Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>	
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Re:	IEEE 802.16Rev2/D4, Letter Ballot 26c Technical Comments	
Abstract	Proposal to provide support for ARQ for the primary management connection	
Purpose	Adopt proposed text changes for IEEE 802.16Rev2/D4 revision	
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ARQ support for Primary Management connection

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1 Summary

Currently in IEEE802.16e, fragmentation is supported for management connections (basic, primary, secondary) and transport connections. However, ARQ is only supported for transport connections and the secondary management connection, but not for primary management connections. For MAC management messages using the primary management connection, full message retransmission is the only means for recovering from a failed transmission.

In poor radio conditions, such as at the cell edge, multiple factors may contribute to an increase in latency:

- More messages will be fragmented due to low modulation order so message transmission is spread over multiple frames.
- Transmission errors cause retransmissions of entire MAC messages. MAC message retransmission is timer-based:
    - Retransmissions are not triggered at the time of a transmission failure.
    - Retransmissions are triggered after a timer has expired and a response to the message has not been received.
- If ARQ were supported for primary management connection:
    - Retransmissions would be triggered at the time of a transmission failure.
    - Only those blocks of data that fail would be retransmitted.
    - Latency would be significantly reduced.
- This is particularly relevant for network entry, which often occurs at the cell edge and is time critical.

It is propose to add support for ARQ for the primary management connection.

Proposed Text Changes:

- ***Modify sections 6.3.2.3.23 and 6.3.2.3.24 as follows:***

6.3.2.3.23 SBC-REQ (SS basic capability request) message

[...]

The following parameters may be included:

Capabilities for construction and transmission of MAC PDUs (see 11.8.2)
Security Negotiation Parameters (see 11.8.4)
Service Information Query (see 11.8.9)
Visited NSP ID (see 11.8.11)
Auth Type for EAP (see 11.8.12)
MIH Capability Supported (see 11.8.10)
Extended capability (see 11.8.15)
ARQ support (11.8.5.1)
ARQ parameters (11.8.5.2)

[...]

6.3.2.3.24 SBC-RSP (SS basic capability response) message

[…]

The following parameters shall be included in the SBC-RSP if found in the SBC-REQ:

Physical Parameters Supported (see 11.8.3)

Bandwidth Allocation Support (see 11.8.1)

The BS response to the subset of SS capabilities present in the SBC-REQ message. The BS responds to the SS capabilities to indicate whether they may be used. If the BS does not recognize an SS capability, it may return this as "off" in the SBC-RSP. Only capabilities set to "on" in the SBC-REQ may be set "on" in the SBC-RSP, as this is the handshake indicating that they have been successfully negotiated.

Security Negotiation Parameters (see 11.8.4)

HMAC/CMAC Tuple

Either HMAC Tuple or CMAC Tuple shall be the final attribute in the message's TLV attribute list. This attribute should be included in the message during HO reentry (see 11.1.2).

ARQ support (11.8.5.1)
ARQ parameters (11.8.5.2)

[…]

- ***Modify section 6.3.4.6.2 as follows:***

6.3.4.6.2 Transmitter state machine

The actions to be taken by the transmitter state machine when it wants to initiate a reset of the receiver ARQ state machine are provided in Figure 52. The actions to be taken by the receiver state machine when it initiates an ARQ Reset message are provided in Figure 53.

When ARQ_TX_WINDOW_START and ARQ_TX_NEXT_BSN are equal (all blocks have been acknowledged) for the Primary Management Connection, the transmitter may suspend the ARQ process. When the transmitter receives an ARQ-Reset Original message for the Primary Management Connection with the

ARQ Suspended parameter set to '0b1', the BSN parameter is equal to ARQ_TX_NEXT_BSN, and ARQ is suspended, the transmitter shall send an ARQ-Reset Acknowledgement message with the ARQ Suspended parameter set to '0b1'. Otherwise, the transmitter shall send an ARQ-Reset Original message with the ARQ Suspended parameter set to '0b0' and perform the transmitter-initiated ARQ-Reset procedure.

[…]

Synchronization of the ARQ state machines is governed by a timer managed by the transmitter state machine. Each time *ARQ_TX_WINDOW_START* is updated, the timer is set to zero. When the timer exceeds the value of *ARQ_SYNC_LOSS_TIMEOUT,* the transmitter state machine shall initiate a reset of the connection's state machines as described in Figure 52.

