Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	Proposed Editorial Re-structuring of 80216-00/01r4
Date Submitted	2000-12-14
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Re:	Session #10, Document 80216-00/01r4
Abstract	This document defines a new outline for the document 80216-00/01r4. The outline is based upon the IEEE 802.11 standard's organization with additional material added.
Purpose	To provide a framework which can be used by the Ad Hoc Editorial Team to direct non-technical changes to the working document. This document can be used by professional editorial staff to perform the document re-organization without supervision.
Notice	
Release	
IEEE Patent Policy	

The following text is a suggested outline for document. The black text defines the new section headings. Portions of the text are based on the format of the 802.11 table of contents. The blue text corresponds to the original table of contents from document 802161-00/01r4. The magenta text requires editing to the actual text as opposed to the simple movement of that block of text to a separate part of the document. These two colored text types were extracted from a 5-level table of contents and then organized to fit into the new structure. Comments about the rationale for placement of the structures and placement of text are given as embedded notes, which are highlighted in a red font.

Please note that the page numbers given in the blue text may be slightly off the original page numbers from the rev4.

Sections of the document also contain new or modified text that should be used in conjunction with the re-organization of the document to better isolate the MAC from the PHY layer. These sections are indicated with change bars and are defined using the re-organized outline.

I consider the following paragraphs to be orphans. The rationale for this decision is given after each section.

The definitions of terminology is for wording within the standard itself (SHALL, etc.). This is a remnant from the DOCSIS specifications. I could not find any such definitions in the IEEE 802 standards.

These two paragraphs are deleted upon completion of action items from Session #10.

1. Overview

1.1 Reference Model

The updated reference model diagram is inserted here. The following paragraphs should provide an overview of the two "planes" that are shown in that diagram along with the different SAP definitions and logical entities.

1.1.1 Data/Control Plane

1.1.2 Management Plane

1.2 IEEE 802 Architectural Conformance

1.3 Scope

1.4 Purpose

Could potentially use text from the three PARs for this section. This is more related to the purpose of the system and not the document itself. This section should be as short as in 802.11, using that format with modification to fit with the PARs. Some text from the Functional requirements may also apply in this area.

2. Normative references

3. Definitions

4. Abbreviations and acronyms

5. Service Specific Convergence Sublayer

The following clauses are place holders.

5.1 ATM Service Specific Convergence Sublayer

5.1.1 Data/Control Plane

5.1.1.1 SSCS Service Definition

5.1.1.2 Message Formats

5.1.1.3 Signaling

5.1.1.4 Convergence Operation

5.1.2 Management Plane

5.1.2.1 Service Interface Specification

5.1.2.2 MIB Definitions

5.2 Ethernet/IEEE 802.3 Service Specific Convergence Sublayer

5.2.1 Data/Control Plane

5.2.1.1 SSCS Service Definition

5.2.1.2 Message Formats

5.2.1.3 Signaling

5.2.1.4 Convergence Operation

5.2.2 Management Plane

5.2.2.1 Service Interface Specification

5.2.2.2 MIB Definitions

5.3 IP Service Specific Convergence Sublayer

5.3.1 Data/Control Plane

5.3.1.1 SSCS Service Definition

5.3.1.2 Message Formats

5.3.1.3 Signaling

5.3.1.4 Convergence Operation

5.3.2 Management Plane

5.3.2.1 Service Interface Specification

5.3.2.2 MIB Definitions

6. MAC Sublayer - Common Part

6.1 MAC Service Definition

The relative ordering of the following sections remains the same but starts at 6.1.

6.2 - Data/Control Plane

6.2.1 Message formats

6.2.1.1 Conventions

6.2.1.1.1 Convergence Sub-layer PDU Formats

6.2.1.1.2 Encryption of Convergence Sub-layer PDUs

6.2.1.2 MAC Management Messages

6.2.1.2.1 Uplink Channel Descriptor Message (UCD) Message

Except for TLV encodings.

6.2.1.2.2 Downlink Channel Descriptor (DCD) Message

Except for TLV encodings.

6.2.1.2.3 Downlink MAP (DL-MAP) Message

Except for TLV encodings.Rewrite PHY sync field to be defined by each PHY layer.

6.2.1.2.4 Downlink MAP (UL-MAP) Message

Except for TLV encodings.

Insert text with generic description of allocation start time and ack time. Exact defintions are found in PHY.

6.2.1.2.5 Ranging Request (RNG-REQ) Message

Except for TLV encodings.

6.2.1.2.6 Ranging Response (RNG-RSP) Message

Except for TLV encodings.

6.2.1.2.7 Registration Request (REG-REQ) Message

Except for TLV encodings.

6.2.1.2.8 Registration Response (REG-RSP) Message

Except for TLV encodings.

6.2.1.2.9 Registration Acknowledge (REG-ACK) Message

Except for TLV encodings.

6.2.1.2.10 Privacy Key Management Messages (PKM-REQ/PKM-RSP)

Except for TLV encodings.

Except for TLV encodings.

6.2.1.2.10.1 Authorization Request (Auth Request) Message

6.2.1.2.10.2 Authorization Reply (Auth Reply) Message

6.2.1.2.10.3 Authorization Reject (Auth Reject) Message

6.2.1.2.10.4 Key Request Message

6.2.1.2.10.5 Key Reply Message

6.2.1.2.10.6 Key Reject Message

6.2.1.2.10.7 Authorization Invalid Message

6.2.1.2.10.8 TEK Invalid Message

6.2.1.2.10.9 Authentication Information (Authent Info) Message

6.2.1.2.10.10 SA Map Request (MAP Request) Message

6.2.1.2.10.11 SA Map Reply (Map Reply) Message

6.2.1.2.10.12 SAID Map Reject (Map Reject)

6.2.1.2.11 Dynamic Service Addition -- Request (DSA-REQ) Message

Except for TLV encodings.

6.2.1.2.12 Dynamic Service Addition -- Response (DSA-REQ) Message

Except for TLV encodings.

6.2.1.2.13 Dynamic Service Addition — Acknowledge (DSA-ACK) Message

Except for TLV encodings

6.2.1.2.14 Dynamic Service Change — Request (DSC-REQ) Message

Except for TLV encodings

6.2.1.2.15 Dynamic Service Change — Response (DSC-RSP) Message

Except for TLV encodings

6.2.1.2.16 Dynamic Service Change — Acknowledge (DSC-ACK) Message

Except for TLV encodings

6.2.1.2.17 Dynamic Service Deletion — Request (DSD-REQ) Message

Except for TLV encodings

6.2.1.2.18 Dynamic Service Deletion — Request (DSD-RSP) Message

Except for TLV encodings

6.2.1.2.19 Multicast Polling Assignment Request (MCA-REQ) Message

Except for TLV encodings

6.2.1.2.20 Multicast Polling Assignment Response (MCA-RSP) Message

Except for TLV encodings

6.2.1.2.21 ARQ-ACK Messag

Except for TLV encodings

6.2.1.2.22 Downlink Burst Type Change Request (DBTC-REQ) Message

Except for TLV encodings

6.2.1.3 Concatentation

Figure 16 and associated text only from:

6.2.1.4 Fragmentation

6.2.1.4.1 Encryption of PDU Fragments

6.2.2 Access Methods

This section needs to be modified to describe the general support of the MAC for different physical layers.

6.3 MAC Support of Duplexing Techniques, Framing, and Scheduling Intervals

The MAC is able to support both a framed and a non-framed physical layer. For a framed PHY layer, the MAC aligns its scheduling intervals with the underlying PHY layer framing. For an unframed PHY layer, the scheduling intervals are chosen by the MAC to optimize system performance.

A frame is a fixed duration of time, which contains both transmit and receive intervals. The relationship between upstream and downstream transmission intervals is fixed within the frame, and are both defined relative to the BS internal timing. The TDD and Burst FDD modes of operation use a framed PHY layer. The Continuous FDD mode of operation has no explicit PHY layer framing. Instead, the upstream and downstream transmission timings are linked via the Uplink TimeStamp within the DL-MAP message and the Allocation Start Time in the UL-MAP message.

6.3.1 Duplexing Techniques

Several duplexing techniques are supported in this standard in order to allow for greater flexibility in spectrum usage. The choice of duplexing technique effects physical layer parameters, as defined in each respective PHY specification.

6.3.1.1 Continuous Frequency Division Duplexing (FDD)

In a system employing FDD, the upstream and downstream channels are located on separate frequencies and all subscriber stations can transmit and receive simultaneously. ~~The frequency separation between carriers is set either according to the target spectrum regulations or to some value sufficient for complying with radio channel transmit/receive isolation and desensitization requirements.~~ In this type of system, the downstream channel is “always on” and all subscriber stations are always listening to it. Therefore, traffic is sent in a broadcast manner using time division multiplexing (TDM) in the downstream channel, while the upstream channel is shared using time division multiple access (TDMA), where the allocation of upstream bandwidth is controlled by a centralized scheduler.

