Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**MAC layer proposal with IP QoS allowances for BWA**
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Re:	This contribution is submitted in response to call for contributions from the IEEE 802.16 chair on Sept. 22nd, 1999 for submission of MAC proposals for BWA
Abstract	The MAC with allowances to provide for efficient IP transport is submitted for consideration by the group to be accepted as MAC characteristics for the standards for BWA
Purpose	This proposal should be accepted as MAC standard for BWA
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Proposal to provide for MAC characteristics to improve QoS-aware IP transport

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Introduction

This contribution proposes that a MAC standard be developed with certain characteristics that will allow for efficient QoS-aware transport of IP data for BWA. These characteristics are a super set of many presently proposed MAC standards such as those based on the DOCSIS 1.1 standard, but do not require DOCSIS 1.1 in order for these proposed MAC characteristics to be implemented. These characteristics will allow for the efficient QoS-aware transport of IP flows in a MAC multiplexed manner, and other desirable features as described below.

Proposed Media Access Control Specification Modifications

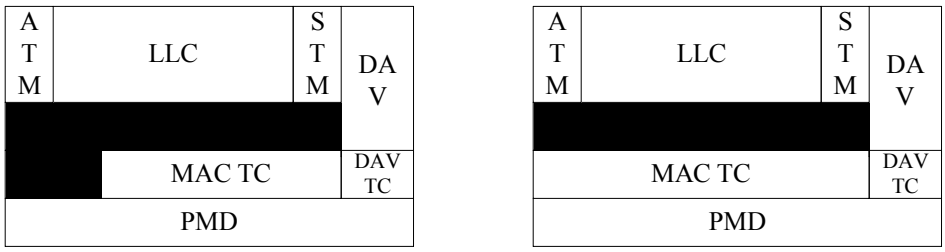
1.) MAC Over PMD without MAC TC for up stream and down stream traffic

Overview of Proposal

Although specific MAC characteristics can be described to optimize efficient QoS-aware IP transport without reference to a particular MAC design, it may be more productive to assume a particular known MAC design and propose appropriate modifications to it. Therefore, in proposing specific MAC characteristics that can provide optimal support for QoS-aware transport of IP data, we will utilize the DOCSIS 1.1 MAC definition as a starting point for the following discussion.

The current system requirement of encapsulating down stream MAC frame in MAC TC layer works with FDD system but does not necessary work well with other types of multiple access RF system such as TDD.

We propose the allowance of the MAC frame directly over the PMD without requirement for the intervening DOCSIS-like MAC TC layer. (The DOCSIS Transmission Convergence sublayer is present in the downstream direction only). This will allow the BWA MAC frames to be transported without the need for packing MAC frames into the DOCSIS-like MPEG structure, although MAC frames would also continue to be permitted to exist in the DOCSIS-like structure (see figure 1 and 2). This proposal, therefore, is to allow the MAC frame be sent out either via the MAC TC layer or directly over the PMD layer.



Proposed protocol stack reference model

Protocol stack reference model based on 802.16 System Requirement

Figure 1. Protocol stack reference model

PMD overhead	MAC header	Data PDU

Figure 2. Generic MAC frame format for both down stream and up stream traffic

MAC-Mediated QoS Jitter and Latency Performance Limitations

With the present DOCSIS requirement for MAC frames within MPEG structures, a possible consequence of meeting the QoS requirements for the transport of jitter or latency sensitive IP flows is low bandwidth utilization for non-FDD systems. This result becomes particularly exacerbated with jitter or latency sensitive IP flows consisting of small packets.

In order to meet the QoS requirements of such jitter-sensitive IP flows by minimizing induced jitter, singular packets may need to be inserted into the current MPEG structure in a timely fashion before subsequent packets from that flow are available. Consequently, in order to meet QoS jitter or latency requirements, an MPEG structure may contain only one small packet, leaving most of the remaining payload empty if no other packets are available for transport at that time.

A clear example of this situation is that of voice over IP, where the voice codec - generated packet contains only 60 bytes, and the IP flows are typically very jitter sensitive. In this example, only 60 of the188 bytes of the MPEG structure are occupied by payload data, equating to only a 32% bandwidth utilization. Conversely, if bandwidth utilization is optimized instead of QoS performance, significantly increased jitter will result.

If we attempt to optimize bandwidth utilization instead, we will wait for three packets in order to optimally fill the 188 MPEG structure. In order to do so, assuming a typical 30ms inter-packet arrival time, we introduce 30ms of delay for the second packet, and an additional 30ms of delay for the third packet. A total of 60ms of latency will have been added along with the addition of large jitter delays.

Therefore for non-FDD systems, QoS jitter optimization and efficient bandwidth utilization cannot both be optimized simultaneously to a given degree with the present unmodified DOCSIS 1.1 MAC definition.

QoS Jitter and Latency and Bandwidth Efficiency Benefit

Several benefits would accrue by not requiring MAC frames to reside within DOCSIS 1.1 MAC TC structures. One is significantly better performance with jitter or latency constrained IP flows. Another benefit results even in the absence of jitter or latency sensitive IP flows. Better bandwidth utilization would result because MAC frames could be transported without the overhead of the MAC TC header fields.

By not requiring MAC frames to appear only in the MPEG MAC TC structures of a DOCSIS 1.1 -like proposal, for example, the overhead of the MPEG headers is eliminated. For long IP packets, (greater than 188 bytes) savings include all MPEG header fields, the Header and Pointer fields, (5 bytes each), saving approximately 40 bytes out of 1500 for 1500 byte IP packets.

2.) MAC Multiplexing for down stream transmission

Overview of Proposal

We propose the provision for multiplexing IP packets within one MAC frame. DOCSIS 1.1 only allows multiplexing of individual MAC frames in the MAC TC layer but not in the MAC layer for down stream traffic, although concatenation of MAC frames is presently allowed for upstream traffic.

This proposal includes a second concatenated MAC header format (see Figure 3.) to further improve bandwidth utilization. Here each data PDU is an IP packet without a MAC header. The variable length multiplexed MAC frame is most suitable for the placement of several short IP packets into one MAC frame. The saving is 6 bytes (MAC frame header) per IP packet.

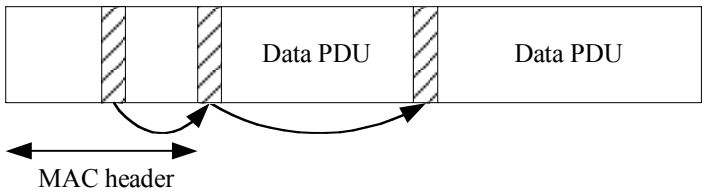


Figure 3. Concatenation in the MAC frame with one MAC frame header and multiple IP packets.

Benefits

By allowing IP packets to be multiplexed within a MAC frame, better QoS jitter and latency performance without consequent bandwidth inefficiencies could be achieved. This is also more of an issue for TDD methods of multiple access than FDD.

For example in DOCSIS, each MAC frame has a 6 byte header. For short IP packets in the neighborhood of 60 bytes, there is a 10 % penalty for MAC header overhead. By concatenating several short packets with similar traffic characteristic into one MAC frame, down stream bandwidth can be better managed.