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AMERICAN NATIONAL STANDARD

ANSI/SCTE 106 2010

DOCSIS Set-Top Gateway (DSG) Specification

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1 SCOPE

1.1 Introduction and Overview

The DOCSIS Set-top Gateway (DSG) specification defines an interface and associated protocol that introduces additional requirements on a DOCSIS CMTS and DOCSIS CM to support the configuration and transport of a class of service known as "Out-Of-Band (OOB) messaging" between a Set-top Controller (or application servers) and the customer premise equipment (CPE). In general, the CPE is intended to be a digital Set-top Device, but may include other CPE devices, such as Residential Gateways or other electronic equipment. Figure 1–1 provides the context for this specification in relation to the data-over-cable reference architecture and the other interface specifications in the family.

Traditionally, the physical transport of this Out-Of-Band messaging has been carried over dedicated channels, as specified by [SCTE 55-1] and [SCTE 55-2]. This specification defines the applicable communications standards and protocols needed to implement an Out-Of-Band messaging interface to the Set-top Device using DOCSIS as a transport. It applies to cable systems employing HFC and coaxial architectures. Specifically, the scope of this specification is to:

- Describe the communications protocols and standards to be employed.
- Specify the data communication requirements and parameters that will be common to all units.

The intent of this document is to specify open protocols, with a preference for existing, well-known, and well-accepted standards. This interface specification is written to provide the minimal set of requirements for satisfactory communication between the Set-top Controller and the Set-top Device over the DOCSIS transport. "DOCSIS Set-top Gateway" (DSG) shall be the general term used to describe this interface.

1.2 Purpose of Document

Cable operators have deployed millions of digital set-top boxes enabling broadcast and interactive services. They have also deployed millions of DOCSIS cable modems with the associated infrastructure, CMTS, routers, and network connectivity. There is significant interest in enabling digital set-top boxes to leverage the existing infrastructure of digital video and DOCSIS networks. This document is one of a series of interface specifications that will permit the early definition, design, development, and deployment of digital cable systems on a uniform, consistent, open, non-proprietary, multi-vendor interoperable basis.

The intended service will allow transparent uni-directional and bi-directional transport of Out-Of-Band messaging over Internet Protocol (IP), between the cable system headend and customer locations, over an all-coaxial or hybrid-fiber/coax (HFC) cable network. This is shown in simplified form in Figure 1–1.

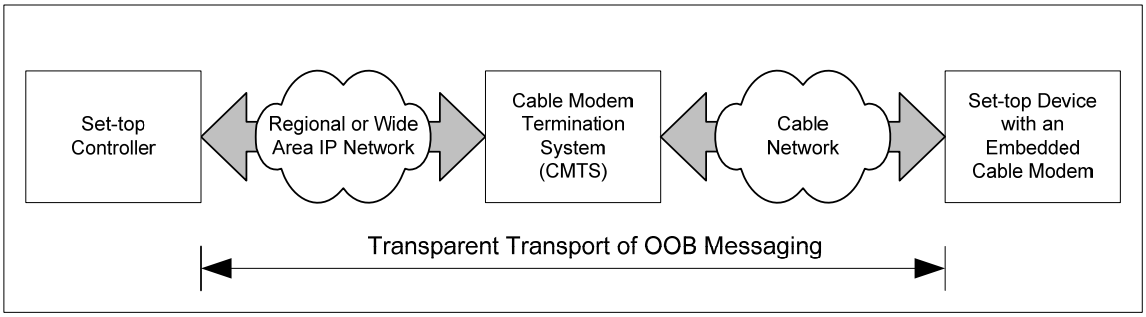

Figure 1–1 - Transparent Out-Of-Band Messaging Via DOCSIS

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The transmission path over the cable system is realized at the headend by a Set-top Controller that is responsible for managing the Set-top Devices, a regional or wide area IP network connecting the Set-top Controller to the Cable Modem Termination System (CMTS), and, at each customer location, a Set-top Device with an embedded Cable Modem. At the headend (or hub), the interface to the data-over-cable system is called the Cable Modem Termination System - Network-Side Interface [DOCSIS CMTS-NSI].

The intent is for the cable operators to transparently transport OOB messaging traffic between these interfaces, including but not limited to UDP over IP datagrams in either unicast, broadcast, or multicast forms. DSG addresses several issues:

- DSG allows the DOCSIS downstream transport to be used for Out-of-Band signaling.
- DSG allows delivery of Out-of-Band messages through the DOCSIS downstream without requiring return path functionality between the Set-top Devices and the CMTS.
- DSG allows legacy non-IP addressing of Set-top Devices by a Set-top Controller to be transported over a tunnel on an IP network.

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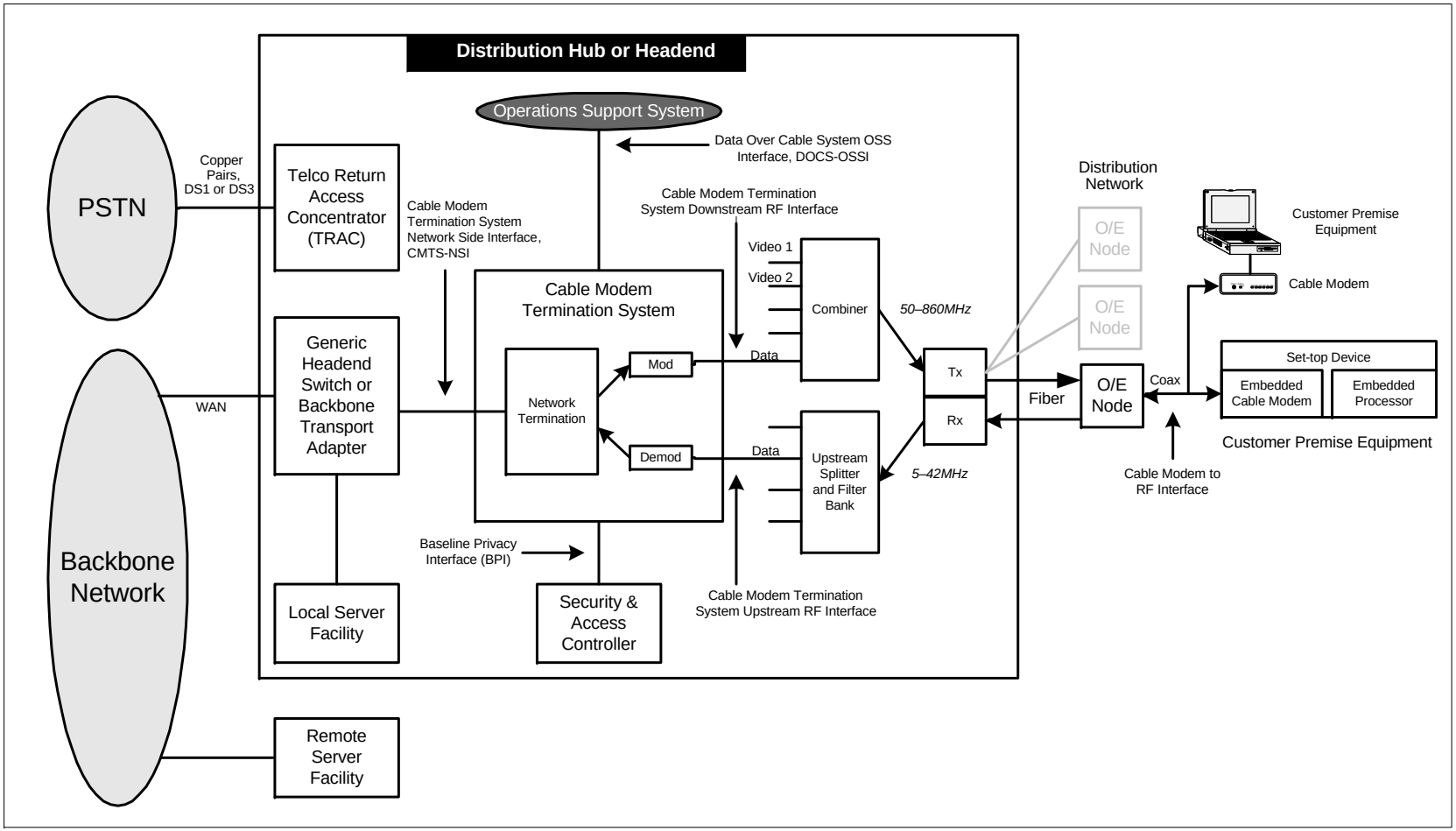

Figure 1–2 - Data-Over-Cable Reference Architecture

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1.3 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.

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2 REFERENCES

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

2.1 Normative References

[DOCSIS RFIv1.1]	ANSI/SCTE 23-1 2005, DOCSIS 1.1 Part 1: Radio Frequency Interface.
[DOCSIS RFIv2.0]	ANSI/SCTE 79-1 2009, DOCSIS 2.0 Part 1: Radio Frequency Interface.
[DOCSIS RFI]	Refers to both [DOCSIS RFIv1.1] and [DOCSIS RFIv2.0].
[DOCSIS MULPI]	ANSI/SCTE 135-2 2008, DOCSIS 3.0 Part 2: MAC and Upper Layer Protocols.
[DOCSIS RFI/MULPI]	Refers to [DOCSIS RFI] and [DOCSIS MULPI].
[DOCSIS CMTS-NSI]	DOCSIS Cable Modem Termination System - Network Side Interface Specification, SP-CMTS-NSI-I01-960702, July 2, 1996, Cable Television Laboratories, Inc.

2.2 Informative References

[SCTE 18]	ANSI/SCTE 18 2007, Emergency Alert Message for Cable.
[SCTE 55-1]	ANSI/SCTE 55-1 2009, Digital Broadband Delivery System: Out of Band Transport Part 1: Mode A.
[SCTE 55-2]	ANSI/SCTE 55-2 2008, Digital Broadband Delivery System: Out of Band Transport Part 2: Mode B.
[SCTE 65]	ANSI/SCTE 65 2008, Service Information Delivered Out-Of-Band For Digital Cable Television.
[CAS ID]	"Conditional Access System Identifier," CA_system_ID, administered by DVB, www.dvb.org.
[DOCSIS OSSIv1.1]	ANSI/SCTE 23-3 2005, DOCSIS 1.1 Part 3: Operations Support System Interface.
[DOCSIS OSSIv2.0]	ANSI/SCTE 79-2 2009, DOCSIS 2.0 Part 2: Operations Support System Interface.
[DOCSIS OSSIv3.0]	ANSI/SCTE 135-4 2008, DOCSIS 3.0 Part 4: Operations Support System Interface
[DOCSIS OSSI]	Refers to [DOCSIS OSSIv1.1], [DOCSIS OSSIv2.0], and [DOCSIS OSSIv3.0].
[eDOCSIS]	ANSI/SCTE 107 2009, Embedded Cable Modem Devices.
[IANA]	"Internet Multicast Addresses," Internet Assigned Numbers Authority, http://www.iana.org/assignments/multicast-addresses.
[IEEE 802.3]	IEEE Std 802.3 Part 3: Carrier sense multiple address with collision detection (CSMA/CD) access method and physical layer specifications, IEEE, December 9, 2009.
[GRE 1]	IETF RFC 1701, Generic Routing Encapsulation (GRE), S. Hanks, T. Li, D. Farinacci, P. Traina, October 1994.
[GRE 2]	IETF RFC 2784, Generic Routing Encapsulation (GRE). D. Farinacci, T. Li, S. Hanks, D. Meyer, P. Traina, March 2000.

