

Project	IEEE 802.16 Broadband Wireless Access Working Group < http://ieee802.org/16 >	
Title	Proposed MAC Enhancements to support adaptive antenna array processing in 802.16.3	
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Re:	This document is presented as proposed enhancements to the 802.16 MAC as described in the 802.16.1/D1-2000 draft standard. The proposed enhancement will allow systems that comply with the 802.16 MAC Draft standard, and work in the frequencies from 2 through 11 GHz, to take advantage of existing adaptive antenna array processing techniques. This will be achieved by adding interfaces to support adaptive antenna array processing needs, regardless of the actual technique used for the PHY or the adaptive antenna array. This document is in response to the CALL FOR CONTRIBUTIONS: PROPOSED MAC ENHANCEMENTS, session #12, from 2001-1-26. It addresses the specific issue for which proposal are invited: MAP Packet Related Issues.	
Abstract	This document contains enhancements to add support of adaptive array processing to the 802.16 MAC. The issues that are handles by these additions are: MAC control packets distribution, and channel estimation feedback to enable downlink antenna array processing (“smart antenna”) at the BS.	
Purpose	Adding these suggestions as text enhancements to the existing 802.16 Draft standard, in the relevant chapters. This will allow compliant systems to use emerging adaptive array techniques.	
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MAC Enhancements to support adaptive antenna array processing in 802.16.3

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Scope

MMDS systems are required to operate in a more severe multipath environment, as compared to LMDS. As a result, the PHY and MAC should be designed to efficiently mitigate these propagation effects. While the PHY may use COFDM or advanced equalization techniques to deal with delay spread and overcome “frequency-selective” fading effect, it will fail to deal with flat fading. The use of adaptive antenna array processing in various ways, can effectively overcome flat fading, thus reducing the total path loss and increasing cell coverage area. Adaptive antenna array techniques will also enable to increase capacity by use of interference suppressing techniques that enables simultaneous use of the same frequency channel. This proposal includes additions to the 802.16.1 MAC that will enable the use of adaptive antenna array processing in MMDS systems.

Introduction

The use of adaptive antenna array processing to enhance link robustness and cell coverage area is part of the PHY layer. It is assumed that array processing schemes will be added to any PHY scheme that will be used for the 802.16.3 PHY. While these additions may not be part of the 802.16.3 PHY specifications, interfaces to add-on solutions are essential. To be able to support such PHY enhancements, The MAC should be able to provide some services that are not included in the 802.16.1 MAC. In this proposal, some specific MAC additions are suggested, aiming to support antenna array processing schemes at the PHY level, which are implemented in the base station. It is applicable to all different types of array processing, space-time processing/coding, diversity schemes and other “smart antenna” techniques.

Overview

This section describes the motivation and concept of solution to the 802.16.3 MAC enhancements of this proposal. Two major properties of the MMDS system with antenna array processing at the BS are:

1. A transmission (a unicast message) to a single SS can use the full potential of the antenna array-processing scheme, unlike the transmission to multiple users (multicast or broadcast message). Because of this limitation, it is suggested to add additional message types that enable transmitting MAC control information to individual SSs.
2. Some antenna array processing schemes require channel reciprocity in order to enable in the downlink use of channel state information obtained from the uplink. This requirement for reciprocity limits the use of array processing in the base station, to TDD systems only. It is suggested, to add a MAC service that will enable passing channel state information, estimated by the SS receiver, to the base station. This will allow FDD systems to enjoy antenna array processing benefits.
3. Some antenna array processing schemes enable to increase capacity by creating multiple signals transmitted simultaneously, at the same frequency channel without interfering with each other. It is assumed that the existing 802.16 MAC specifications can support this capability without any modifications (by using existing scheduling and channel allocation services of the MAC).

Adding private MAC control messages

In the 802.16-1 MAC, the definition of a channel assumes that all SS using the same downlink channel can hear the channel control messages. These messages (UCD, DCD, MAP, etc.) are used to synchronize BS and SS, and to coordinate multiple SS transmission.

