Data-Over-Cable Service Interface Specifications

Operations Support System Interface Specification

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INTERIM SPECIFICATION

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Key to Document Status Codes

Work in Process An incomplete document, designed to guide discussion and generate feedback, that may include several alternative requirements for consideration.

Draft A document in specification format considered largely complete, but lacking review by DOCSIS and vendors. Drafts are susceptible to substantial change during the review process.

Interim A document which has undergone rigorous DOCSIS and vendor review, suitable for use by vendors to design in conformance with, and suitable for field testing.

Released A stable document, reviewed, tested and validated, suitable to enable cross-vendor interoperability.

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Data-Over-Cable Services: Operations Support System Interface Specification

1. Scope and Purpose

1.1 Scope

This interim specification (SP-OSSI) documents the operations support system interface for high-speed data-over-cable systems developed by the Data-Over-Cable Service working group. This specification is intended to enable prospective vendors of cable modems and other data-over-cable systems to address the operations support requirements in a uniform and consistent manner. In particular, this specification specifies the managed objects and the management communications protocol.

This specification includes several documents. This document gives an overview of the management requirements for a data over cable system environment.

Other OSSI documents include management information for DOCSIS network elements or interfaces. These specifications define requirements for managed objects. The managed objects are defined in Simple Network Management Protocol (SNMP) Management Information Bases (MIBs) and are referenced in separate addendums to this document. These documents are:

- DOCSIS OSSI for Radio Frequency Interface (SP-OSSI-RFI)
- DOCSIS OSSI for Baseline Privacy Interface (SP-OSSI-BPI)
- DOCISIS OSSI for Telephony Return Interface (SP-OSSI-TRI)

The defined managed objects and referenced Requests For Comments (RFCs) in this set of documents provide a framework capable of supporting the business concepts and processes that cable operators are likely to employ in their launch of data-over-cable services. This specification is expected to facilitate interoperability and to accelerate development of conformant Operations Support Systems (OSSs) and/or associated Business Support Systems (BSSs).

A technical report entitled "Operations Support System Framework" (MCNS5) is a companion to this set of documents and focuses on business processes and operational scenarios which provide a service and business context for this specification.

1.2 Requirements

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

"MUST"	This word or the adjective "REQUIRED" 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 specfication.
"SHOULD"	This word or the adjective "RECOMMENDED" 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 or the adjective "OPTIONAL" 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.

Other text is descriptive or explanatory.

1.3 Background

1.3.1 Service Goals

Cable operators are interested in deploying high-speed data communications services on cable television systems. Comcast Cable Communications, Inc., Cox Communications, Tele-Communications, Inc., Time Warner Cable, Continental Cablevision, Inc., Rogers Cablesystems Limited, and Cable Television Laboratories, Inc. (on behalf of CableLabs member companies) have decided to prepare a series of interface specifications that will permit the early definition, design, development and deployment of data-over-cable systems on a uniform, consistent, open, non-proprietary, multi-vendor interoperable basis.

The intended service will allow transparent bi-directional transfer of Internet Protocol (IP) traffic, between the cable system headend and customer locations, over a hybrid fiber/coax (HFC) cable television system. This is shown in simplified form in Figure 1-1.

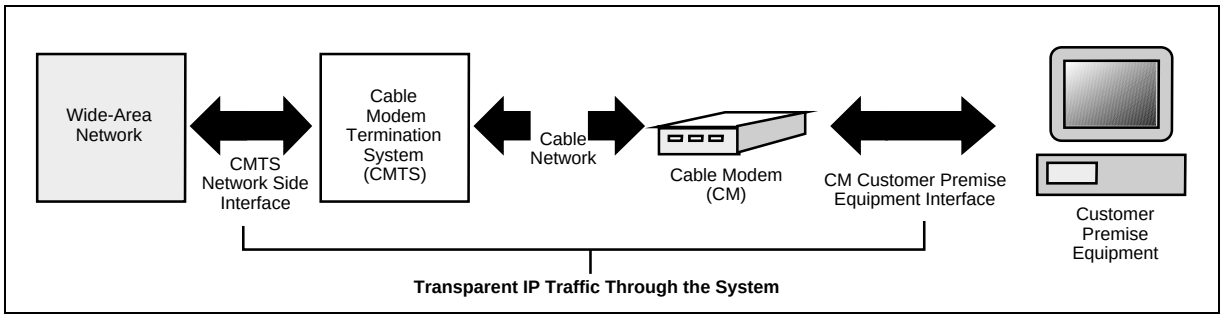

Figure 1-1: Transparent IP Traffic Through the Data-Over-Cable System

The transmission path over the cable system is realized at the headend by a CMTS, and at each customer location by a CM. At the headend (or hub), the interface to the data-over-cable system is called the Cable Modem Termination System - Network-Side Interface (CMTS-NSI) and is specified in [MCNS3]. At the customer locations, the interface is called the cable-modem-to-customer-premise-equipment interface (CMCI) and is specified in [MCNS4]. The intent is for the MCNS operators to transparently transfer IP traffic between these interfaces, including but not limited to datagrams, DHCP, ICMP, and IP Group addressing (broadcast and multicast).