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[MPEG-SI]	Information Technology - Generic Coding of Moving Pictures and Associated Audio: Systems, Recommendation H.222.0, ISO/IEC 13818-1, Section 2.6.17.
[OC CC]	OpenCable CableCARD™ Interface 2.0 Specification, OC-SP-CCIF2.0-I21-100507, May 07, 2010, Cable Television Laboratories, Inc.
[OC CDL]	OpenCable Common Download 2.0 Specification, OC-SP-CDL2.0-I11-100507, May 07, 2010, Cable Television Laboratories, Inc.
[OC HOST2.1]	OpenCable Host Device 2.1 Core Functional Requirements, OC-SP-HOST2.1-CFR-I11-100507, May 07, 2010, Cable Television Laboratories, Inc.
[OCAP]	OpenCable Application Platform Specification, (OCAP) 1.1.2, OC-SP-OCAP1.1.2-090930, September 30, 2009, Cable Television Laboratories, Inc.
[OUI]	Organizationally Unique Identifier, IEEE, http://standards.ieee.org/regauth/oui.
[RFC 1112]	IETF RFC 1112, Host Extensions for IP Multicasting, Steve E. Deering, August 1989.
[RFC 3171]	IETF RFC 3171, IANA Guidelines for IPv4 Multicast Address Assignments, Z. Albanna, K. Almeroth, D. Meyer, M. Schipper, August 2001.
[RFC 3569]	IETF RFC 3569, An Overview of Source-Specific Multicast (SSM), S. Bhattacharyya, July 2003.
[RFC 4639]	IETF RFC 4639, Cable Device Management Information Base for Data-Over-Cable Service Interface Specification (DOCSIS) Compliant Cable Modems and Cable Modem Termination Systems. R. Woundy, K. Marez, December 2006.

2.3 Reference Acquisition

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- Institute of Electrical and Electronics Engineers, http://standards.ieee.org
- Internet Engineering Task Force, http://www.ietf.org/rfc
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3 DEFINITIONS AND ABBREVIATIONS

3.1 Terms and Definitions

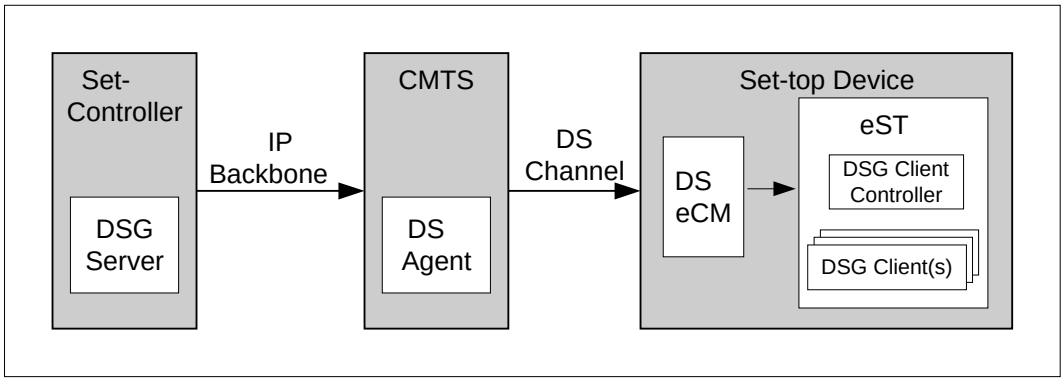

Figure 3–1 - DSG Terminology

This specification defines the following terms:

Application ID This is a 16-bit field indicating a numeric ID for an application running on the Set-top Device. The Application ID is typically assigned through a Source Name Sub-table (SNS) from [SCTE 65] carried in the Broadcast DSG Tunnel.

CA_system_ID This is a 16-bit field indicating the type of CA system applicable for either the associated ECM and/or EMM streams. The CA_system_ID may be used as a DSG Client ID in DSG Advanced Mode.

Card A detachable CableCARD™ device defined in OpenCable and distributed by cable providers that connects to the cable receiver and manages Conditional Access.

DOCSIS Set-top Gateway The DOCSIS Set-top Gateway (DSG) defines functionality on a DOCSIS CMTS and DOCSIS CM to support the configuration and transport of a class of service known as "Out-Of-Band (OOB) messaging" between a Set-top Controller (or application servers) and the customer premise equipment (CPE). The DSG is not intended for the delivery of programming content.

DSG Address Table The collection of DSG Rules and DSG Classifiers contained within the DCD message. The DSG Client uses its DSG Client ID as an index into the DSG Address Table to determine what DSG Tunnel Address to receive.

DSG Advanced Mode Operation with the DCD message. Address assignment is dynamic. The DSG Tunnel Address is determined by the DSG Agent and learned by the DSG Client through the DSG Address Table in the DCD message.

DSG Agent The DSG Agent is the implementation of the DSG protocol within the CMTS. The DSG Agent creates the DSG Tunnel, places content from the DSG Server into the DSG Tunnel, and sends the DSG Tunnel to the DSG Client.

DSG Basic Mode A deprecated mode of DSG operation without the DCD message. Address assignment was static in this mode. The DSG Tunnel Address was determined by the DSG Client and learned by the DSG Agent through configuration. This mode provided backwards compatibility with earlier versions of the DSG specification. This mode is not required to be supported by DSG eCMs.

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DSG Channel	Any DOCSIS downstream channel that contains one or more DSG Tunnels.
DSG Classifier	A description of layer 3 and layer 4 filtering applied to DSG Tunnel traffic. DSG Classifiers may be specified in the DSG Agent and sent as a component of the DSG Address Table in the DCD Message.
DSG Client	The DSG Client terminates the DSG Tunnel and receives content from the DSG Server. There may be more than one DSG Client within a Set-top Device.
DSG Client Controller	The portion of the Set-top Device that handles the processing of DCD messages and makes decisions regarding the forwarding of DSG Tunnels within the Set-top Device.
DSG Client ID	This is an identifier that uniquely identifies a DSG Client. The DSG Client ID is unique per DSG Client, but is not unique per Set-top Device as the same DSG Client which provides the same function may exist in multiple Set-top Devices. In DSG Advanced Mode, the DSG Client ID may be an Application ID, a CA_system_ID, a DSG Well-Known MAC Address, or a broadcast ID.
DSG eCM	A DOCSIS Cable Modem that has been embedded into a Set-top Device and includes DSG functionality.
DSG Rule	A row entry within the DSG Address Table that assigns a DSG Client ID to a DSG Tunnel Address.
DSG Server	The DSG Server refers to any server such as an Application Server or other network attached device that provides content that is transported through the DSG Tunnel to the DSG Client.
DSG Tunnel	A stream of packets sent from the CMTS to the Set-top Terminal. In DSG Advanced Mode, a DSG Tunnel might be identified solely by its DSG Tunnel Address, or it might be identified by a combination of the DSG Tunnel Address along with other DSG Rule parameters: UCID List, Classifier IP addresses, and UDP port numbers.
DSG Tunnel Address	This specifically refers to the destination MAC address of the DSG Tunnel. If the source MAC address, the destination IP address, or the source IP address is to be referenced, then that reference must be explicitly stated.
Embedded Set-top Box	An embedded Set-top Box is an embedded Service Application Functional Entity (eSAFE) defined in [eDOCSIS]. It includes the DSG Client(s), a DSG Client Controller, an embedded processor for an application environment, and either an embedded or removable module for Conditional Access.
One-Way	This expression infers that the downstream path (from the network to the subscriber) is operational, and that the upstream path (from the subscriber to the network) is not operational. This may occur because the upstream path is not available, the Set-top Device is not registered, or the Set-top Device does not support a Two-way mode of operation.
Out-Of-Band Messaging	The control and information messages sent from the Set-top Controller (or Application Server or similar device for legacy Out-Of-Band (OOB) messaging) to one or more Set-top Devices. Specifically, OOB infers the use of a dedicated channel for signaling which is separate from the video channels. This includes the following types of messages: • Conditional Access (CA) messages including entitlements • Service Information (SI) messages • Electronic Program Guide (EPG) messages • Emergency Alert System (EAS) messages Other control or information messages

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QoS Parameter Set	The set of Service Flow Encodings that describe the Quality of Service attributes of a Service Flow or a Service Class.
Service Class	A set of queuing and scheduling attributes that is named and that is configured at the CMTS. A Service Class is identified by a Service Class Name. A Service Class has an associated QoS Parameter Set.
Set-top Controller	This is the computer system responsible for managing the Set-top Devices within a cable system. It manages Set-top Devices through control and information messages sent via the Out-Of-Band channel.
Set-top Device	A cable receiver that contains an embedded Cable Modem for DOCSIS connectivity and an embedded Set-top Box. In OpenCable, this definition refers to the combination of an OpenCable Host Device 2.1 and a Card.
Two-Way	This expression infers that the downstream path and the upstream path are operational.
Well-Known MAC Address	This refers to the MAC address of the DSG Client within the Set-top Device. This MAC address has been assigned by the manufacturer of a removable Card and/or embedded Conditional Access system, and has been made known to the MSO for use in configuring the DSG Agent.

3.2 Abbreviations and Acronyms

This specification uses the following abbreviations:

CA	Conditional Access
CM	Cable Modem
CMTS	Cable Modem Termination System
CPE	Customer Premises Equipment
DCC	Dynamic Channel Change
CVT	Code Version Table (Common Download)
DCD	Downstream Channel Descriptor
DOCSIS®	Data-Over-Cable Service Interface Specifications
DS	Downstream
DSG	DOCSIS Set-top Gateway
DVS	Digital Video Subcommittee
EAS	Emergency Alert System
eCM	Embedded Cable Modem
EPG	Electronic Program Guide
eSTB	Embedded Set-top Box
HFC	Hybrid Fiber Coax
IP	Internet Protocol
MAC	Media Access Control
MSO	Multi System Operator
MTA	Multimedia Terminal Adaptor

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MTU	Maximum Transmission Unit
OCAP	OpenCable Application Platform
OOB	Out-Of-Band
SCTE	Society of Cable Telecommunications Engineers
SI	Service Information
SNS	Source Name Sub-Table
SSD	Secure Software Download
STD	Set-top Device
TCP	Transmission Control Protocol
TLV	Type-Length-Value
UCID	Upstream Channel ID
uimsbf	unsigned integer, most significant bit first
UDP	User Datagram Protocol
US	Upstream
VSP	Vendor-Specific Parameter
XAIT	Extended Application Information Table (OCAP)

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4 REFERENCE ARCHITECTURE

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

The DOCSIS Set-top Gateway architecture is an adaptation of the DOCSIS reference architecture shown in Figure 1–1. Figure 4–1 below shows how the DOCSIS Set-top Gateway layers on the DOCSIS reference architecture. As shown in this figure, there are potentially multiple servers (1 to K) that function as the Set-top Controller, a regional IP network or IP backbone that connects these servers to potentially multiple CMTSs (1 to M) located in distribution hubs or headends, and an HFC/Cable Network that connects the CMTS to the Set-top Devices located in the subscriber's home. The DOCSIS Set-top Gateway as shown in this diagram is implemented in the CMTS.