6.3.1.2 Burst FDD

A burst FDD system refers to a system in which the upstream and downstream channels are located on separate frequencies but the downstream data is transmitted in bursts. This facilitates the use of different modulation types and allows the system to simultaneously support full duplex subscriber stations (ones which can transmit and receive simultaneously) and optionally half duplex subscriber stations (ones which cannot transmit and receive simultaneously). If half duplex subscriber stations are supported, this mode of operation imposes a restriction on the bandwidth controller not to allocate upstream bandwidth for a half duplex subscriber station at the same time that the subscriber station is expected to receive data on the downstream channel.~~ Frequency separation is as defined in section 2.6.1.1~~.

The following figure illustrates an example of the burst FDD mode of operation. In order to simplify the bandwidth allocation algorithms, the upstream and downstream channels are divided into fixed sized frames, with the allowed frame sizes defined in corresponding PHY specification. A full duplex subscriber station must always attempt to listen to the downstream channel. A half duplex subscriber station must always attempt to listen to the downstream channel when it is not transmitting in the upstream channel.

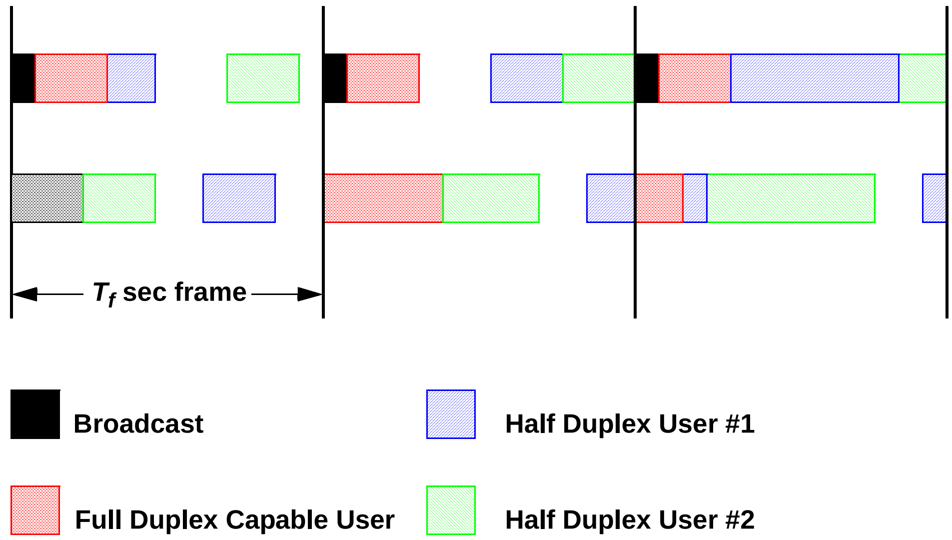

Figure 120—Example of Burst FDD Bandwidth Allocation

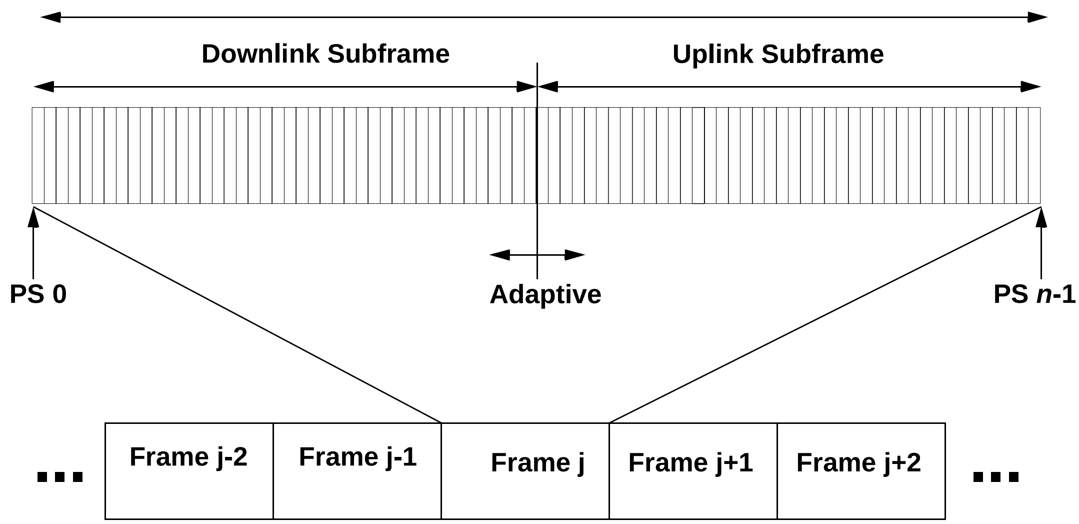

Figure 121— TDD Frame Structure

6.3.1.3 Time Division Duplexing (TDD)

In the case of TDD, the uplink and downlink transmissions share the same frequency, but are separated in time. A TDD frame also has a fixed duration, as defined in the corresponding PHY specification, and contains one downstream and one upstream subframe. The frame is divided into an integer number of physical slots (PS), which help to partition the bandwidth easily. The TDD framing is adaptive in that the bandwidth allocated to the downstream versus the upstream can vary. The split between upstream and downstream is a system parameter and is controlled at higher layers within the system.

6.3.1.3.1 Tx / Rx Transition Gap (TTG)

The TTG is a gap between the downlink subframe and the uplink subframe. This gap allows time for the BS to switch from transmit mode to receive mode and SSs to switch from receive mode to transmit mode. During this gap, the BS and SS are not transmitting modulated data, but it simply allows the BS transmitter carrier to ramp down, the Tx / Rx antenna switch to actuate, and the BS receiver section to activate. After the TTG, the BS receiver will look for the first symbols of upstream burst. The TTG has a variable duration, which is an integer number of PSs and is defined for each PHY separately. The TTG starts on a PS boundary.

6.3.1.3.2 Rx / Tx Transition Gap (RTG)

The RTG is a gap between the downlink subframe and the uplink subframe. This gap allows time for the BS to switch from receive mode to transmit mode and SSs to switch from transmit mode to receive mode. During this gap, BS and SS are not transmitting modulated data but simply allowing the BS transmitter carrier to ramp up, the Tx / Rx antenna switch to actuate, and the SS receiver sections to activate. After the RTG, the SS receivers will look for the first symbols of QPSK modulated data in the downstream burst. The RTG is an integer number of PSs and is defined for each PHY separately. The RTG starts on a PS boundary.

6.3.2 DL and UL structure defintion

The BS must transmit control information at regular intervals as defined in the respective PHY specifiacttions. This control section must contain a DL-MAP message for the channel followed by one UL-MAP message for each associated uplink channel. In addition the control section may contain DCD and UCD messages, defining the burst profiles following the last UL-MAP message. No other messages may be sent in the PHY/MAC Control portion of the frame

6.3.2.1 Upstream Mini-Slot Definition

The uplink bandwidth allocation (UL-MAP) uses a time unit of Mini-Slots. The size of the Mini-Slot (N) is specified as a number of PHY slots (PS) and is carried in the Physical Channel Descriptor for each upstream channel. One Mini-Slot contains N PHY slots (PS), where $N = 2^m$ (where m = 0..7). ~~Since each PS contains 4 modulation symbols, the number of modulation symbols contained in one Mini-Slot equals 4N.~~

Practical Mini-Slots are expected to represent relatively few PS to allow efficient bandwidth utilization with respect to the Mini-Slot size. Larger Mini-Slot sizes allow the BS to allocate transmission opportunities for a longer uplink interval.~~define large contention intervals (up to 2^{12}–1 or 4095 Mini-Slots)~~ using the current UL-MAP. ~~Note that the modulation level and hence the symbols/byte is a characteristic of an individual burst transmission, not of the channel~~.

Note that a Mini-Slot is only the unit of granularity for upstream transmission allocations. There is no implication that any PDU can actually be transmitted in a single Mini-Slot.

6.3.2.2 Upstream Interval Definition

All of the Information Elements defined below shall be supported by conformant SSs. Conformant BS may use any of these Information Elements when creating a UL-MAP message.

6.3.2.2.1 The Request IE

Via the Request IE, the Base Station specifies an upstream interval in which requests may be made for bandwidth for upstream data transmission. The character of this IE changes depending on the type of Connection ID used in the IE. If broadcast, this is an invitation for SSs to contend for requests. If unicast, this is an invitation for a particular SS to request bandwidth. Unicasts may be used as part of a Quality of Service scheduling scheme that is vendor dependent. PDUs transmitted in this interval shall use the Bandwidth Request Header Format (see 2.5).