1.3.2 Reference Architecture

The reference architecture for the data-over-cable services and interfaces is shown in Figure 1-2.

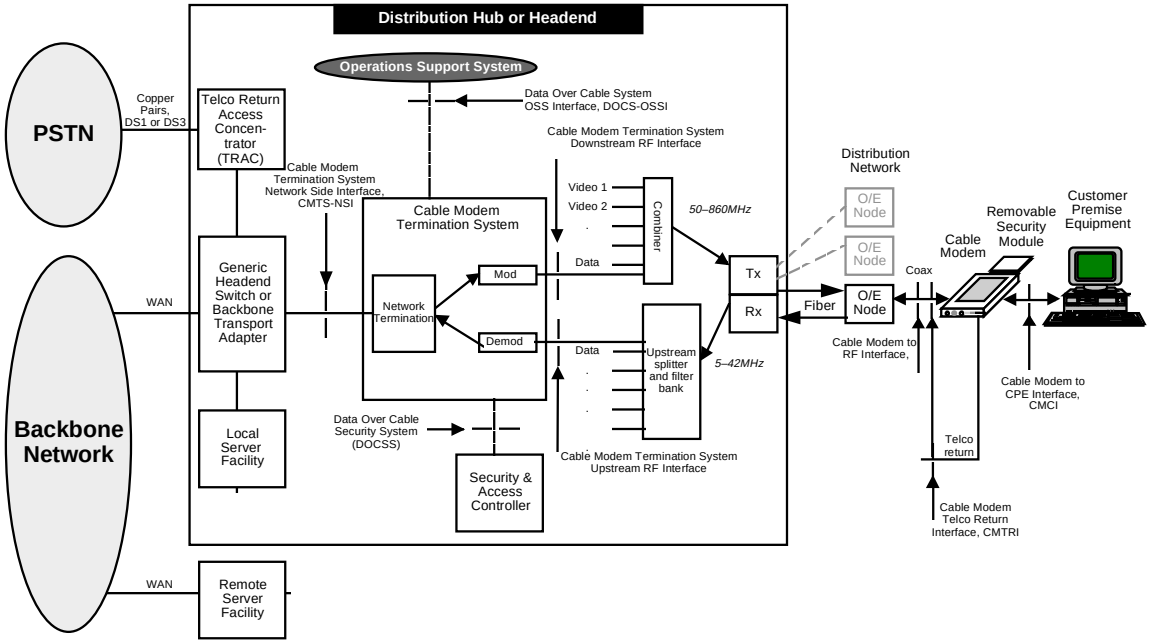

Figure 1-2: Data-over-Cable Reference Architecture

1.3.2.1 Categories of Interface Specification

The basic reference architecture of Figure 1-2 involves three categories of interfaces. These are being developed in phases.

a. Phase 1

Data Interfaces - These are the CMCI [MCNS4] and CMTS-NSI [MCNS3], corresponding respectively to the cable modem to customer-premise-equipment (CPE) interface (for example between the customer's computer and the cable modem), and the cable modem termination system network side interface between the cable modem termination system and the data network.

b. Phase 2

Operations Support System Interfaces - OSSI - This is the element management layer interface between the network elements and higher level OSSs which support the basic business processes and are covered in this document and the following MIB documents: [MCNS12], [MCNS13], and [MCNS14].

Telephone Return Interface - CMTRI - This is the interface between the cable modem and a telephone return path, for use in cases where the return path is not provided or not available via the HFC network and is documented in [MCNS6].

c. Phase 3

RF Interfaces -

- Between the cable modem and the cable network.
- Between the CMTS and the cable network, in the downstream direction (traffic toward the customer)
- Between the CMTS and the cable network, in the upstream direction (traffic from the customer)

Security System Interface - This is the interface between the CMTS and CM, and the Data Over Cable Security Specification (DOCSS) and is described in the following documents: [MCNS8], [MCNS9], and [MCNS10].