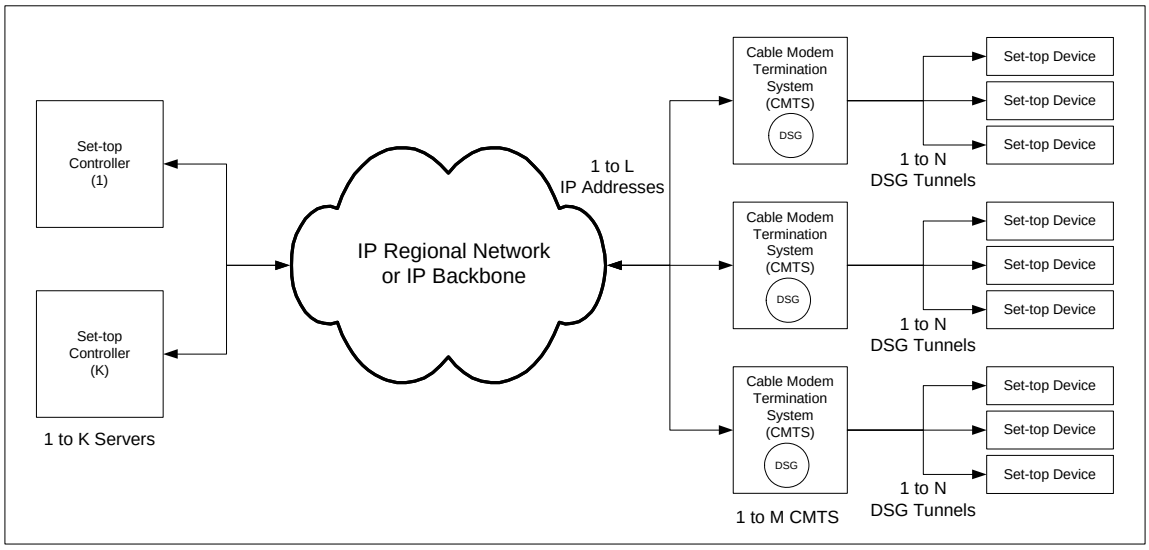

Figure 4–1 - DOCSIS Set-top Gateway System Physical Diagram

The DSG Agent maps IP datagrams received on its IP Network Interface to N DSG Tunnels on the DOCSIS transport. In particular, the DSG Agent:

- Receives IP Multicast datagrams on potentially multiple IP addresses (1 to L).
- It then maps these datagrams to one of potentially multiple DSG Tunnels on the DOCSIS transport and forwards them on to the DSG Clients.

Networking solutions are available for either legacy DSG Servers or legacy IP networks that do not support IP Multicast. Refer to Section 5.7.8.

The instantiation of the DSG Protocol within the Set-top Device is referred to as the DSG Client. The instantiation of the DSG Protocol within the CMTS is referred to as the DSG Agent. The Set-top Controller or application server which sources content is referred to as the DSG Server. Thus the OOB messages originate at the DSG Server, pass through the DSG Agent, onto the DSG Tunnel, and terminate at the DSG Client. The expression DSG Tunnel Address implicitly refers to the destination MAC address of the DSG Tunnel.

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The logical view of the DOCSIS Set-top Gateway is shown in Figure 4–2.

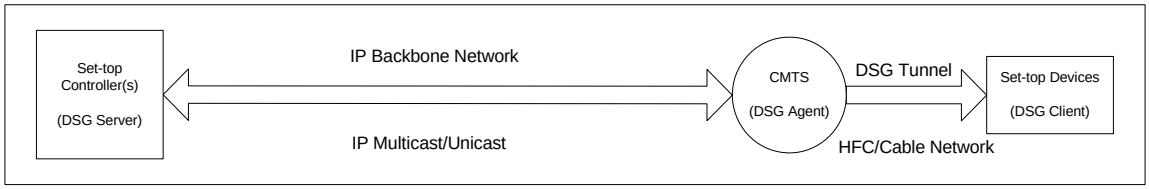

Figure 4–2 - DOCSIS Set-top Gateway Logical Diagram

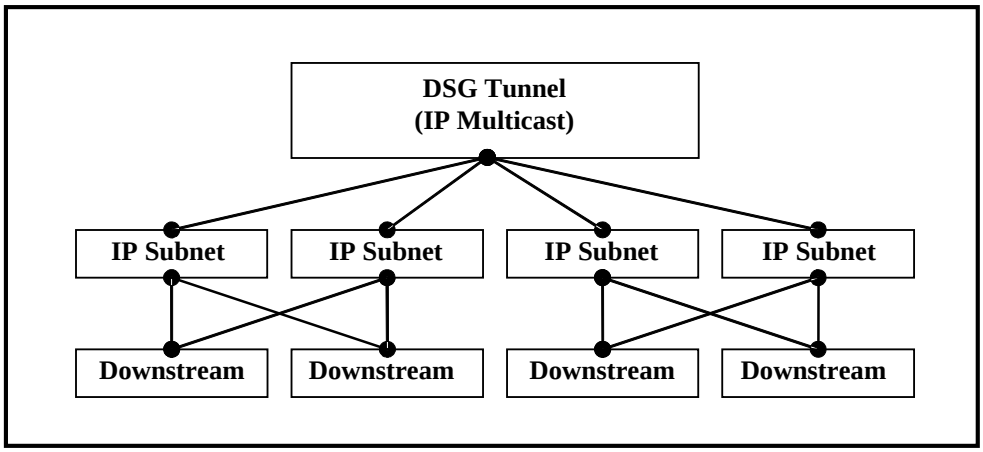

Figure 4–3 - DSG Tunnel within the DSG Agent

The DSG Agent has to define the uniqueness of a DSG Tunnel in relation to an IP Multicast destination address, IP subnets, and DOCSIS downstreams. This relationship is shown in Figure 4–3 above and is described below.

The following conditions exist at the DSG Agent:

- A DSG Agent may have one or more DOCSIS downstream channels and one or more IP subnets.
- An IP subnet may span one or more DOCSIS downstream channels.
- A DOCSIS Downstream Channel may be a member of one or more IP Subnets.
- There is one instantiation of the DSG Tunnel per DSG Agent and each IP subnet requiring the DSG Tunnel joins the IP Multicast session. The IP address associated with the DSG Tunnel is the IP address of the IP Multicast connection from the DSG Server to the DSG Agent.

4.1 DSG Basic Mode

The term DSG Basic Mode was previously used in this specification to refer to a method of delivering DSG Tunnels without using a DCD message. This mode of operation is now deprecated. There may still be legacy units operating in DSG Basic mode deployed in some systems.

4.2 DSG Advanced Mode

In DSG Advanced Mode, the DSG Tunnel Address is determined dynamically by an entry in the DSG Address Table. The DSG Address Table is located in the DOCSIS MAC Management Message called Downstream Channel

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Descriptor (DCD). The DSG Address Table is indexed by the DSG Client with its DSG Client ID. The following features may be achieved by performing an appropriate DSG Client ID to DSG Tunnel Address association and the concept of regionalization:

- Multiple DSG Clients can be assigned to a single DSG Tunnel. This would be a one-to-many scenario.
- A DSG Client can be given different DSG Tunnels based upon downstream or upstream associations.
- The uniqueness of a DSG Tunnel for a particular DSG Client is per downstream on a one-way HFC plant, and per upstream on a two-way HFC plant.

DSG Advanced Mode uses a multicast (group) MAC address for the DSG Tunnel Address. Since more than one IP multicast address may map to the same multicast MAC address when using IP Multicast [RFC 1112], the DSG Client should use both the destination MAC address and the destination IP address to receive the DSG Tunnel.

A multicast (group) MAC address is used for DSG Advanced Mode since DSG Tunnels are multicast in nature. Use of DSG Advanced Mode presumes that the DOCSIS 1.0 CMs have been configured to disable the IP Multicast forwarding of DSG traffic.

4.3 DSG and IP Multicast

DSG is intended as an extension to IP Multicast. In the general case, the addressing of the IP Multicast packet and the DSG Tunnel are the same. The DSG Tunnel encapsulates the IP Multicast datagram in a DOCSIS frame. The one exception to the addressing is that under certain circumstances, DSG allows the MAC address to be re-written to another multicast MAC address.

The signaling protocols for the two are different. The fundamental reason for this is the need for DSG to work on a one-way plant. IP Multicast has several different protocols which allow end points to join an IP Multicast session. In DSG, the CMTS assigns end points to DSG Tunnels using a DOCSIS MAC management message.

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5 DOCSIS SET-TOP GATEWAY

The DSG Agent is intended to provide transparent transport of Out-Of-Band messaging over a DOCSIS channel that is traditionally carried on dedicated channels, specifically those defined in [SCTE 55-1] and [SCTE 55-2]. The following sections detail the requirements and normative behavior of the DSG Server, DSG Agent, and DSG Client for this service.

5.1 Assumptions and Constraints

The DSG Agent will exist within a constrained environment. This section details the assumptions regarding the environment that is required in order to enable this service.

- Any implementation of the DOCSIS Set-top Gateway will work with DOCSIS 1.0, DOCSIS 1.1, DOCSIS 2.0, and DOCSIS 3.0 networks.
- Any implementation of the DOCSIS Set-top Gateway will work for both embedded and removable security implementations within a Set-top Device.
- Any implementation of the DOCSIS Set-top Gateway will not impact the security of the CA systems negatively.
- The DSG Agent will support the transport of multiple simultaneous Conditional Access systems.
- The DSG Agent will provide one-way downstream transport for Out-Of-Band messaging.
- Since the DSG Agent provides a one-way stream of Out-Of-Band messages, DOCSIS Baseline Privacy Interface (BPI) and Baseline Privacy Plus Interface (BPI+) do not apply to the DSG transport.
- The Set-top Device will use an IP session over DOCSIS for all return traffic. For example, if an Out-Of-Band polling message is sent from the DSG Server to the Set-top Device via the DSG Agent within the CMTS, the Set-top Device response to the message is returned to the headend via IP over DOCSIS.
- The Set-top Device will operate in a one-way environment. Examples of the limited functionality available to a Set-top Device in a one-way environment might be:
    - Analog NTSC audio-visual programming (clear, non-scrambled).
    - Digital audio-visual programming using MPEG-2 transport including, but not limited to, standard and high definition MPEG-2 Main Profile @ Main Level video and Dolby AC-3 audio.
    - Broadcast (in-the-clear), subscription-based (scrambled or encrypted), and call-ahead Pay-Per-View (PPV) (scrambled or encrypted) services. (Call-ahead Pay-Per-View is a paid service in which the viewer pre-subscribes selected programming via telephone.)
    - Processing and enforcement of Copy Protection.
    - Pass through of digital high definition audio-visual programming.
- Considerations for DOCSIS 3.0
    - DSG Tunnels will not contain IPv6 data unless it is encapsulated.
    - DSG Agents, DSG Client Controllers and DSG eCMs will not support IPv6 DSG classifiers.
    - A DSG Client Controller will not be affected by DOCSIS 3.0 operation; no new messages will be used between the DSG Client Controller and the eCM.

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5.2 Requirements - General

5.2.1 DSG Server

- For DSG Basic Mode only, the DSG Server MUST maintain a minimum data rate of one packet per second on at least one DSG Tunnel within each unique group of DSG Tunnels which serve a CPE device. This requirement is to keep the acquisition time of the appropriate DOCSIS channel to less than one second. The intent is that the data be present at a sufficiently high rate such that in the process of searching for and trying to acquire a DOCSIS channel, no exorbitant amount of time needs to be spent on any DOCSIS channel that does not carry OOB data.
- The DSG Server MUST support either IP Multicast or IP Unicast.
- The DSG Server MUST NOT send packets of a size that would cause IP fragmentation to occur.

Note: The calculation of payload size should allow for the 20 byte IP protocol overhead, the 8 byte UDP overhead, and any VPN/IPSec or other IP protocol overhead that may be in use. Fragmented IP/UDP packets would not contain the port number in every fragment. For the eCM classifiers to successfully filter fragments by port, the filters would have to be stateful filters; a complication to be avoided. Annex D was added to provide for the orderly segmentation of MPEG tables by the DSG Server.