A small number of Priority Request CIDs are defined in 2.1. These allow contention for Request IEs to be limited to service flows of a given Traffic Priority (2.3.5.5.2).

6.3.2.2.2 The Initial Maintenance IE

Via the Initial Maintenance IE, the Base Station specifies an interval in which new stations may join the network. A long interval, equivalent to the maximum round-trip propagation delay plus the transmission time of the Ranging Request (RNG-REQ) message, shall be provided in some UL-MAPs to allow new stations to perform initial ranging. Packets transmitted in this interval shall use the RNG-REQ MAC Management message format (refer to 2.5.5).

6.3.2.2.3 The Station Maintenance IE

Via the Station Maintenance IE, the Base Station specifies an interval in which stations are expected to perform some aspect of routine network maintenance, such as ranging or power adjustment. The BS may request that a particular SS perform some task related to network maintenance, such as periodic transmit power adjustment. In this case, the Station Maintenance IE is unicast to provide upstream bandwidth in which to perform this task. Packets transmitted in this interval shall use the RNG-REQ MAC Management message format (see 2.5.5).

6.3.2.2.4 Data Grant Burst Type IEs

The Data Grant Burst Type IEs provide an opportunity for a CPE to transmit one or more upstream PDUs. These IEs are issued either in response to a request from a station, or because of an administrative policy providing some amount of bandwidth to a particular station (see class-of-service discussion in Section TBD). These IEs may also be used with an inferred length of zero mini slots (a zero length grant), to indicate that a request has been received and is pending (a Data Grant Burst Type Pending).

There are six different Data Grant Burst Types that may be defined: Data Grant Burst Types 1 through 6 are associated with IUCs 4 through 9 respectively. Each Data Grant Burst Type description is defined in the UCD message.

If this IE is a Data Grant Burst Type Pending (a zero length grant), it shall follow the NULL IE. This allows CPE modems to process all actual allocations first, before scanning the Map for data grant burst types pending and data acknowledgments.

6.3.2.2.5 Expansion IE

The Expansion IE provides for extensibility, if more than 16 code points or 32 bits are needed for future IEs.

6.3.2.2.6 Null IE

A Null IE terminates all actual allocations in the IE list. It is used to infer a length for the last interval. All Data Acknowledge IEs and All Data Grant Burst Type Pending IEs (Data Grant Burst Types with an inferred length of 0) must follow the Null IE.

6.3.3 Network Entry

6.3.4 Ranging

6.3.5 Quality of Service

The following clauses are not yet defined. These headings are placeholders.

6.4 MAC Sublayer Common Part - Management Plane

6.4.1 MAC Sublayer - Common Part Service Interface Specification

6.4.2 MAC Sublayer - Comon Part MIB Definitions

7. Security sublayer functional description

7.1 Architectural Overview

The relative ordering of the following sections remains the same.

7.2 Privacy Key Management (PKM Protocol)

The relative ordering of the following sections remains the same.

8. PHY

8.1 PHY service specifications

8.1.1 Scope and field of application

8.1.2 Overview of the service

8.1.3 Overview of interactions

8.1.4 PHY-SAP detailed service specification

8.1.4.1 PHY-CHARACTERISTICS.request

8.1.4.2 PHY-CHARACTERISTICS.confirm

8.1.4.3 PHY -TXSTART.request

8.1.4.4 PHY-TXSTART.confirm

8.1.4.5 PHY-TXEND.indication

8.1.4.6 PHY -RXSTART.request

8.1.4.7 PHY -RXSTART.confirm

8.1.4.8 PHY -RXCONT.request

8.1.4.9 PHY -RXCONT.confirm

8.1.4.10 PHY-DATA.request

8.1.4.11 PHY-RXDATA.request

8.1.4.12 PHY-DATA.confirm

8.1.4.13 PHY-DATA.indication

8.1.4.14 PHY-RXEND.indication

8.2 Physical Layer for 10 - 66 GHz

8.2.1 Overview

8.3 Overview

The following physical layer specification was designed to meet the functional requirements that have been defined for Broadband Wireless Access (BWA) systems. It incorporates many aspects of existing standards in order to leverage existing technology for reduced equipment cost and demonstrated robustness of implementation, with modifications to ensure reliable operation in the targeted 10-66 GHz frequency band. In addition, this physical layer was designed with a high degree of flexibility in order to allow service providers the ability to optimize system deployments with respect to cell planning, cost considerations, radio capabilities, offered services, and capacity requirements. Two modes of operation have been defined for the downstream channel, one targeted to support a continuous transmission stream and one targeted to support a burst transmission stream. Having this separation allows each to be optimized according to their respective design constraints, while resulting in a standard that supports various system requirements and deployment scenarios.

8.3.1 Multiplexing and Multiple Access Technique

3.1.1 Multiplexing and Multiple Access Technique261

The upstream physical layer is based on the use of a combination of time division multiple access (TDMA) and demand assigned multiple access (DAMA). In particular, the upstream channel is divided into a number of “time slots.” The number of slots assigned for various uses (registration, contention, guard, or user traffic) is controlled by the MAC layer in the base station and can vary over time for optimal performance. The downstream channel can be based either upon time division multiplexing (TDM), where the information for each subscriber station is multiplexed onto the same stream of data and is received by all subscriber stations located within the same sector, or in an alternative method (defined for the burst mode of operation) which allows bursts to be transmitted to specific CPEs in a similar fashion to the TDMA upstream bursts.

8.3.2 Duplexing Technique

Several duplexing techniques are supported with this physical layer. The continuous transmission downstream mode that is defined supports frequency division duplexing (FDD) only, while the burst mode of operation supports FDD with adaptive modulation or time division duplexing (TDD). Furthermore, the burst mode of operation in the FDD case can handle subscribers incapable of transmitting and receiving at the same instant due to their specific transceiver implementation. The continuous downstream mode is based on a concatenated Reed-Solomon, interleaver, and convolutional code, and can support different orders of modulation on separate carriers. The burst mode supports the capability to have different modulation formats transmitted on the same carrier so that the modulation level can be chosen on a subscriber level basis (*i.e.*, adaptive modulation). Note that adaptive modulation is supported with any of the duplexing techniques that use the burst mode of operation.

8.3.3 Physical Media Dependent (PMD) Sublayers

Two different downstream physical layers have been defined in this standard. A Mode A downstream physical layer has been designed for continuous transmission, while a Mode B physical layer has been designed to support a burst transmission format.

Mode A is based upon a continuous transmission stream supporting a concatenation of Reed Solomon coding, interleaving, and convolutional coding for use in an FDD only system. Mode B supports a burst format that allows systems to implement an adaptive modulation scheme for an FDD system as well as supporting TDD configurations.

This approach to standardization allows for service providers to pick the format which best allows them to meet their system requirements. Standards compliant subscriber stations are required to support at least one of the downstream modes of operation as defined here.

A single upstream physical layer is also defined here to support a TDMA based burst upstream transmission.

8.3.3.1 Continuous Downstream PMD Sublayer (Mode A) Overview

The Mode A downstream physical layer first encapsulates MAC packets into a convergence layer frame as defined by the transmission convergence sublayer. Then, the data is randomized and encoded using a (204,188) Reed-Solomon code over GF(256). Following the outer block encoder, the data goes through a convolutional interleaver with a depth of I=12. Then, the data must either pass through an inner, constraint length 7, convolutional code with a rate of 1/2, 2/3, 3/4, 5/6, 7/8, or 1, or pass through a differential encoder (i.e., bypassing the convolutional encoder) as defined in the following sections. Code bits are then mapped to a QPSK, 16-QAM (optional), or 64-QAM (optional) signal constellation with symbol mapping as described here. Finally, symbols are Nyquist filtered using a square-root raised cosine filter with a roll-off factor of 0.15, 0.25 or 0.35.

8.3.3.2 Burst Downstream PMD Sublayer (Mode B) Overview

The Mode B downstream physical layer has a framing mechanism associated with it that simplifies the support for TDD systems and half-duplex terminals. The frame can either be configured to support a TDM transmission format, which would typically be used in a TDD system or an FDD system supporting adaptive modulation/FEC groups (to be discussed later). One unique preamble is used to indicate the beginning of a frame, which is followed by the PHY/MAC control data. A PHY control map is used to indicate the beginning of different modulation/FEC groups, which will typically be in the order of QPSK followed by 16-QAM and 64-QAM with the FEC scheme chosen to meet each desired C/I requirements. In addition, the modulation/FEC group specifications can change with time in order to adjust to the changing channel conditions. Various frame configurations for FDD and TDD are supported, as was discussed in section 8.3.5, Figure 51, and Figure 52. All subscriber station data is FEC block encoded allowing for a shortening of the last codeword of a burst. The Mode B downstream physical layer also goes through a transmission convergence sublayer that inserts a pointer byte at the beginning of the payload information bytes to help the receiver identify the beginning of a MAC packet. Data bits coming from the transmission convergence layer are first randomized, encoded using the defined outer and possibly inner codes, and then mapped, along with the preambles, to a QPSK, 16-QAM, or 64-QAM (optional) signal constellation. The modulated symbols are then Nyquist filtered using a square-root raised cosine filter with a roll-off factor of 0.15, 0.25 or 0.35.

