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Embedded Cable Modem Devices

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1 INTRODUCTION

1.1 Executive Summary

Existing DOCSIS specifications were created for stand-alone cable modems that provide high-speed broadband services using the hybrid-fiber-coaxial cable infrastructure. The emergence of a class of devices that embeds additional functionality with a Cable Modem such as packet-telephony, home networking, and video, has necessitated the creation of this specification to define additional requirements such as interfaces, management, and provisioning models. This is necessary to ensure that the Cable Modem will function properly and interact properly with the embedded Service/Application Functional Entities (eSAFEs).

The present document corresponds to and is the technical equivalent of the CableLabs [eDOCSIS] specification.

1.2 Scope

This specification defines additional features that must be added to a DOCSIS Cable Modem for implementations that embed the Cable Modem with another application, such as an IPCablecom MTA.

1.3 Goals

The goals for this specification are:

- To preserve functional separation of the DOCSIS cable modem entity from eSAFEs within the eDOCSIS Device, so that existing DOCSIS cable plant integrity, cable modem configuration, management and provisioning security are not compromised.
- To isolate DOCSIS cable modem functionality so that specification compliance can be tested for the eCM component independent of eSAFEs.
- To enable the service provider to enable or disable forwarding traffic between each eSAFE and the eCM within the eDOCSIS Device.
- To maximize compatibility with existing back-office management/provisioning infrastructure so that new services enabled by eDOCSIS devices can be deployed rapidly.
- To architect eDOCSIS devices in such a way as to scale to new services and applications, and to take advantage of technology innovations to achieve low cost and high functionalities.

1.4 DOCSIS Base Specifications

There are currently four versions of what are, in this document, referred to as the DOCSIS Base Specifications. These versions are commonly referred to as DOCSIS 1.0, DOCSIS 1.1, DOCSIS 2.0, and DOCSIS 3.0. A list of the document categories in the Data-Over-Cable Service Interface Specifications family is provided below. For updates, please refer to <http://www.cablemodem.com/>.

Designation				Title	
DOCSIS 1.0	DOCSIS 1.1	DOCSIS 2.0	DOCSIS 3.0		
SP-RFI	SP-RFIV1.1	SP-RFIV2.0	SP-DRFI	Radio Frequency Interface Specification	Downstream Radio Frequency Interface Specification
			SP-PHYV3.0		Physical Layer Specification
			SP-MULPIV3.0		Media Access Control and Upper Layer Protocols Interface Specification
SP-OSSI	SP-OSSIV1.1	SP-OSSIV2.0	SP-OSSIV3.0	Operations Support System Interface Specification	

Designation			Title
SP-BPI	SP-BPI+	SP-SECv3.0	Baseline Privacy and Security Interface Specification
SP-CMCI		SP-CMCIv3.0	Cable Modem to Customer Premises Equipment Interface Specification

1.5 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2 REFERENCES

2.1 Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1.1 SCTE References

[SCTE 23-2]	ANSI/SCTE 23-2 2012, DOCSIS 1.1 Part 2: Baseline Privacy Plus Interface
[DOCSIS OSSI]	Refers to [SCTE 23-3], [SCTE 79-2], and [SCTE 135-4].
[DOCSIS RFI/MULPI]	Refers to [SCTE 23-1], [SCTE 79-1], and [SCTE 135-2].
[SCTE 106]	ANSI/SCTE 106 2010, DOCSIS Set-Top Gateway (DSG) Specification
[SCTE 140]	ANSI/SCTE 140 2013, Cable Modem IPv4 and IPv6 eRouter Specification
[SCTE 135-2]	ANSI/SCTE 135-2 2013, DOCSIS 3.0 Part 2:MAC and Upper Layer Protocols
[SCTE 22-3]	ANSI/SCTE 22-3 2012: DOCSIS 1.0 Operations Support System Interface.
[SCTE 23-3]	ANSI.SCTE 23-3 2010, DOCSIS 1.1 Part 3:Operations Support System Interface
[SCTE 79-2]	ANSI/SCTE 79-2 2016, DOCSIS 2.0 Operations Support System Interface.
[SCTE 135-4]	ANSI.SCTE 135-4 2013, DOCIS 3.0 Part 4: Operations Support System Interface
[SCTE 22-1]	ANSI/SCTE 22-1 2012: DOCSIS 1.0 Radio Frequency Interface.
[SCTE 23-1]	ANSI/SCTE 23-1 2010, DOCSIS 1.1 Part 1: Radio Frequency Interface
[SCTE 79-1]	ANSI/SCTE 79-1 2016, DOCSIS 2.0 Part 1: Radio Frequency Interface
[SCTE 79-3]	ANSI/SCTE 79-3 2011, DOCSIS 2.0 + IPv6 Cable Modem Standard
[SCTE 135-5]	ANSI/SCTE 135-5 2009, DOCSIS 3.0 Part 5: Cable Modem to Customer Premise Equipment Interface Specification

