Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**ARQ Sequence Numbering for 802.16a**
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Re:	IEEE 802.16 Working Group Letter Ballot #4 (P802.16a/D1-2001)
Abstract	This document proposes an ARQ sequence-numbering scheme that is consistent with the FSN defined in the baseline document. This numbering scheme not only simplifies the ARQ protocols, but also does not require non-ARQ connections to use a complex block numbering scheme.
Purpose	Incorporate the changes proposed in this document into P802.16a/D1-2001
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1 Introduction and Summary

The ARQ sequence numbering used in the current 802.16a draft is based on the concept of ARQ blocks. The ARQ block-numbering scheme fundamentally changes the way fragmentation is done in 802.16a. Non-ARQ connections also have to implement such a complex numbering scheme, in order to avoid having two different fragmentation/reassembly mechanisms within the same system. Moreover the benefits of such a complex scheme is not proven, even for ARQ connections. If the block-numbering scheme were included in the standard, it would be very difficult to add future extensions to 802.16, considering the various incompatible options between the baseline and 802.16a MACs.

This contribution proposes a sequence numbering scheme that is straightforward extension of the 802.16 baseline FSN (Fragment Sequence Number) that provides almost all the benefits of the block numbering scheme, with much less complexity. In the earlier drafts of 802.16 baseline MAC, the FSN was defined as a per-MSDU number that wraps around at MSDU boundaries. This was later changed to a running count in order to avoid an ambiguity problem in 802.16 MAC reassembly. Now that FSN is a running count, it can be used as ARQ sequence number, just by extending the size of the FSN field.

802.16 MAC implies that fragmentation should be performed only when the whole MSDU cannot be fit into a MAC PDU due to a scheduling decision or other framing constraints, as it does not make sense to fragment an MSDU, when the scheduler has allocated sufficient BW to carry the whole MSDU. However, this restriction can be relaxed for the 802.16a ARQ connections in order to support retransmission flexibility (one of the benefits that block numbering scheme is supposed to provide). 802.16a MAC should allow multiple consecutive fragments of the same MSDU be carried within the same MAC PDU. This allows the ARQ transmitter and the scheduler to choose the optimal fragment size either statically or dynamically based on various system parameters, connection properties and link conditions.

The following section describes the specific changes to be made to P802.16a/D1-2001.

2 Specific Changes to P802.16a/D1-2001

Globally replace "ARQ Block" with "ARQ Fragment", "Block" with "Fragment", and "BSN" with "FSN" under all sections pertaining to ARQ

Page 42, Remove Figure 135

Page 42, Remove the last sentence "The ARQ block numbering scheme is detailed in clause 6.2.4.1"

Page 43, Section 6.2.3.4.3.1 replace the text (lines 43 – 48) with the following:

"The 2 – 11 GHz Fragmentation sub-header is a simple extension of the Fragmentation sub-header defined for 10 – 66 GHz systems. Table 164 shows the fragmentation sub-header."

Page 45, Section 6.2.3.4.3.1, Replace Table 164, with the following:

Table 161: Format of 2 – 11 GHz Fragmentation sub-header

Syntax	Size	Notes
2_11_GHz_Fragmentation_Sub_Header_Format() {		
FC	2 bits	Fragmentation Control Indicates the fragmentation state of the payload: 00 = no fragmentation 01 = last fragment 10 = first fragment 11 = continuing (middle) fragment
Reserved	2 bits	
ACK Request ("A-bit")	1 bit	Receiver must send an acknowledgement when this bit is set and ARQ is enabled for this connection. Non-ARQ connections shall ignore this bit.
FSN	11 bits	Fragment Sequence Number
}		

Page 45, Section 6.2.3.4.3.2 replace first paragraph (text from lines 35-44) with the following:

"In this case each PDU may contain multiple MAC SDUs or fragments thereof and ARQ feedback payload. Each of the packed MAC SDU or MAC SDU fragments or ARQ feedback payload requires its own packing sub-header as some of them may be transmissions while other are re-transmissions. The position of 2 – 11 GHz Packing sub-header within a PDU and the contents of the packing sub-header are shown in Figure 138 and Table 165 respectively. Note that the A-bit is not present in the packing sub-header."

