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Title	**Dedicated Bandwidth Reservation for RS in MR Networks**	
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Re:	Call for Technical Proposal regarding IEEE 802.16j (IEEE 802.16j-06/034)	
Abstract	Proposes to allocate a dedicated control channel between an MMR-BS and an RS for the purpose of transporting control messages from the RS to the MMR-BS. By periodically allocating uplink bandwidth to an RS, the RS can transmit control messages necessary for the management of an MMR network to the MMR-BS without having to request bandwidth whenever there is a control messge to transmit.	
Purpose	Adoption in the IEEE 802.16j specification	
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Dedicated Bandwidth Reservation for RS in MMR Networks

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Background

The objective of the multi-hop relay (MR) is to improve the performance and service coverage of the IEEE 802.16 networks by introducing relay stations (RSs) to the network. The introduction of RSs implies extra delay in delivery time of not only the data packets but also the control or management messages. Since the time delay in delivery of the management messages has an immediate impact on the performance of the network system, it is essential to have an efficient means to exchange management messages between the MR-BS and the RSs to achieve the goal of MR.

The information exchanged between an MR-BS and RSs using management messages includes the channel quality information between an RS and a mobile station (MS), topology change information, ranging information, and many others whose delay can cause adverse effect on the performance of the network. For smooth operation of the network (e.g., efficient handover, improved throughput, seamless backward compatibility with legacy MSs, etc), RSs should be able to deliver these information to the MR-BS in a timely manner.

Figure 1 illustrates the control messages created during an intra MR-BS handover, where an MS is traveling from the communication range of one relay station (RS1) to another. When RS2 detects the MS entering its cell boundary, RS2 needs to communicate with the MR-BS and report a number of PHY measurements such as the received signal strength to the MR-BS. Based on the reports from RS1 and RS2, the MR-BS determines whether and when to perform an intra MR-BS handover. In this case, excessive time delay of the control messages (i.e., the PHY measurements) can cause temporary outage for MS.

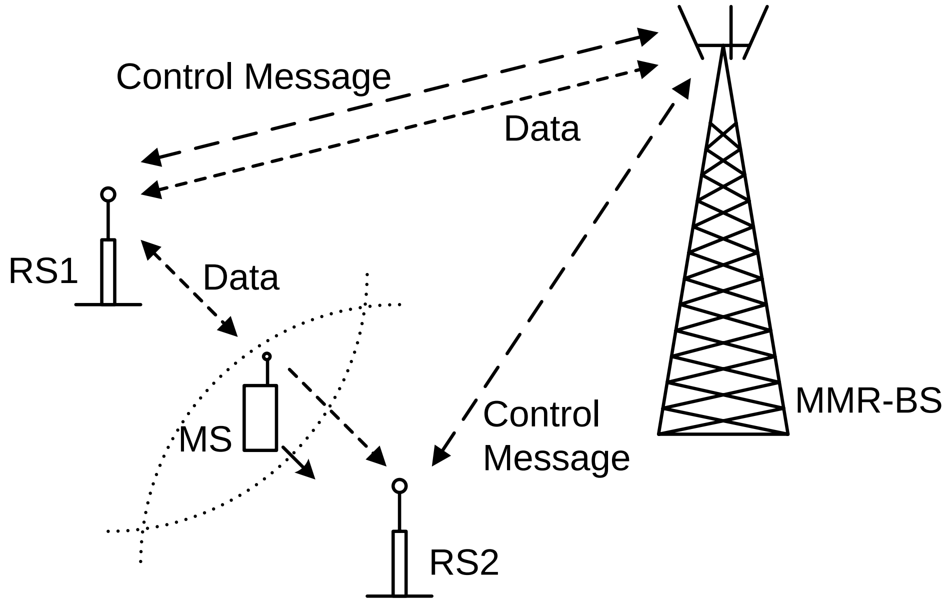

Figure 1 Intra MR-BS handover and control messages.

The transport mechanisms for control messages currently provided by the IEEE 802.16e are adequate for the op eration of single hop networks, but are inappropriate for the purpose of MR. Figure 2 shows a message flow cha rt between an RS and an MR-BS, where the RS is trying to transmit a management message created by an event between the RS and an MS using a contention based transmission mechanism.