1.3.2.2 Data-Over-Cable Interface Documents

A list of the documents in the Data-Over-Cable Interface Specifications family is provided below. For update, please refer to URL http://www.cablemodem.com.

Designation	Title
SP-CMCI	Cable Modem to Customer Premises Equipment Interface Specification
SP-CMTS-NSI	Cable Modem Termination System Network Side Interface Specification
SP-CMTRI	Cable Modem Telephony Return Interface Specification
SP-OSSI	Operations Support System Interface Specification
SP-OSSI-RF	Operations Support System Interface Specification RF Interface
SP-OSSI-TR	Operations Support System Interface Specification Telephony Return Interface
SP-OSSI-BPI	Operations Support System Interface Baseline Privacy Interface
SP-RFI	Radio Frequency Interface Specification

SP-BPI	Baseline Privacy Specification

Key to Designation:

SP Specification

TR Technical Report (provides a context for understanding and applying the specification.)

1.4 Structure of this Document

For relevant background and context, please refer to the companion technical paper entitled "Operations Support System Framework" [MCNS5]. So that this document can be interpreted on a stand-alone basis, some of the technical report is summarized in Section 2 below.

Section 3 specifies the protocol for management communications and further describes requirements related to security.

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2. Approach and Framework

This draft specification (SP-OSSI) defines the management interface. This interface is made up of the communications protocol and managed objects required to ensure manageability of CMs and CMTSs by network management systems within an OSS infrastructure that supports data-over-cable services. This interface may also be used by BSSs needed for the commercial deployment of such services.

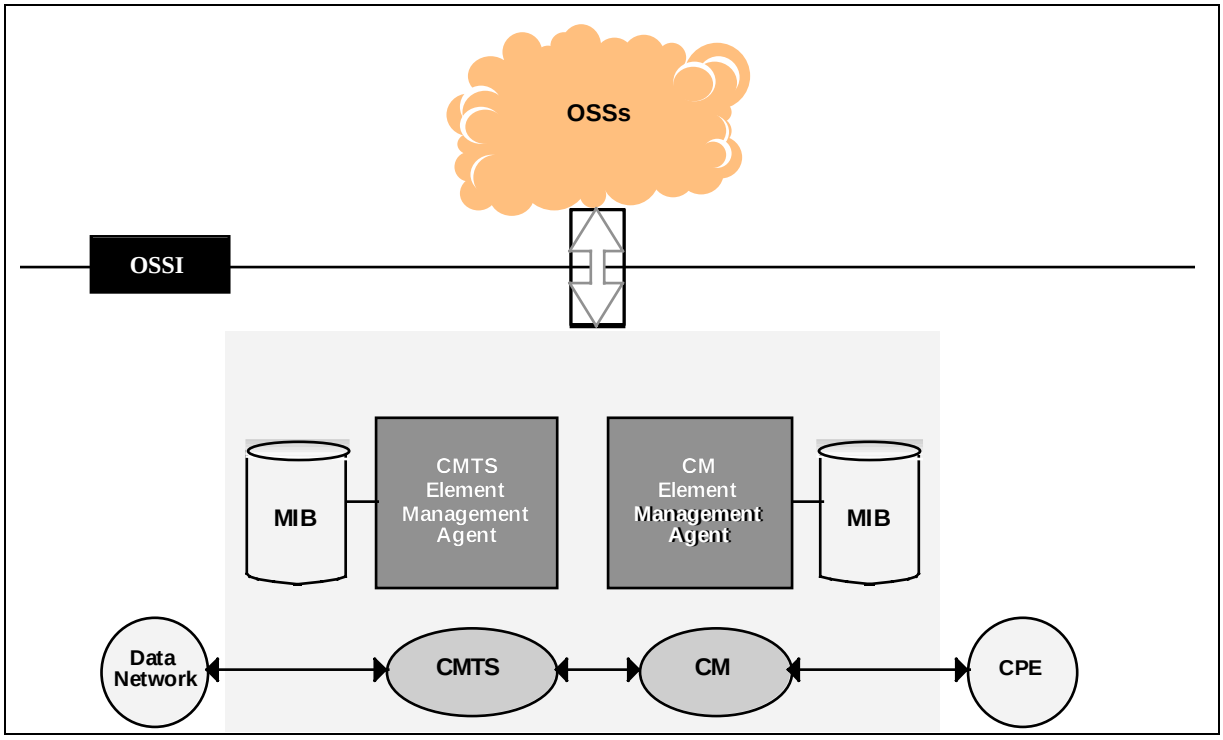

Figure 2-1: Scope of SP-OSSI Specification

The OSS "cloud" in Figure 2-1 contains the management systems supporting the core business processes. Although the physical data-over-cable network infrastructure depicted at the bottom of Figure 2-1 includes CPE and the backbone data network, this specification addresses only the CM and CMTS management issues.