2.1.2 Other Organizations References

[CANN-DHCP]	CableLabs DHCP Options Registry, CL-SP-CANN-DHCP-Reg-I10-130808, August 8, 2013, Cable Television Laboratories, Inc.
[CDL2]	OpenCable Common Download 2.0 Specification, OC-SP-CDL2.0-I13-120531, May 31, 2012, Cable Television Laboratories, Inc.
[CL BB]	Battery Backup MIB Specification, CL-SP-MIB-BB-I04-100608, June 8, 2010, Cable Television Laboratories, Inc.
[CMCI]	DOCSIS Cable Modem to Customer Premise Equipment Interface Specification, CM-SP-CMCI-C01-081104, November 4, 2008, Cable Television Laboratories, Inc.
[DOCSIS CMCI]	Refers to [SCTE 135-5] and [CMCI].
[HOST2.1]	OpenCable Host 2.1 Core Functional Requirements, OC-SP-HOST2.1-CFR-I17-130418, April 18, 2013, Cable Television Laboratories, Inc.

- [RFC 768] IETF STD6, RFC 768, User Datagram Protocol, J. Postel, August, 1980.
- [RFC 791] IETF STD5, RFC 791, Internet Protocol, J. Postel, September 1981.
- [RFC 1493] IETF RFC 1493, Definitions of Managed Objects for Bridges, E. Decker, P. Langille, A. Rijssinghani & K. McCloghrie, July 1993.
- [RFC 2011] IETF RFC 2011, SNMPv2 Management Information Base for the Internet Protocol using SMIV2, K. McCloghrie, November 1996.
- [RFC 2131] IETF RFC 2131, Dynamic Host Configuration Protocol, Droms, R., March 1997.
- [RFC 2132] IETF RFC 2132, DHCP Options, and BOOTP Vendor Extensions, Alexander, S., and R. Droms, March 1997.
- [RFC 2863] IETF RFC 2863, The Interfaces Group MIB, K. McCloghrie, F. Kastenholz, June 2000.
- [RFC 3396] IETF RFC 3396, Encoding Long Options in the Dynamic Host Configuration Protocol (DHCPv4), Lemon, T., and S. Cheshire, November, 2002.
- [RFC 3418] IETF STD62, RFC 3418, Management Information Base (MIB) for the Simple Network Management Protocol (SNMP), R. Presuhn, Ed., December 2002.
- [RFC 4188] IETF RFC 4188, K. Norseth, Ed. and E. Bell, Ed., Definitions of Managed Objects for Bridges, October 2005.
- [RFC 4293] IETF RFC 4293, Management Information Base for the Internet Protocol (IP), S. Routhier, April 2006.

2.2 Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

2.2.1 SCTE References

- [SCTE 136-5] ANSI/SCTE 136-2 2013, Cable Modem TDM Emulation Interface Standard
- [SCTE 24-5] ANSI/SCTE 24-5 2016, IPCablecom 1.0 Part 5: Media Terminal Adapter (MTA) Device Provisioning Requirements for the Delivery of Real-Time Services over Cable Television Using Cable Modems
- [SCTE 24-6] ANSI/SCTE 24-6 2016, IPCablecom 1.0 Part 6: IPCablecom Management Information Base (MIB) Framework
- [SCTE 24-5] IPCablecom Part 5: Media Terminal Adapter (MTA) Device Provisioning Requirements for the Delivery of Real-Time Services over Cable Television Using Cable Modems,

2.2.2 Other Organizations References

- [CH1.0] CableHome 1.0 Specification, CH-SP-CH1.0-C01-060728, July 28, 2006, Cable Television Laboratories, Inc.
- [CH1.1] CableHome 1.1 Specification, CH-SP-CH1.1-C01-060728, July 28, 2006, Cable Television Laboratories, Inc.
- [RFC 2578] IETF STD58, IETF RFC 2578, Structure of Management Information Version 2 (SMIV2), K. McCloghrie, D. Perkins, J. Schoenwaelder, April 1999.
- [eDOCSIS] eDOCSIS Specification, Data-Over-Cable Service Interface Specifications, CM-SP-eDOCSIS-I28-15035, March 5, 2010, Cable Television Laboratories, Inc.

3 GLOSSARY

This specification uses the following terms.