8.3.3.3 Upstream PMD Sublayer Overview

The upstream physical layer has been designed to support burst modulation for a TDMA based system. Since many of the specific upstream channel parameters can be programmed by MAC layer messaging coming from the base station, several parameters can be left unspecified and configured by the base station during the registration process in order to optimize performance for a particular deployment scenario. In this mode, each burst is designed to carry MAC messages of variable lengths. The transmitter first randomizes the incoming data, and then encodes the data using an outer code and possibly an inner code to be selected by the MAC messages. The length of the codeword and the error correction capability of the code are programmable by the MAC messages coming from the base station via a burst configuration message. Each burst also contains a variable length preamble and a variable length guard space at the end of the burst. The preamble and coded bits are mapped to QPSK, 16-QAM (optional), or 64-QAM (optional) constellations. Nyquist pulse shaping using a square-root raised cosine filter is also employed with a roll-off factor of 0.15, 0.25, or 0.35.

Include a brief discussion of how this PHY layer fits in the reference model.

8.3.4 PHY Continuous FDD Mode Support

In continuous FDD operation, the upstream and downstream signals have no defined framing, and they operate on separate frequencies, which allows all subscribers to transmit on the upstream independently of what is being transmitted on the downstream signal.

The BS periodically transmits downstream and upstream MAP messages, which are used to syncronize the upstream burst transmissions with the downstream. The usage of the mini-slots is defined by the UL-MAP message, and can change according to the needs of the system. A fixed modulation is used with PHY mode A.

8.3.5 PHY Burst Mode Support

In the burst mode, the uplink and downlink can be multiplexed in a TDD fashion as described in 6.3.1.3 or in an FDD fashion as described in 6.3.1.2. Each uses a frame with a duration as specified in 3.3.1. Within this frame are a downlink subframe and an uplink subframe. In the TDD case, the downlink subframe comes first, followed by the uplink subframe. In the burst FDD case, the downlink and uplink subframes occur simultaneously on their respective frequencies, and occupy the whole frame. In both cases, the downlink subframe is prefixed with information necessary for frame synchronization.

The available bandwidth in both directions is defined with a granularity of one PHY slot (PS). The number of PHY slots with each frame is a function of the modulation rate. The modulation rate is selected in order to obtain an integral number of PS within each frame. For example, with a 20 Mbaud modulation rate, there are 5000 PS within a 1-ms frame.

This standard provides the capability to efficiently support either a fixed modulation level per downstream carrier or an adaptively changing modulation level and FEC coding set on a per subscriber station basis. Depending on the deployment scenario, one may be preferred over the other. The adaptive modulation/FEC capability is supported on a frame-by-frame basis when the downstream Mode B physical layer is implemented.

The structure of the downlink subframe used by the BS to transmit to the SSs, using time division duplexing (TDD), is shown in Figure 122. The structure of the downlink subframe used by the BS to transmit to the SSs, using Burst FDD, is shown in Figure 123. These burst structure define the downlink physical channel. It starts with a Frame Control Header that is always transmitted in QPSK. This frame header contains a preamble used by the PHY for synchronization and equalization. It also contains control sections for both the PHY and the MAC that is encoded with a fixed FEC scheme defined in this standard in order to ensure interoperability. The Frame Control Header also may periodically contain PHY Parameters as defined in the DCD and UCD.

Within the TDD downlink subframe, transmissions are organized into different modulation and FEC groups, where the modulation type and FEC parameters are defined through MAC layer messaging. The PHY Control portion of the Frame Control Header contains a downlink map stating the PSs at which the different modulation/FEC groups begin. Data should be transmitted in robustness order. For modulations this means followed by 16-QAM, followed by 64-QAM. If more than 1 FEC is defined (via DCD messages) for a given modulation, the more robust FEC/modulation combination appears first. There is a Tx/Rx Transition Gap (TTG) separating the downstream subframe from the upstream subframe in the case of TDD.

Each SS continuously receives the entire downstream burst, decodes the data in the DS burst, and looks for MAC headers indicating data for that SS.

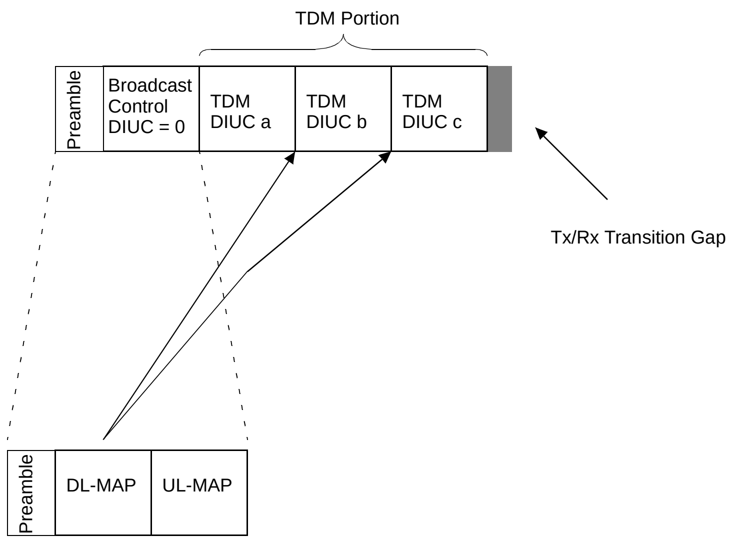

Figure 122—TDD Downlink Subframe Structure

Like the TDD downlink subframe, the burst FDD subframe starts with a TDM section that is organized into

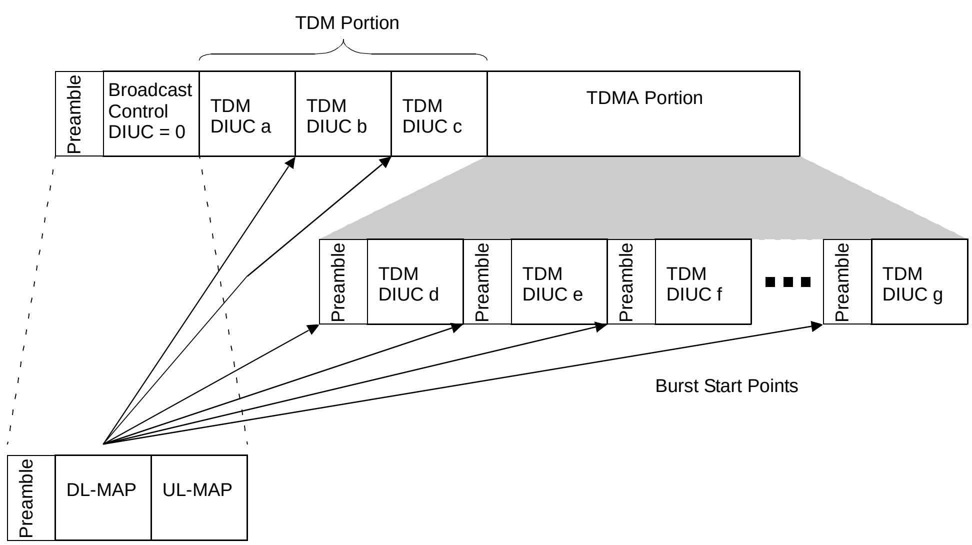

Figure 123—Burst FDD Downlink Subframe Structure

different modulation and FEC groups. This portion of the downlink subframe contains data transmitted to SSs that are either full-duplex, are scheduled to transmit later in the frame than they receive, or are not scheduled to transmit this frame. As in the TDD case, the TDM portion of the downlink is ordered by decreasing robustness. The downlink subframe continues with a TDMA section. This portion of the downlink subframe contains data transmitted to half-duplex SSs that are scheduled to transmit earlier in the frame than they receive, if any. This allows an individual SS to decode a specific portion of the downstream without the need to decode the whole DS burst. In this particular case, each transmission associated with different burst types is required to start with a short preamble for phase re-synchronization the TDMA portion does not need to be ordered by robustness. The PHY control portion contains a downlink map stating the PSs at which the different modulation/FEC groups begin in the TDM section and stating the PS (and modulation/FEC) of each of the TDMA sub-bursts

Note that the TDD downlink subframe, which inherently contains data transmitted to SSs that can only transmit later in the frame than they receive, is identical in structure to the Burst FDD downlink subframe for a frame in which no half-duplex SSs are scheduled to transmit before they receive.