Page 46, Section 6.2.3.4.3.2 replace Table 165 with the following:

Table 162: Format of 2 – 11 GHz Packing sub-header

Syntax	Size	Notes
2_11_GHz_Packing _Sub_Header_Format() {	24 bits	
FC	2 bits	Fragmentation Control Indicates the fragmentation state of the payload: 00 = no fragmentation 01 = last fragment 10 = first fragment 11 = continuing (middle) fragment FC bits shall be ignored, if the payload followed by this packing sub-header is an ARQ feedback payload
Length	11 bits	The length in bytes of the MAC SDU or MAC SDU fragment or ARQ feedback payload, including the three-byte 2_11_GHz_Packing sub-header
FSN	11 bits	Fragment Sequence Number The FSN shall be ignored, if the payload followed by this packing sub-header is an ARQ feedback payload.
}		

Page 46 - 47, Remove section 6.2.4.1.

Page 47, Table 166, Replace BSN with FSN and Block Sequence Number with Fragment Sequence Number on line 31

Page 47, Table 166, for the text in column 3, from lines 42 to 48, replace "ARQ Block" with "ARQ Fragment", "BSN" with "FSN" and "block numbers" with "Fragment Sequence Numbers"

Page 47, Remove section 6.2.4.3.1

Page 48, Section 6.2.4.3.2, replace "ARQ blocks" with "ARQ Fragments", "ARQ Block" with "ARQ Fragment" and "ARQ_MAX_BSN" with "ARQ_MAX_FSN"

Page 48, Section 6.2.4.3.3,Rename the section title to "ARQ_FRAGMENT_LIFETIME". Same for the text. Also, replace "ARQ blocks" with "ARQ Fragments"

Page 48, Section 6.2.4.3.4, Replace "ARQ block" with "ARQ Fragment"

Page 48, Section 6.2.4.4.1.1, replace "BSN" with FSN", "next block" with "next fragment" and "ARQ_TX_NEXT_BSN" with "ARQ_TX_NEXT_FSN"

Page 48, Section 6.2.4.4.1.2, replace "BSN" with FSN", "highest block" with "highest fragment" and "ARQ_TX_HIGHEST_BSN" with "ARQ_TX_HIGHEST_FSN"

Page 48-49, Section 6.2.4.6.1, replace "BSN" with "FSN", "blocks" with "fragments", "bsn" with "fsn", "BSN_base" with "FSN_base" and "ARQ_MAX_BSN" with "ARQ_MAX_FSN"

Page 49, Remove Section 6.2.4.6.2 and Figure 139

Page 50, Section 6.2.4.6.3, replace first paragraph (text from lines 3 to 11) with the following:

"The ARQ protocol is responsible for choosing the right fragment size on a per-fragment basis. The fragment size is not a fixed value that remains constant for a particular connection. Unlike non-ARQ connections, where a single MAC PDU cannot have two consecutive fragments of the same MSDU, such fragmentation is allowed for ARQ connections. ARQ connections may send consecutive fragments of the same MSDU in a single MAC PDU for retransmission flexibility. Once defined, the size of a fragment cannot be changed between retransmissions.

An ARQ fragment may be in one of the following four states, *not-sen*t, *outstandin*g, *discarded* and *waiting-for-retransmissio*n. Any ARQ fragment begins as *not-sen*t. After it is sent it becomes *outstanding* for a period of time termed **ACK_RETRY_TIMEOUT**. While a fragment is in *outstanding* state, it either is acknowledged and is *discarde*d, or transitions to *waiting-for-retransmission* after **ACK_RETRY_TIMEOUT**. An ARQ fragment can become *waiting-for-retransmission* before the **ACK_RETRY_TIMEOUT** period expires if it is negatively acknowledged. An ARQ fragment may also change from *waiting-for-retransmission* to *discarded* when an ACK message for it is received or after a timeout **ARQ_FRAGMENT_LIFETIM**E."

Page 50, Section 6.2.4.6.3 and Figure 140, replace "block" with "fragment" and "BSN" with "FSN"

Page 51, Section 6.2.4.6.4 replace "block" with "fragment" and "BSN" with "FSN"

Page 225, Remove Section 11.4.8.18.2