CableCARD Device	A PCMCIA card distributed by cable providers and inserted into a Host device to enable premium services in compliance with the OpenCable specifications; also called "Card" and "Point of Deployment" (POD) module.
Cable Modem	A modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system.
CMCI	Cable Modem (CM) to Customer Premise Equipment (CPE) Interface as defined in [CMCI].
Downstream Service Identifier	A 20-bit value in a DOCSIS extended header that identifies a stream of packets distributed to the same cable modem or group of cable modems. The DSID value is unique within a MAC Domain. For sequenced packets, the DSID identifies the resequencing context for downstream packet bonding in the CM.
eCM	An eCM is an embedded Cable Modem, i.e., one that has been enhanced with the features of this specification.
eDOCSIS	eDOCSIS is the embedded DOCSIS specification that defines the interface between the eCM and an eSAFE.
eDOCSIS Device	An eDOCSIS Device is one that includes an eCM entity, one or more eSAFEs and supports a single software image download that is used for the entire device.
eDVA	Embedded Digital Voice Adapter. An embedded component within an E-DVA
E-DVA	Embedded DVA device, a type of user equipment. An E-DVA is a single physical device embedded with an eDOCSIS-compliant eCM and an IPCablecom 2.0 eDVA.
Embedded Security eSTB	An eSTB with integrated security functions.
eMTA	Embedded Multimedia Terminal Adapter. An embedded component within an E-MTA.
E-MTA	Embedded MTA device, a type of user equipment. An E-MTA is a single physical device embedded with an eDOCSIS-compliant eCM and an IPCablecom 1.5 eMTA.
ePS	Embedded Portal Service Element. A CableHome-compliant eSAFE that provides management and network address translation functions between the DOCSIS network and the home network.
E-PS	Embedded PS device. An eDOCSIS device that contains both an ePS and an eCM.
eRouter	DOCSIS Embedded Router: An eSAFE that is compliant with [SCTE 140], providing IPv4 and/or IPv6 data forwarding, address configuration, and Domain Name services to Internet Protocol host devices connected to the cable modem in a customer's premises.
eSAFE	Embedded Service/Application Functional Entity. An embedded version of CableLabs-specified application, such as an IPCablecom Multimedia Terminal Adapter (MTA), that provides a service using the DOCSIS IP platform, or a function or set of functions, such as the eRouter logical element, that supports the delivery of one or more services over an IP platform.
eSG	Embedded Security, Monitoring, and Automation Gateway eSAFE. An embedded version of an SMA Gateway.

E-SG	Embedded Security, Monitoring, and Automation Gateway device. An eDOCSIS device that contains both an eSG and an eCM.
eSTB	Embedded Set-Top Box: An eSAFE that is compliant with [SCTE 106], providing video, audio, and data services. An example OpenCable-compliant eSTB is further specified in [HOST2.1].
eTEA	Embedded TDM Emulator Adapter: An eSAFE that is compliant with [SCTE 136-5], providing T1 and E1 Circuit transport over IP.
E-TEA	Embedded TDM Emulator Adapter device. An eDOCSIS device that contains both an eTEA and an eCM.
Firmware	A type of software which provides low-level instructions to embedded hardware devices, used interchangeably with software, software image, binary image and code image.
Hard Reset	Describes a full reset of the eDOCSIS device and its constituent eSAFE application elements (such as the eRouter) and embedded CM.
LCI	Logical CPE Interface. A bi-directional or uni-directional data-only logical 802.3/Ethernet MAC frame interface between eCM and an eSAFE.
Logical Element	An individual eSAFE within an eDOCSIS device. Used interchangeably with the term “component” or simply “element”.
Monolithic Firmware Image	A single firmware image containing one or more code images for the entire eDOCSIS device. For eDOCSIS devices, the Monolithic Firmware Image contains both the eCM code image as well as the applicable eSAFE code image. As an example for an eDOCSIS device containing an eSTB, the Monolithic Firmware Image contains the eCM code image as well as the eSTB code image (which may also be composed from multiple eSTB code images).
Multicast DSID Forwarding	A mechanism by which multicast traffic is forwarded by a CM based on a multicast DSID signaled by the CMTS to the CM. A multicast DSID identifies a subset of CMs intended to receive the same Multicast session and for the CM the DSID is a filtering and forwarding criterion for multicast packets.
MTA	Multimedia Terminal Adapter as defined in [SCTE 24-5]. Contains the interface to a physical voice device, a network interface, CODECs, and all signaling and encapsulation functions required for VoIP transport, class features signaling and QoS signaling.
NVT	The Network Virtual Terminal as defined in the Telnet Protocol. NVT was a bi-directional character device, representing characters as 7-bit ASCII codes, using an 8-bit field.
OpenCable Host eSTB	An eSTB device built to CableLabs OpenCable Host specifications.
Reset	Describes a routine in which the operational state is interrupted by the instruction to shutdown and restart. The term is synonymous with the terms re-initialization and reboot. The term can describe either a full device reset (a Hard Reset) or the re-initialization of an individual eSAFE’s software application (a Soft Reset) and any associated routines necessary to notify connected clients or other nodes of the device becoming temporarily unavailable.
Secure Microprocessor	The security element in a device that supports downloadable conditional access.
SEBC	A Set-top Device with an impaired upstream channel, using Set-top Extender Bridge (SEB) Client mode of operation to establish interactive IP connectivity.

SEBS	A Set-top Device with functional two-way connection, providing Set-top Extender Bridge (SEB) Server mode support for any SEBC devices on the subscriber's home network.
Segmented Firmware Image	A single firmware image containing one or more code images for one or more software components of an eDOCSIS device. As an example, for an eDOCSIS device containing an eSTB, the Segmented Firmware Image contains a component of the eSTB code image but does not necessarily contain the eCM code image and may not contain the full eSTB code image.
Set-top Device	An eDOCSIS device that contains an eSTB.
Soft Reset	Describes a reset operation in which the software layer of the eRouter eSAFE application is re-initialized without impacting other eSAFEs or the embedded CM within an eDOCSIS device.
TDM	Time Division Multiplexing: The means by which multiple digital signals can be carried on a single transmission path by interleaving portions of each signal in time.