When using adaptive antenna arrays at the base station, there is a significant difference between unicast and broadcast, which requires more careful design of the MAC control transmission. The smart antenna system tends to optimize the performance towards a single SS. On the other hand, when broadcast transmission is required, as in the case of MAC control packet transmission, the antenna array must create a wide beam that will reach as many SS as possible.

In order to cope with this problem, it is proposed to add an alternative way to deliver MAC control to a SS:

- Each MAC control information field that is normally part of a broadcast MAC control message can be also included in an alternative unicast MAC control message. The messages used for this purpose are:
- P-DUCD (Private Uplink/Downlink Channel Descriptor) used as an alternative to UCD and DCD
- P-MAP (Private MAP) used as an alternative to UL-MAP and DL-MAP.

It is proposed to add the following after clause 6.2.1.2.2:

6.2.1.2.x Private Uplink/Downlink Channel Descriptor (P-DUCD) message

A Private Uplink/Downlink Channel Descriptor message shall be transmitted by the BS to each SS that did not receive the last DCD or UCD. The P-DUCD message should contain all information contained in the DCD and UCD messages that is relevant to the addressed SS.

The MAC header and Downlink/Uplink channel ID are identical to the type-0 (UCD) packet format. The Type field value is TBD. The Configuration Change Count field is the sum of the values of Configuration Change Count fields in both corresponding UCD and DCD messages, to allow each SS to track changes and discard the P-DUCD message, in case no changes made since last update.

All TLV information that describe Uplink and Downlink channel and burst profiles are identical to their corresponding fields in the original DCD/UCD messages (the final TLV encodings should be updated after determination of the final channel encodings and DCD/UCD fields content for 802.16.3). A SS receiving a P-DUCD will ignore the message, if it had received the UCD and DCD containing the same information. This can be verified easily by comparing the Configuration Change Count field.

6.2.1.2.x Private MAP (P-MAP) message

The BS shall generate a Private MAP (P-MAP) message for each SS that had not received the last UL-MAP or DL-MAP. The P-MAP message defines the access to Downlink and Uplink information and contains all information relevant to the addressed SS, contained in the UL-MAP and DL-MAP messages.

The MAC header and Downlink/Uplink channel ID are identical to the type-2 (DL-MAP) packet format. The Type field value is TBD. The P-MAP contains the same fields of UL-MAP and DL-MAP, in a single message. Unlike the typical UL-MAP, which has a large number of information elements (one for each connection for several SSs), the P-MAP shall have only few information elements, since only connections relevant to the

addressed SS are informed. A SS receiving a P-MAP will ignore the message, if it had received the MAP of the current frame correctly.

