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| Project | IEEE P802.16 Broadband Wireless Access Working Group | | |
| Title | DOCSIS1.1 Overview | | |
| Date Submitted | 30 June, 1999 | | |
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| Re: | This document is intended for informational purposes. The material contained in this document should be useful to the MAC subgroup. | | |
| Abstract | This document provides an overview of the DOCSIS (Data Over Cable System Interface Specification) 1.1 protocol. This protocol provides mechanisms which may be useful in developing a data standard for wireless. | | |
| Purpose | This document is intended for informational purposes. This document outlines mechanisms within existing protocols that might be useful for the MAC layer of the 802.16 protocol. | | |
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| Release | The contributor acknowledges and accepts that this contribution may be made publicly available by 802.16. | | |

DOCSIS1.1 Overview for IEEE802.16

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What is DOCSIS?

- **Data Over Cable System Interface Specification was created by the vendor community and CableLabs®**
- **DOCSIS consists of a group of specifications that cover Operations Support Systems, Management, Data interfaces, as well as MAC and PHY transport**
- **The specification includes extensive MAC and PHY-layer upstream parameter control for robustness and adaptability**
- **Provides link-layer security with authentication for prevention of theft of service and traffic integrity**
- **Radio-Frequency Interface (RFI) Specification recently expanded to include support for multiple QoS and flow types per modem**

DOCSIS1.0 Features

- **Designed for Best Effort Service**
- **Uses request/grant mechanism for accessing upstream bandwidth**
- **Single Quality of Service association per modem**
- **Baseline Privacy provides in-line 56-bit DES encryption/decryption to secure the privacy of the connection**
- **Specification evolved over last 3 years.**
- **As of June 28,1999, 10 modem vendors “certified”**

DOCSIS 1.1 Features

- **Quality of Service**
 - Data and Voice/Video Applications, etc.
 - Service Flows
 - Classifiers
 - Scheduling Types
 - Dynamic Service Establishment
- **Fragmentation - Allows segmentation of large packets simplifying bandwidth allocation for CBR-type services**
- **Concatenation - Allows bundling of multiple small packets to increase throughput**
- **Security Enhancements (Authentication) - Baseline Privacy Plus provides authentication as well as in-line DES encryption/decryption**
- **Encryption support for Multicast Signaling (IGMP-Internet Group Management Protocol)**
- **Payload Header Suppression- Allows suppression of unnecessary ethernet/IP header information for improved bandwidth utilization**

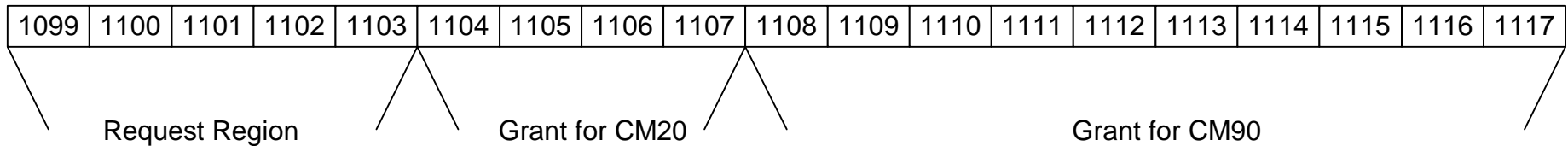
Protocol Overview

- **Single station acts as controller**
- **TDM with MPEG TC sublayer from controlling station to remote stations (“downstream”)**
- **TDMA from remote stations to controlling station (“upstream”)**
- **Bandwidth allocated via reservation or individual request-grant**
- **Physical characteristics for upstream transmission are determined by burst type**
- **Physical layer includes Forward Error Correction (FEC) for both upstream and downstream channels.**