8.3.5.0.1 Downstream and Upstream Operation

A Short discussion is required in this overview section summarizing important PHY issues; Elaborated discussion should be done in relevant sub-sections following

8.3.5.0.2 Downstream

Placeholder only.

>>> Restructure to emphasize downstream vs. upstream and the fact that the downstream has 2 modes sharing the same upstream

8.3.5.1 PHY/MAC Control transmission

The PHY Control portion of the downlink is used for physical information destined for all CPEs. The PHY Control information is FEC encoded, but is not encrypted. The information transmitted in this section is always transmitted using a well known DL Burst Type. This burst type is specified separately for each mode.

.

8.3.5.2 Downlink Data Transmission

The downlink data sections are used for transmitting data and control messages to the specific SSs. This data is always FEC coded and is transmitted at the current operating modulation of the individual SS. ~~Message headers are sent unencrypted. Payloads of user data connections are encrypted. Payloads of MAC control connections are not encrypted.~~

8.3.5.2.0.1 Mode A (Continuous Downstream)

8.3.5.3 MAP Relevance for Mode A PHY

In the Continuous PHY system, the downstream MAP (DL-MAP) only contains the Upstream Time Stamp, and does not define what information is being transmitted. All SS continuously search the downstream signal for any downstream message that is addressed to them. The Upstream MAP (UL-MAP) message in the downstream contains the Time Stamp that indicates the first mini-slot that the MAP defines.

The delay from the end of the UL-MAP to the beginning of the first Upstream interval defined by the MAP shall be greater than maximum round trip delay plus the processing time required by the SS (see Figure 57).

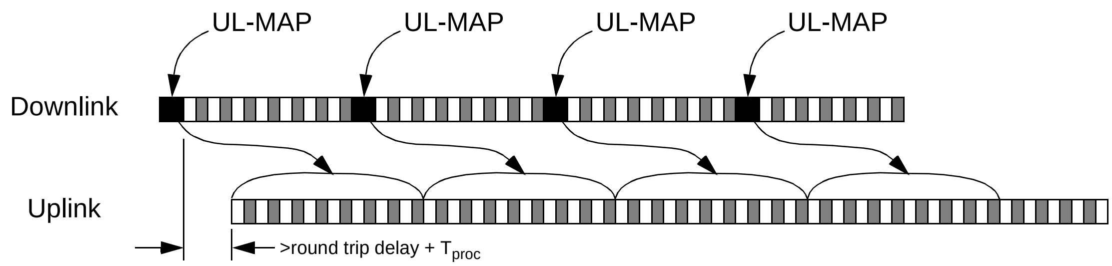

Figure 57—Time Relevance of Upstream MAP Information (Continuous FDD)

8.3.5.3.0.1 Mode B (Burst Downstream)

8.3.5.3.0.2 Mode B Downstream transmission

In the burst mode cases, data is transmitted in robustness order in the TDM portion. In the TDMA portion, the data is grouped into separately delineated bursts, which do not need to be in modulation order. ~~The PHY Control portion of the Frame Control Header contains a map stating the PS at which modulation will change.~~ If the downlink data does not fill the entire downlink subframe and the PHY mode is burst downstream, the transmitter is shut-down.

8.3.6 MAP Relevance

8.3.6.1 MAP Relevance for Mode B PHY Systems

The information in the PHY Control portion of the Frame Control Header pertains to the current frame (i.e., the frame in which it was received). The information in the Uplink Subframe Map in the MAC Control portion of the Frame Control Header pertains to the current or following frame. This timing holds for both the

TDD and FDD variants of the burst system. The TDD variant is shown in Figure 53 and Figure 56. The FDD variant is shown in Figure 54 and Figure 55.

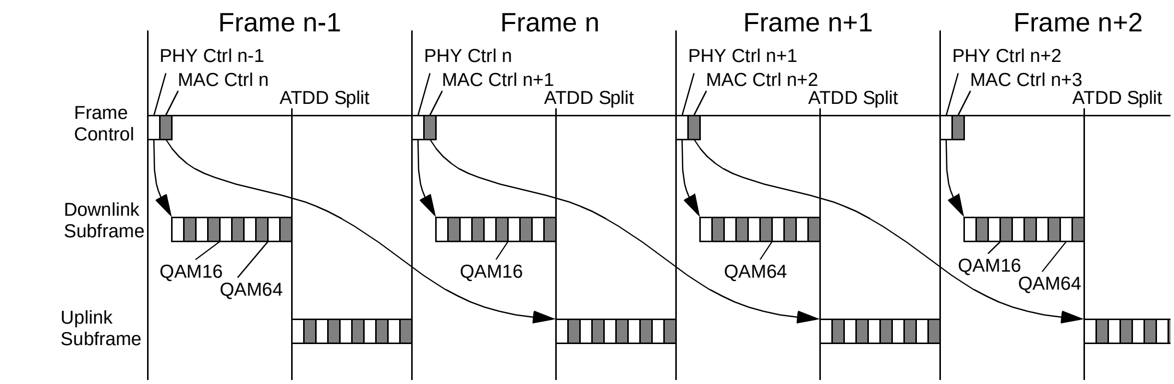

Figure 53—Maximum Time Relevance of PHY and MAC Control Information (TDD)

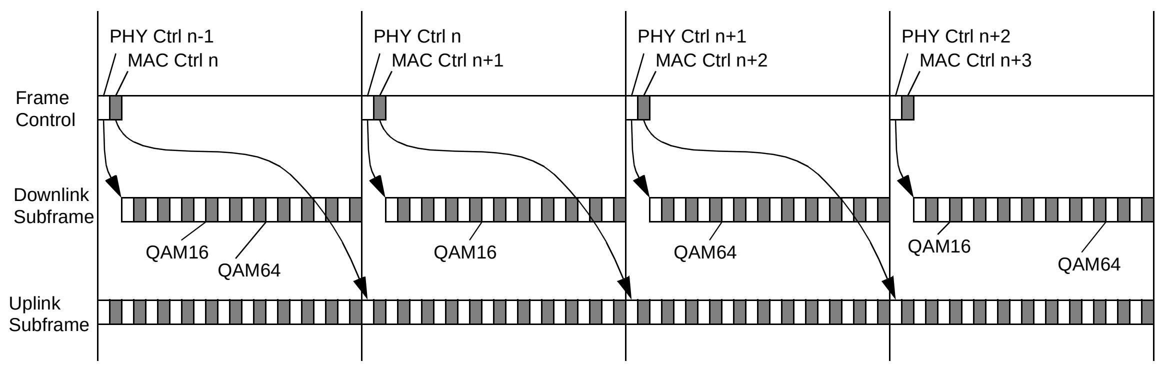

Figure 54—Maximum Time Relevance of PHY and MAC Control Information (FDD)

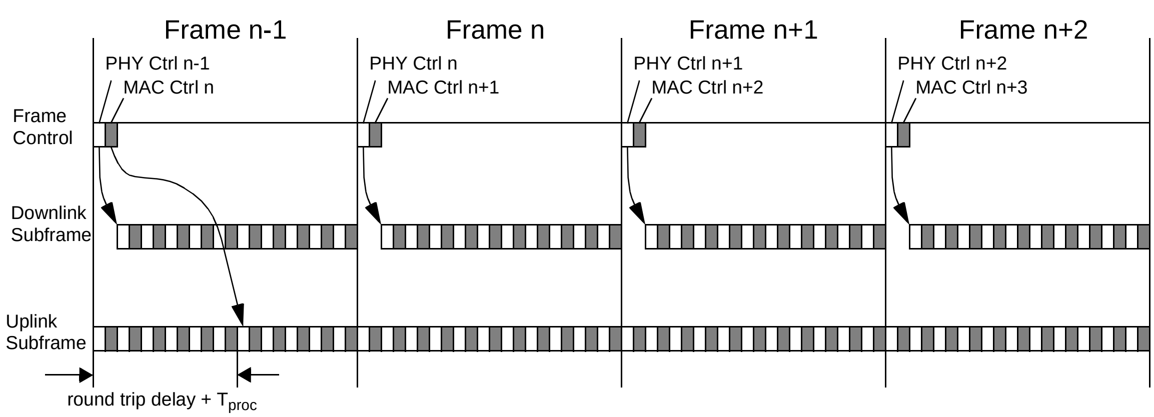

Figure 55—Minimum Time Relevance of PHY and MAC Control Information (FDD)