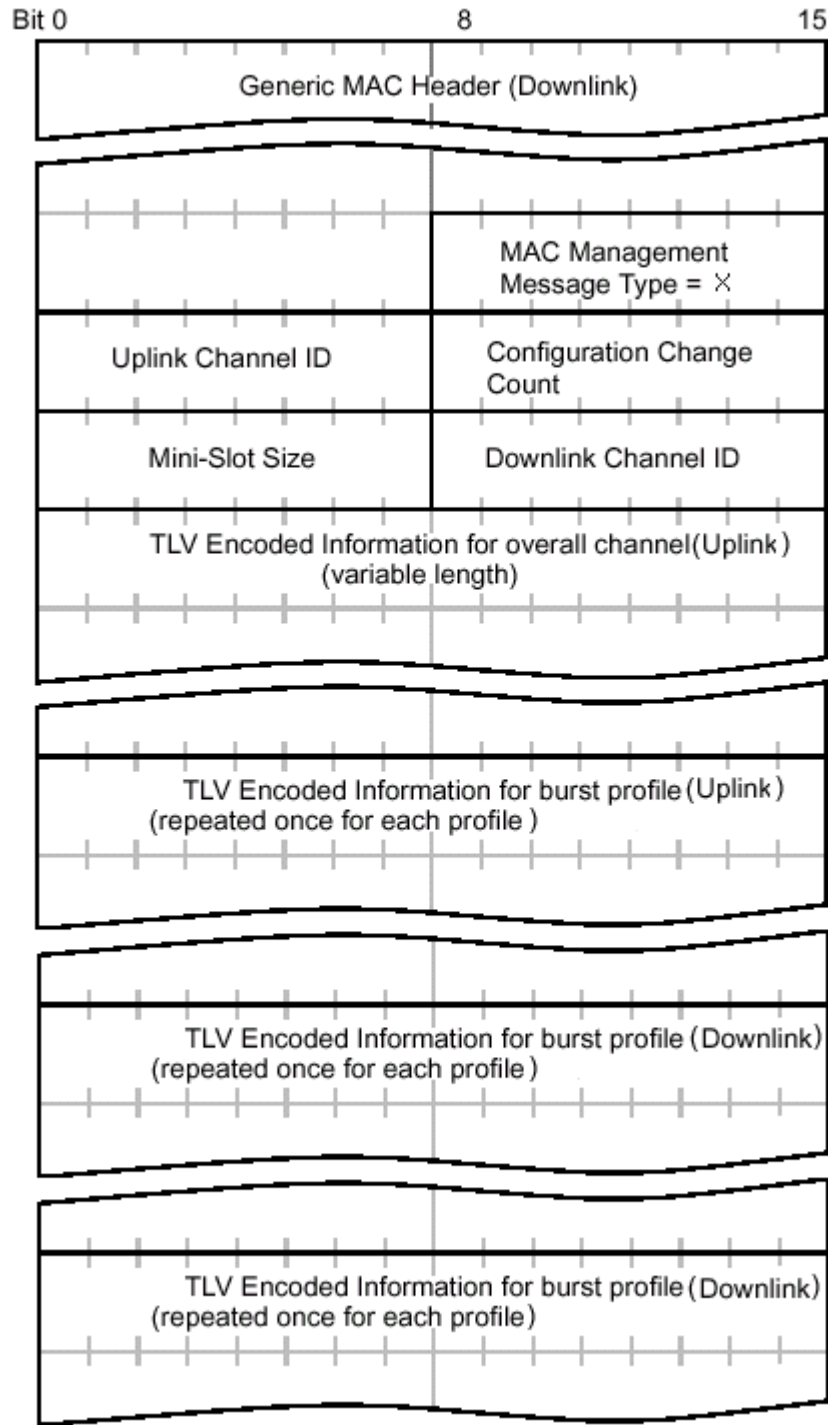


Figure 1: P-UDCD message

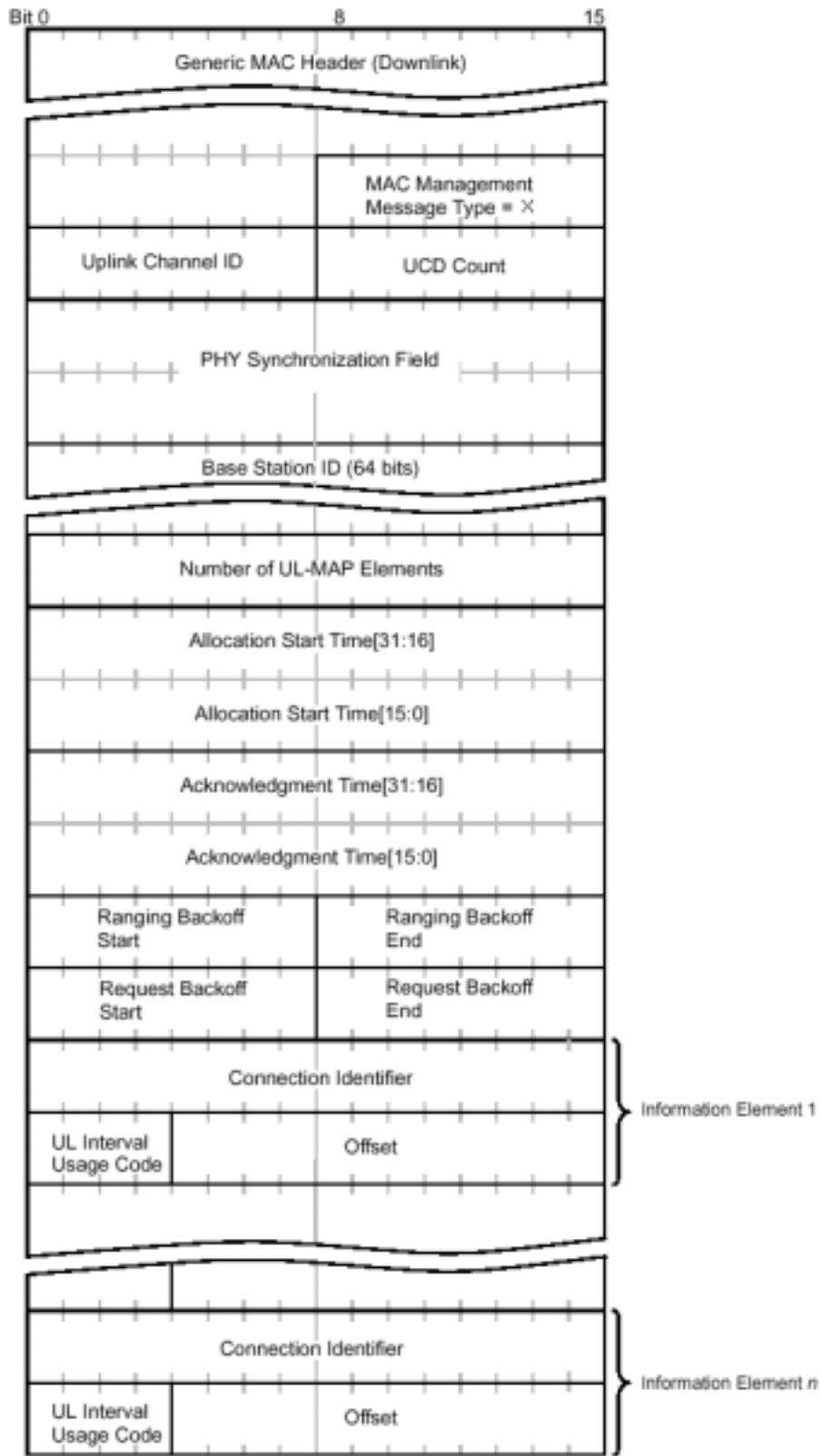


Figure 2: P-MAC message

Adding Channel State Feedback (CSF) messages

In FDD systems, the uplink and downlink propagation channels are different due to the large frequency separation between uplink and downlink. To enable antenna array processing in the transmitter, there should be a way to deliver channel state information from the receiver, where it is estimated, to the transmitter where it is used. To this end, it is proposed to include two additional messages to the MAC control messages. These messages shall contain a request for estimation and a reply. The reply will include channel state information, obtained at the SS. The channel state information shall be computed periodically during Channel Estimation Interval (CEI). The CEI is time allowed from the arrival of the signal that the SS uses for channel estimation, to the reply send by the SS. The value of CEI shall be determined by the BS and broadcasted to all SSs at registration.

6.2.1.2.x CSF-REQ message

The Channel State Feedback Request (CSF-REQ) message shall be sent by the BS from time to time, to signal the SS that channel state information should be updated. The time between requests is an internal parameter of the BS MAC, and should not be limited to any specific value. The SS should perform channel estimations on a regular time basis, in order to be able to provide up-to-date estimations upon request.

