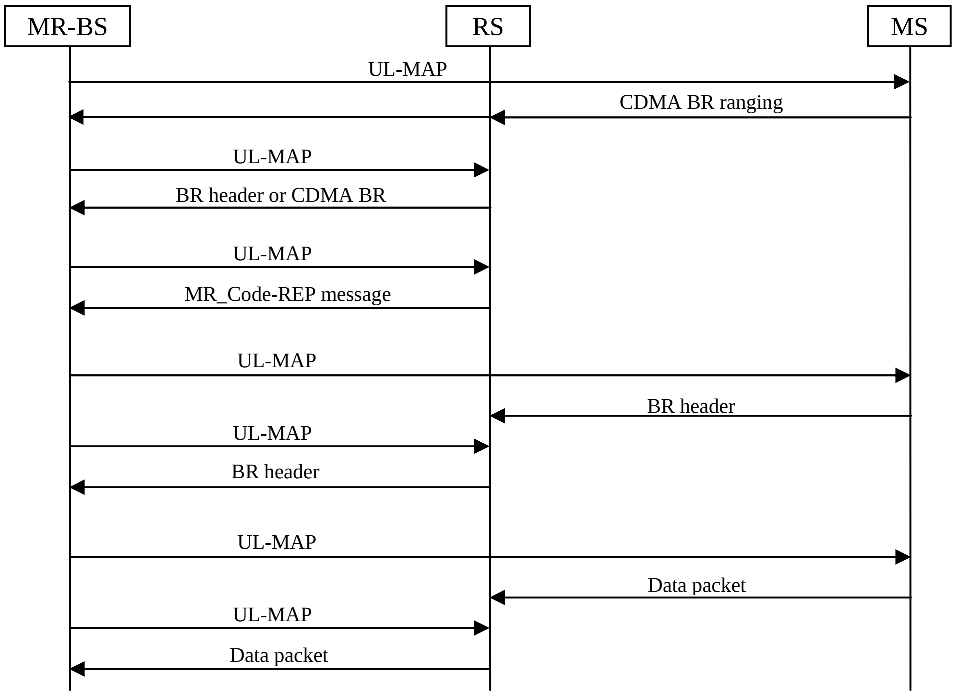

Figure X—BW request/allocation signaling for transparent RS

[Insert new subclause 6.3.6.5.2:]

6.3.6.5.2 Unique RS CDMA code allocation

The MR-BS shall assign unique CDMA ranging codes to each RS in its MR-cell so that it can immediately determine the purpose and the originator of the code. Some codes allow the RS to quickly inform the MR-BS that it is engaged in a ranging process with one of its downstream stations and receive bandwidth from the MR-BS on which to continue or complete the process. Other codes allow the RS to quickly inform the MR-BS that allocations are needed along the route from the RS to the MR-BS on which to forward a specific type of message.

The RS may be assigned several unique CDMA ranging codes in RNG-RSP for communicating the following requests to the MR-BS:

1) RS needs BW on its access downlink (to SS) on which to send a RNG-RSP message. In this case, the RS does not send an RS BR header to the MR-BS.

2) RS needs BW on the relay uplinks along the path to the MR-BS on which to send an MR Code-REP message, which contains the attributes of one CDMA ranging code and all adjustment information.

3) RS needs BW on its relay downlink (i.e. to its subordinate RS) on which to send a RNG-RSP message. In this case, the RS does not send RS BR header to the MR-BS.

4) RS needs BW on the relay uplinks along the path to the MR-BS on which to forward a 6-byte header

5) RS needs BW on the relay uplinks on which to forward an HARQ error report.

[Change all Mesh subclauses to 6.3.6.7.x.x.x and insert the following as subclause as 6.3.6.6]

6.3.6.6 Relay specific bandwidth allocation procedures

Two additional bandwidth allocation procedures are introduced for relay networks in order to improve relay performance. The first is a dedicated relay channel that reduces delay in forwarding relay bursts to the MR-BS. The other is a flow control protocol that helps RSs improve their bandwidth allocation decisions.

6.3.6.6.1 Dedicated relay uplink channel allocation

After RS network entry and initialization, the RS may be assigned a dedicated uplink channel (RS_UL_DCH) by its scheduling station (i.e. the superordinate station in distributed scheduling mode; the MR-BS in centralized scheduling mode).