- A DSG Server that produces an industry-standard data stream among those listed in Table 5–2 MUST NOT include in this stream any data other than that allowed by the indicated standard. The DSG Server MUST emit the data stream such that a DSG Rule and its optional Classifiers can distinctly describe a tunnel containing only this stream. For instance, distinct UDP port numbers or distinct destination IP addresses, sometimes in combination with source IP addresses, are adequate to distinguish streams.
- A DSG Server that produces an Object or Data Carousel data stream associated with an Application Client ID MUST NOT include in this stream any other data including non-carousel related MPEG sections or unspecified data formats. Annex E was added to provide for the encapsulation of such data.

5.2.2 DSG Agent

The following are the normative requirements for the DSG Agent within a CMTS.

5.2.2.1 General Operation

- The DSG Agent MUST be implemented on a CMTS.
- The DSG Agent MUST implement the MIB defined in Annex A of this specification and be configurable through this MIB.
- The DSG Agent SHOULD allow SNMP access to the DSG MIBs on the same IP address it allows access to the DOCSIS MIBs.

5.2.2.2 Network Side Operation

- The DSG Agent MUST NOT forward frames with Ethertypes other than 0x0800, corresponding to IP, onto the DSG Tunnel.
- The DSG Agent MUST be able to filter packets based on the UDP port number and the IP protocol type, after de-encapsulation of any IP tunneling protocols that may have been used between the DSG Server and the DSG Agent. This requirement should be interpreted as an input access list on a CMTS. This requirement should not be interpreted as the CMTS using the UDP ports to route packets to different DSG Tunnels.
- The DSG Agent MAY use source IP address verification to prevent forwarding of packets originating from other than a trusted DSG Server.

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- The DSG Agent MAY use dedicated links, Secure Sockets Layer (SSL/TLS), virtual private networks (VPN), IPSec, or other means to provide secure connections between it and the DSG Server. The specifics of how this may be implemented are beyond the scope of this document.

5.2.2.3 RF Side Operation

- The DSG Agent MUST support a one-way (downstream) transport without requiring return path functionality from the DSG Client.
- The DSG Agent MUST be able to support forwarding on one or more DOCSIS downstream channels.
- The DSG Agent MUST simultaneously support STDs operating in DSG Basic Mode and STDs operating in DSG Advanced mode.
- The downstream DOCSIS PDUs encapsulating the DSG OOB messages MUST have Frame Control bits set to the Packet PDU code point by the CMTS.
- The CMTS MUST NOT send standard DOCSIS MAC Management messages to the DSG Tunnel Address.
- The DSG Agent MUST be able to support at least 32 DSG Rules per DCD Message.

Note: Since a single DSG Rule represents a single DSG Tunnel on a particular downstream channel, in effect this requires the DSG Agent to support at least 32 DSG Tunnels per downstream channel.

- The DSG Agent MUST be capable of rate limiting or rate shaping each DSG Tunnel, as described in [DOCSIS RFI]. The rate limiting parameters MUST be configurable per DSG Tunnel and are determined by the QoS Parameter Set associated with the Service Class assigned to the DSG Tunnel. The DCD MAC Management Message is not included in this calculation.

Note: One application in which rate-limiting functionality may be used is an OpenCable Host. The buffer capacity contained in the OpenCable Host is limited and data rates in excess of 2.048 Mbps can potentially overflow this buffer. Thus, the maximum sustained traffic rates for all DSG Tunnels that cross the Card interface for a particular OpenCable host device should be chosen such that the total traffic crossing the Card interface for that host—including DCD message fragments, DSG Tunnels, and any other data—does not exceed 2.048 Mbps. Note that encapsulation overhead and the size of the packets traversing this interface could reduce the available bandwidth. Refer to [OC CC] for additional information.

- The DSG Agent MUST forward the IP packets received at its configured IP address(es) by performing a MAC level rewrite by replacing the destination MAC address with the DSG Tunnel Address and the source MAC address with the DSG HFC-side MAC address. The DSG Agent MUST NOT modify the IP Source Address, IP Destination Address, or IP Protocol Type of the IP header. The CMTS containing the DSG Agent MUST NOT modify the IP Source Address or IP Protocol Type of the IP header. The CMTS containing the DSG Agent MUST NOT modify the IP Destination Address of the IP header except in the context of supporting IP Unicast message streams as defined in Section 5.2.2.4. The DSG Agent or containing CMTS MAY modify other fields of the IP header. The payload of the IP packet, including the UDP port numbers, MUST remain unchanged.

5.2.2.4 IP Addressing for DSG Tunnels

- The DSG Agent MUST allow the mapping of an IP Multicast address to a DSG Tunnel Address. The DSG Agent MUST NOT allow one IP Multicast address to be mapped to more than one DSG Tunnel Address.

Note: Many DSG Servers may send content to the same IP Multicast stream which would be associated to one DSG Tunnel. This scenario is referred to as "many-to-one" in this specification.

- The DSG Agent MUST be configured so that each interface requiring the DSG Tunnel is a member of the appropriate multicast group. An IP Multicast address to DSG Tunnel Address association MAY span one or more IP subnets. An IP Subnet MAY span one or more downstreams.

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Note: A DSG Rule with a Broadcast Client ID among those listed in Table 5–2 can have one and only one Broadcast client ID. When configuring the DSG Agent the operator needs to ensure that the eSTB behind the DSG eCM will be able to uniquely identify data from the different Broadcast tunnel data streams. For this reason when configuring a DSG Rule with a Broadcast Client ID, if the Client ID and the DSG Tunnel Address are not enough to uniquely identify the different data streams, then the operator needs to define for that DSG Rule a single DSG classifier with at least the Destination IP address and a single UDP destination port number. The combination of DSG MAC Address, Source IP address/mask, IP destination address and UDP destination port number needs to be unique across all rules in a DCD containing Broadcast Client IDs. A given DCD may contain multiple rules for a given Broadcast Client ID. The DSG Client Controller is expected to select at most one rule to use for a given Broadcast Client ID.

The use of an IP Unicast address to transport DSG Tunnel information is intended only to support legacy DSG servers and networks that do not support multicast IP routing. Otherwise, the binding of an IP Unicast address to a DSG Tunnel is explicitly deprecated. If the message stream from the DSG Server to the DSG Agent is IP Unicast, then the CMTS that hosts the DSG Agent MUST support that IP Unicast message stream by at least one of the following three methods:

- The CMTS supports IP Multicast tunneled over IP Unicast. The DSG Server or a router external to the DSG Server would encapsulate the IP Multicast packet within an IP Unicast packet. The CMTS would de-encapsulate the IP Unicast tunnel and forward the IP Multicast packet to the DSG Agent [GRE 1] [GRE 2]. In this case, the DSG Agent receives an IP Multicast packet, and so the DSG Classifier is configured with the appropriate IP Multicast destination address.
- The CMTS translates the IP Unicast address to an IP Multicast address. The new multicast packet would be forwarded to the DSG Agent. In this case, the DSG Agent receives an IP Multicast packet, and so the DSG Classifier is configured with the appropriate IP Multicast destination address.
- The CMTS forwards the IP Unicast packet directly onto the DOCSIS downstream. This option may cause an IP Unicast packet with the provisioned DSG Tunnel MAC address to be forwarded in a multicast fashion on multiple DOCSIS downstream channels. In this case, the DSG Agent receives an IP Unicast packet, and so the DSG Classifier is configured with the appropriate IP Unicast destination address.

5.2.2.5 MAC Addressing for DSG Tunnels

- The destination MAC address of the DSG Tunnel is known as the DSG Tunnel Address. The DSG Agent MUST be configurable to use a multicast (group) MAC address as the DSG Tunnel Address. The use of a unicast MAC address is explicitly deprecated.
- A multicast (group) MAC address may be derived by taking a unicast (individual) MAC address, and setting the I/G bit to a one. The I/G bit is the Individual/Group bit, and it is the LSB of the first byte of the MAC address [IEEE 802.3].
- A DSG Client Controller would use a DSG Client ID as an index into the DSG Address Table in the DCD MAC management message to discover the DSG Tunnel Address. The DSG Client ID could be a DSG Broadcast ID, a Well-Known MAC Address, an Application ID, or a CA_system_ID.
- In certain cases, an operator may want DSG Clients that support DSG Advanced Mode to receive DSG Basic Mode Tunnels. To support such a configuration, and to provide consistency of provisioning, a DSG Basic Mode Tunnel is defined as a DSG Tunnel in which both the DSG Tunnel Address and the DSG Client ID match the Well-Known MAC Address provided by the Set-top Device manufacturer.

5.2.2.6 DOCSIS 3.0 DSG Agent Considerations

DOCSIS 3.0 introduces new concepts which are relevant to DSG Agent operation including downstream channel bonding and enhanced multicast.

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5.2.2.6.1 Downstream Bonding Considerations

The DSG Agent is to be configured such that all DSG tunnels are sent on primary-capable downstream channels. A DSG eCM discards DCD messages or DSG tunnel traffic received on non-Primary Downstream channels.

The DSG Agent MUST transmit each instance of a DSG Tunnel on a single downstream channel, as non-bonded traffic.

In DOCSIS 3.0, a downstream channel may be shared by multiple CMTS MAC domains. A downstream channel shared by multiple MAC domains contains multiple MDD messages with different source MAC addresses. A DOCSIS 3.0 eCM parses the source MAC address of the MDD and DCD messages to ensure that the CMTS MAC domain of the MDD message is the same as that of the DCD message. However, a Pre-3.0 DOCSIS DSG eCM does not parse the source MAC address of the DCD message and would be confused if it received multiple DCDs from different MAC Domains on a downstream channel. The DSG Agent MUST NOT insert DCD messages from more than one MAC Domain on any downstream channel.

5.2.2.6.2 Multicast Considerations

In DOCSIS 3.0, the DSG Agent labels all multicast traffic with a DSID to be used by the eCM for filtering and forwarding purposes. The DSG Agent broadcasts the DSID(s) to be used for DSG tunnel traffic in the DSG DA-to-DSID Association Entry TLV in the MDD message. Exactly one DSID value is assigned for each DSG Tunnel Address, and as each DSG Tunnel can have multiple classifiers associated with it, multiple IP Multicast streams can be associated with a single DSID. Thus, forwarding of DSG Tunnel traffic is different from standard DOCSIS 3.0 Multicast forwarding where each IP Multicast Session is assigned and labeled with its own DSID. The DSG Agent is not permitted to modify the DSID that is associated with a Destination Address once it has been added to the MDD message; as such, entries in the DSG DA-to-DSID Association Entry TLV can only be added or deleted, but never modified. The DSG Agent can only modify the DSG DA-to-DSID Association Entry TLV in the MDD message when it modifies the DCD message due to the addition or deletion of DSG rules.

The DSG Agent is responsible for ensuring that the DSG eCM continues to receive DSG tunnel traffic labeled with DSIDs known to the DSG eCM. The DSG Agent is also responsible for ensuring that DSG tunnel traffic is not sent to any eCM interface other than the DSG tunnel interface.

The DSG Agent is not permitted to add or delete any multicast DSIDs associated with the DSG tunnel interface in the Registration Response message. This includes any static multicast sessions erroneously created via the CMTS Static Multicast Session Encodings in which the Static Multicast CMIM indicates the DSG tunnel interface. The DSG Agent MUST NOT signal any multicast DSIDs used to label DSG tunnel traffic in the Registration Response message.

The DSG Agent is not permitted to initiate a DBC transaction to add or delete a multicast DSID associated with the DSG tunnel interface. The DSG Agent MUST NOT initiate a DBC transaction to signal any multicast DSIDs used to label DSG tunnel traffic.