4 ABBREVIATIONS

This specification uses the following abbreviations:

ASCII	American Standard Code for Information Interchange
BSoD	Business Services over DOCSIS
CATV	Community Access Television, Cable Television
CM	Cable Modem
CMCI	Cable Modem to Customer Premises Equipment Interface
CMTS	Cable Modem Termination System
CVC	Code Verification Certificate
DHCP	Dynamic Host Configuration Protocol
DIX	Digital Intel Xerox
DNS	Domain Name Server
DOCSIS	Data-Over-Cable Service Interface Specifications
DSG	DOCSIS Set-top Gateway
DSID	Downstream Service Identifier
DVA	Digital Voice Adapter
eCM	Embedded Cable Modem
eDOCSIS	Embedded DOCSIS
eDVA	Embedded Digital Voice Adapter
eMTA	Embedded Multimedia Terminal Adapter
ePS	Embedded Portal Services Element
eSAFE	Embedded Service/Application Functional Entity
eSG	Embedded Security, Monitoring, and Automation Gateway
eSTB	Embedded Set-Top Box
eTEA	Embedded T1/E1 TDM Emulation Adapter (TEA)
FCS	Frame Check Sequence
FQDN	Fully Qualified Domain Name
HTTP	Hyper Text Transfer Protocol
IP	Internet Protocol
LCI	Logical CPE Interface
LLC	Logical Link Control
MAC	Media Access Control
MDF	Multicast DSID Forwarding
MIC	Message Integrity Check
MTA	Multimedia Terminal Adapter
OCAP™	OpenCable Application Platform

PS	Portal Services
RF	Radio Frequency
ROM	Read Only Memory
SG	SMA Gateway
SLED	Software Loopback for eDOCSIS
SMA	Security, Monitoring, and Automation
SNMP	Simple Network Management Protocol
SSD	Secure Software Download
STB	Set-Top Box
SW	Software
TDM	Time Division Multiplexing
TEA	TDM Emulation Adapter
TFTP	Trivial File Transfer Protocol
TLV	Type/Length/Value
UDP	User Datagram Protocol
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
WAN	Wide Area Network

5 EMBEDDED DOCSIS CABLE MODEM

5.1 Device Interface Reference Model

Referring to Figure 5–1, an eDOCSIS device consists of an embedded DOCSIS cable modem (eCM) and one or more embedded Service/Application Functional Entities (eSAFEs). An eDOCSIS device may also have one or more physically exposed interfaces.

eSAFEs include:

- ePS: embedded CableHome Portal Services Logical Element [CH1.0], [CH1.1].
- eDVA: embedded IPCom 2.0 Digital Voice Adapter [SCTE 24-5].
- eMTA: embedded IPCom Multimedia Terminal Adapter [SCTE 24-5], [SCTE 24-6].
- eSG: embedded IPCom Security, Monitoring, and Automation Gateway.
- eSTB: embedded Set-Top Box. An eSAFE that is compliant with [SCTE 106], providing video, audio, and data services. An example OpenCable-compliant eSTB is further specified in [HOST2.1].
- eTEA: embedded T1/E1 TDM Emulation Adapter (eTEA) [SCTE 136-5].
- eRouter: An eSAFE that is compliant with [SCTE 140], providing Internet Protocol data forwarding, address configuration, and Domain Name services.

Within an eDOCSIS device, each eSAFE interfaces to the eCM via a point-to-point logical CPE interface.