If the RS is not allocated a dedicated relay uplink channel, it may request one. The dedicated relay uplink channel is assigned via an RS_UL_DCH assignment IE in the RMAP and is available starting the next frame after it is received by the RS.

When a dedicated channel is established for an RS, it impacts the bandwidth requirements on all the relay uplink channels along the path to the MR-BS. In centralized scheduling, the MR-BS shall allocate a dedicated relay uplink channel for each hop along the path. If these already exist, the MR-BS shall adjust their size to accommodate the new RS. In distributed scheduling mode, the RS's superordinate station shall inform the next upstream station along the path to the MR-BS of the new bandwidth requirements so that it can make the proper adjustments to the dedicated channel between them. This process shall continue all the way to the MR-BS.

The initial (and minimum) size of a dedicated relay uplink channel shall be large enough for a management message. This size and/or allocation interval can be increased or decreased based on traffic load. The RS may calculate the traffic load periodically or in response to specific events.

When an SS adjusts its service flow requirements, it impacts the bandwidth requirements on all the dedicated relay uplink channels along the path to the MR-BS. In centralized scheduling, the MR-BS shall adjust the dedicated channel sizes along the path from the SS based on the service flow parameters contained in the signaling exchange of the DSA, DSC or DSD processes.

In distributed scheduling, the service flow adjustment is communicated to the MR-BS via DSA, DSC, or DSD messages. In response, the MR-BS may adjust the dedicated relay uplink channel of the subordinate RS that constitutes the "next hop" along the path to the ~~M~~SS by sending a new RS_UL_DCH assignment IE. This IE contains size adjustment and the CID of the updated service flow. Based on this information, the RS can determine whether the "next hop" to the MS contains yet another dedicated relay uplink channel that needs to be adjusted.

The dedicated resources for all RS UL_DCH shall be allocated consecutively before the non-dedicated RS UL bursts.

When successfully receiving an RS_UL_DCH assignment IE in the R-MAP, an RS shall send a DCH Assignment ACK in the form of an RS UL_DCH signaling header with DCH TYPE=0001~~,~~ to its scheduling station. This RS_UL_DCH signaling header shall appear in the first position of the PHY burst specified by the RS_UL_DCH assignment IE in the first frame in which the dedicated uplink resource is activated.

The RS_UL_DCH signaling header with DCH Assignment ACK contains the frame number in which the RS_UL_DCH assignment IE was received. After sending an RS_UL_DCH assignment IE to an RS, the scheduling station shall receive the RS UL_DCH signaling header with DCH Assignment ACK and finish updating resources for the dedicated uplink channel. If the scheduling station fails to receive the RS UL_DCH signaling header with DCH Assignment ACK, it shall transmit the RS_UL_DCH assignment IE again.

When the scheduling station removes a dedicated uplink channel that is assigned to a particular RS, the RS shall send an RS UL_DCH signaling header with DCH Assignment ACK utilizing any of its other uplink allocations.

[Insert new subclause 6.3.6.6.2:]

6.3.6.6.2. Downlink flow control for relay networks with distributed scheduling

When RSs operating in distributed scheduling mode are employed in an MR network, the MR-BS may configure individual RSs to send flow control messages to regulate the flow of DL traffic. The MR-BS shall configure DL flow control within the MR-Cell using the REG-REQ/RSP message. Within these messages the MR-BS shall indicate whether DL flow control is enabled or not.

When flow control is enabled within an MR-cell, flow control is performed independently on traffic destined for each RS in the MR-cell. Flow control of the traffic destined for an RS is performed on the link between the RS and its superordinate station. In this case the superordinate station is the transmitter and the RS is the receiver. In addition, when the path between the RS and MR-BS has more than two hops, flow control of the traffic destined for an RS shall be performed between its superordinate RS and the MR-BS. In this case the MR-BS is the transmitter and the superordinate RS is the receiver.

The DL flow control protocol shall operate in one of two states. The first state is called uncontrolled state. In uncontrolled state, the transmitter may send traffic without restriction. The second state is called controlled state. In controlled state, the receiver grants credit to the transmitter specifying the amount of DL traffic that it can safely accept from the transmitter. When flow control is first enabled, it shall begin in the uncontrolled state between all transmitters and receivers in the MR-Cell.