2.1 Approach

This specification relies on open standards, with a preference for proven, well-known and widely accepted communications standards and allows for scalability and evolvability of operations support capabilities. The SNMPv1 management protocol developed by the Internet Engineering Task Force (IETF) has been selected as the management protocol for data-over-cable services.

Operations support requirements for managing the CM and CMTS can be viewed from two perspectives. The bottom-up view focuses on MIBs which are described in the MIB addendums to this document [MCNS12], [MCNS13], and [MCNS14]. The top-down view focuses

on the business process support requirements for higher layer OSSs and BSSs and their impact on management of the CM and CMTS. This is described in the companion technical report [MCNS5]. Neither this specification nor the companion technical report attempts to specify functional requirements for cable operators' OSSs/BSSs nor does it define their architecture or prescribe business processes to be used.

2.2 Framework

The data-over-cable system MUST operate satisfactorily in the environment consistent with assumptions described in [MCNS7], some of which are reiterated in this section. The element management framework in this document assumes the conceptual structure of the CM and CMTS as depicted in Figure 2-2 below. However, this structure does not imply any particular physical implementation of either the CM or CMTS.

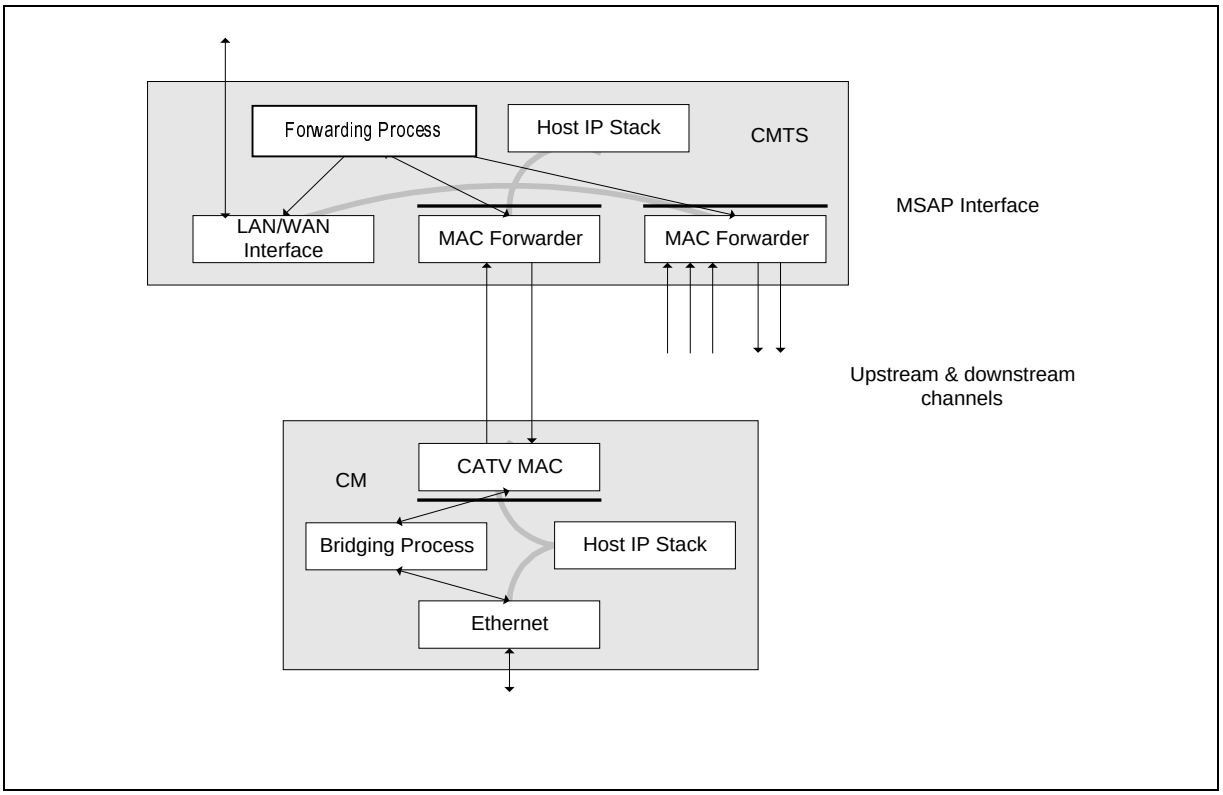

Figure 2-2: Conceptual Structure of the CM and CMTS

Elements of the conceptual structure:

- A MAC Service Access Point (MSAP) interface is an attachment to a MAC-layer domain. A MAC-layer domain is a collection of upstream and downstream channels for which a single MAC Allocation and Management protocol is run. Its attachments include one CMTS and some number of CMs. The CMTS must service all of the upstream and downstream channels; each CM may access one or more upstream and downstream channels.