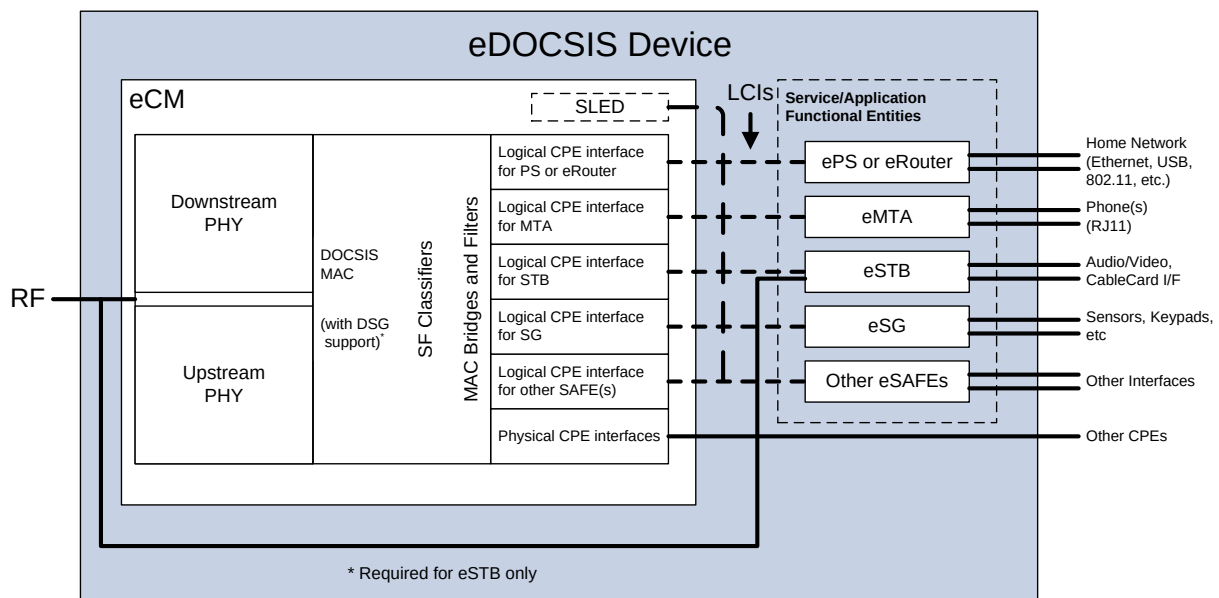


Figure 5–1 - eDOCSIS Reference Model

5.1.1 ePS Reference Model

Figure 5–2 presents a typical CableHome Home Access eDOCSIS Device reference model.

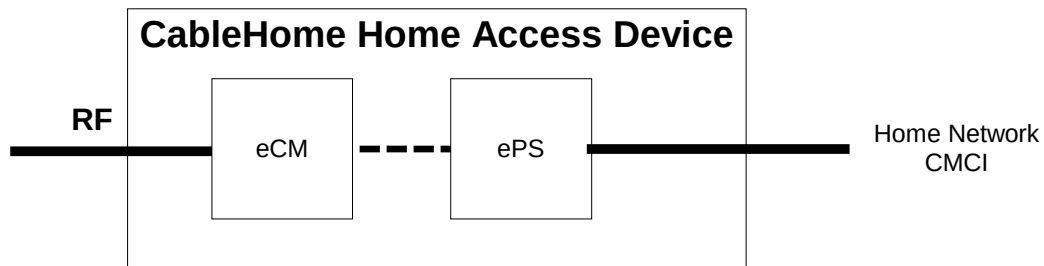


Figure 5–2 - CableHome Home Access eDOCSIS Device Reference Model

Figure 5–3 presents a logical view of protocol stacks for an eCM to ePS interface.

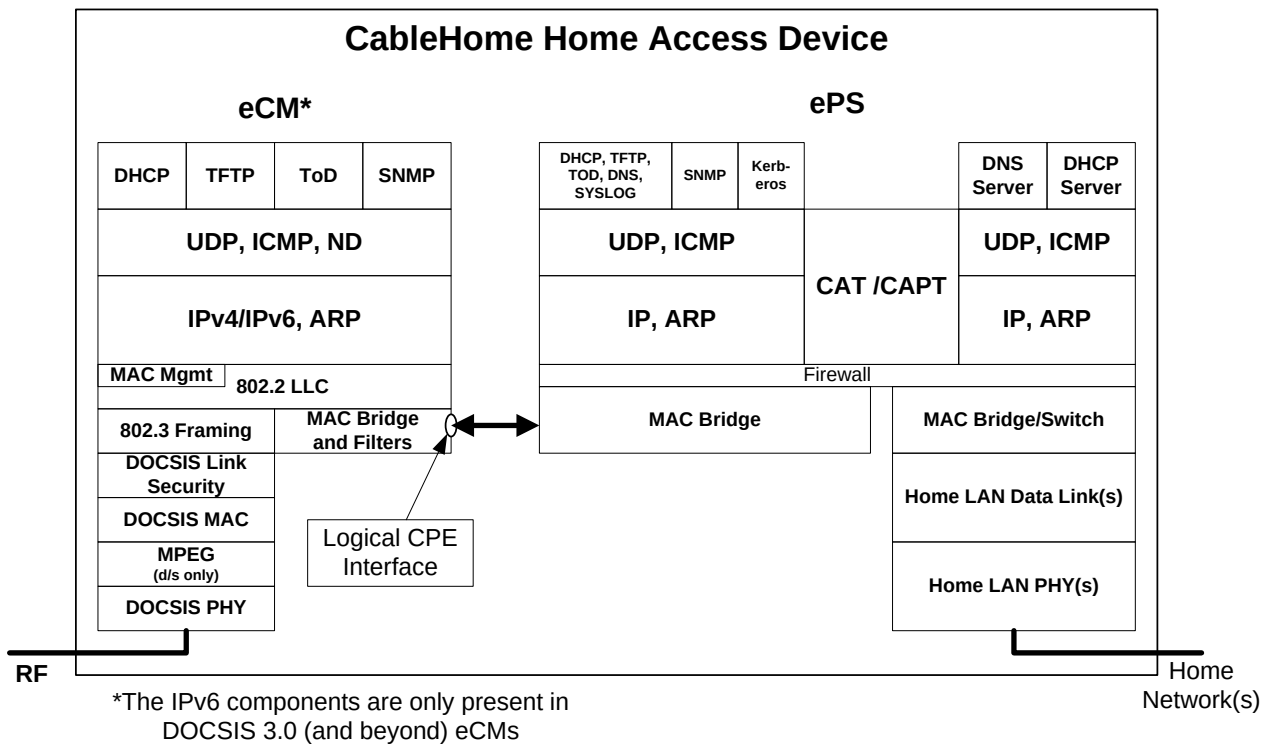


Figure 5–3 - eCM - ePS Protocol Stacks

5.1.2 eMTA Reference Model

Figure 5–4 presents a typical IP/Cablecom E-MTA (with DOCSIS cable modem) eDOCSIS Device reference model.