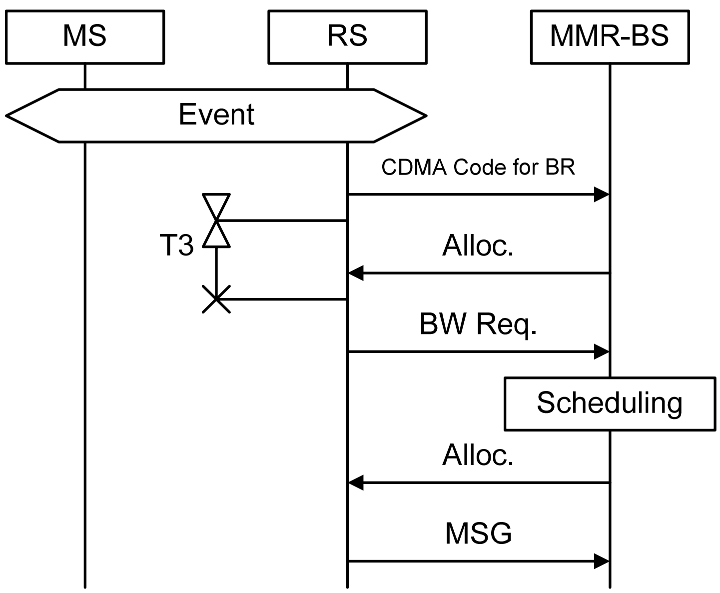

Figure 2 Contention based packet transmission.

Contention based packet transmission scheme is event driven, and thus is very efficient in terms of resource util ization. However, contention based packet transmission is not an option in many cases for reliable and efficient operation of relay networks due to the possibility of collision and excessive time delay; T3 is set to 200msec.

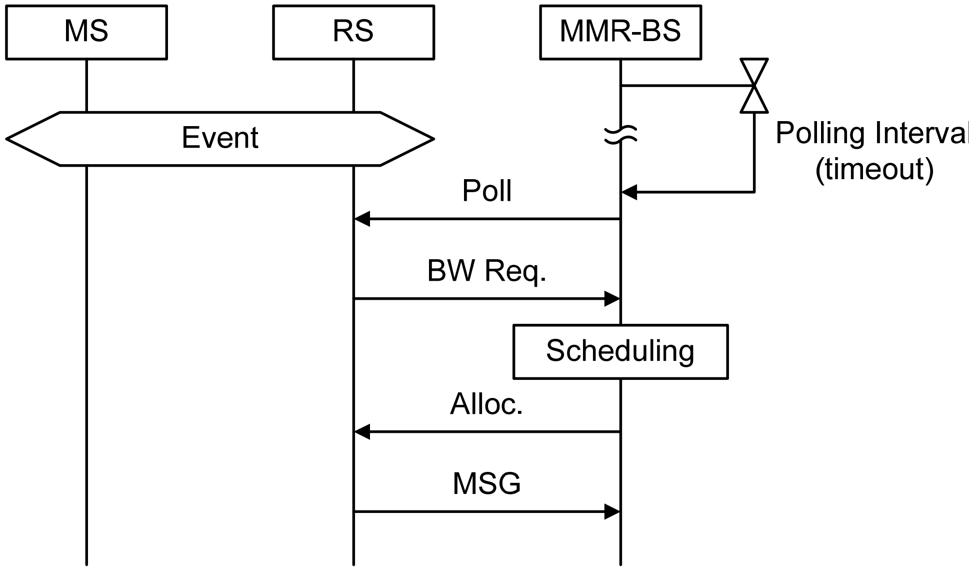

Figure 3 Polling based packet transmission.

Figure 3 illustrates a message flow of a packet transmission mechanism based on polling. Polling is a reliable m ethod to allocate bandwidth to relay/mobile stations, but it still requires a polling followed by a bandwidth requ est before the actual bandwidth allocation. When a relay station needs to transmit a lot of control messages occu rring periodically or randomly in time to the MR-BS, needing to send bandwidth request for every single contro l message is highly inefficient.

Proposed Solution

The proposed solution to the problem is to allocate a dedicated control channel between an MR-BS and an RS f or the purpose of transporting control messages from the RS to the MR-BS. By periodically allocating uplink ba ndwidth to an RS, the RS can transmit control messages necessary for the management of an MR network to the MR-BS without having to request bandwidth whenever there is a control message to transmit.