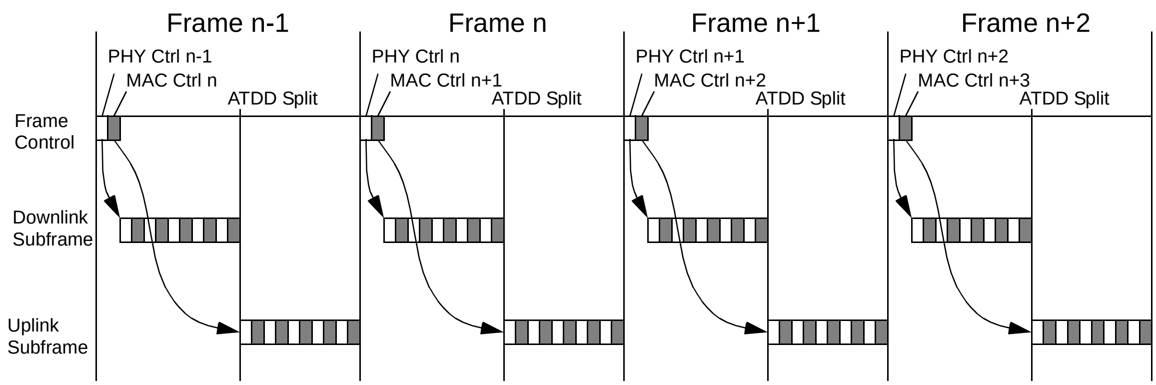

Figure 56—Minimum Time Relevance of PHY and MAC Control Information (TDD)

8.3.6.2 Duplexing Techniques

2.6.1 Duplexing Techniques118

>>MERGED<<

8.3.6.2.1 Upstream

8.3.7 Uplink Burst types

The BS periodically broadcasts the Upstream MAP message (UL-MAP) on the downstream, which defines the permitted usage of each upstream mini-slot within the time interval covered by that MAP message (see Figure 126). The structure of the uplink interval used by the SSs to transmit to the BS is illustrated in Figure 125.

There are three main classes transmissions by the SSs during the uplink frame:

a) Transmssions in contention slots reserved for station registration. These transmissions must be made with parameters specified for UIUC=2
b) Transmssions in contention slots reserved for response to multicast and broadcast polls for bandwidth needs. These transmissions must be made with parameters specified for UIUC=1

c) Transmssions in bandwidth specifically allocated to individual SSs. These transmissions use param-

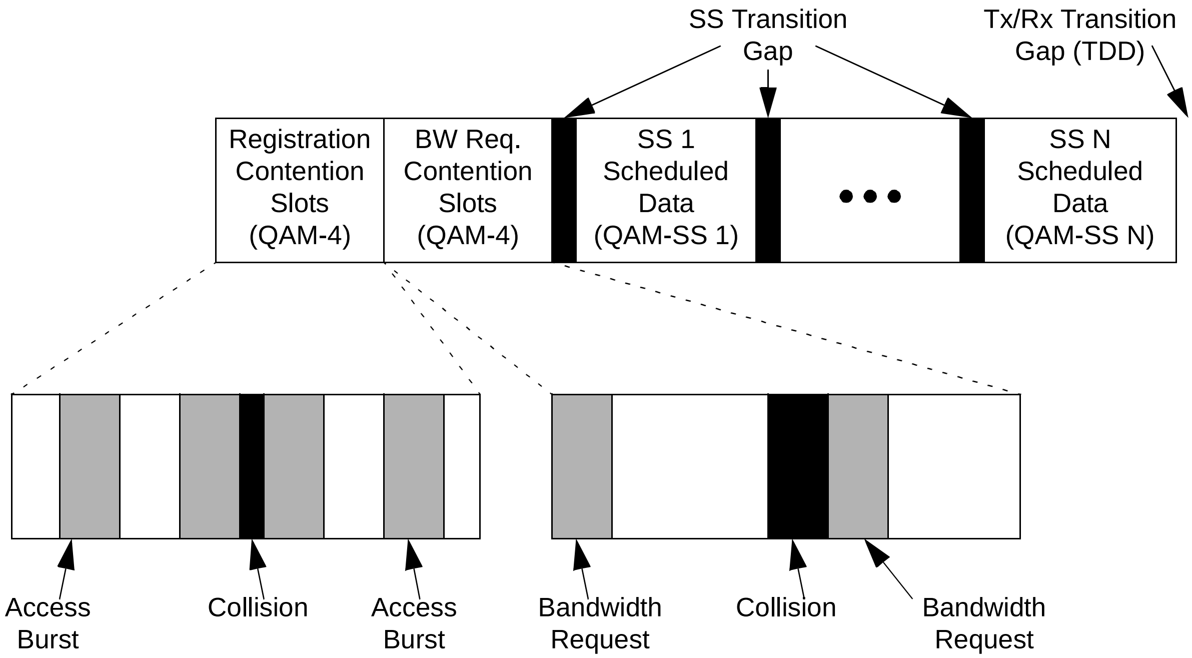

Figure 125—Uplink Subframe Structure

eters associated to the specified UIUC.

Adaptive modulation may be used in the upstream, in which different users are assigned different modulation types by the base station. During its scheduled bandwidth, a SS transmits with the modulation specified by the base station, as determined by the effects of distance and environmental factors on transmission to and from that SS. SS Transition Gaps (STG) separate the transmissions of the various SSs during the uplink subframe. The STGs contain a gap to allow for ramping down of the previous burst, followed by a preamble allowing the BS to synchronize to the new SS. The preamble and gap lengths are broadcast periodically in the UCD message by the base station in the Frame Control Header.

8.3.8 Continuous Downstream and Upstream Structure

~~In the continuous PHY mode, The timing of the upstream bursts are based upon a downstream syncronization message (DS-SYNC). The UL-MAP messages are transmitted approximately 250 times a second, but this can vary to optimise the system's operation.~~

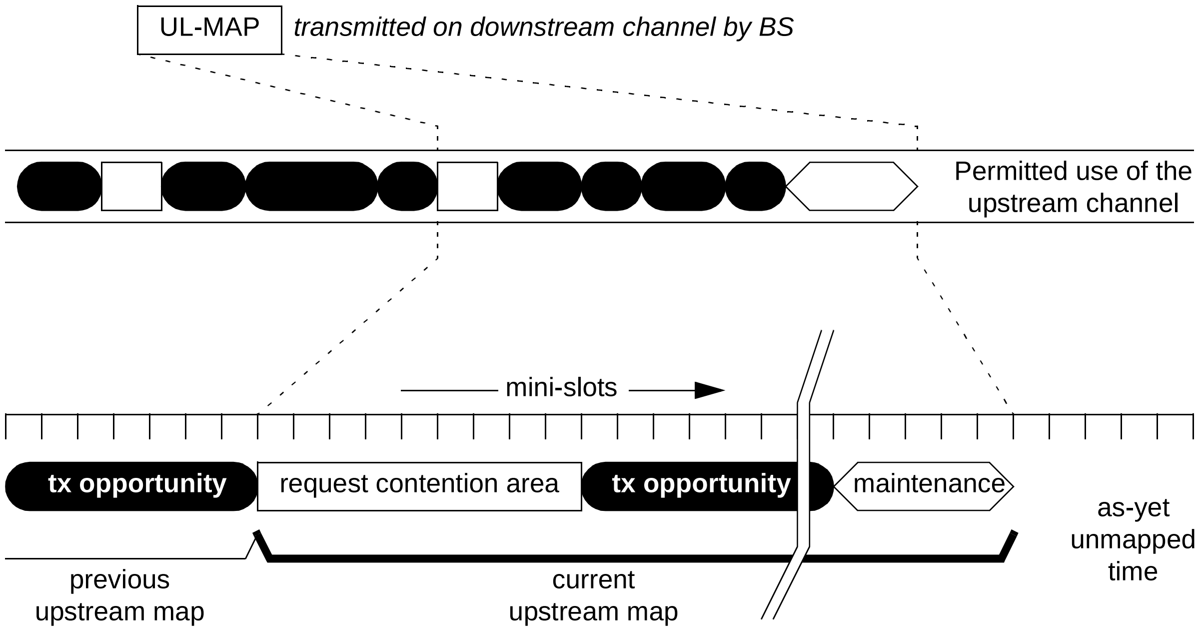

Figure 126—Continuous Downstream FDD Mapping

8.3.9 PHY SAP Parameter Definitions

8.3.10 Downstream Physical Layer

8.3.10.1 Mode A (Continuous Downstream Transmission)

8.3.10.2 Downstream Mode A: Message field definitions

8.3.10.2.1 Mode A: DL-MAP PHY Synchronization Field definition

TLVs moved to parameter section. Insert content from section 2.5.3 NEEDS to be rewritten.

