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| Re: | This document is a response to the following calls for contributions:<br><br>Call for Contributions for Proposed Modifications of 802.16 MAC and 802.11a-HYPERLAN/2 PHY for the WirelessHuman“ Standard 802.16.4-00/01.<br><br>IEEE 802.16 Task Group 3 Call For Contributions: Proposed MAC Enhancements, Key Characteristics, and Evaluation Criteria: Session #11 , 802.16.4-00/25. |
| Abstract | This contribution provides a low-overhead mechanism that will permit multiple data PDUs to be carried within a single MAC encapsulation. This will improve link efficiency for small size packets and permit the piggybacking of ARQ ACK/NACK packets. |
| Purpose | For Consideration for inclusion in the proposed 802.16.3 and 802.16.4 MAC standards. |
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# A Proposal for the Enhancement of the 802.16.1 MAC: Multiple Higher Layer PDUs per MAC Encapsulation

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## Introduction

The current 802.16.1 MAC was designed for operation in the 10 — 66 GHZ bands where high data rates are achieved. The 802.16.1 MAC can be used in the below 10GHZ bands, but it needs some additional capabilities to optimize for use in these bands.

## Comparative Analysis

The following section compares two likely 802.16.1 TDD implementations; one using a 10 - 66 GHZ band and the other aUNII band. The numbers used in both examples are estimates and so do not provide to-the-byte accuracy. However, such accuracy should still be sufficient for broad comparison.

An 802.16.1 MAC TDD system with a 1 mS frame, 20 Mbaud modulation rate, roll-off factor of 0.25 and a 4 modulation symbol physical slot will produce a frame with 5000 physical slots. If 64-QAM is used for modulation, each symbol will carry 6 bits . If we assume a _ coding rate, each symbol will carry 4.5 data bits. Therefore each frame will carry 5000 slots x 4.5 data bits-per-symbol x 4 symbols-per-slot or 11,250 bytes of data(90Mbps). Consider a frame in which the downstream portion uses 100 percent of the frame, a generic header of 6 octets and a payload size of 64 bytes bound for each SS. This equates to a minimum of 70 bytes or about 125 symbols per SS. This shows that approximately 160 SSs will be able to be sent data during a single frame time. If there are 1000 active subscribers, each with their own CPE, and the scheduler in the BS is performing a Round Robin algorithm, then each CPE will be serviced roughly every 6 frames.

By contrast, the 802.16.4 WG is using the UNII band with OFDM encoding following the 802.11 PHY. A TDD system based on the 802.16.1 MAC, with a 1 mS frame time, 48 sub-carriers, 64-QAM, _ coding rate and 216 bits per symbol will have a 54Mbps data rate and a frame with 250 symbols or 6750 bytes. As each symbol represents 216 bits (27 bytes), a 70 byte packet will require 3 symbols and 11 bytes from the last symbol will be wasted . Approximately 83 SSs will be able to be sent data during a single frame time. If there are again 1000 subscribers, each CPE will be serviced roughly every 12 frames.

Thus the OFDM-based UNII band system must use symbols with much higher granularity than those of the 10-66GHZ system in order to efficiently carry traffic. This higher granularity greatly increases the chance that a large number of payload bits in a last symbol may be wasted.

This contribution proposes a modification to the current 802.16.1 MAC draft that allows the BS and SS to place multiple higher layer PDUs in a single MAC encapsulation. This capability would provide several benefits.

1. Small packets can be grouped together to reduce header overhead.
2. Small packets may be piggybacked on larger PDUs for transmission over the wireless link. This reduces header overhead, permits the use of an unused fragment of a symbol(s) and thereby increase the utilization of the link.
3. In permitting the piggybacking of smaller packets, MAC layer ARQ mechanisms can be made more efficient then if they rely solely on ARQ-ACK type MAC messages.

## Multiple PDU Encapsulation MPE

The encapsulation of multiple PDUs should be simple and optional. In order to use this option, the sending station must request its use of the receiving station. This is done using either the Dynamic Service Addition or Change message with the inclusion of a new parameter; the Multiple PDU Encapsulation TLV.

### Multiple PDU Encapsulation Parameter

The Multiple PDU Encapsulation TLV indicates that the sending station would like to use MPE..

The DSA/DSC-RSP message will contain:

1. An acknowledgement of this parameter, signified by the parameter s exclusion from an SFES (if one is included).
2. A negative acknowledgement signified by the presence of an unmodified copy of the TLV parameter in the SFES.