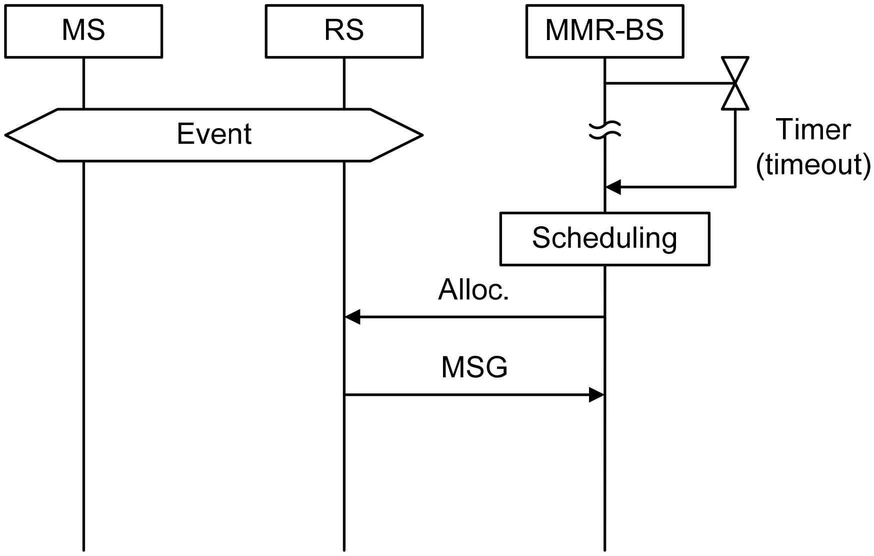

Figure 4 Dedicated control channel between MR-BS and RS.

Figure 4 shows a message flow chart of a control message transmission from an RS to an MR-BS using a dedic ated control channel. In MR networks, it is expected that an RS will need to transmit a lot of control messages f or relay management to the MR-BS, and the proposed scheme makes it possible for an RS to transmit control m essages with minimal time delay and thus to improve the overall performance of MR networks.

Example Scenarios

After a network entry procedure of an RS, the MR-BS may allocate a dedicated control channel to the correspo nding RS without a request by the RS. If the MR-BS does not allocate a dedicated control channel to an RS, the RS can request an allocation of a dedicated control channel by transmitting a request message. If necessary, the MR-BS can terminate or decrease the bandwidth of the allocation of a dedicated control channel without reques t from the RS.

To reduce the overhead of allocating a dedicated control channel to an RS, a dedicated control channel can be al located and released based on the expected demand of the uplink bandwidth. For example, in the case of the intr a MR-BS handover depicted in Figure 1, the RS may request an allocation of a dedicated control channel when it detects an MS entering its communication range, and release the dedicated control channel after the handover procedure is completed. Figure 5 illustrates a message flow of allocating and releasing a dedicated control chan nel between a MR-BS and RS.