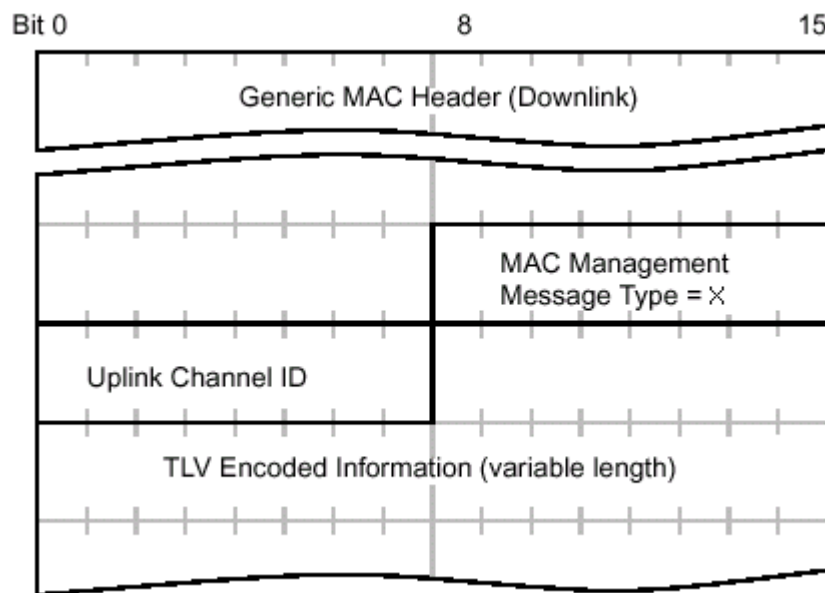


Figure 3: CSF-REQ message

The CID used in the header will be the basic CID of the SS that is addressed.

The following parameters may be included in the TLV encoded information of the message:

- Frequency adjust information
- Power adjust information
- Timing adjust information

6.2.1.2.x CSF-REP message

The Channel State Feedback Reply (CSF-REP) message shall be sent by the SS as a response to a CSF-REQ sent by the BS. The SS reply shall be the most up-to-date estimation of the channel, obtained during a **Channel Estimation Interval (CEI)**. The Channel Estimation Age field shall be used to indicate the number of CEI periods elapsed since the channel estimation was performed. Any value of Channel Estimation Age field, greater than zero, indicates to the BS that the channel information send by SS is not up to date.

Note:

The value of CEI shall be predefined according to channel stability over time (a typical value is 20 msec), The BS is responsible to determine the actual value of CEI, and for the distribution of this value to all SSs.

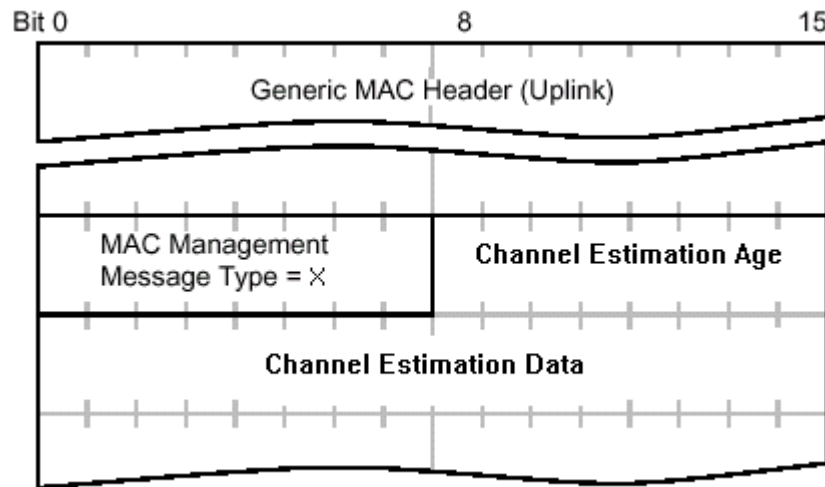


Figure 4: CSF-REP message

The Channel Estimation Data is a stream of data bits captured by the SS PHY. The definition of this stream is left to the PHY, since it may be different for different PHY types. As an example only, this data stream may represent 64 consecutive complex samples (of 8 bits I and Q) of the received preamble or synchronization signal.