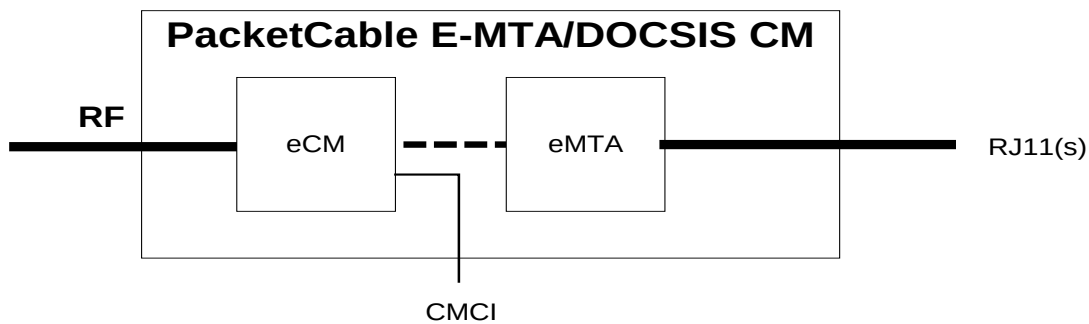


Figure 5–4 - IP/Cablecom E-MTA (with DOCSIS CM) eDOCSIS Reference Model

Figure 5–5 presents a logical view of protocol stacks for an eCM to eMTA interface.

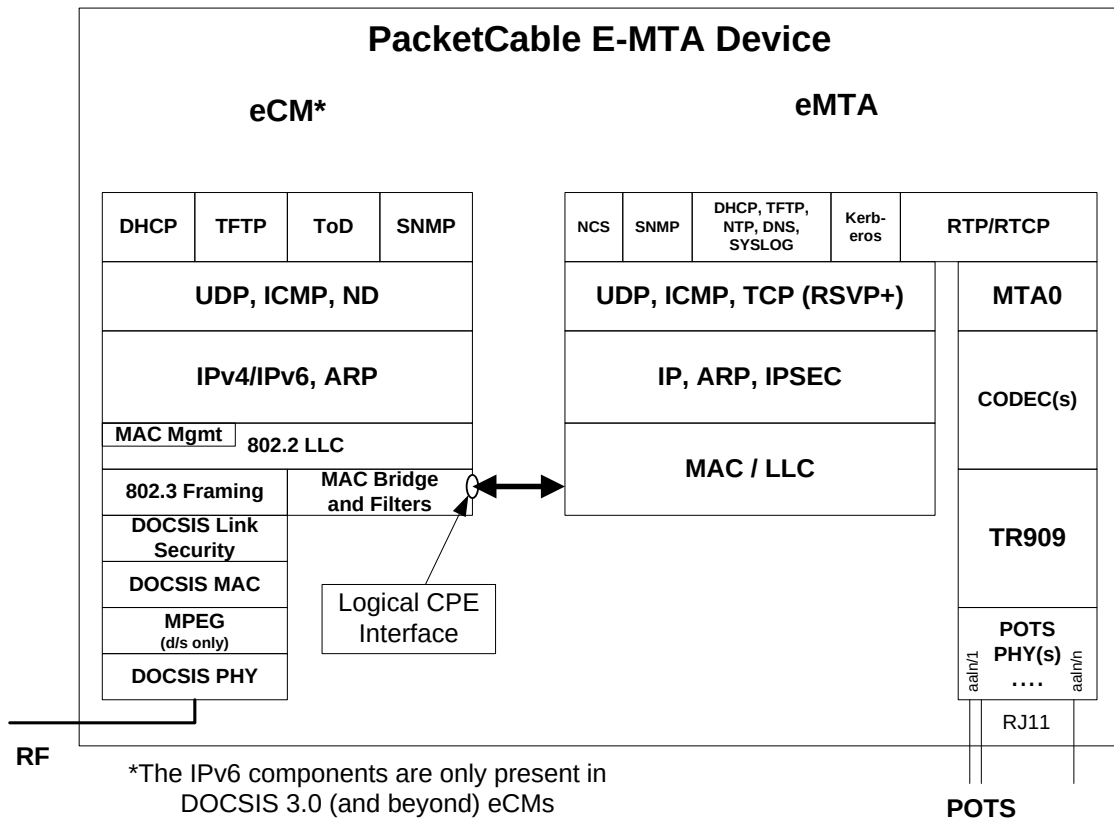


Figure 5–5 - eCM - eMTA Protocol Stacks

5.1.3 eSTB Reference Model

Figure 5–6 presents a typical OpenCable Host 2.1 eDOCSIS Device reference model where the Host provides DSG Socket Flow support.