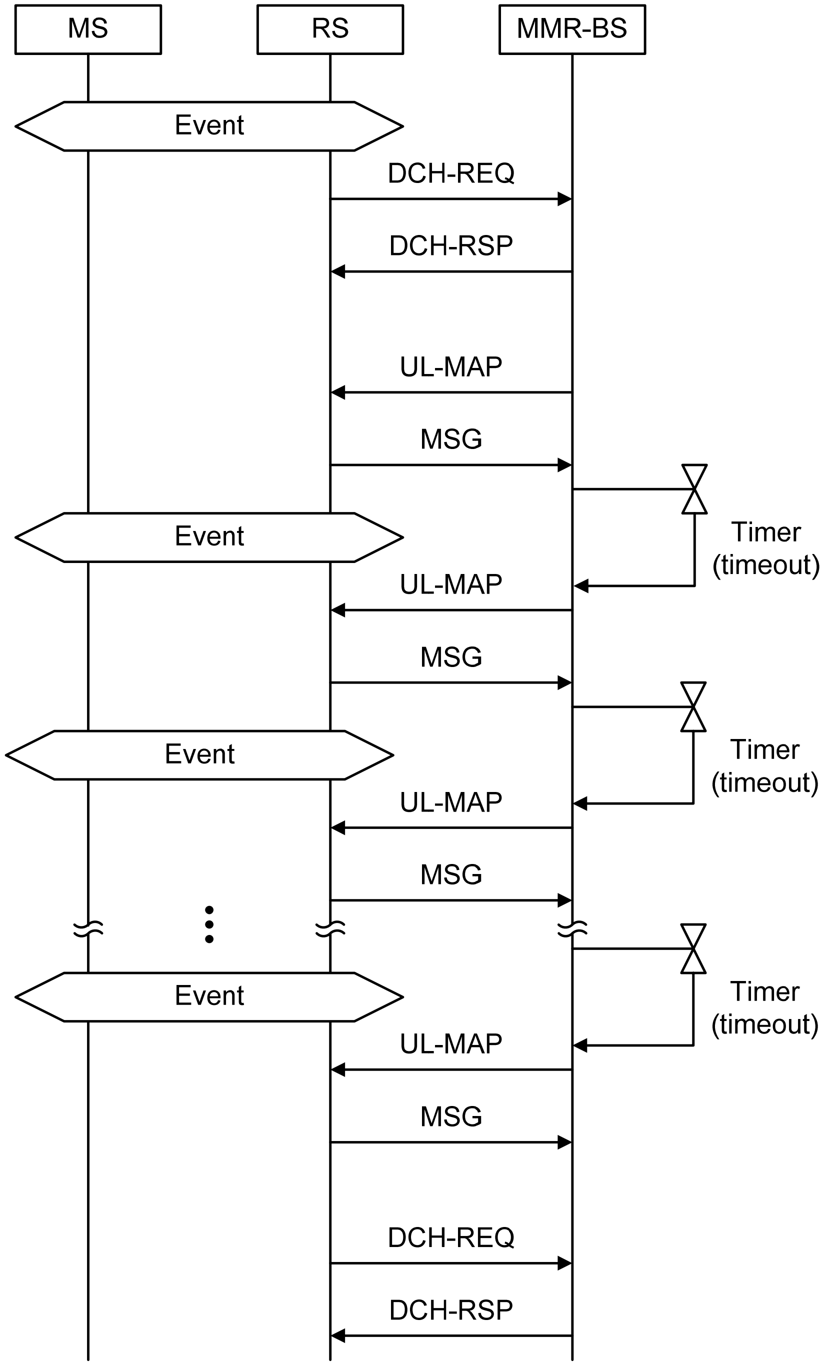

Figure 5 Allocation and release of a dedicated control channel between MR-BS and RS.

Rate-Based Bandwidth Request Mechanism

To further reduce the number of BR headers disseminated over the relay links and shorten the latency before data being granted in MR networks, a rate-based bandwidth request (RBR) mechanism is proposed here.

An RS calculates the average data rate of a connection periodically based on the received BR headers (i.e. 16e BR headers) from an SS. The period of evaluating the average data rate shall be much longer than the inter-arrival time between two BR headers from an SS. That is, the average date rate represents the long term statistics of the BRs from a connection. The message overhead of the RBR mechanism is much reduced because of less BR headers are disseminated over the relay link.

The purpose of introducing a RBR message is simply to reduce but not to eliminate the number of conventional 16e BR headers disseminated over relay links. To be more specific, the conventional BR headers are still required in the following three scenarios to cover the deficiency of the RBR mechanism.
1) Initial stage: In the first period of evaluating the average data rate, RSs still need to relay conventional BR headers to the MR-BS. Then data grant based on the conventional BR headers can be allocated to an SS before an RS generates the first RBR message.
2) Overflow: In the events of abrupt increase in the BRs (in terms of total requested amount) from an SS or buffer overflow at the RS, the RS may send a conventional BR header to ask for additional resource from the MR-BS.
3) Disconnect stage: If an uplink connection no longer exists, an RS may send a conventional BR header with the value of BR equal to zero to inform the MR-BS of the discontinuity of this connection.

Note that the RBR mechanism is particularly useful to the near-constant bit rate connections such as rtPS, ertPS, and nrtPS. On the other hand, since a bursty connection (e.g. a BE connection) might show a large fluctuation in BR, an RS may aggregate BRs of bursty connections from the same class.

Text Proposal

6.3.2.3 MAC Management messages

Change Table 14 as indicated:

66	MOB_ASC-REP	Association result report message	primary management
67	DCH-REQ	Dedicated control channel request message	basic
68	DCH-RSP	Dedicated control channel response message	basic
69	RBR	Rate-based Bandwidth Request	basic
~~67~~70-255		*Reserved*	–

Insert new subclause 6.3.2.3.62:

6.3.2.3.62 Dedicated control channel request (DCH-REQ) message

A DCH-REQ is sent by an RS to an MMR-BS to request, change, or release a dedicated control channel allocati on.

