

# **A Walk-Through of the DOCSIS Set-top Gateway (DSG) Protocol Specification**

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# Agenda

- Overview
- ECR Walk-Through
- Applications
- Examples

**Content in BLUE is taken directly from the DSG Specification.**

**MUST, MAY, and SHOULD are highlighted in RED.**

**Content in BLACK is commentary**

**This presentation has been prepared against:  
DSG-O-04.0133-9, John Chapman, CPE=4/27/2004**



# **DSG Overview**

## **DOCSIS Set-Top Gateway**

# History

- **Dec 2000**: Problem proposed to Cisco by Time Warner. Cisco (John T. Chapman) responds with the basic DSG concept.
- **Feb 2001**: OpenCable Committee formed headed by Ralph Brown.
- **Feb 2002**: Interim Draft 1 is released
- **3Q 2003**: DSG Committee Reconvenes.
- **2Q 2004**: Interim Draft 2 to be released.
- **3Q 2004**: Interoperability testing at CableLabs

# OOB Applications

- **These are well established applications which are broadcast from a software carousel.**
  - **Conditional Access (CA) messages including entitlements**
  - **System Information (SI) messages**
  - **Electronic Program Guide (EPG) messages**
  - **Emergency Alert System (EAS) messages**
  - **Other generic messages**
- **Current systems use a 2 Mbps proprietary Out-Of-Band (OOB) path for signaling.**
  - **The OOB signaling will be carried over DSG.**
- **Newer applications with middleware are emerging.**

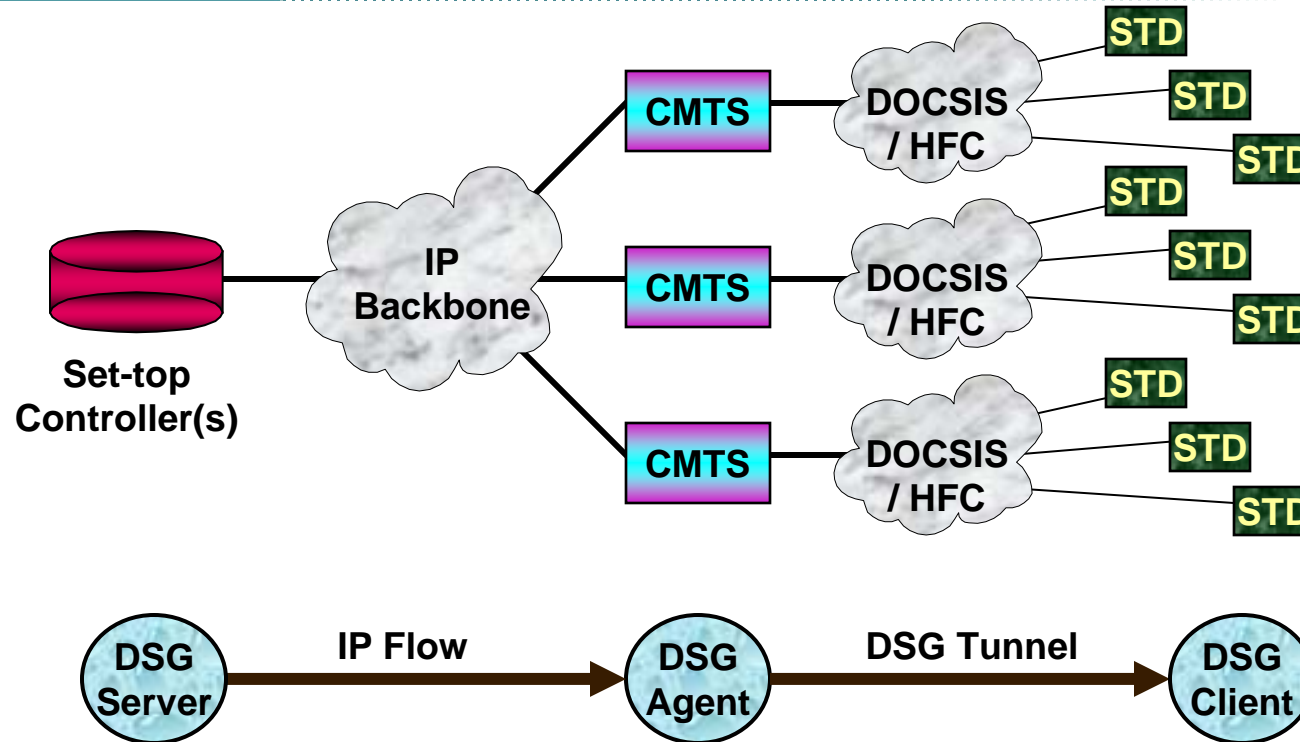
# DSG Functionality

- **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 Device and the CMTS.**
  - **One-way DOCSIS**
- **DSG allows legacy non-IP addressing of Set-top Device by a Network Controller to be transported over a tunnel on an IP network.**
  - **DSG defines the address scheme.**

**“DSG is like IP Multicast – except when it is not”**

# DSG Network Diagram

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- Legacy addressing on the OOB or DSG of Set-top Devices by the Set-top Controller is done with serial numbers or Smart Card addresses, not with IP addresses.
  - DSG preserves this application layer addressing.