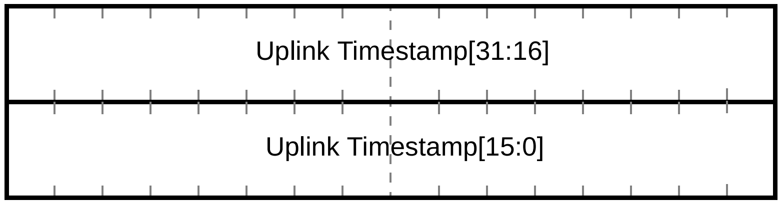

Figure 17—PHY Synchronization Field (PHY Type = 2)

The Uplink Timestamp jitter must be less than 500 ns peak-to-peak at the output of the Downstream Transmission Convergence Sublayer. This jitter is relative to an ideal Downstream Transmission Convergence Sublayer that transfers the TC packet data to the Downstream Physical Media Dependent Sublayer with a perfectly continuous and smooth clock at symbol rate. Downstream Physical Media Dependent Sublayer processing shall not be considered in timestamp generation and transfer to the Downstream Physical Media Dependent Sublayer.

Thus, any two timestamps N1 and N2 (N2 > N1) which were transferred to the Downstream Physical Media Dependent Sublayer at times T1 and T2 respectively must satisfy the following relationship:

$$(N2 - N1)/(4 \times \text{Symbol Rate}) - (T2 - T1) < 500 \text{ nsec}$$

The jitter includes inaccuracy in timestamp value and the jitter in all clocks. The 500ns allocated for jitter at the Downstream Transmission Convergence Sublayer output must be reduced by any jitter that is introduced by the Downstream Physical Media Dependent Sublayer.

The following table indicates the various frame times that are allowed for the current downstream Mode B physical layer. The actual frame time used by the downstream channel can be determined by the periodicity of the frame start preambles.

8.3.10.2.2 Mode A:UL-MAP Allocation Start Time definition

Inserted def,

~~In a framed mode of operation, the mini-slot represents the granularity of upstream allocation units. In the non-frame mode, the mini-slot definition is related to a timestamp generated by the BS~~.

The Alloc Start Time is the effective start time of the uplink allocation defined by the UL-MAP in units of mini-slots. The start time is relative to the time of BS initialization (PHY Type = 5). The UL-MAP Allocation Start Time is given as an offset to the Upstream Time Stamp defined in 8.3.10.2.1. Figure 52 illustrates the relation of the Upstream Time Stamp maintained in the BS to the BS Mini-slot Counter.

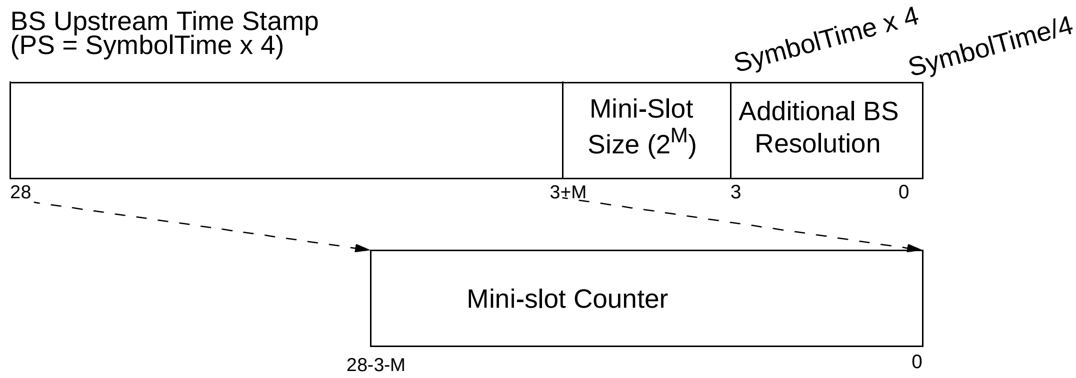

Figure 52—BS System and Mini-slot Clocks

The BS and SS base the upstream allocations on a 32-bit counter that normally counts to (2^{32} –1) and then wraps back to zero. The bits (i.e., bit 0 to bit 31-3-M) of the mini-slot counter shall match the most-significant bits (i.e., bit 3 + M to bit 31) of the DL-MAP timestamp counter. That is, mini-slot N begins at timestamp value ($N * T * 16$), where $T = 2^M$ is theUCD multiplier that defines the mini-slot size (i.e., the number of PS per mini-slot).

The constraint that the UCD multiplier be a power of two has the consequence that the number of PS per mini-slot must also be a power of two.

8.3.10.2.3 UL-MAP Ack Time definition

The Ack Time is the latest time processed in uplink in units of mini-slots. This time is used by the SS for collision detection purposes. The Ack Time is given relative to the BS initialization time.

8.3.10.3 Downstream Mode B: Physical Convergence Sublayer

8.3.10.4 Mode B (Burst Downstream Transmission)

>>> The following sections should refer to the relevant section of Mode A and text duplication should be minimized for comprehension and natural flow

3.2.2.2.3-> 3.2.1.2.2 (Randomization)

3.2.2.2.5-> 3.2.1.2.3 (Reed Solomon Code)

3.2.2.2.12->3.2.1.2.9 (Pulse Shaping)

8.3.10.4.1 Downlink Mode B: DL-MAP PHY Syncronization Field definition

TLV moved to parameter section. Insert content from 2.5.3 . REWRITE!

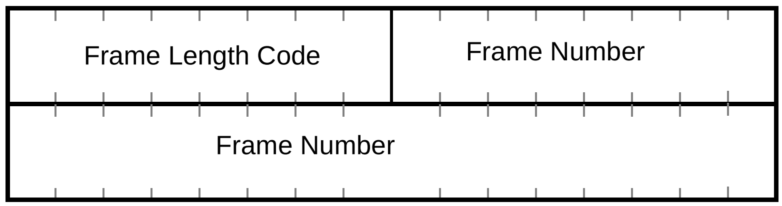

Figure 16—PHY Synchronization Field (PHY Type = {0,1})

The following table indicates the various frame times that are allowed for the downstream Mode B physical layer. The actual frame time used by the downstream channel can be determined by the SS from the periodicity of the frame start preambles.

Table 1— Allowable frame times and Frame Length Code Encodings

Frame Length Code	Frame time (T_F)	Units
0	0.5	msec
1	1	msec
2	2	msec

8.3.10.4.2 UL-MAP Allocation Start Time definition

Inserted allocation start time definition and define time reference

The Alloc Start Time is the effective start time of the uplink allocation defined by the UL-MAP in units of Mini-Slots. The start time is relative to the start of a frame in which UL-MAP message is transmitted.

8.3.10.4.3 UL-MAP Ack Time definition

Inserted Ack time def

The Ack Time is latest time processed in uplink in units of Mini-Slots. This time is used by the SS for collision detection purposes. The ack time is relative to the start of a frame in which UL-MAP message is transmitted.

8.3.10.5 Downstream Mode B: Physical Convergence Sublayer

8.3.11 Upstream Physical Layer

8.3.11.1 Upstream Timing

The upstream timing is based on the Upstream Time Stamp reference, which is acounter that increments at a rate that is 4 times the modulation rate. It therefore has a resolution that equals 1/4th of the modulation symbol period. This allows the SS to track the BS clock with a small time offset. The Upstream Time Stamp from the BS is then used to adjust the SS internal Time Stamp so that it tracks the BS timing. The SS Time Stamp is offset from the BS Time Stamp by the Timing Adjustment amount sent to each SS in the RNG-RSP message. The offset causes the upstream bursts arrive at the BS at the proper time. After either the BS or SS Time Stamps reach the maximum value they roll over to zero and continue to count.

8.3.11.1.1 Burst Mode Upstream Timing

In the burst PHY modes, at the start of each frame the Upstream Time Stamp counter in the BS must be reset to zero, while in the SS must be reset using the current Timing Adjustment value as sent from the BS using the RNG-RSP message.

8.3.11.2 Upstream Channel and Burst Descriptors

8.3.11.3 Upstream Physical Convergence Sublayer

8.3.11.4 Upstream Physical Media Dependent (PMD) Sublayer

>>> The following sections should refer to the relevant section of Mode B and text duplication should be minimized for comprehension and natural flow

3.3.3.1-> 3.2.1.2.2 (Randomization)

3.3.3.2-> Most of the text is in 3.2.2.2.4 to 3.2.2.2.9

3.3.3.5-> 3.2.2.2.12 or 3.2.1.2.9

8.3.12 Baud Rates, RF Channel Bandwidths and Framing lengths

8.3.13 Radio Sub-system Control

8.3.14 Minimum Performance

>>> Heavily modified at Session #10

8.3.15 PHY for 10 - 66 GHz Management Plane

More definition for outline needs to be added (MIBs).