Table xxx – DCH-REQ message format

Syntax	Size	Note
DCH-REQ_Message_format() {		
Management Message Type = 67	8 bits	

Frame Number	24 bits	
Bandwidth Request	16 bits	0 = Release request of the allocation
Allocation Interval	8 bits	Set to zero when the bandwidth request field is set to zero.
}		

An RS shall generate DCH-REQ messages in the form shown in Table xxx, including the following parameters:

Frame Number

The frame number of the first allocation of the dedicated control channel. In case the DCH-REQ is a re lease request, Frame Number indicates the frame from which on the RS requests to release the bandwid th allocation.

Bandwidth Request

The number of bytes of the single uplink bandwidth allocation requested by the RS. Zero in this field i ndicates the DCH-REQ is a bandwidth release request.

Allocation Interval

The interval of the periodic bandwidth allocation in number of frame. This field is set to zero when the Bandwidth Request field is zero.

Insert new subclause 6.3.2.3.63:

6.3.2.3.63 Dedicated control channel response (DCH-RSP) message

A DCH-RSP shall be generated in response to a received DCH-REQ, or to terminate a dedicated control channe l allocated to an RS..

Table xxx – DCH-RSP message format

Syntax	Size	Note
DCH-RSP_Message_format() {		
Management Message Type = 68	8 bits	
Frame Number	24 bits	
Allocated Bandwidth	16 bits	0 = Indicates release of the allocation
Allocation Interval	8 bits	Set to zero when the bandwidth request field is set to zero.
}		

An MMR-BS shall generate DCH-RSP message in the form shown in Table xxx, including the following parameters:

Frame Number

The frame number of the first allocation of the dedicated control channel. In case the DCH-RSP is the response to a bandwidth release request, Frame Number indicates the frame from which on the MMR-BS stops the bandwidth allocation.

Allocated Bandwidth

The number of bytes of the allocated single uplink bandwidth. When DCH-RSP is a response to a DCH-REQ requesting non-zero bandwidth, zero in this field indicates failing to allocated bandwidth.

Allocation Interval

The interval of the periodic bandwidth allocation in the number of frame. This field is set to zero when the Allocated Bandwidth field is set to zero.

Insert new subclause 6.3.2.3.64:

6.3.2.3.64 Rate-based bandwidth request (RBR) message

A rate-based bandwidth request (RBR) message may be sent by an RS at a periodic interval T_d (Table 342) to inform its MR-BS (or RS) of the average data rate of a connection. The procedure of how to estimate the average data rate is outside the scope of the standard.

Table xxx – Rate-based bandwidth request (RBR) message format

Syntax	**Size**	**Notes**
RBR_message format(){	—	
Management Message Type = 69	8 bits	
Progressive rate	12 bits	
Request CID	16 bits	
}	—	

An RS shall generate RBRs in the format shown in Table xxx, including the following parameters:

Progressive rate

Average data rate of the CID with the progressive resolution unit. It is set according to Table 109aa.

Request CID

The CID indicates the connection for which uplink (or downlink) bandwidth is requested.

The field of Progressive rate represents the average data rate (with the unit of bit per second) of the connection measured at an RS (or an SS). It contains the information of both the unit and the magnitude of the average data. The encodings and decoding of Progressive rate filed is based on Table 7m. In particular, the unit value is not a fixed value but with the progressive resolution. When the value of data rate is low, a smaller unit with higher resolution is adopted to encode the data rate. On the other hand, if the data rate value is large, a large unit with coarse resolution is adopted to represent the data rate. For instance, if the data rate is between 2 kBps (kilobyte per second) and 4 kBps, the encoding rule of the second entry (101x xxxxxxxx) in Table xxx is used. The first two MSB of Progressive rate field are used to indicate that the Unit is 2^2 (=4) Bps (byte per second) while the next 10 LBS are used to represent the magnitude of the data rate. The allowed magnitude rage is between 2^9 and 2^{10}-1 as the most significant bit in these 10 bits is specified as “1”. Therefore, the range of the data rate value (i.e. the multiply of the Unit and Magnitude) is between 2^{11} and 2^{12}-2^2.