When DL flow control is enabled within an RS, the RS shall monitor the flow of DL traffic in order to determine whether it is necessary to control the flow of DL traffic coming into it. When an RS determines that it is necessary to control the flow of DL traffic, it shall send a DL Flow Control Header (see subclause 6.3.2.1.2.2.2.5) to its superordinate station indicating the amount of credit that it is granting the superordinate station. This header shall be sent using the subordinate RS's Basic CID. The credit shall be specified as the number of bytes of DL traffic that the RS can safely receive. This message indicates to the superordinate that flow control is transitioning into the controlled state.

When an RS receives a DL_Flow_Control Header from its subordinate RS it performs one of the following actions:

- If the CID specified in the DL_Flow_Control Header is the Basic CID of its immediate subordinate station, the RS examines the credit field in the header. If the credit field contains a value other than 0b11111111 it limits the amount of data that it transmits to the subordinate RS to the amount of bytes specified in the credit field. If the credit field contains a value of 0b11111111 the RS turns off flow control for traffic destined for the subordinate RS which sent the DL_Flow_Control Header
- If the CID specified in the DL_Flow_Control Header is not the Basic CID of its immediate subordinate RS, the RS which received the DL_Flow_Control Header forwards it without modification to its superordinate station. This forwards the DL_Flow_Control Header all the way to the MR-BS. In response, the MR-BS may adjust the flow of packets to the RS specified by the basic CID.

When the MR-BS receives a DL_Flow_Control Header it examines the credit field in the header. If the credit field contains a value other than 0b11111111 the MR-BS limits the amount of data that it transmits to the RS whose Basic CID was specified in the header to the number of bytes specified in the credit field. If the credit field contains a value of 0b11111111 the MR-BS shall change the state of flow control to the uncontrolled state for the RS whose Basic CID was specified in the header.

When the MR-cell topology contains paths that are longer than 2 hops, it is possible for the receiver of a DL Flow Control Header to be an RS. When such an RS receives a DL Flow Control Header from its subordinate it may in turn send a DL Flow Control Header to the MR-BS, using the Basic CID of the subordinate RS which has requested flow control. The superordinate RS may indicate the same credit value or a different credit value depending on its internal state. It may also decide not to send a DL Flow Control Header to the MR-BS.

When flow control is in the controlled state, the receiver which initiated flow control shall send DL Flow Control Headers updating the number of bytes of DL traffic that it can safely receive. When the receiver determines that flow control is no longer necessary, it shall send a DL_Flow_Control Header with a credit value of 0b11111111, indicating the transition to uncontrolled state. Upon receiving a DL_Flow_Control Header with a credit value of 0b11111111, the transmitter may go back to sending DL traffic to the receiver in an unrestricted manner.

Figure 60f shows a sample topology that is used to illustrate the flow control process.

Figure 60g illustrates an example flow of DL Flow control message flows. This example assumes the topology in Figure 60f. In this example, RS1 determines that it is congested and sends a DL_Flow_Control Header to RS3 using its Basic CID and indicating that it can accept no more than 500 bytes of data. RS3 limits the amount of data that it send to RS1 to 500 bytes, but decides that it has enough room in its buffers that it need not ask the MR-BS to control the flow of data to RS1. At some later point in time, RS1 has cleared its buffers and sends another DL_Flow_Control Header to RS3 indicating that flow control is off. RS3 resumes sending data to RS1 without flow control.

Figure 60h illustrates a second example flow of DL Flow control message flows. This example also assumes the topology in Figure 60f. In this example, RS1 determines that it is congested and sends a DL Flow Control Header to RS3 using its Basic CID and indicating that it can accept no more than 500 bytes of data. RS3 limits the amount of data that it sends to RS1 to 500 bytes. At some later point in time, RS3 determines that the amount of data destined for RS1 has exceeded an acceptable limit and sends a DL_Flow_Control-Header to the MR-BS. It sends this header on the Basic CID of RS1, in order to indicate to the MR-BS that it should limit the flow of packets to RS1. In this example, RS3 indicates to the MR-BS that it can receive no more than 1000 bytes of data destined for RS1. When the MR-BS receives the DL_Flow_Control Header it limits the amount of data destined for RS1 that it sends to 1000 bytes. It does not limit the amount of data that it sends to RS2 even though this data flows through RS3. At some later point in time, RS1 has cleared its buffers and sends another DL Flow Control Header to RS3 indicating that flow control is off. RS3 resumes sending data to RS1 without flow control. RS3 also sends a DL_Flow_Control Header to the MR-BS indicating the flow control for RS1 is turned off. The MR-BS resumes sending data destined for RS1 without flow control.