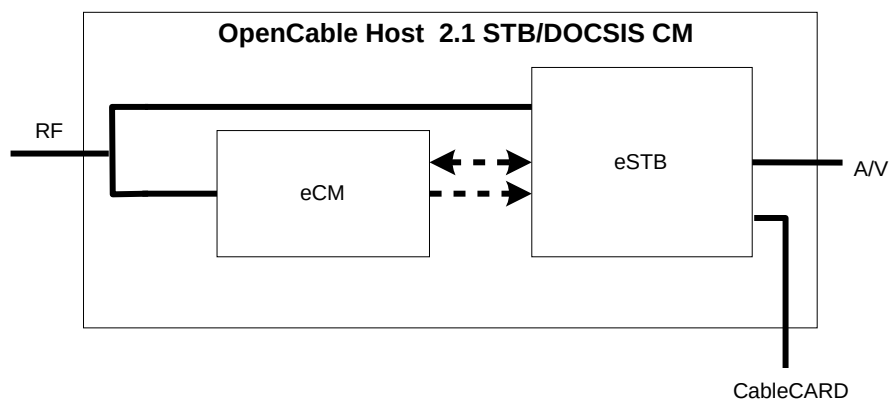
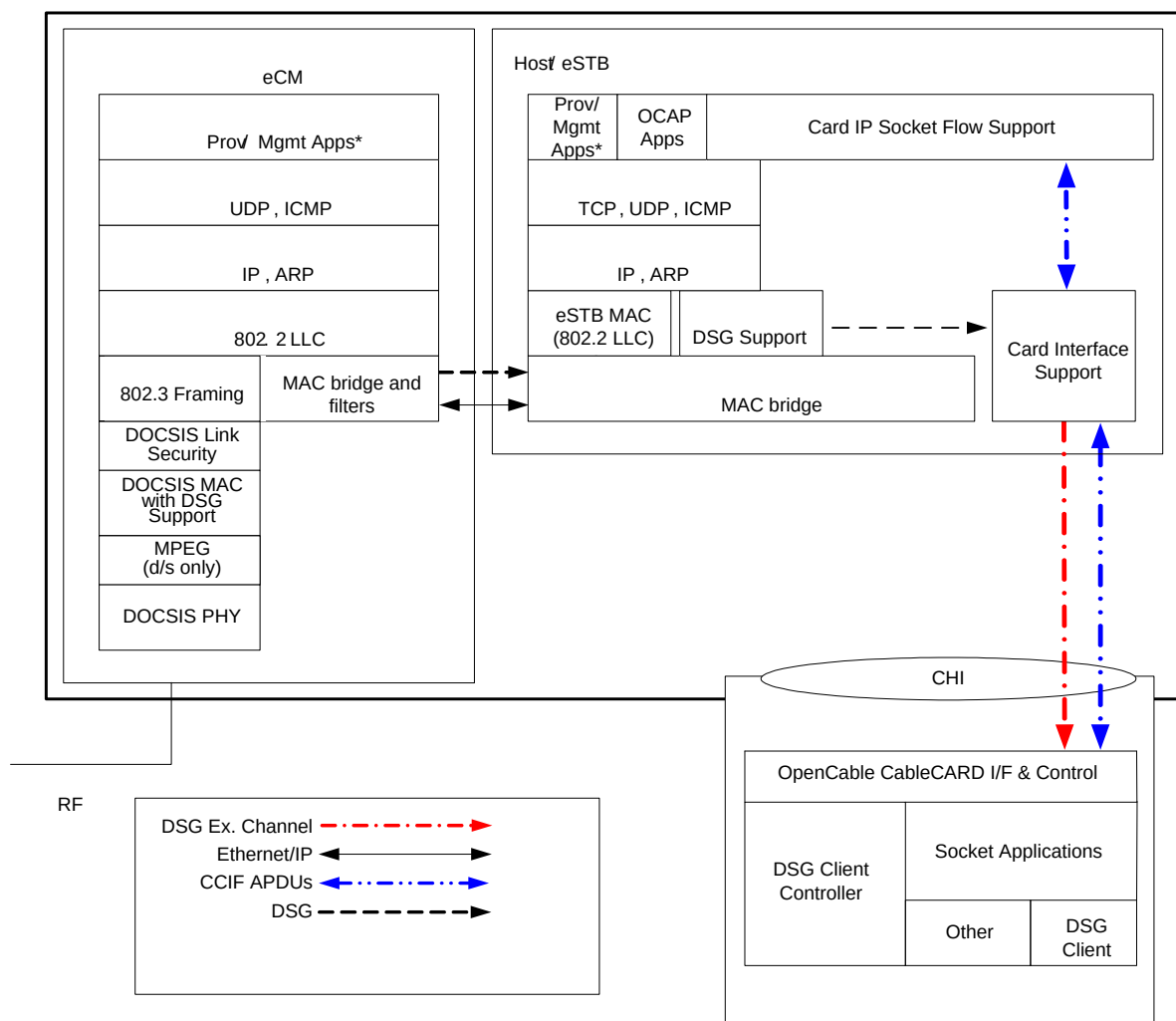


Figure 5-6 - OpenCable Host 2.1 eDOCSIS Reference Model

Figure 5-7 presents a logical view of protocol stacks for an eCM to eSTB to CableCARD interface (OpenCable [HOST2.1]) where the Host provides DSG and Socket Flow support.