- ***Modify section 6.3.4.6.3 as follows:***

6.3.4.6.3 Receiver state machine

The actions to be taken by the receiver state machine when an ARQ Reset message is received are provided in Figure 52. The actions to be taken by the receiver state machine when it wants to initiate a reset of the transmitter ARQ state machine or to request the status of ARQ Suspended for the Primary Management Connection are provided in Figure 53.

When the receiver requests the status of ARQ Suspended, it shall set the ARQ Suspended parameter in the ARQ-Reset Original message to '0b1' and set the BSN parameter to ARQ_RX_HIGHEST_BSN. If the receiver receives an ARQ-Reset Acknowledgement message from the transmitter with the ARQ Suspended parameter set to '0b1', the receiver shall send an ARQ-Reset Confirmation message with the ARQ Suspended parameter set to '0b1', shall not perform the ARQ reset procedure, shall maintain the counters at their current value, and shall not start the ARQ_SYNC_LOSS_TIMEOUT timer reactivate the ARQ process until a block is received. If the receiver receives an ARQ-Reset Original message from the transmitter with the ARQ Suspended parameter set to '0b0', the receiver shall perform the transmitter-initiated ARQ-Reset procedure.

Synchronization of the ARQ state machines is governed by a timer managed by the receiver state machine. Each time *ARQ_RX_WINDOW_START* is updated, the timer is set to zero. When the timer exceeds the value of *ARQ_SYNC_LOSS_TIMEOUT* the receiver state machine shall initiate a reset of the connection's state machines or, for the Primary Management Connection, shall request the status of the ARQ Suspended as described in Figure 53.

[…]

- ***Modify section 6.3.2.3.32 as follows:***

6.3.2.3.32 ARQ-Reset message

This message is applicable to ARQ-enabled connections only.

The transmitter or the receiver may send this message. The message is used in a dialog to reset the parent connection's ARQ transmitter and receiver state machines or for the receiver to request and confirm the status of ARQ Suspended and for the transmitter to indicate ARQ Suspended. The ARQ Reset message shall be sent as a MAC management message on the basic management connection of the appropriate direction. Table 101 shows the format of the reset message.

Table 101—ARQ-Reset message format

Syntax	Size (bit)	Notes
ARQ_Reset_Message_Format() {	—	—
Management Message Type = 35	8	—
Connection ID	16	CID to which this message refers
Type	2	0b00 = Original message from Initiator 0b01 = Acknowledgment from Responder 0b10 = Confirmation from Initiator 0b11 = Reserved
Direction	2	0b00 = UL or DL 0b01 = UL 0b10 = DL 0b11 = Reserved
ARQ Suspended	1	0b0 = No ARQ Suspended status request or indication 0b1 = ARQ Suspended status request or indication
If (ARQ Suspended == 1) {		—
If (Type == 0b00) {		—
BSN	11	Next Block Sequence Number of the ARQ receiver
} else {	—	—
Reserved	3	Shall be set to zero
}	—	—
} else {	—	—
Reserved	3	Shall be set to zero
}	—	—
}	—	—

For Transport CIDs, the Direction bits shall be set to 0b00 on transmission, and ignored on reception. For Secondary Management CIDs, the Direction bits shall be set to 0b01 or 0b10 as appropriate and other values shall cause the message to be treated as invalid and discarded on reception.

- ***Modify sections 6.3.4 and 6.3.4.1 as follows:***

6.3.4 ARQ mechanism

ARQ shall not be used with the PHY specification defined in 8.1. If ARQ is supported, then support of the cumulative ACK entry' and at least one of other acknowledgement types is mandatory.

The ARQ mechanism is a part of the MAC, which is optional for implementation. When implemented, ARQ may be enabled on a per-connection basis. The per-connection ARQ shall be specified and negotiated during connection creation. Only the primary management connection may ~~A connection cannot~~ have a mixture of ARQ and non-ARQ traffic but only when ARQ_ALL_PMC_SDUS is set to '0'. Similar to other properties of the MAC protocol the scope of a specific instance of ARQ is limited to one unidirectional connection.

For ARQ-enabled connections, enabling of fragmentation is optional. When fragmentation is enabled, the transmitter may partition each SDU into fragments for separate transmission based on the value of the

ARQ_BLOCK_SIZE parameter. When fragmentation is not enabled, the connections, except the primary management connection, shall be managed as if fragmentation was enabled. In this case, regardless of the negotiated block size, each fragment formed for transmission shall contain all the blocks of data associated with the parent SDU.