Table xxx Encodings of Progressive rate field

Bitmap of Progressive rate field (x: don’t care)	**# of MSB bits for Unit**	**Unit**	**Magnitude**	**Range of overall value (Bps) (i.e. Multiple of Unit and Magnitude)**
0xxx xxxxxxxx	1	2^0	$0 \sim 2^{11} - 1$	$0 \sim 2^{11} - 2^0$
101x xxxxxxxx	2	2^2	$2^9 \sim 2^{10} - 1$	$2^{11} \sim 2^{12} - 2^2$
1101 xxxxxxxx	3	2^4	$2^8 \sim 2^9 - 1$	$2^{12} \sim 2^{13} - 2^4$
1110 1xxxxxxx	4	2^6	$2^7 \sim 2^8 - 1$	$2^{13} \sim 2^{14} - 2^6$
1111 01xxxxxx	5	2^8	$2^6 \sim 2^7 - 1$	$2^{14} \sim 2^{15} - 2^8$
1111 101xxxxx	6	2^{10}	$2^5 \sim 2^6 - 1$	$2^{15} \sim 2^{16} - 2^{10}$
1111 1101xxxx	7	2^{12}	$2^4 \sim 2^5 - 1$	$2^{16} \sim 2^{17} - 2^{12}$
1111 11101xxx	8	2^{14}	$2^3 \sim 2^4 - 1$	$2^{17} \sim 2^{18} - 2^{14}$
1111 111101xx	9	2^{16}	$2^2 \sim 2^3 - 1$	$2^{18} \sim 2^{19} - 2^{16}$
1111 1111101x	10	2^{18}	$2^1 \sim 2^2 - 1$	$2^{19} \sim 2^{20} - 2^{18}$
1111 11111101	11	2^{20}	1	$\geq 2^{20}$

Change subclause 6.3.6 as indicated:

6.3.6 Bandwidth allocation and request mechanism

Note that during network entry and initialization every SS or RS 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) bandwidth requirement is necessary for all services except incompressible constant bit rate UGS connections. The needs of incompressible UGS connections do not change between connection establishment and termination. The requirements of compressible UGS connections, such as canalized T1, may increase or decrease depending on traffic. 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 message to the BS containing the immediate requirements of the DAMA connection. QoS for the connection was established at connection establishment and is looked up by the BS.

There are numerous methods by which the SS or RS can get the bandwidth request message to the BS. The methods are listed in 6.3.6.1 through 6.3.6.6. The method by which an RS request a dedicated control channel is described in 6.3.6.8.

Insert new subclause 6.3.6.8

6.3.6.8 Bandwidth request and allocation mechanisms for MMR

6.3.6.8.1 Dedicated control channel between MMR-BS and RS

An RS shall request a dedicated control channel using DCH-REQ message (see 6.3.2.3.62) for the purpose of transporting control messages from the RS to the MMR-BS. A dedicated control channel is a periodic allocation of uplink bandwidth.

To reduce the overhead of allocating a dedicated control channel to an RS, a dedicated control channel can be allocated, changed, and released based on the expected demand of the uplink bandwidth.

MMR-BS may allocated a dedicated control channel to an RS without an explicit request from the RS by sending a DCH-RSP message to the RS.

If necessary, an MMR-BS can terminate or decrease the bandwidth and/or the allocation interval of the dedicated control channel without request from an RS.

If the uplink path from an RS to an MMR-BS includes other RSs, the MMR-BS shall allocated dedicated control channel for each hop within the path in response to an DCH-REQ.

6.3.6.8.2 Rate-based bandwidth request mechanism for MMR

In this subclause, a rate-based BR (RBR) mechanism is presented. RBR message is described in 6.3.2.3.62. An RBR carries the average data rate of a connection (also identified by the CID) in the unit of bytes per second (Bps).

The connection in an RBR could be a connection, a set of connections related to a station, a set of connections related to a service QoS class, a virtual group of stations, or any combination of the aforementioned groups. The utilization of the aggregation level is implementation specific.

Compared to the short-term statistics of BR mechanism in 6.3.6.1, the RBR message carries the information of statistics in a much longer duration. The interval between two RBR messages, T_d, is defined in Table 342. Since the transmission number of RBR messages is much less than that of BR headers, the control overhead of BRs can be much reduced. On the other hand, since an RS updates the value of data rate of RBR in a longer period, the RBR information is more suited to the resource allocation scheme with a longer adjustment period.

In the case of abrupt increase of traffic demand happening between two periodical RBR messages, the BR header defined from 6.3.2.1.2.1.1 to 6.3.2.1.2.1.6 may be used by an RS to ask for additional resource from the MR-BS.

Insert the following text at the end of Table 342:

System	**Name**	**Time Reference**	**Minimum value**	**Default value**	**Maximum value**
MR-BS, RS	T_d	Time interval of measuring the average data rate	10s	30s	-