9. Configuration File

The following sections are renumbered beginning with 9.1.

10. Parameters and Constants

10.1 Global Values

10.1.1 PHY-specific Values

10.1.1.1 10- 66 GHz Parameter and Constant Definitions

Definition of PS needs to go here. Timebase tick also.

10.2 Well know addresses and identifiers

11. TLV Encodings

11.1 MAC Management Message Encodings

The following set of TLV encodings are specific to each MAC Management Message and have a scope that is bounded by the message itself.

11.1.1 Uplink Channel Descriptor Message (UCD) Message

Only message-specific TLV encodings.

11.1.2 Downlink Channel Descriptor (DCD) Message

Only message-specific TLV encodings.

11.1.3 Downlink MAP (DL-MAP) Message

Only message-specific TLV encodings.

11.1.4 Downlink MAP (UL-MAP) Message

Only message-specific TLV encodings.

11.1.5 Ranging Request (RNG-REQ) Message

Only message-specific TLV encodings.

11.1.6 Ranging Response (RNG-RSP) Message

Only message-specific TLV encodings.

11.1.7 Registration Request (REG-REQ) Message

Only message-specific TLV encodings.

11.1.8 Registration Response (REG-RSP) Message

Only message-specific TLV encodings.

11.1.9 Registration Acknowledge (REG-ACK) Message

Only message-specific TLV encodings.

11.1.10 Privacy Key Management — Request (PKM-REQ) Message

Only message-specific TLV encodings.

11.1.11 Privacy Key Management—Response (PKM-RSP) Message

Only message-specific TLV encodings.

11.1.12 Dynamic Service Addition -- Request (DSA-REQ) Message

Only message-specific TLV encodings.

11.1.13 Dynamic Service Addition -- Response (DSA-REQ) Message

Only message-specific TLV encodings.

11.1.14 Dynamic Service Addition — Acknowledge (DSA-ACK) Message

Only message-specific TLV encodings

11.1.15 Dynamic Service Change — Request (DSC-REQ) Message

Only message-specific TLV encodings

11.1.16 Dynamic Service Change — Response (DSC-RSP) Message

Only message-specific TLV encodings

11.1.17 Dynamic Service Change — Acknowledge (DSC-ACK) Message

Only message-specific TLV encodings

11.1.18 Dynamic Service Deletion — Request (DSD-REQ) Message

Only message-specific TLV encodings

11.1.19 Dynamic Service Deletion — Request (DSD-RSP) Message

Only message-specific TLV encodings

11.1.20 Multicast Polling Assignment Request (MCA-REQ) Message

Only message-specific TLV encodings

11.1.21 Multicast Polling Assignment Response (MCA-RSP) Message

Only message-specific TLV encodings

11.1.22 ARQ-ACK Messag

Only message-specific TLV encodings

11.1.23 Downlink Burst Type Change Request (DBTC-REQ) Message

Only message-specific TLV encodings

11.2 PKM Message Encodings

The following sections are renumbered beginning with 11.2.1.

11.2.1 Configuration File Encodings

The following sections are renumbered beginning with 11.2.1.1.

11.2.2 Common Encodings

The following table provides an overview of the common TLV encodings and their scope of use.

Table 2—Common Encodings

Type	Parameter Name	Scope
0	Pad	Configuration File
1	Downstream Frequency Configuration Setting	Configuration File REG-REQ
2	Upstream Channel ID Configuration Setting	Configuration File REG-REQ
3	Network Access Control Object (NACO)	Configuration File REG-REQ
4	Downstream Modulation Configuration Setting	REG-REQ
5.X	SS Capabilities Encodings	REG-REQ REG-RSP
5.1-5.5		Unused
5.6	Privacy Support	REG-REQ REG-RSP
5.7		Unused
5.8	Upstream CID Support	REG-REQ REG-RSP
5.9-5.11		Unused
5.12	SS Demodulator Types	REG-REQ REG-RSP
5.13	SS Modulator Types	REG-REQ REG-RSP
5.14	Duplexing Support	REG-REQ REG-RSP

Table 2—Common Encodings

Type	Parameter Name	Scope
5.15	Bandwidth Allocation Support	REG-REQ REG-RSP
6	SS Message Integrity Check (MIC) Configuration Setting	Configuration File
7	BS Message Integrity Check (MIC) Configuration Setting	Configuration File
8	Vendor ID Encodings	REG-REQ
9	Software Upgrade Filename	Configuration File
10	SNMP Write-Access Control	Configuration File
11	SNMB MIB Object	Configuration File
12		Unused
13	Service(s) not available responses	
14-16		unused
17.X	Privacy Configuration Setting Options	
17.1	Authorize Wait Timeout	Configuration File REG-REQ
17.2	Reauthorize Wait Timeout	Configuration File REG-REQ
17.3	Authorization Grace Tutorial	Configuration File REG-REQ
17.4	Operational Wait Timeout	Configuration File REG-REQ
17.5	Rekey Wait Timeout	Configuration File REG-REQ
17.6	TEK Grace Time	Configuration File REG-REQ
17.7	Authorize Reject Wait Timeout	Configuration File REG-REQ
17.8	SA Map Timeout	Configuration File REG-REQ
17.9	SA Map Max Retries	Configuration File REG-REQ
18		unused
19	Trivial File Transfer Protocol Server Timestamp	REG-REQ
20	TFTP Server Provisioned SS Address	REG-REQ
21	Software Upgrade TFTP Server	Configuration File
24.X	Upstream Service Flow Encodings	Configuration File REG-REQ REG-RSP DSX-REQ/RSP/ACK

Table 2—Common Encodings

Type	Parameter Name	Scope
25.X	Downstream Service Flow Encodings	Configuration File REG-REQ REG-RSP DSX-REQ/RSP/ACK
[24/25].1	Service Flow Reference	
[24/25].2	Service Flow Identifier	
[24/25].3	Connection Identifier	
[24/25].4	Service Class Name	
[24/25].5.X	Service Flow Error Encodings	
[24/25].5.1	Error Parameter	
[24/25].5.2	Error Code	
[24/25].5.3	Error Message	
[24/25].6	Quality of Service Parameter Set Type	
[24/25].7	Priority	
24.8	Upstream Maximum Sustained Traffic Rate	
25.8	Downstream Maximum Sustained Traffic Rate	
[24/25].9	Maximum Traffic Burst	
[24/25].10	Minimum Reserved Traffic Rate	
[24/25].11	Assumed Minimum Reserved Rate Packet Size	
[24/25].12	Timeout for Active QoS Parameters	
[24/25].13	Timeout for Admitted QoS Parameters	
[24/25].43	Vendor Specific QoS Parameters	
24.15	Service Flow Scheduling Type	
24.17	Nominal Polling Interval	
24.16	Request/Transmission Policy	
24.18	Tolerated Poll Jitter	
24.19	Unsolicited Grant Size	

Table 2—Common Encodings

Type	Parameter Name	Scope
24.20	Nominal Grant Interval	
24.21	Tolerated Grant Jitter	
24.22	Grants per Interval	
25.14	Maximum Downstream Latency	
26		Unused
27	HMAC-Digest	Configuration File REG-REQ REG-RSP DSX-REQ/RSP/ACK
30	Authorization Block	SS-initiated DSA-REQ/DSC-REQ
29	Privacy Enable	Configuration File REG-REQ
43	Vendor-Specific Information	Configuration File REG-REQ
255	End-of-Data Marker	Configuration File

11.2.3 PHY 10-66 GHz specific parameter encodings

11.2.3.1 Encodings for Configuration and MAC-Layer Messaging

11.2.3.1.1 Message specific encodings

11.2.3.1.2 UCD

11.2.3.1.2.1 Burst descriptor

Insert contents 'Table 7 '

11.2.3.1.2.2 Uplink Physical Layer Burst profile parameters

Insert contents of 'Table 9'

11.2.3.1.3 DCD

11.2.3.1.3.1 Burst descriptor

Contents of table 10

11.2.3.1.3.2 Downlink Physical layer Burst profile Parameters

Contents of table 12

Annex A(Informative) Functional Requirements

Move to PHY Begin

11.2.4 Upstream Map

Whether in the Burst or Continuous PHY modes, the upstream MAP message (UL-MAP) defines the usage for the upstream mini-slots using a series of Information Elements (IE), which define the useage of each upstream interval. The UL-MAP defines the upstream usage in terms of the offset from the previous IE start (the length) in numbers of mini-slots.

I think the sections below could be deleted.

Move to PHY End

Move to Phy Begin

Move to PHY END