Burst Types

- **Initial Maintenance** - used for initial contact between remote station and controller (broadcast or multicast)
- **Station Maintenance** - used to maintain transmission alignment between remote station and controller (unicast)
- **Request** - used by remote station to request bandwidth for “upstream” transmission (broadcast, multicast, or unicast)
- **Request/Data** - used by remote station for sending a request OR sending “immediate” data (broadcast or multicast)
- **Short Grant** - used for transmission of data using smaller FEC codeword size (unicast)
- **Long Grant** - used for transmission of data using larger FEC codeword size (unicast)

DOCSIS Bandwidth Allocation



- **The upstream is divided into minislots with N bytes per minislot where N is fixed for a given upstream channel. N is communicated via an Upstream Channel Descriptor (UCD) message.**
- **The cable modem receives time stamp (SYNC) messages from the CMTS and finds the minislot boundaries using the UCD.**
- **Each cable modem is assigned a Service Identifier (SID) for bandwidth allocation purposes.**
- **Downstream messages called MAPs assign upstream minislots to SIDs.**
- **Portions of the upstream bandwidth are open to all modems (contention) for requesting upstream bandwidth and for initial ranging.**
- **Each requesting modem monitors the MAPs for a grant or grant pending. The CMs also monitor the ACK time in the MAP. Should the ACK time exceed the time the CM transmitted the request, the modem's request was lost and it uses truncated binary exponential backoff to pick another request slot.**

MAP Information
 Upstream Channel ID
 UCD Count
 (misc.)
 MAP start time = 1099
 ACK time=0800
 Ranging Backoffs
 Data Backoffs
 Request Region Offset=0
 Grant for CM20 Offset=5
 Grant for CM90 Offset=9
 Null Offset=19
 Zero Length Grants (Data Grant Pending)

Cable Modem Initialization

[When shipped from manufacturer, each modem contains a unique IEEE 802 48-bit MAC address and security information for authentication.]

- **Find downstream channel and acquire PHY and MAC lock (Sync Messages)**
- **Obtain transmit parameters (Upstream Channel Descriptor Messages, MAP Messages)**
- **Perform ranging (Ranging Messages, temporary SID assignment)**
- **Establish IP connectivity (DHCP messages sent as data PDUs)**
- **Establish Time of Day (UDP messages sent as data PDUs)**
- **Transfer operational parameters (TFTP file transfer as data PDUs)**
- **Registration (Registration Messages, SID assignment)**
- **Baseline Privacy (BP) Initialization (BP Key Management)**