A peer may attempt to enable or disable MPE at any time using the DSC mechanism and this TLV parameter.

The DSA/DSC-REQ message includes the following QoS parameter.

| **Name** | **Type (1 byte)** | **Length (1 byte)** | **Value (Variable Length)** |
|---|---|---|---|
| Multiple PDU Encapsulation | 1 | 4 | Unsigned 16-bit value<br>0 — disable MPE<br>1 — enable MPE<br>All other values are illegal, ignore TLV<br>The peer sending this TLV parameter indicates its desire to use MPE by including this parameter.<br><br>MPE is not used by default. |

## Current MAC PDU Packet Format

Figure 1 depicts the MAC PDU Format.

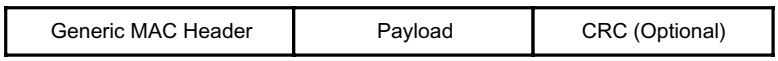


**Figure 1 MAC PDU Format**

## Multiple PDU Packet Format

Figure 2 depicts the proposed layout of the new encapsulation. Note that it does not change the current format, but simply adds to it.

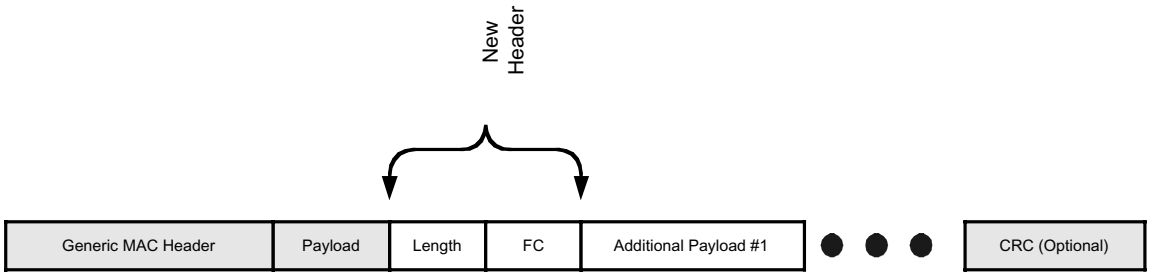


**Figure 2 Multiple PDU Format**

To carry additional payloads within the same MAC encapsulation requires a length filed and a pair of Fragmentation Control bits.

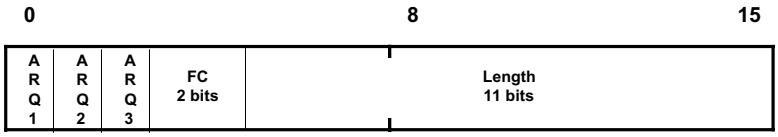


**Figure 3 New Additional PDU Header Format**

The new format follows these rules:

1. If MPE has been approved for use on the link, all MAC PDUs that have unused bytes following the end of any payload must have the first two bytes set to zero if no additional higher layer PDUs are included.
2. A new 16-bit Subheader field follows both the normal payload section and all but the last additional PDU. This field is depicted in figure 3.
3. The FC bits will treated as if they are they were in their original location in the Generic Header for a follow-on packet.
4. The optional CRC shall include all bytes in all payloads and all non-zero length subheaders.
5. The sequence number in the Generic Header can be reused.
6. The 3 ARQ bits are used to encode information pertaining to ARQ. The valid values for this field are:

| Name | ARQ1 | ARQ2 | ARQ3 |
|---|---|---|---|
| No Piggybacking | 0 | 0 | 0 |
| Additional Data Payload | 0 | 0 | 1 |
| ACK | 0 | 1 | 0 |
| NACK | 1 | 0 | 0 |

## ACK/NACK Format

If the ACK/NACK capability of the subheader is used, the following 16-bit field must follow the subheader.

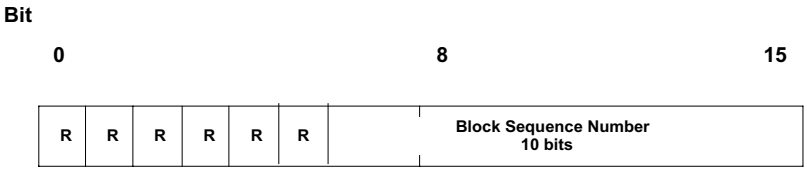


**Figure 4 ACK/NACK format for use with subheader**

## References

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