The Downstream Multicast QoS mechanisms described in [DOCSIS MULPI] do not apply to DSG tunnels.

5.2.3 DSG eCM

- The DSG eCM MUST coexist with other DOCSIS devices on the same DOCSIS channel (Standalone Cable Modem, Embedded MTA, Embedded PS, etc.).
- The DSG eCM component MUST implement the MIB module DSG-IF-STD-MIB defined in Annex B of this specification to indicate the eCM and DSG Client Controller interactions for DSG operations in a Set-top Device.
- The DSG eCM MUST support the DOCSIS Event extensions defined in Annex C of this specification.

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- The DSG eCM MUST be able to function in either a one-way or two-way environment.
- The DSG eCM MUST support the bridging of 8 simultaneous DSG Tunnel MAC addresses .

Note: A DOCSIS 3.0 DSG eCM in MDF enabled mode [DOCSIS MULPI] will use a DSID in place of the DSG Tunnel MAC address for purposes of forwarding DSG tunnel traffic.

- The DSG eCM MUST support at least twelve simultaneous DSG Classifiers per DSG Tunnel MAC Address, and MUST support at least thirty-two simultaneous DSG Classifiers in total.
- The DSG eCM MUST NOT perform any DSG operations if a DSG Client Controller is not present in the Set-top Device. DSG operations include but are not limited to: the hunt for a DOCSIS downstream channel with a valid DSG tunnel identifier (DCD and/or well-known CA MAC addresses); acquisition of the DCD; acquisition and forwarding of any DSG tunnels; etc. As a result, the provisions of this specification only apply to a DSG eCM when DSG is active.
- The DSG eCM MUST follow the standard DOCSIS initialization and registration process, with the following specific exceptions:
    - In acquiring the appropriate DOCSIS downstream channel in DSG Advanced Mode, the DSG eCM MUST search for the first DOCSIS channel that contains a DCD message, and pass the contents of the DCD message (including fragment information) to the DSG Client Controller. The DSG Client Controller will make a determination on the suitability of the DCD.
    - The DSG eCM MUST only attempt to register on the network after acquiring the appropriate DOCSIS downstream channel.
    - The DSG eCM MUST NOT reboot under circumstances in which the upstream channel is impaired. Instead of rebooting, the DSG eCM MUST continue to receive and process the DOCSIS downstream channel.
    - The DSG eCM MUST periodically attempt to re-register after loss of the upstream channel (except when the upstream transmitter has been disabled).
    - The state transition between the One-way and Two-way modes of operation MUST be as shown in Figure 5–1.

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The specifics of how these requirements are implemented are detailed in Section 5.4.

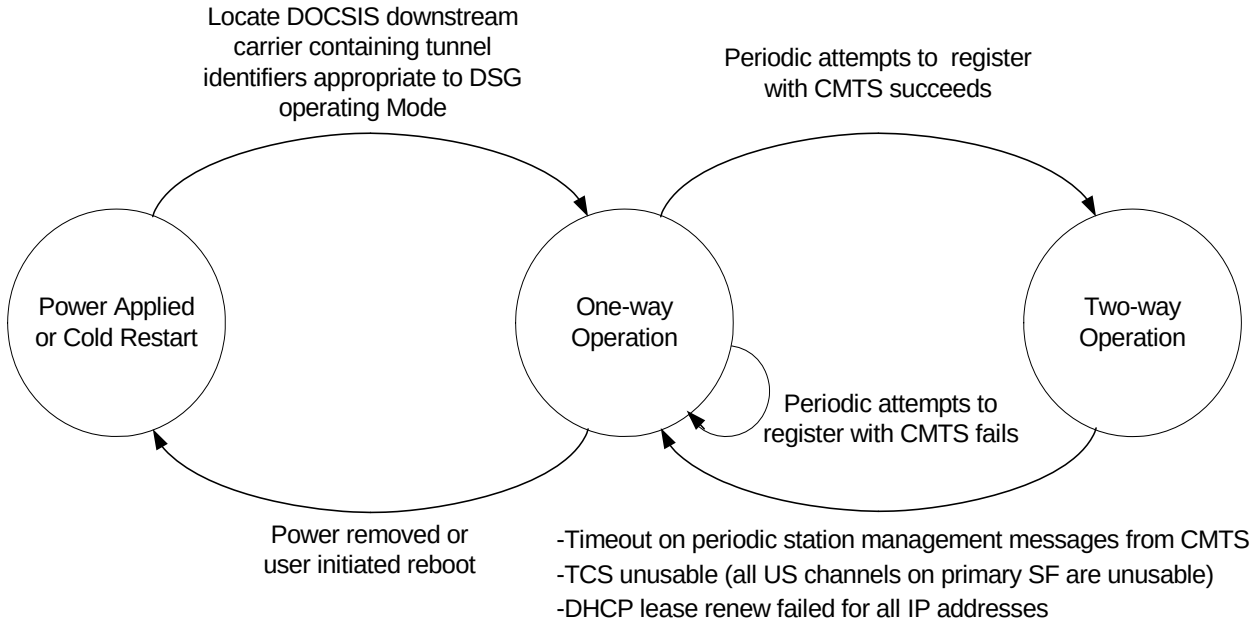

Figure 5–1 - DSG eCM State Transition Diagram

5.2.3.1 DOCSIS 3.0 DSG eCM Considerations

DOCSIS 3.0 introduces several new concepts which are relevant to DSG operation: downstream service group resolution, upstream channel bonding, and enhanced multicast.

Upon initialization, the DOCSIS 3.0 DSG eCM searches for a DSG downstream channel which carries both DOCSIS SYNC messages and a DCD message. The DOCSIS downstream channel on which the DSG eCM finds a DCD message may be considered a DOCSIS 3.0 primary-capable downstream channel if it additionally contains an MDD message containing ambiguity resolution TLVs. If no MDD messages are detected, the DSG eCM reverts to DOCSIS 2.0 operation, continues to gather upstream parameters, then ranges before continuing on to establish IP connectivity and then registers with the CMTS.

If the DSG eCM finds a DCD message on a primary-capable downstream channel which also contains an MDD message, the eCM ensures that the MDD message has a source MAC address matching the source MAC address of the DCD message. This ensures that the MAC domain of the DCD message is the same as the MAC domain of the MDD message. If the source MAC address of the MDD message differs from the source MAC address of the DCD message, the DSG eCM discards the MDD message and reverts to DOCSIS 2.0 operation.

If the DOCSIS downstream channel on which the eCM finds a DCD message contains an MDD message with a source MAC address matching that of the DCD message, the eCM determines the MD-DS-SG (MAC domain downstream service group) prior to forwarding the DCD message to the DSG Client Controller. This is to maintain consistency in tuner usage in downstream ambiguity resolution for both CMs and DOCSIS 3.0 DSG eCMs. If the DSG client controller considers the DCD message to be invalid, the DOCSIS 3.0 DSG eCM searches all primary-capable downstream channels within the MAC domain for a valid DSG downstream before scanning other downstream channels. This increases the chance that the DSG eCM will register as a DOCSIS 3.0 DSG eCM. The DSG eCM uses the 'Downstream Active Channel List TLV' in the MDD message to get the list of primary-capable downstream channels in the MAC domain.

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Neither DCD messages nor DSG tunnel traffic are sent bonded across multiple downstreams. The DOCSIS 3.0 DSG eCM forwards DCD messages and DSG tunnels received on the Primary Downstream Channel to the DSG Client Controller. The DOCSIS 3.0 DSG eCM discards DCD messages and DSG tunnels not received on the Primary Downstream Channel.

In the case of a failure in the upstream path, the DOCSIS 3.0 DSG CM operating in Multiple Transmit Channel (MTC) Mode enters One-way mode when the CM loses all of the upstream channels on which the primary upstream service flow is assigned. (This includes the case in which the DOCSIS 3.0 DSG eCM maintains upstream connectivity with one or more upstream channels not associated with the primary upstream service flow.) If a failure occurs in the upstream path that causes it to switch from an operational state to One-way mode, the DOCSIS 3.0 DSG eCM in MTC Mode periodically attempts to restart the upstream ambiguity resolution process after the expiration of the Tdsg3 timer.

In DOCSIS 3.0, all downstream multicast traffic is labeled with a DSID, which is communicated to the eCM to be used for filtering and forwarding purposes. DSG tunnel traffic is to be labeled with a DSID that the CMTS advertises in the DSG DA-to-DSID Association Entry in the MDD message. If the DSG DA-to-DSID Association Entry is present in the MDD message, the DOCSIS 3.0 DSG eCM filters and forwards DSG tunnel traffic based on the DSID communicated in the DSG DA-to-DSID Association Entry in the MDD message. When filtering and forwarding DSG tunnel traffic based on a DSID, it may be necessary for the DOCSIS 3.0 DSG eCM to update it's DSIDs in response to an indication of a change to its DSG tunnels such as a DCD message with an updated change count or message from the DSG Client Controller altering a DSG tunnel.

5.3 Requirements - DSG Tunnel Definition

DSG Advanced Mode Tunnels use a DOCSIS MAC management message called the Downstream Channel Descriptor (DCD), which provides dynamic provisioning of DSG Tunnels and allows the implementation of several additional features:

Consolidated Keep-Alive: The one DCD message provides a consolidated keep-alive function for all the DSG Tunnels on a downstream. This keep-alive is provided by the DSG Agent rather than the DSG Server.

Enhanced Security: This is achieved through a combination of techniques. First, the destination MAC address of the DSG Tunnel may be replaced dynamically. If the DSG Client ID were to ever become widely known, it may provide the opportunity for a PC to assume that MAC address and snoop the DSG Tunnel. This problem is reduced by substituting the known DSG Tunnel Address with a MAC addresses assigned by the DSG Agent. DSG Advanced Mode also allows the DSG Tunnel to be further qualified by the destination IP address, source IP address, and destination UDP port.

One-to-Many: With the ability to re-assign the DSG Tunnel Address, it is possible to have one DSG Tunnel service more than one distinct DSG Client.

Regionalization: DSG Advanced Mode allows the DSG Tunnels to be unique per downstream on a one-way plant, and unique per upstream on a two-way plant.

Layer 4 Multiplexing: In DSG Advanced Mode, a DSG Server may use destination UDP ports to distinguish content, and then combine all the content onto one IP session. This reduces the number of IP Unicast or IP Multicast addresses required for the configuration of DSG Tunnels. Specifically, the DSG Server would do the multiplexing of UDP ports into an IP stream, the DSG Agent would forward that IP stream to a DSG Tunnel, and the DSG Client would de-multiplex the stream based upon UDP port number.

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5.3.1 Downstream Channel Descriptor (DCD)

DSG Advanced Mode uses a DSG Address Table within a DOCSIS MAC Management Message called the Downstream Channel Descriptor (DCD) to manage the DSG Tunnel. The DCD message provides several functions:

- It provides a consolidated keep-alive mechanism for all DSG Tunnels on a particular downstream, even if the IP network has been interrupted. The keep-alive for a particular DSG Tunnel is based upon the existence of a series of DCD messages and upon the inclusion of that DSG Tunnel within those DCD messages.
- It provides an address substitution and classification mechanism to increase the flexibility and security of the DSG Tunnel.
- It allows the use of multicast addresses. Specifically, multicast sessions from the IP backbone based upon [RFC 1112] addressing may be passed through the DSG Agent as a DSG Tunnel without address translation.
- It allows the MSO to assign any Set-top Device to any DSG Tunnel.
- It allows global changes to the DSG Client timers to allow operator driven changes in DSG eCM performance.
- It provides a list of downstream frequencies which contain DSG Tunnels.