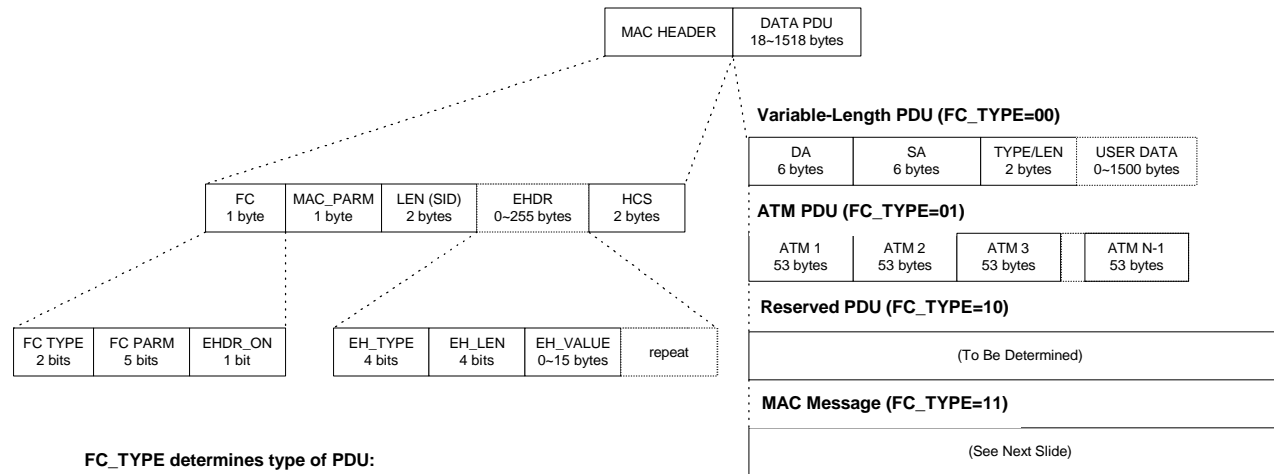
Normal Modem Operation

- **Periodic Ranging (Ranging Messages)- Provides continuous adaptation to changing physical parameters. The periodicity is configurable at the CMTS.**
- **Upstream Channel Parameter Change (UCD Messages) - Allows reconfiguration of upstream channel to meet current demands**
- **Upstream Channel Change (UCC Messages) - Allows movement of modems from one upstream channel to another for load balancing and fault protection**
- **Dynamic Service Configuration (DSA, DSC, DSD) - Allows dynamic service flow operation**

Frame Formats

- **Each DOCSIS frame consists of a DOCSIS header and an optional PDU.**
- **DOCSIS Header**
 - Frame Control (1B)-determines frame type
 - MAC_PARM (1B)-purpose determined by frame control
 - LEN (2B)- usually represents length of PDU, represents SID when used in a request
 - EHDR (0-240 B)-provides packet-specific information such as security information, payload header suppression information, and piggyback requests
 - HCS (2B)- header check sequence over entire DOCSIS header
- **PDU Types**
 - Variable-Length PDU
 - ATM Cell PDU (not covered in current DOCSIS specifications)
 - Reserved PDU
 - DOCSIS MAC-specific PDU

DOCSIS Data Formats



FC_TYPE determines type of PDU:

- 00 Variable-Length PDU (802.3)
- 01 ATM Cells
- 10 Reserved for future use
- 11 MAC specific messaging

If EHDR present, MAC_PARM=Length of EHDR
LEN=Length of EHDR plus PDU
If EHDR not present,
LEN=Length of PDU

Downstream MAC Message Formats

MAC Management Message ISO 8802-2

| | | | | | | | | | | |
|---------------|---------------|-------------------|----------------|----------------|-------------------|-------------------|--------------------|----------------|-----------------------------------|----------------|
| DA 6 bytes | SA 6 bytes | msgLEN 2 bytes | DSAP 1 byte | SSAP 1 byte | control 1 byte | version 1 byte | msg type 1 byte | RSVD 1 byte | management message payload | CRC 4 bytes |
|---------------|---------------|-------------------|----------------|----------------|-------------------|-------------------|--------------------|----------------|-----------------------------------|----------------|

Downstream MAC Management Message Payloads

Upstream Channel Descriptor (UCD)

| | | | | | | |
|------------------------------|--------------------------|-----------------------------|-----------------------------|-------------------------------------|---------------------------------------|--|
| Config. Change cnt 1 byte | Mini-Slot Size 1 byte | Upstream Chan. ID 1 byte | Dnstream Chan. ID 1 byte | TLV- For overall channel 4 bytes | TLV- For Burst Description 4 bytes | TLV- For subsequent burst descriptors 4 bytes |
|------------------------------|--------------------------|-----------------------------|-----------------------------|-------------------------------------|---------------------------------------|--|

Upstream Bandwidth Allocation Map (MAP)

| | | | | | |
|---------------------------|---------------------------|-----------------|------------------------------|---------------------|-----------------------------------|
| Upstream Ch. ID 1 byte | Number elements 1 byte | RSVD 2 bytes | Alloc. start time 4 bytes | Ack Time 4 bytes | Map Info. Elem. 4 bytes per IE |
|---------------------------|---------------------------|-----------------|------------------------------|---------------------|-----------------------------------|

Reg. Response (REG-RSP)

| | |
|---|-------------------------|
| SID from corresponding RNG-REQ 2 bytes | TLV Encoded Information |
|---|-------------------------|