When ARQ is enabled for the primary management connection and ARQ_ALL_PMC_SDUS is set to '1', then all SDUs shall be processed in the same way as for transport connections. All SDUs shall use ARQ and the fragmentation or packing header will be used for each PDU. When ARQ is enabled for the primary management connection and ARQ_ALL_PMC_SDUS is set to '0', then only fragmented SDUs using the primary management connection shall use ARQ. If a fragmentation or packing header is used for an unfragmented (non-ARQ) SDU, then BSNs will be assigned to the blocks of the SDU and indicated in the fragmentation/packing header. If a fragmentation or packing header is not used for an unfragmented (non-ARQ) SDU, then BSNs will not be assigned to the blocks of the SDU.

6.3.4.1 ARQ block usage

A MAC SDU is logically partitioned into blocks whose length is specified by the connection TLV parameter ARQ_BLOCK_SIZE. For ARQ-enabled primary management connection, when ARQ_ALL_PMC_SDUS is set to '1', all MAC SDUs are logically partitioned into blocks and when ARQ_ALL_PMC_SDUS is set to '0', only SDUs using the fragmentation/packing header are partitioned into blocks. When the length of the SDU is not an integer multiple of the connection's block size, the final block of the SDU is formed using the SDU bytes remaining after the final full block has been determined.

[…]

- ***Add section 11.8.5 as follows:***

11.8 SBC-REQ/RSP management message encodings

[…]

11.8.5 ARQ parameters

11.8.5.1 ARQ Support

This field indicates the availability of SS support for ARQ.

Type	Length	Value	Scope
10	1	0: No ARQ support capability 1: ARQ supported 2–255: Reserved	SBC-REQ, SBC-RSP

[…]

11.8.5.2 ARQ Parameters

This field provides the fragmentation and ARQ parameters for the Primary Management connection. For purposes of ARQ parameter negotiation, the appearance of the field in the SBC-REQ message is equivalent to its appearance in the DSA-REQ message. The appearance of the field in the SBC-RSP message is equivalent to its appearance in the DSA-RSP message.

This field is a compound TLV that may take on any of the ARQ parameters described in 11.13.18. The subtype values defined for use within the 145/146 service flow definitions are applicable for this TLV as well.

Type	Length	Value	Scope
1	*variable*	Compound	SBC-REQ, SBC-RSP

[…]

- ***Add SBC-REQ and SBC-RSP messages to the scope of the ARQ TLVs in sections 11.13.18.1 through 11.13.18.9 as follows:***

11.13.18.1 ARQ Enable TLV

This TLV indicates whether ARQ use is requested for the connection that is being setup. A value of 0 indicates that ARQ is not requested and a value of 1 indicates that ARQ is requested. The DSA-REQ shall contain the request to use ARQ or not. The DSA-RSP message shall contain the acceptance or rejection of the request. ARQ shall be enabled for this connection only if both sides report this TLV to be nonzero. The SS shall either reject the connection or accept the connection with ARQ.

Type	Length	Value	Scope
[145/146].181.18	1	0 = ARQ Not Requested/Accepted 1 = ARQ Requested/Accepted	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.2 ARQ_WINDOW_SIZE TLV

This parameter is negotiated upon connection setup or during operation. The DSA-REQ/DSC-REQ message shall contain the suggested value for this parameter. The DSA-RSP/DSC-RSP message shall contain the confirmation value or an alternate value for this parameter. The smaller of the two shall be used as the ARQ_WINDOW_SIZE TLV.

Type	Length	Value	Scope
[145/146].19 1.19	2	> 0 and ≤ (ARQ_BSN_MODULUS/2)	DSA-REQ, DSA-RSP REG-REQ, REG-RSP

			SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.3 ARQ_RETRY_TIMEOUT TLV

The ARQ_RETRY_TIMEOUT TLV should account for the transmitter and receiver processing delays and any other delays relevant to the system. TRANSMITTER_DELAY: This is the total transmitter delay, including sending (e.g., MAC PDUs) and receiving (e.g., ARQ feedback) delays and other implementation dependent processing delays. If the transmitter is the BS, it may include other delays such as scheduling and propagation delay. RECEIVER_DELAY: This is the total receiver delay, including receiving (e.g., MAC PDUs) and sending (e.g., ARQ feedback) delays and other implementation-dependent processing delays. If the receiver is the BS, it may include other delays such as scheduling and propagation delay. The DSA-REQ and DSA-RSP messages shall contain the values for these parameters, where the receiver and transmitter each declare their capabilities. When the DSA handshake is completed, each party shall calculate ARQ_RETRY_TIMEOUT TLV to be the sum of TRANSMITTER_DELAY and RECEIVER_DELAY.