- A CMTS consists of one or more CATV MAC interfaces, one or more LAN interfaces (Ethernet or Fast Ethernet), a forwarding process, and an internal IP host.
- A CM typically consists of a single CATV MAC interface, a single LAN interface, a bridging process, and an internal IP host. (Nothing in this specification precludes additional interfaces).
- An upstream channel is a single frequency band providing simplex data delivery from CMs to the CMTS.
- A downstream channel is a single frequency band providing simplex data delivery from the CMTS to some set of CMs.
- The bridging process performs transparent forwarding based on destination MAC address.
- The MAC forwarder (see [MCNS7]), forwards traffic from upstream channels to downstream channels within a MAC interface. Although its operation is similar, it is not part of the bridging process.
- The IP host is a protocol stack that provides the IP, ICMP, ARP, UDP, SNMP, DHCP, and TFTP needed for provisioning and management of the device.
- Within each MAC Domain, Service IDs provide both device identification and quality-of-service management. In particular, they are integral to upstream bandwidth allocation. Within a MAC domain, all Service IDs are unique. The CMTS may assign one or more Service IDs to each CM, corresponding to the classes of service required by the CM.
- The forwarding process performs either transparent bridging or IP routing between the CMTS RF interfaces and CMTS network side interfaces (NSI).

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3. Protocol

The SNMPv1 protocol [RFC 1157] has been selected as the communications protocol for management of data-over-cable services and MUST be implemented. Many of the managed objects described in the MIB addendums are configurable parameters and allow read-write access. As operators of public data networks, most cable operators will wish to restrict access to these objects, both at the CM and at the CMTS. Two mechanisms are provided to accomplish this.

First, the `docsDevNMAccessTable` in the Cable Device MIB described in [MCNS12] provides a means of restricting access to particular network management stations over particular interfaces using specific community strings. For example, the CMTS may be configured to respond only to SNMP requests originating on its network-side interface.

Second, writable-access for individual managed objects is controlled through the provisioned configuration file as described in [MCNS7]. That is, each read-write object can be redefined at provisioning time to be read-only.

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Appendix A – References

[CSMIMIB] Masuma Ahmed and Mario P. Vecchi. Definitions of Managed Objects for HFC RF Spectrum Management (internet draft draft-ahmed-csmimib-mib-00.txt). June 13,1996

[MCNS1] MCNS Data Over Cable Service Interface Specification Request for Proposals, December 11, 1995 (can be downloaded on the World Wide Web from http://www.cablemodem.com)

[MCNS3] Cable Modem Termination System - Network-Side Interface Specification SP-CMTS-NSID04-960409 (CMTS-NSI), April 9, 1996

[MCNS4] Cable Modem to Customer Premise Equipment Interface Specification SP-CMCID04-960409 (CMCI), April 9, 1996

[MCNS5] Operations Support System Framework TR-OSSF (under preparation)

[MCNS6] Data Over Cable Services Cable Modem TELCO Return Interface Specification SP-CMTRID02-961016 (under preparation)

[MCNS7] Data Over Cable Services Cable Modem Radio Frequency Interface Specification SP-RFID01-970321

[MCNS8] Data Over Cable Services Security Specification SP-DOCSS (under preparation)

[MCNS9] Data Over Cable Services Cable Modem to Subscriber Security Module Interface Specification (under preparation)

[MCNS10] CNS Data Over Cable Services Data Privacy Specification (under preparation)

[MCNS11] Data Over Cable Services Operations Support System Interface Specification SP-OSSII01-970403

[MCNS12] Data Over Cable Services Operations Support System Interface Specification Radio Frequency Management Information Base SP-OSSI-RFI01-970403

[MCNS13] Data Over Cable Services Operations Support System Interface Specification Telephony Return Management Information Base SP-OSSI-TR (under preparation)

[MCNS14] Data Over Cable Services Operations Support System Interface Specification Security Management Information Base SP-OSSI-SEC (under preparation)

[RFC-1157] Schoffstall, M., Fedor, M., Davin, J. and Case, J., A Simple Network Management Protocol (SNMP), IETF RFC-1157, May, 1990

