Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Suggested modifications to 802.16.1 standard draft to support MAC level ARQ**
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Re:	Call for Comments on 802.16.1-00/01r1
Abstract	This documents provides details on how to modify current 802.16.1 standard draft to include support for ARQ (Document IEEE 802.16.1-00/01r1)
Purpose	Include the modifications proposed in this document to the new 802.16.1 standard draft.
Notice	
Release	
Patent Policy and Procedures	

Suggested modifications to 802.16.1 standard draft to support MAC level ARQ

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General

The ARQ mechanism is part of the MAC layer. It is an optional service, and is only used for services and installations that may benefit from its use. The ARQ service is specified only for the upstream direction, as it is expect to suffer from burst noise at the receiver (see IEEE 802.16.1mc-00/19).

Specifying usage of ARQ

ARQ is viewed as a MAC service provided to the convergence sub-layers above it. In order to use this service, the convergence sub-layers specifies upon connection creation whether ARQ is required or not, and what are the parameters for deploying it. The additional parameters associated with an ARQ-enabled connection are whether ARQ is used or not, maximum re-transmission limit, and acknowledgment window size. These parameters are added to an *ARQ parameters* field of the *MAC-CREATE-CONNECTION* and *MAC-CHANGE-CONNECTION* primitives.

ARQ operation – CPE

ARQ is only supported in the upstream direction, therefore usage of ARQ needs to be indicated in the upstream MAC generic header. This requires one bit. Possible allocations for this bit are the CSI bit, or one bit from the eight bits GM field. The ARQ mechanism requires adding control and checksum fields to each ARQ enabled packet. The checksum field is four bytes long, standard IEEE CRC-32, and it is appended at the end of the packet. The control field is two bytes long and is prepended at the beginning of the packet. The control bit structure is shown in the drawing below,

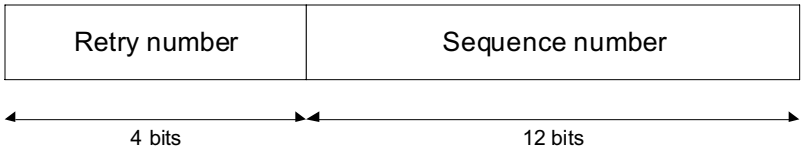

Figure 1: ARQ control field

The retry number field is reset when a packet is first sent, and is incremented whenever it is retransmitted (up to the terminal value of 15). The sequence number field is assigned to each packet upon its first transmission, and then incremented. The sequence number does not change when a packet is retransmitted. These ARQ related fields are added only to packets for which the ARQ usage indication is set in the generic MAC header. To summarize, the ARQ service in the sending party performs the following list of functions,

- Identify packets belonging to ARQ-enabled connections.
- For each ARQ-enabled packet, set the ARQ bit of the generic MAC and add the ARQ specific fields.
- Place the packet in the retransmission queue of its connection.
- Select packet(s) from the retransmission queue for transmission based on a window algorithm.
- Maintain the retransmission queue by eliminating packets that were acknowledged, or passed their maximum allowed retransmissions limit

ARQ operation – BST

The ARQ mechanism in the receiver examines each incoming packet belonging to ARQ-enabled connections. The packet integrity is determined based on the integrity of the CRC32 field. An acknowledgment message is sent to

the sender for packets received correctly. The acknowledgment message may group together more than one packet, and carries the sequence number(s) for packets that have been correctly received. The acknowledgement message is an additional MAC management header message, and its format is shown below,

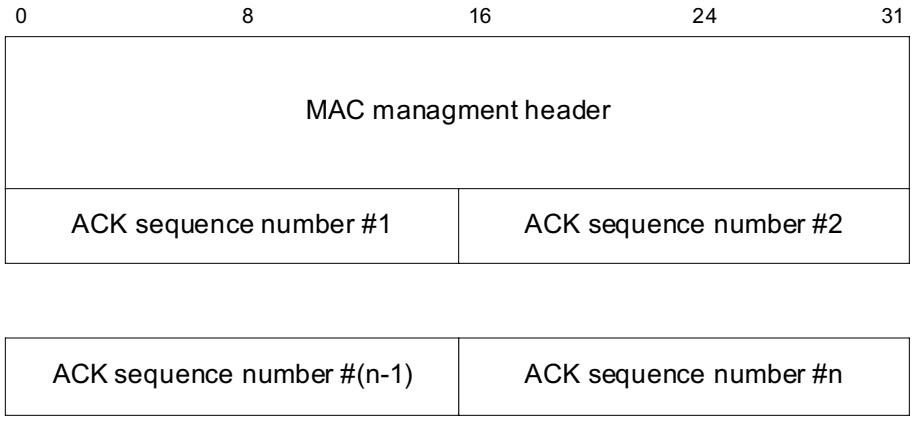

Figure 2: ARQ acknowledgement message

To summarize, the ARQ service in the receiving party performs the following list of functions,

- Identify packets belonging to ARQ-enabled connections.
- Check packet integrity based on CRC32 field value.
- Place packets received correctly and in sequence, in the receive queue. Discard duplicate packets.
- Send acknowledgement messages for correctly received packets.
- Maintain the receive queue by handing to the upper layers packets that where either correctly received, or timed out.

ARQ operation – window algorithm

The window algorithm enables the sending party at each transmission opportunity, to determine whether it should attempt to send a new packet or re-send an already sent one. The basic parameter of this algorithm is the acknowledgment window size, which measures the amount of time (since a certain packet is sent until is acknowledged by the receiving party. This time includes all processing delays of both PHY and MAC at both the transmitter and the receiver. The window algorithm divides the packets at the sender to four types, not-sent, outstanding, acknowledged and not-acknowledged. Any packet begins as not-sent. When it is sent it becomes outstanding for an acknowledgement window duration, after which it either is acknowledged, or becomes not-acknowledged. The window algorithm defines the following policy that if any not-acknowledged packets exist, they should be transmitted at the next transmission opportunity, otherwise a not-sent packet should be sent. The acknowledgment window duration is set at connection establishment.