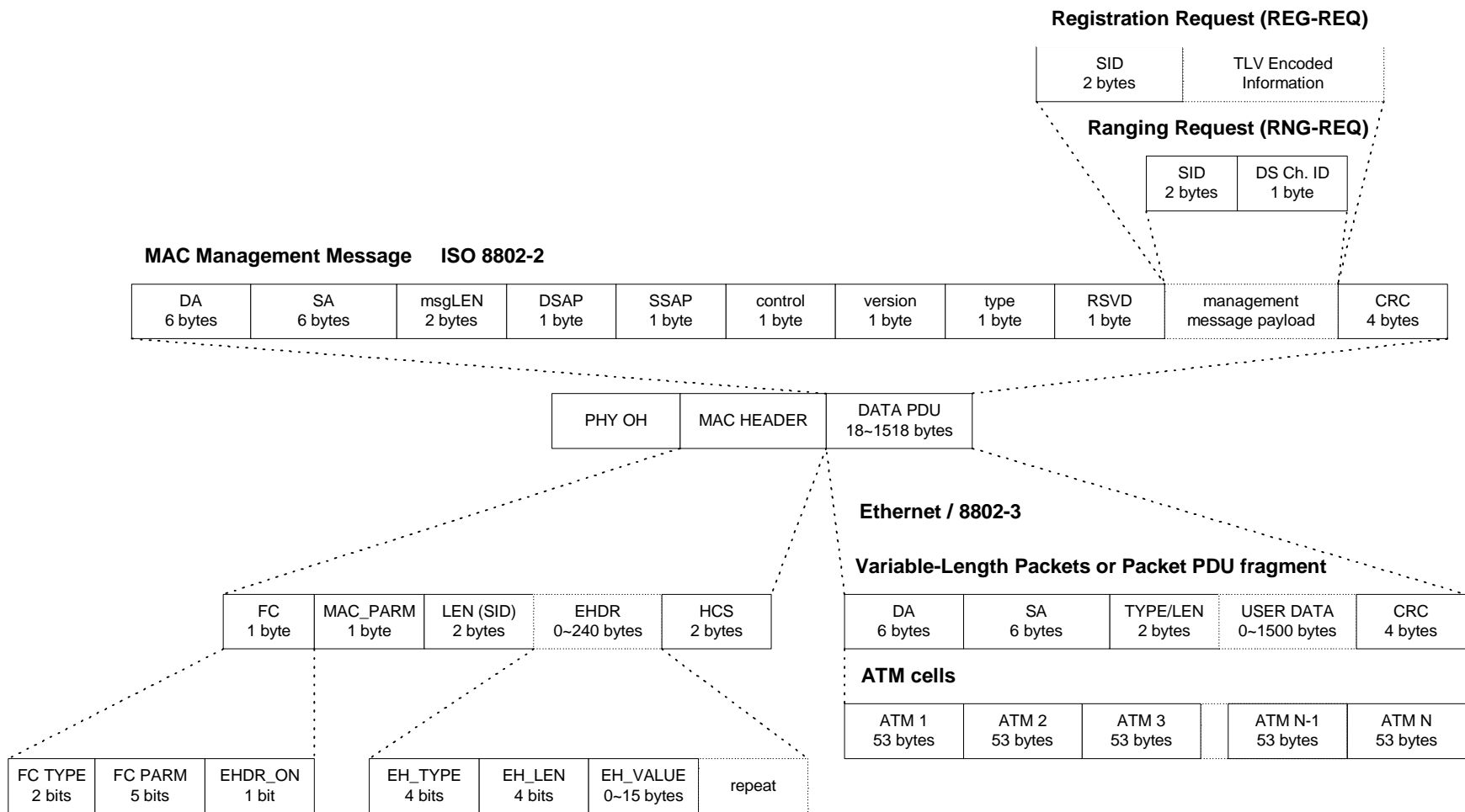
Time Synchronization

| | |
|---------------------------|------------------------------------|
| CMTS Timestamp 4 bytes | MAC SYNC Interval (MSI) 4 bytes |
|---------------------------|------------------------------------|