The DCD Message contains a group of DSG Rules and DSG Classifiers. This collection of DSG Rules and DSG Classifiers in the DCD message is known as the DSG Address Table. The DSG Address Table contains information relevant to the tunnels on the current downstream that allows a DSG Client Controller to discover the presence of applicable tunnels, their DSG Tunnel Addresses and associated DSG Classifiers. The DSG Agent MUST include all DSG Tunnels on the current downstream in the DSG Address Table in the DCD message. The DCD message is unique per downstream. When necessary, the DCD message is broken into a number of DCD message fragments.

The DSG Agent MUST insert at least one DCD message fragment per second. The DSG Agent SHOULD send a complete DCD message at least once per second on each DOCSIS downstream that contains a DSG Tunnel. Since a DCD message containing a single TLV cannot be fragmented, the DSG Agent MUST be capable of inserting a DCD message containing only a DSG Configuration TLV at least once per second on each DOCSIS downstream that does not contain a DSG Tunnel. It is expected that the DSG Client Controller will accept the inclusion of a DSG Client ID in the DSG Address Table as an indication that a DSG Tunnel exists on this downstream for a DSG Client corresponding to that DSG Client ID.

The DCD message fragments MUST be LLC unnumbered information frames and be compatible with the format of a DOCSIS MAC Management Message. The DCD message fragments MUST NOT exceed 1522 bytes in length, as measured from the beginning of the Ethernet destination MAC address to the end of the CRC. The MAC Management Message Header and the values of the Version field and the Type field for DCD in the MAC Management Message Header are defined in [DOCSIS RFIv2.0].

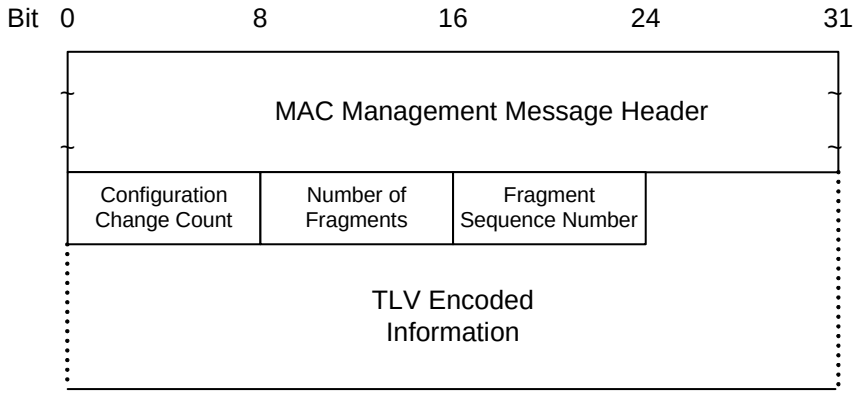

Figure 5–2 - DCD Message Fragment Structure

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A DSG Agent MUST generate Downstream Channel Descriptors in the form shown in Figure 5–2, including the following parameters:

Configuration Change Count: Incremented by one (modulo the field size) by the DSG Agent whenever any of the values of the Downstream Channel Descriptor change. The configuration change count MUST be the same value across DCD message fragments.

Number of Fragments: Fragmentation allows the DCD TLV parameters to be spread across more than one DOCSIS MAC Frame, thus allowing the total number of DCD TLV parameters to exceed the maximum payload of a single DCD MAC management frame. The value of this field represents the number of DCD MAC management frames that a unique and complete set of DCD TLV parameters are spread across to constitute the DCD message. This field is an 8-bit unsigned integer. The default value for this field is 1.

Fragment Sequence Number: This field indicates the position of this fragment in the sequence that constitutes the complete DCD message. Fragment Sequence Numbers MUST start with the value of 1 and increase by 1 for each fragment in the sequence. Thus, the first DCD message fragment would have a Fragment Sequence Number of 1 and the last DCD message fragment would have a Fragment Sequence Number equal to the Number of Fragments. The DSG Agent MUST NOT fragment within any top level or lower level TLVs. Each DCD message fragment is a complete DOCSIS frame with its own CRC. Other than the Fragment Sequence Number, the framing of one DCD message fragment is independent of the framing of another DCD message fragment. This allows the potential for the Set-top Device to process fragments as they are received rather than reassembling the entire payload. This field is an 8-bit unsigned integer. The default value for this field is 1.

Note: A change in the structure of any of the fields that are not TLVs could cause backward compatibility issues for deployed devices, and therefore should be avoided.

All other parameters are coded as TLV tuples. The DSG Agent MUST be capable of changing these parameters dynamically during normal operation in response to configuration changes. If these parameters are changed, the DSG Agent MUST increment the configuration change count (modulo the field size). In some events (for example failover, hot swap, etc,) discontinuities in the value of configuration change count may occur. After any event that can cause a discontinuity in the configuration change count, the DSG Agent MUST ensure that the configuration change count is incremented (modulo the field size) between two subsequent DCD messages (even if the DCD message does not change). This is done to ensure that, after a failover or hot-swap, the new configuration change count does not match the configuration change count used before the failover event. When the configuration change count is changed, all DSG Rules and DSG Classifiers from the previous DCD message are considered invalid and are replaced by the DSG Rules and DSG Classifiers from the current DCD message. The DSG eCM MUST NOT re-initialize if any of these operational parameters are changed.

Note: DSG Tunnels are not guaranteed to provide reliable transport to DSG clients. In particular, there could be some packet loss when DSG Tunnel parameters are changed, while the DSG clients adapt to the new parameters.

DSG Vendor Specific Parameters: Vendor-specific information for DSG Clients, if present, MUST be encoded in the vendor specific information field (VSIF) (code 43) using the Vendor ID field (code 8) to specify which TLV tuples apply to which vendor's products. Vendor Specific Parameters may be located inside or outside of a DSG Rule. Vendor Specific Parameters are coded as TLV tuples and are defined in Annex C of [DOCSIS RFI].

DSG Classification Parameters: The DSG Classifier is used to provide additional layer 3 and layer 4 filtering for the DSG Tunnel.

DSG Rules: These parameters are used by the DSG Client Controller to determine which DSG Tunnel to receive and if there are any DSG Classifiers to apply.

DSG Configuration: These include various operating parameters for the DSG eCM, including timer values for the DSG eCM state machines and a list of the downstream frequencies containing DSG Tunnels.

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The DSG Agent MUST support the above TLVs through the MIB defined in Annex A. DOCSIS 1.0 CMTSs that implement DSG Advanced Mode MUST support these parameters on the DOCSIS signaling interface, but are not obligated to use the same data structures in their internal implementation. The DSG eCM MUST pass all TLVs in a DCD message to the DSG Client Controller without processing. It is expected that the DSG Client Controller will reject, without failure, any TLV that it does not recognize while accepting the remaining TLVs that it does recognize.

These TLVs used by the DSG Agent and the DSG Client Controller are summarized in Table 5–1 and then described in the subsequent sections. A check mark beneath the DSG Agent column indicates that the corresponding TLV is intended for use when processing packets received by the DSG Agent. A check mark beneath the DSG Client Controller column indicates that the corresponding TLV may be included in the DCD message and is intended for use when processing packets received by the DSG eCM. The Mandatory/Optional in DCD column indicates whether or not the TLV MUST be included by the DSG Agent in order for the DCD message to be considered valid. Note that a sub-TLV that is labeled Mandatory does not override the fact that its parent TLV is optional, i.e., the sub-TLV is only required if the optional parent TLV is present. The Repeatable in DCD column indicates whether or not a TLV may be included multiple times in the DCD message. Note that the Repeatability of a sub-TLV is specified only in the context of its parent TLV, i.e., a non-repeatable sub-TLV may be included at most once within each instance of its parent TLV. Note that, as per [DOCSIS RFI], the maximum value for the length octet in any TLV is 254. This places limitations on the number of repeated sub-TLVs that can be included within any TLV.

Table 5–1 - Summary of DCD TLV Parameters

Type	Length	Name	DSG Agent	DSG Client Controller	Mandatory/ Optional in DCD	Repeatable in DCD
23	-	Downstream Packet Classification Encoding	√	√	O	√
23.2	2	Classifier Identifier	√	√	M	
23.5	1	Classifier Priority	√	√	M	
23.9	-	IP Packet Classification Encodings	√	√	M	
23.9.3	4	Source IP Address	√	√	O	
23.9.4	4	Source IP Mask	√	√	O	
23.9.5	4	Destination IP Address	√	√	M	
23.9.9	2	Destination TCP/UDP Port Start		√	O	
23.9.10	2	Destination TCP/UDP Port End		√	O	
50	-	DSG Rule		√	O	√
50.1	1	DSG Rule Identifier		√	M	
50.2	1	DSG Rule Priority		√	M	
50.3	n	DSG UCID List		√	O	
50.4	-	DSG Client ID		√	M	
50.4.1	2	DSG Broadcast		√	O	
50.4.2	6	DSG Well-Known MAC Address		√	O	√
50.4.3	2	CA System ID		√	O	
50.4.4	2	Application ID		√	O	√
50.5	6	DSG Tunnel Address	√	√	M	
50.6	2	DSG Classifier Identifier	√	√	O	√
50.43	-	DSG Rule Vendor Specific Parameters		√	O	√
51	-	DSG Configuration		√	O	

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Type	Length	Name	DSG Agent	DSG Client Controller	Mandatory/ Optional in DCD	Repeatable in DCD
51.1	4	DSG Channel List Entry		√	O	√
51.2	2	DSG Initialization Timeout (Tdsg1)		√	O	
51.3	2	DSG Operational Timeout (Tdsg2)		√	O	
51.4	2	DSG Two-way Retry Timer (Tdsg3)		√	O	
51.5	2	DSG One-way Retry Timer (Tdsg4)		√	O	
51.43	-	DSG Config Vendor Specific Parameters		√	O	√

5.3.1.1 DSG Classifier

DSG Classifiers are for classifying packets and are coded as TLV tuples. The definitions of the TLV values are defined in section "Packet Classification Encodings" in Annex C of [DOCSIS RFI]. The DSG Classifier parameters are set through the DSG MIB. They are not intended to be configured via a CM Configuration File. When a DSG Classifier is configured to be included in the DCD, the DSG Agent MUST include the DSG Classifier in the DCD message on the downstream channel to which the Classifier applies. The DSG Classifier ID is unique per DSG Agent.

The DSG Agent applies the DSG Classifier parameters to incoming packets from the DSG Server in order to assign the packet to the appropriate DSG Tunnel. The DSG Agent MUST classify incoming packets based upon the Classification Parameters listed in Table 5–1 with the exception of the UDP Port.

The DSG Client Controller will use the DSG Classifier parameters to establish a packet filter on the DSG eCM for the downstream DSG Tunnel packet flow. DSG Tunnel packets which match filters established by the DSG Client Controller MUST be forwarded by the DSG eCM.

The DCD message, which is intended for use by the DSG Client Controller, may include any of the Classification Parameters in Table 5–1. The DCD message MUST NOT include any classification parameters not listed in Table 5–1. The DSG Agent MUST NOT include any Ethernet LLC Packet Classification Encodings as these might interfere with the DSG Rule parameters.

Type	Length	Value
23	n	

5.3.1.2 DSG Rule

The DSG Agent MUST support all DSG Rule TLVs.

The DSG Rule is only intended to be included in the DCD message and is not intended to be included in the CM Configuration File.

Type	Length	Value
50	n	

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5.3.1.2.1 DSG Rule Identifier

The value of the field specifies an identifier for the DSG Rule. This value is unique per DCD Message. The DSG Agent assigns the DSG Rule Identifier.