Type	Length	Value	Scope
[145/146].20 1.20	2	TRANSMITTER_DELAY 0-6553500 µs (100 µs granularity)	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP
[145/146].21 1.21	2	RECEIVER_DELAY 0-6553500 µs (100 µs granularity)	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.4 ARQ_BLOCK_LIFETIME TLV

The DSA-REQ message shall contain the value of this parameter as defined by the parent service flow. If this parameter is set to 0, then the ARQ_BLOCK_LIFETIME TLV value shall be considered infinite.

Type	Length	Value	Scope
[145/146].22 1.22	2	0 = Infinite 1-6553500 µs (100 µs granularity)	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.5 ARQ_SYNC_LOSS_TIMEOUT TLV

The BS shall set this parameter. The DSA-REQ or DSA-RSP messages shall contain the value of this parameter as set by the BS. If this parameter is set to 0, then the ARQ_SYNC_LOSS_TIMEOUT TLV value shall be considered infinite.

Type	Length	Value	Scope
[145/146].23 1.23	2	0 = Infinite 1-6553500 µs (100 µs granularity)	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.6 ARQ_DELIVER_IN_ORDER TLV

The DSA-REQ message shall contain the value of this parameter. This TLV indicates whether data is to be delivered by the receiving MAC to its client application in the order in which the data was handed off to the originating MAC.

Type	Length	Value	Scope
[145/146].24 1.24	1	0 – Order of delivery is not preserved 1 – Order of delivery is preserved	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

If this flag is not set, then the order of delivery is not preserved. If this flag is set (to 1), then the order of delivery is preserved.

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.7 ARQ_RX_PURGE_TIMEOUT TLV

The DSA-REQ message shall contain the value of this parameter as defined by the parent service flow. If this parameter is set to 0, then the ARQ_RX_PURGE_TIMEOUT TLV value shall be considered infinite.

Type	Length	Value	Scope
[145/146].25 1.25	2	0 = Infinite 0-6553500 µs (100 µs granularity)	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.8 ARQ_BLOCK_SIZE TLV

This value of this parameter specifies the size of an ARQ block. This parameter shall be established by negotiation during the connection creation dialog. The requester includes its desired minimum and maximum

setting in the DSA-REQ/REG-REQ message. The receiver of the DSA-REQ/REG-REQ message shall select the value it prefers witin the range of the two values, inclusive, in the DSA-REQ/REG-REQ message. This selected value is included in selected block size of the DSA-RSP/REG-RSP message. Absence of the parameter during a DSA dialog shall indicate the originator of the message desires the maximum value.

Type	Length	Value	Scope
[145/146].26 1.26	2	For DSA-REQ and REG-REQ: Bit 0-3: encoding for proposed minimum block size (M) Bit 4-7: encoding for proposed maximum block size (N) where: The minimum block size is equal to 2^(M+4) and the maximum block size is equal to 2^(N+4), M≤6, N≤6, and M≤N For DSA-RSP and REG-RSP: Bit 0-3: encoding for selected block size (P) Bit 4-7: set to 0 where: The selected block size is equal to 2^(P+4), P≤6 and M≤P≤N	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

11.13.18.9 RECEIVER_ARQ_ACK_PROCESSING_TIME TLV

The BS or SS may provide this parameter. The DSA-REQ and DSA-RSP messages may contain the value of this parameter. This optional parameter indicates the number of ms required by the ARQ receiver to process the received ARQ blocks and provide a valid ACK or NAK. This does not mean that the receiver would actually transmit an ACK or NAK after this time, but rather it can be optionally used by the transmitter that receives an ACK bit-map to determine which bits are retransmissions of historical NAKs or ACKs, that are not based on newly received ARQ blocks.

Type	Length	Value	Scope
[145/146].27 1.27	1	0-255	DSA-REQ, DSA-RSP REG-REQ, REG-RSP SBC-REQ, SBC-RSP

When included in a SBC-REQ/RSP message, the TLV applies to the Primary Management connection.

- ***Add section 11.13.18.10 ARQ_ALL_BLOCKS_ASSIGNED_BSN TLV as follows:***

11.13.18.10 ARQ_ALL_PMC_SDUS TLV

When ARQ is enabled for the primary management connection, this TLV indicates whether all SDUs use ARQ or whether only fragmented SDUs use ARQ. A value of 0 indicates that only fragmented SDUs use ARQ and a value of 1 indicates that all SDUs use ARQ.

Type	**Length**	**Value**	**Scope**
[x/x].x.x	1	0 = Only fragmented SDUs use ARQ 1 = All SDUs use ARQ.	SBC-REQ, SBC-RSP