[RFC-1212] K. McCloghrie and M. Rose. Concise MIB Definitions, IETF RFC-1212, March, 1991

[RFC-1213] K. McCloghrie and M. Rose. Management Information Base for Network Management of TCP/IP-base internets: MIB-II, IETF RFC-1213, March, 1991

[RFC-1224] L. Steinberg., Techniques for Managing Asynchronously Generated Alerts, IETF RFC-1224, May, 1991

[RFC-1493] E. Decker, P. Langille, A. Rijsinghani, and K.McCloghrie., Definitions of Managed Objects for Bridges, IETF RFC-1493, July, 1993

[RFC-1533] S. Alexander and R. Droms. DHCP Options and BOOTP Vendor Extensions. IETF RFC-1533. October, 1993.

[RFC-1573] K. McCloghrie and Kastenholz., Evolution of the Interfaces Group of MIB-II, IETF RFC-1573, January, 1994

[RFC-1643] F. Kastenholz., Definitions of Managed Objects for the Ethernet-like Interface Types, IETF RFC-1643, July, 1994

Appendix B – Glossary

Address Resolution Protocol (ARP) – the protocol used for discovery of IP addresses in shared media (particularly IEEE 802-like) networks.

American National Standards Institute (ANSI) – A U.S. standards body.

ANSI – See American National Standards Institute.

ARP – See Address Resolution Protocol.

Asynchronous Transfer Mode (ATM) – A protocol for the transmission of a variety of digital signals using uniform 53-byte cells.

ATM – See Asynchronous Transfer Mode.

Availability – In cable television systems, availability is the long-term ratio of the actual RF channel operation time to scheduled RF channel operation time (expressed as a percent value) and is based on a bit error rate (BER) assumption.

BPDU – See Bridge Protocol Data Unit.

Bridge Protocol Data Unit – any of the messages exchanged between spanning tree bridges used for spanning tree configuration and maintenance.

Broadcast Addresses – A predefined destination address that denotes the set of all data network service access points.

BSS – See Business Support System.

Business Support System (BSS) – a collection of computing equipment maintaining accounting, billing, and access control for a cable modem network.

Cable Modem (CM) – A modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system.

Cable Modem Termination System (CMTS) – Cable modem termination system, located at the cable television system headend or distribution hub, which provides complementary functionality to the cable modems to enable data connectivity to a wide-area network.

Cable Modem Termination System - Network Side Interface (CMTS-NSI) – The interface, defined in [MCNS3], between a CMTS and the equipment on its network side.

Cable Modem to CPE Interface (CMCI) – The interface, defined in [MCNS4], between a CM and CPE.

CM – See Cable Modem.

CMCI – See Cable Modem to CPE Interface.

CMTS – See Cable Modem Termination System.

CMTS-NSI – See Cable Modem Termination System - Network Side Interface.

CPE – See Customer Premise Equipment.

Cross-Modulation – A form of television signal distortion where modulation from one or more television channels is imposed on another channel or channels.

Customer – See End User.

Customer Premises Equipment (CPE) – Equipment at the end user's premises; MAY be provided by the end user or the service provider.

Data Link Layer – Layer 2 in the Open System Interconnection (OSI) architecture; the layer that provides services to transfer data over the transmission link between open systems.

DHCP – See Dynamic Host Configuration Protocol.

Distribution Hub – A location in a cable television network which performs the functions of a Headend for customers in its immediate area, and which receives some or all of its television program material from a Master Headend in the same metropolitan or regional area; see, for example, [MCNS1].

Downstream – In cable television, the direction of transmission from the headend to the subscriber.

Drop Cable – Coaxial cable that connects to a residence or service location from a directional coupler (tap) on the nearest coaxial feeder cable.

Dynamic Host Configuration Protocol (DHCP) – An Internet protocol used for assigning network-layer (IP) addresses.

Dynamic Range – The ratio between the greatest signal power that can be transmitted over a multichannel analog transmission system without exceeding distortion or other performance limits, and the least signal power that can be utilized without exceeding noise, error rate or other performance limits.

Electronic Industries Association (EIA) – A voluntary body of manufacturers which, among other activities, prepares and publishes standards.

End User – A human being, organization, or telecommunications system that accesses the network in order to communicate via the services provided by the network.

Feeder Cable – Coaxial cables that run along streets within the served area and connect between the individual taps which serve the customer drops.

Fiber Node – A point of interface between a fiber trunk and the coaxial distribution.

Forward Channel – The direction of RF signal flow away from the headend toward the end user; equivalent to Downstream.