Type	Length	Value
50.1	1	1-255

5.3.1.2.2 DSG Rule Priority

The value of the field specifies the priority for the DSG Rule, which is used for determining the order of application of the DSG Rule. A higher value indicates higher priority. The default value is 0 which is the lowest priority.

Type	Length	Value
50.2	1	0-255

5.3.1.2.3 DSG UCID List

The values of the field specify the matching parameters for the Upstream Channel ID (UCID) for which the DSG Rule applies. If this TLV is omitted, then the DSG Rule applies to all values of UCID, regardless if the UCID is known or unknown by the DSG Client Controller.

Note: If this TLV is included, then an additional DSG Rule would have to be written for a DSG Client Controller residing on a Set-top Device that does not have a UCID available to it because the DSG eCM is operating in One-way mode. This additional DSG Rule would be given a lower DSG Rule Priority, while the DSG Rule with the UCID TLV would be assigned a higher DSG Rule Priority.

UCIDs are 8 bit unsigned integers.

Type	Length	Value
50.3	n	<UCID-1>, <UCID-2>, … , <UCID-n>

5.3.1.2.4 DSG Client ID

The value of the field specifies the matching parameters for the DSG Client ID for which the DSG Rule applies. A DSG Rule will apply to a DSG Client if there is a match on one of the DSG Client ID fields AND a match on the UCID List (if present).

The DSG Client ID recognizes that IDs may originate from different address spaces. Each of those address spaces are coded as sub-TLVs within the DSG Client ID TLV. These sub-TLVs MAY be repeated within the DSG Client ID TLV to include additional DSG Client IDs. The same DSG Client ID MAY be listed in more than one DSG Rule. If the same DSG Client ID is listed in more than one DSG Rule, the expected behavior of the DSG Client Controller is to take the DSG Rule Priority field into account when applying DSG Rules.

The DSG Agent MUST support all ID types.

Type	Length	Value
50.4	n	

5.3.1.2.4.1 DSG Broadcast ID

Traffic for a DSG Client ID of this type conforms to specific industry standards. This traffic is received by a DSG Client that operates with standard data. A DSG Client ID of this type should not have a Length of zero (0). If the

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Length is 0 then the DSG Client Controller should disregard the rule if a Length of zero is not supported by the DSG Client Controller (the use of this subtype with Length 0 is deprecated). If the Length is 2 and the Value is non-zero, a specific type of industry-standard data is denoted per Table 5–2. The DCD MUST NOT contain a DSG Broadcast ID TLV of Length 2 and Value 0.

Note: Client behavior is not defined if data streams for multiple standards are mixed into a single tunnel, and provisioning by the operator is expected to prevent such mixing.

Note: The DCD can contain multiple rules with a DSG Broadcast ID, each to indicate the presence of a specific industry-standard data stream.

Subtype	Length	Value
50.4.1	0	unspecified broadcast; the use of this subtype with Length 0 is deprecated
50.4.1	2	as defined in Table 5–2

Table 5–2 - DSG Broadcast ID Value Definitions

Value	Definition
0	Prohibited.
1	Contains [SCTE 65] - Delivery as defined in Annex D of this document.
2	Contains [SCTE 18] - Delivery as defined in Annex D of this document.
3	Contains OCAP Object Carousel [OCAP]; the use of this Value is deprecated.*
4	Contains OpenCable Common Download Carousel [OC CDL]; the use of this Value is deprecated.*
5	Contains XAIT and/or CVT data as specified in [OC CDL] - Delivery as defined in Annex D of this document.
6-55534	Reserved for future use.
55535-65535	Reserved for MSO specific use.

* Carousel data will be carried in tunnels labeled with Application Client IDs.

5.3.1.2.4.2 DSG Well-Known MAC Address

A DSG Client ID of this type is received by a DSG Client that has been assigned a MAC Address. The first three bytes of the MAC address are known as the Organizationally Unique Identifier (OUI) as defined in [OUI]. The MAC address is assigned by the DSG Client Controller. While the DSG Tunnel MAC address is restricted to being a Group MAC Address, no such restriction applies to this encoding.

Subtype	Length	Value
50.4.2	6	dst1, dst2, dst3, dst4, dst5, dst6

Note: The Well-Known MAC address can be used as a transition from the DSG Basic mode deployment to DSG advanced mode deployment.

5.3.1.2.4.3 CA System ID

A DSG Client ID of this type is received by a DSG Client that has been assigned a CA_system_ID as defined by [MPEG-SI] and assigned by [CAS ID]. The CA_system_ID is sent "uimsbf" (unsigned integer most significant bit first).

Subtype	Length	Value
50.4.3	2	CA_system_ID

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5.3.1.2.4.4 Application ID

A DSG Client ID of this type is received by a DSG Client that has been assigned an Application ID. The Application ID is sent "uimsbf" (unsigned integer most significant bit first). The Application ID would be taken from a private address space managed by the MSO. The Application ID can be assigned to the DSG Client from a table contained within the DSG Broadcast Tunnel such as the Source Name Sub-table (SNS) as defined in [SCTE 65]. (Refer to Annex D for information on the delivery of SCTE 65 tables.)

There may be one or more applications per DSG Tunnel. There may be one or more DSG Tunnels that are used for carrying application traffic.

Subtype	Length	Value
50.4.4	2	Application_ID

5.3.1.2.5 DSG Tunnel Address

This is the destination MAC address that will be used for the DSG Tunnel. This TLV allows the DSG Tunnel Address to be dynamically remapped to another MAC address. A 3.0 DSG eCM with Multicast DSID forwarding enabled only uses the DSG Tunnel address to identify the DSID for the DSG tunnel Data from the DA to DSID Association Entry TLV.

Type	Length	Value
50.5	6	Destination MAC Address of the DSG Tunnel

5.3.1.2.6 DSG Classifier Identifier

The value of the field specifies a Classifier Identifier that identifies the corresponding DSG Classifier to be used with this DSG Rule. The Classifier Identifier MUST correspond to a DSG Classifier included in the same DCD message.

This TLV may be repeated within a DSG Rule to include additional DSG Classifiers.

Type	Length	Value
50.6	2	1 - 65535

5.3.1.2.7 DSG Rule Vendor-Specific Parameters

This allows vendors to encode vendor-specific DSG parameters within a DSG Rule. The Vendor ID MUST be the first TLV embedded inside Vendor-Specific Parameters. If the first TLV inside Vendor-Specific Parameters is not a Vendor ID, then the TLV will be discarded. Refer to [DOCSIS RFI] for the definition of Vendor ID.

This TLV may be repeated within a DSG Rule to include additional DSG Rule Vendor-Specific Parameters. The length (n) of this TLV can be between 5 and 55 bytes (5 bytes for the Vendor ID, and up to 50 bytes for the subsequent values).

Type	Length	Value
50.43	n	

5.3.1.3 DSG Configuration

This group of TLVs contains parameters for configuration and operation of the DSG eCM. The DSG Channel List allows a DSG Agent to advertise which downstreams contain DSG Tunnels. This is intended to reduce the Set-top Device initial scan time.

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The state machines of the DSG eCM in the Set-top Device have several timer values which define the operation of DSG. The set of DSG Timer TLVs allows those timer values to be dynamically provisioned from the DSG Agent.

Type	Length	Value
51	n	

5.3.1.3.1 DSG Channel List Entry

The value of this field is a receive frequency that is available to be used by the Set-top Device for receiving DSG Tunnels. This TLV MAY be repeated to create a DSG Channel List which would be a list of downstreams containing DSG Tunnels. This DSG Channel List may be transmitted on any DOCSIS downstream channel, regardless of the presence or absence of DSG Tunnels on that channel. This TLV may be the only TLV present in the DCD message, or it may co-exist with other TLVs within the DCD Message.

This is the center frequency of the downstream channel in Hz stored as a 32-bit binary number. The receive frequency assigned by the CMTS MUST be a multiple of 62500 Hz.

Note: The intent of the DSG Channel List is to contain a list of all the downstream frequencies that contain DSG Tunnels.

Type	Length	Value
51.1	4	Rx Frequency

5.3.1.3.2 DSG Initialization Timeout (Tdsg1)

This is the timeout period for the DSG packets during initialization of the DSG eCM defined in seconds. The default value is 2 seconds. If this sub-TLV is present, it is intended to overwrite the default value of Tdsg1 in the DSG eCM initialization state machine. If the DSG Initialization Timeout sub-TLV is not present, then the DSG eCM MUST utilize the default value. The valid range of values is 1 to 65535.

Type	Length	Value
51.2	2	Tdsg1 (in seconds)

5.3.1.3.3 DSG Operational Timeout (Tdsg2)

This is the timeout period for the DSG packets during normal operation of the DSG eCM defined in seconds. The default value is 600 seconds. If this sub-TLV is present, it is intended to overwrite the default value of Tdsg2 in the DSG eCM operational state machine. If the DSG Operational Timeout sub-TLV is not present, then the DSG eCM MUST utilize the default value. The valid range of values is 1 to 65535.

Type	Length	Value
51.3	2	Tdsg2 (in seconds)

5.3.1.3.4 DSG Two-Way Retry Timer (Tdsg3)

This is the retry timer that determines when the DSG eCM attempts to reconnect with the CMTS and establish two-way connectivity defined in seconds. The default value is 300 seconds. If this sub-TLV is present, it is intended to overwrite the default value of Tdsg3 in the DSG eCM operational state machine. If the DSG Two-way Retry Timer sub-TLV is not present, then the DSG eCM MUST utilize the default value. The valid range of values is 0 to 65535. A value of zero (0) indicates that the DSG client must continuously retry Two-way operation.

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Type	Length	Value
51.4	2	Tdsg3 (in seconds)

5.3.1.3.5 DSG One-Way Retry Timer (Tdsg4)

This is the retry timer that determines when the DSG eCM attempts to rescan for a downstream DOCSIS channel that contains DSG packets after a Tdsg2 timeout defined in seconds. The default value is 1800 seconds. If this sub-TLV is present, it is intended to overwrite the default value of Tdsg4 in the DSG eCM operational state machine. If the DSG One-way Retry Timer sub-TLV is not present, then the DSG eCM MUST utilize the default value. Valid range of values is 0 to 65535. A value of zero (0) indicates the DSG client must immediately begin scanning upon Tdsg1 or Tdsg2 timeout.

Type	Length	Value
51.5	2	Tdsg4 (in seconds)

5.3.1.3.6 DSG Configuration Vendor Specific Parameters

This allows vendors to encode vendor-specific parameters outside the DSG Rule but within the DCD message. The Vendor ID MUST be the first TLV embedded inside Vendor Specific Parameters. If the first TLV inside Vendor Specific Parameters is not a Vendor ID, then the TLV will be discarded. Refer to [DOCSIS RFI] for the definition of Vendor ID.

This TLV may be repeated within a DSG Rule to include additional DSG Configuration Vendor Specific Parameters. The length (n) of this TLV can be between 5 and 55 bytes (5 bytes for the Vendor ID, and up to 50 bytes for the subsequent values).

Type	Length	Value
51.43	n	

5.3.2 DSG Service Class

The DSG Service Class is used to manage the Quality of Service of the DSG Tunnels within the DSG Agent. The DSG Service Class is identified with a Service Class Name and has an associated QoS Parameter Set. The DSG Service Class parameters are set through the DSG MIB. Multiple DSG Tunnels may reference the same DSG Service Class. Each DSG Tunnel MUST only have one Service Class reference. The DSG Service Class parameters are not intended to be included in the DCD message or the CM Configuration File.