* Prov/Mgmt Apps include DHCP, TFTP, DNS, SNMP, ToD, etc. as dictated by the relevant specification.

Figure 5-7 - eCM - eSTB Protocol Stacks - OpenCable Host 2.1 - Socket Flow

Figure 5–8 presents a typical embedded security STB eDOCSIS Device reference model.

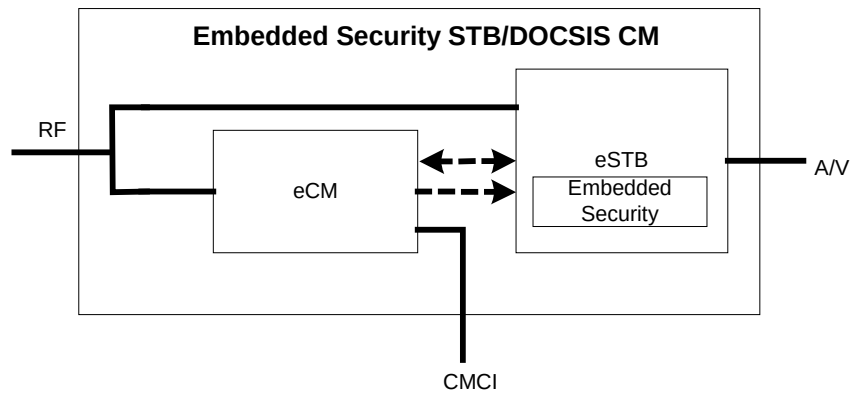
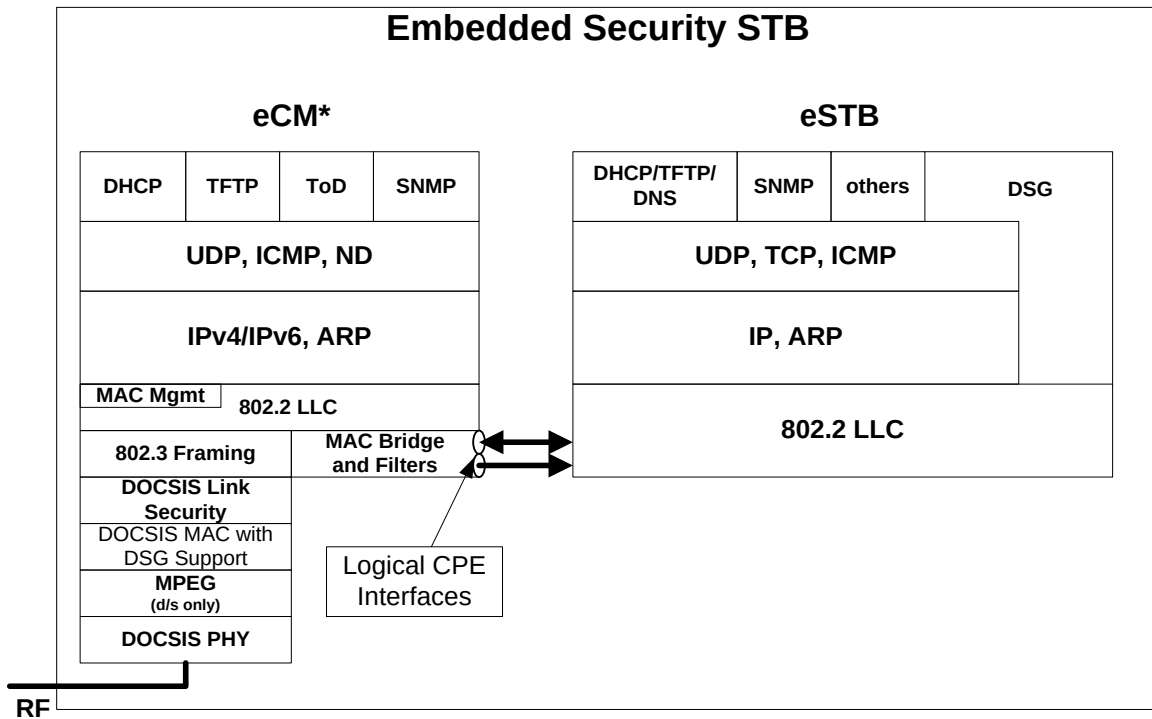


Figure 5–8 - Embedded Security STB eDOCSIS Reference Model

Figure 5–9 presents a logical view of protocol stacks for an eCM to eSTB interface (embedded security STB).



*The IPv6 components are only present in DOCSIS 3.0 (and beyond) eCMs

Figure 5–9 - eCM - eSTB Protocol Stacks - Embedded Security STB

5.1.4 eSTB Reference Model with Set-top Extender Bridge (SEB)

Figure 5–10 presents an OpenCable Host 2.1 Set-top Extender Bridge (SEB) Device reference model where the Host acting as a Set-top Extender Bridge Server provides Socket Flow and IP Flow support. The SEB Server is also providing an IP connection to the SEB Client by way of the SEB Server's eCM and the home network interface. The SEB Client continues to consume downstream DSG data using its embedded cable modem (eCM).