Headend – The central location on the HFC network that is responsible for injecting broadcast video and other signals in the downstream direction. See also Master Headend, Distribution Hub.

Header – Protocol control information located at the beginning of a protocol data unit.

HFC – See Hybrid Fiber/Coax (HFC) System.

High Frequency (HF) – Used in this document to refer to the entire subsplit (5-30 MHz) and extended subsplit (5-42 MHz) band used in reverse channel communications over the cable television network.

High Return – A frequency division scheme that allows bi-directional traffic on a single coaxial cable. Reverse channel signals propagate to the headend above the downstream passband.

Hybrid Fiber/Coax (HFC) System – A broadband bidirectional shared-media transmission system using fiber trunks between the headend and the fiber nodes, and coaxial distribution from the fiber nodes to the customer locations.

ICMP – See Internet Control Message Protocol.

IEEE – See Institute of Electrical and Electronic Engineers.

IETF – See Internet Engineering Task Force.

Internet Control Message Protocol (ICMP) – An Internet network-layer protocol.

International Electrotechnical Commission (IEC) – An international standards body.

Institute of Electrical and Electronic Engineers (IEEE) – A voluntary organization which, among other things, sponsors standards committees and is accredited by the American National Standards Institute.

Internet Engineering Task Force (IETF) – A body responsible, among other things, for developing standards used in the Internet.

Internet Protocol (IP) – An Internet network-layer protocol.

International Organization for Standardization (ISO) – An international standards body, commonly known as the International Standards Organization.

IP – See Internet Protocol.

Latency – The time, expressed in quantity of symbols, taken for a signal element to pass through a device.

Layer – A subdivision of the Open System Interconnection (OSI) architecture, constituted by subsystems of the same rank

LLC – See Logical Link Control (LLC) procedure.

Local Area Network (LAN) – A non-public data network in which serial transmission is used for direct data communication among data stations located on the user's premises.

Logical Link Control (LLC) procedure – In a local area network (LAN) or a Metropolitan Area Network (MAN), that part of the protocol that governs the assembling of data link layer frames and their exchange between data stations, independent of how the transmission medium is shared.

MAC – See Media Access Control (MAC) procedure.

MAC Service Access Point (MSAP) – The conceptual binding of a MAC-layer service provider to the protocol entities (i.e., data link layers) above it.

Master Headend – A headend which collects television program material from various sources by satellite, microwave, fiber and other means, and distributes this material to Distribution Hubs in the same metropolitan or regional area. A Master Headend MAY also perform the functions of a Distribution Hub for customers in its own immediate area; see, for example, [MCNS1].

MCNS – See Multimedia Cable Network System (MCNS) partners.

Mean Time to Repair (MTTR) – In cable television systems, the MTTR is the average elapsed time from the moment a loss of RF channel operation is detected up to the moment the RF channel operation is fully restored.

Media Access Control (MAC) address – The “built-in” hardware address of a device connected to a shared medium.

Media Access Control (MAC) procedure – In a subnetwork, that part of the protocol that governs access to the transmission medium independent of the physical characteristics of the medium, but taking into account the topological aspects of the subnetworks, in order to enable the exchange of data between nodes. MAC procedures include framing, error protection, and acquiring the right to use the underlying transmission medium.

Media Access Control (MAC) sublayer – The part of the data link layer that supports topology-dependent functions and uses the services of the Physical Layer to provide services to the logical link control (LLC) sublayer.

Mini-Slot – The unit of allocation for time-division of the upstream channel. The size of a mini-slot is configurable, but normally it is a time interval corresponding to 16 byte-times (QPSK) or 32 byte-times (QAM16).

MSAP – See MAC Service Access Point.

Multimedia Cable Network System (MCNS) partners – A consortium of Comcast Cable Communications, Inc., Cox Communications, Tele-Communications, Inc., and Time Warner Cable, interested in deploying high-speed data communications systems on cable television systems.

Multipoint Access – User access in which more than one terminal equipment is supported by a single network termination.

Multipoint Connection – A connection among more than two data network terminations.

National Cable Television Association (NCTA) – A voluntary association of cable television operators which, among other things, provides guidance on measurements and objectives for cable television systems in the U.S.A.

Network Layer – Layer 3 in the Open System Interconnection (OSI) architecture; the layer that provides services to establish a path between open systems.

Network Management – The functions related to the management of data link layer and physical layer resources and their stations across the data network supported by the hybrid fiber/coax system.

National Television Systems Committee (NTSC) – Committee which defined the analog color television broadcast standard used today in North America.