The DSG Agent MUST recognize the following DSG Service Class Parameters. These parameters are defined in the section "Service Flow Encodings" in Annex C of [DOCSIS RFI]:

- Service Class Name
- Traffic Priority
- Downstream Maximum Sustained Traffic Rate (R)
- Maximum Traffic Burst (B)
- Minimum Reserved Traffic Rate
- Assumed Minimum Reserved Rate Packet Size

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5.4 DSG eCM Operation

This section describes the behavior of DSG eCMs for two different versions of DOCSIS.

- Section 5.4.3 describes the behavior of Pre-3.0 DOCSIS DSG eCMs
- Section 5.4.4 describes the behavior of DOCSIS 3.0 DSG eCMs. A DOCSIS 3.0 DSG eCM follows the initialization sequence outlined in these sections even if it is registering on a Pre-3.0 DOCSIS DSG CMTS.

5.4.1 DSG Modes

The DSG Client Controller, acting on behalf of a Client (or Clients), instructs the eCM to begin DSG operation. In DSG Advanced Mode the DSG Client Controller becomes aware of MSO-defined tunnel MAC addresses by indexing into the DSG Address Table in the DCD message.

The following requirements apply to the DSG eCM:

- The DSG eCM MUST NOT begin DSG operation unless explicitly instructed to do so by the DSG Client Controller (Figure 5–11 - DSG Operation and Figure 5–29 - DOCSIS 3.0 DSG Operation).
- The DSG eCM MUST forward the unaltered contents of each DCD fragment that comprises the first DCD message received to the DSG Client Controller.
- After any change in the DCD message (as indicated by the change count), the DSG eCM MUST forward the unaltered contents of each DCD fragment that comprises the new DCD message to the DSG Client Controller.
- The DSG eCM MUST scan additional downstream channels for a DCD message if the DSG Client Controller indicates that the DCD message was in error or invalid.
- If the DSG eCM has been unable to identify a downstream channel with an appropriate DCD message after a complete downstream scan, it MUST inform the DSG Client Controller that it could not locate a DCD message and continue scanning.

5.4.2 DSG eCM Initialization and Operation

The DSG eCM will have an initialization sequence that differs from the standard DOCSIS cable modem, primarily related to how the DSG eCM responds to the various timeouts and error conditions. The DSG eCM will remain tuned to a DOCSIS downstream containing DSG packets and continue to process the IP packets carried in the DSG tunnel even when the return channel is impaired or two-way connectivity is lost. This is necessary to enable the delivery of downstream OOB messages regardless of two-way capabilities.

The Pre-3.0 DOCSIS DSG eCM initialization sequence is based on the CM initialization sequence defined in the "Cable Modem Initialization" section of [DOCSIS RFI]. The DOCSIS 3.0 DSG eCM initialization sequence is based on the CM initialization sequence defined in the "Cable Modem Initialization and Reinitialization" section of [DOCSIS MULPI]. The differences from the DOCSIS standard are detailed in the following sections as well as highlighted in gray in the accompanying figures. The DSG eCM initialization sequence introduces two new timers and two new retry timers. These are:

- Tdsg1 - The timeout period for the DSG channel during initialization of the DSG eCM.
- Tdsg2 - The timeout period for the DSG channel during normal operation of the DSG eCM.
- Tdsg3 - Two-way retry timer - The retry timer that determines when the DSG eCM attempts to reconnect with the CMTS and establish two-way connectivity.
- Tdsg4 - One-way retry timer - The retry timer that determines when the DSG eCM attempts to rescan for a downstream DOCSIS channel that contains DSG packets after a Tdsg2 timeout.

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When operating in DSG Advanced mode, the DSG eCM MUST use the default timer values as specified in Sections 5.3.1.3.2 through 5.3.1.3.5, unless they are overridden by the DSG Client Controller in response to an override from a DCD message. If the default timer values are overridden by the DSG Client Controller, the DSG eCM MUST use those updated values until it is rebooted or another override is received.

In general, the intent of this initialization sequence is to avoid rebooting the DSG eCM if at all possible and continue to receive downstream OOB messages via DSG in all cases. To achieve this the DSG Specification introduces a One-way mode of operation that is distinguished from normal Two-way DOCSIS operation by remaining tuned to and processing the DOCSIS downstream during periods when the upstream channel is impaired or other timeout conditions occur. As shown in the following sections, this is achieved by modifying all instances that would result in re-initializing the MAC layer in DOCSIS to go to the One-way mode of operation. The DSG eCM recovers from these error conditions by periodically attempting to reacquire the upstream channel and establish two-way connectivity.

When a DSG eCM loses its upstream channel capability, either through upstream channel impairment or other reasons, it will no longer respond to periodic ranging requests from the CMTS. The CMTS will eventually de-register the DSG eCM. Consequently, when the DSG eCM attempts to reacquire two-way connectivity it will begin the Upstream Acquisition process by collecting UCD messages or by resolving MD-US-SG (3.0 DSG eCM only).

Further, since the DSG tunnel is not guaranteed to be present on all downstream DOCSIS channels, the initialization sequence is also modified to make certain that a valid DOCSIS downstream is acquired that is deemed by the DSG Client Controller as a Valid DSG channel.

The DSG Client Controller needs to be made aware of any eCM limitations that may impact 2-Way data forwarding, so it can provide the proper reactions on such limitations. If data forwarding to any or all of the eSTB MAC addresses cannot be supported, the eCM MUST report these limitations to the DSG Client Controller.

5.4.2.1 DCC considerations for DSG eCMs

The DSG Client Controller needs to be made aware of DCC operations so it can track DCC progress, provide the proper reactions to upstream and downstream channel changes, and maintain a valid DSG channel. Such DCC operations are bracketed in time between two CM generated messages: DCC-RSP (Depart) and DCC-RSP (Arrive) [DOCSIS RFI].

- When the CM sends a "DCC-RSP (Depart)" message, the eCM MUST also send a "DCC Depart, Initialization Type <IT> " (where IT = "DCC initialization type") message to the DSG Client Controller.
- When the CM sends a "DCC-RSP (Arrive)" message, the eCM MUST also send a "2-Way OK, UCID <P1>" (where P1 = Upstream Channel ID) message to the DSG Client Controller.

5.4.2.2 DBC considerations for DOCSIS 3.0 DSG eCMs

In a set-top box containing a DOCSIS 3.0 DSG eCM, the DSG Client Controller needs to be made aware of DBC operations so it can track DBC progress, provide the proper reactions to upstream and downstream channel changes, and maintain a valid DSG channel. On a DOCSIS 3.0 DSG eCM, if the DBC changes the primary downstream channel or changes the upstream with the lowest numbered UCID, the eCM sends the "DCC depart message" to the DSG Client Controller. The intent here is to reuse the DCC Depart message from the Pre-3.0 DOCSIS eCMs for the DBC case as well, so that the DSG Client Controller does not see any differences with respect to DOCSIS 3.0 or pre-3.0 DOCSIS DSG eCMs. The eCM MUST send the "DCC Depart Message" before it sends the DBC-RSP. The eCM SHOULD send the "DCC Depart Message" prior to implementing the changes indicated in the DBC-REQ.

After a successful DBC operation affecting the primary downstream or the upstream with the lowest numbered UCID, when the eCM sends a "DBC-RSP " message, the eCM MUST also send a "2-Way OK, UCID <P1>" (where P1 = Upstream Channel ID) message to the DSG Client Controller.

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The DSG eCM MUST initialize and operate as described in the following subsections and their state transition diagrams. Note that the eCM MUST be prepared to receive instruction from the DSG Client Controller at any time and act upon that instruction.

5.4.3 Pre-3.0 DOCSIS DSG eCM Operation

This section only applies to Pre-3.0 DOCSIS DSG eCMs.

5.4.3.1 DSG eCM State Transition Diagrams

The operation of a DSG eCM is described here by two separate state machines. The first, "DSG eCM Initialization and Operation," is covered by the state transition diagrams in Figure 5–3 through Figure 5–10 (and described in Section 5.4.2.2 to Section 5.4.3.7), and the second, "DSG Operation," is covered by the state transition diagram in Figure 5–11 (and described in Section 5.4.3.8). These two different state machines operate in parallel, and the "DSG Operation" state machine provides inputs into the "DSG eCM Initialization and Operation" state machine.

These state transaction diagrams apply only to the eCM. The messages sent between the two state machines, and to and from the DSG Client Controller, are provided in the following sections.

5.4.3.1.1 Messages sent/received by "DSG eCM Initialization and Operation"

Inputs from the DSG Operation state machine:

- Valid DSG Channel
- Invalid DSG Channel
- DCD Present (DSG Advanced Mode only)

Inputs from the DSG Client Controller:

- Disable upstream transmitter
- Enable upstream transmitter

Outputs to DSG Client Controller:

- Downstream Scan Completed
- 2-Way OK, UCID
- Entering One-way Mode
- Cannot forward 2-Way traffic, NACO <val>, Max CPE <val>
- DCC Depart, Initialization Type <IT> (where IT = "DCC initialization type")

5.4.3.1.2 Messages sent/received by "DSG Operation"

Inputs from the DSG Client Controller:

- Start DSG Advanced Mode
- Filter these MAC Addresses and Classifiers
- Not Valid. Hunt for new DSG Channel

Outputs to DSG Client Controller:

- DCD Message information

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5.4.3.2 DSG eCM Initialization Overview

The following figure corresponds to the "CM Initialization Overview" figure in [DOCSIS RFI]. The difference in the initialization of the DSG eCM is scanning for the downstream DSG channel and going to Two-way Operation as opposed to just becoming Operational. This process is described in detail in the following sections.

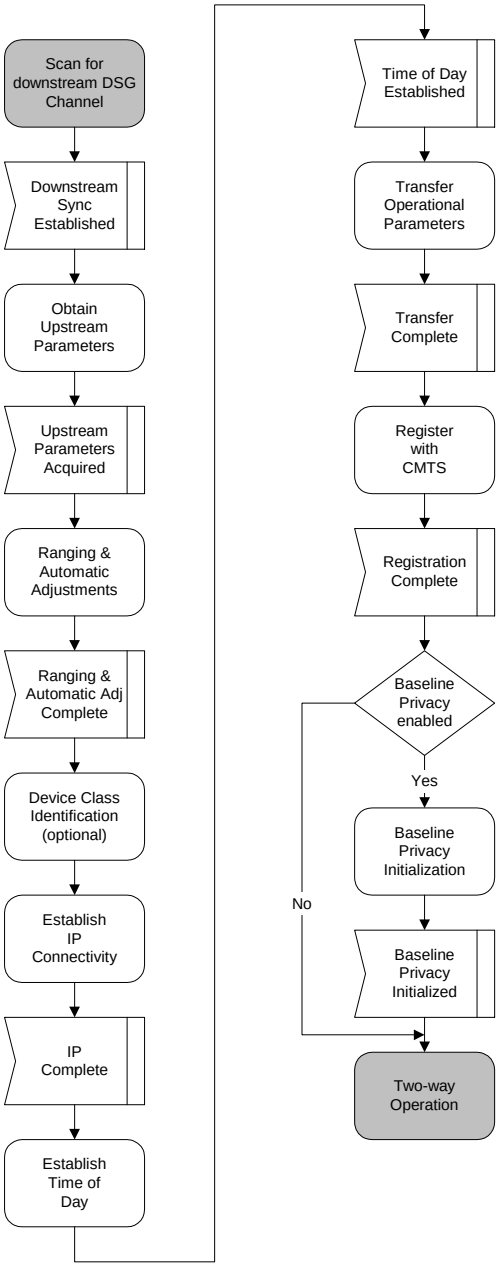

Figure 5–3 - DSG eCM Initialization Overview

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