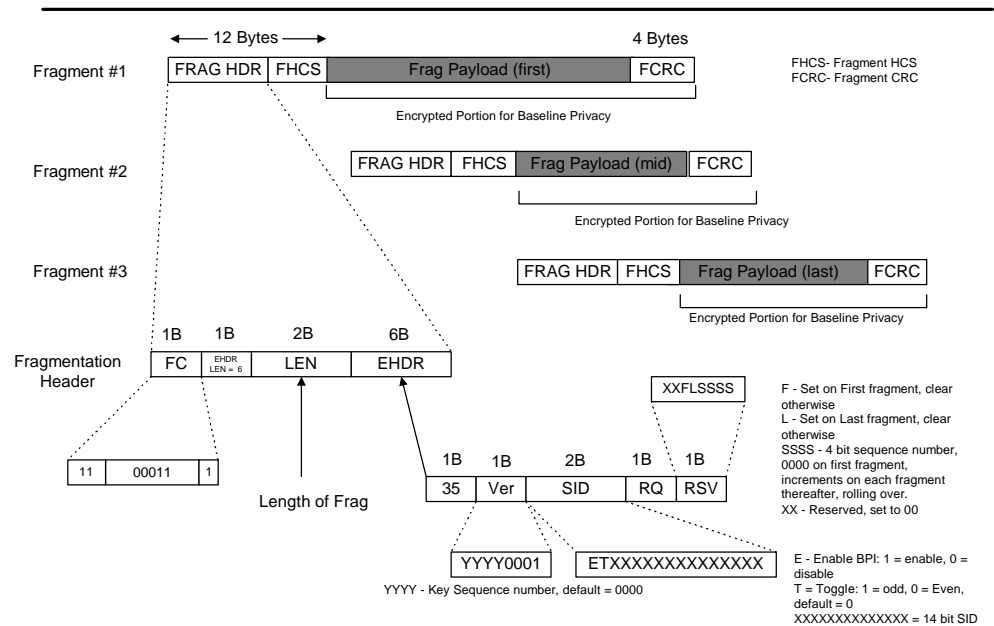
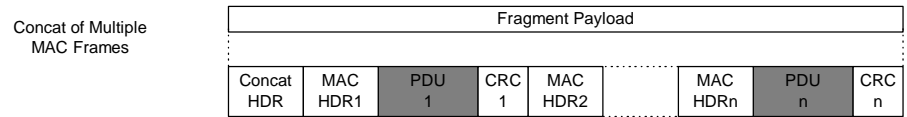
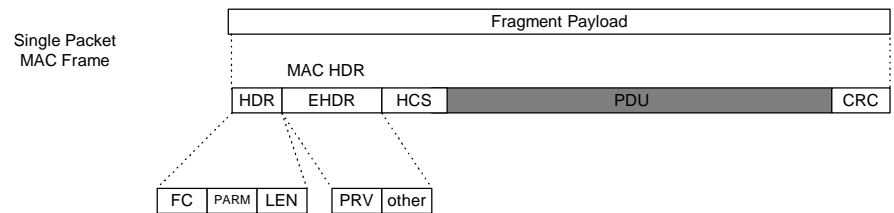
Ranging Response (RNG-RSP)

| | |
|-----------------------------|-------------------------------|
| SID from request 2 bytes | Upstream channel ID 1 byte |
|-----------------------------|-------------------------------|

Upstream MAC Frame Formats



Upstream Fragmentation



Possible Extensions for Wireless

- **Support for higher symbol rates in “upstream” and “downstream”**
- **Support for ATM cell transport**
 - PDU type already reserved for ATM cell transport
 - Needs further definition
- **Support for longer equalizer**