Open Systems Interconnection (OSI) – A framework of ISO standards for communication between different systems made by different vendors, in which the communications process is organized into seven different categories that are placed in a layered sequence based on their relationship to the user. Each layer uses the layer immediately below it and provides a service to the layer above. Layers 7 through 4 deal with end-to-end communication between the message source and destination, and layers 3 through 1 deal with network functions.

Operations Support System (OSS) – The backoffice software used for configuration, performance, fault, accounting and security management.

Organization Unique Identifier (OUI) – A 3-octet IEEE assigned identifier that OUI can be used to generate Universal LAN MAC addresses and Protocol Identifiers per ANSI/IEEE Std 802 for use in Local and Metropolitan Area Network applications.

OSI – See Open Systems Interconnection.

OSS – See Operations Support System.

OUI – See Organization Unique Identifier.

PDU – See Protocol Data Unit.

PHY – See Physical (PHY) Layer.

Physical (PHY) Layer – Layer 1 in the Open System Interconnection (OSI) architecture; the layer that provides services to transmit bits or groups of bits over a transmission link between open systems and which entails electrical, mechanical and handshaking procedures.

Protocol – A set of rules and formats that determines the communication behavior of layer entities in the performance of the layer functions.

Protocol Data Unit (PDU) – A discrete piece of information like a frame or a packet in the appropriate format for encapsulation and segmentation in the payload of a cell.

QoS – See Quality of Service.

Quality of Service (QoS) –The accumulation of the cell loss, delay, and delay variation incurred by cells belonging to a particular connection.

Radio Frequency (RF) – In cable television systems, this refers to electromagnetic signals in the range 5 to 1000 MHz.

Return Loss – The parameter describing the attenuation of a guided wave signal (e.g., via a coaxial cable) returned to a source by a device or medium resulting from reflections of the signal generated by the source.

Reverse Channel – The direction of signal flow towards the headend, away from the subscriber; equivalent to Upstream.

Request For Comments (RFC) – A technical policy document of the IETF; these documents can be accessed on the World Wide Web at http://ds.internic.net/ds/rfcindex.html.

RFC – See Request for Comments.

Service Access Point (SAP) – The point at which services are provided by one layer, or sublayer to the layer immediately above it.

Service Data Unit (SDU) – Information that is delivered as a unit between peer service access points

Service Identifier (SID) – An identifier appearing in the MAC allocation map message which identifies the entities which may make use of a particular upstream bandwidth assignment. A cable modem may have one or more unicast service IDs. A group of cable modems may share a multicast service ID.

SID – See Service Identifier.

Simple Network Management Protocol (SNMP) – A network management protocol of the IETF.

SMS – See Spectrum Management System.

SNAP – See Subnetwork Access Protocol.

SNMP – See Simple Network Management Protocol.

Spectrum Management System (SMS) – A system, defined in [SMS], for managing the RF cable spectrum.

Subscriber – See End User.

Sublayer – A subdivision of a layer in the Open System Interconnection (OSI) reference model.

Subnetwork – Subnetworks are physically formed by connecting adjacent nodes with transmission links.

Subnetwork Access Protocol (SNAP) – An IEEE 802 framing convention that allows the link-layer encapsulation of ethernet (DIX) frames on 802 networks.

Subsystem – An element in a hierarchical division of an Open System that interacts directly with elements in the next higher division or the next lower division of that open system.

Systems Management – Functions in the application layer related to the management of various open systems Interconnection (OSI) resources and their status across all layers of the OSI architecture.

Telecommunications Management Network (TMN) – a management concept that defines the relationship between basic network functional building blocks (operations systems, data communications networks, and network elements) in terms of standard interfaces.

TFTP – See Trivial File-Transfer Protocol.

TMN – See Telecommunications Management Network.

Transmission Control Protocol (TCP) – A transport-layer Internet protocol which ensures successful end-to-end delivery of data packets without error.

Trivial File-Transfer Protocol (TFTP) – An Internet protocol for transferring files without the requirement for user names and passwords that is typically used for automatic downloads of data and software.

Transmission Link – The physical unit of a subnetwork that provides the transmission connection between adjacent nodes.

Transmission Medium – The material on which information signals may be carried; e.g., optical fiber, coaxial cable, and twisted-wire pairs.

Transmission System – The interface and transmission medium through which peer physical layer entities transfer bits.

Transmit On/Off Ratio – In multiple-access systems, the ratio between the signal powers sent to line when transmitting and when not transmitting.

Trunk Cable – Cables that carry the signal from the headend to groups of subscribers. The cables can be either coaxial or fiber depending on the design of the system.

Upstream – The direction from the subscriber location toward the headend.