# DSG Basic Mode

- **Setup**
  - **Set-top Devices/CableCard™ publishes up to 8 DSG Client MAC addresses.**
- **Operation**
  - **The Set-top Controller sends its messages to the CMTS with IP unicast or IP multicast. For IP Unicast, an IP address on the CMTS has been reserved for each DSG Tunnel.**
  - **The CMTS re-writes the incoming packet's MAC Destination Address with the DSG Client MAC Address, duplicates the packet, and forwards the packets to all participating downstreams.**
  - **The eCM in the Set-top Device filters packets based upon its the DSG Client MAC Address and passes the contents of the packets to the CableCard™ (for OpenCable™).**

# DSG Advanced Mode

- **Setup**
  - **The CMTS provisions the DSG Tunnels with a DSG Address Table (DAT) in a new Downstream Channel Descriptor (DCD) DOCSIS MAC message**
- **Operation**
  - **The Set-top Device uses its DSG Client ID as an index into the DAT to find the new DSG Tunnel Address and DSG Classifier used for the DSG Tunnel.**
  - **CMTS receives IP packets, rewrites MAC address.**
  - **Set-top Device receives DSG Tunnels based upon DSG Tunnel Address (MAC Address) and Packet Classifier**

# DSG Will Be Required Until ...

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- **Set-top Device/CableCard™ addressing is done with IP addresses**
- **Provisioning and signaling software has been rewritten to use IP addresses**
- **Content from Set-top Controller to Set-top Device is standardized.**
- **All HFC plants and homes are two-way**
- **There are no impairments on the plant which would bring down the upstream**

**This might be awhile!**



**DSG ECR Walk Through**

**DOCSIS Set-Top Gateway**

# DSG ECR Walk Through

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## Agenda

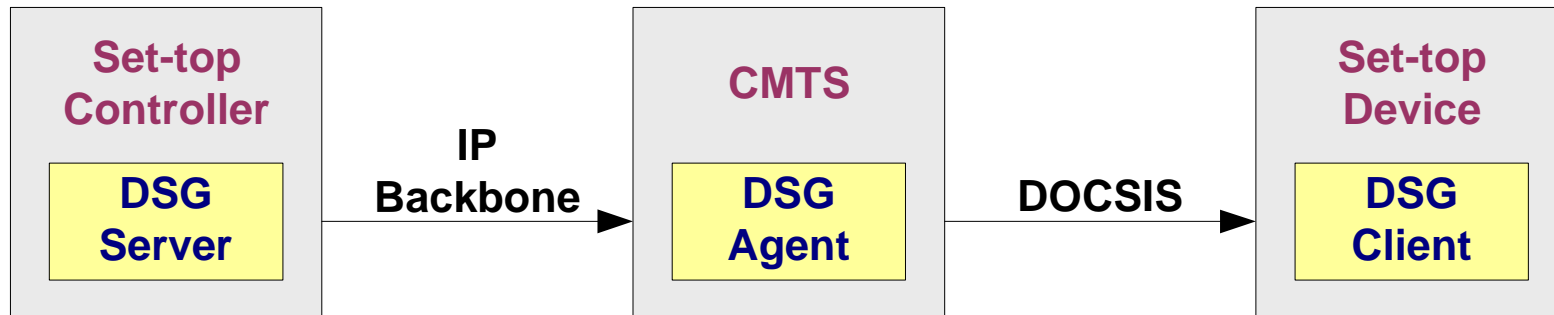
- **Definitions**
- **DSG Network Components**
  - **DSG Server, DSG Agent**
- **IP and MAC Addressing**
- **The DCD Message**
- **DSG Service Class**
- **Security**



# Definitions

## ***DSG ECR Walk-Through***

# Definitions



<b>Set-top Controller</b>	<b>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.</b>
<b>Set-top Device</b>	<b>A cable receiver that contains an embedded Cable Modem for DOCSIS connectivity, an embedded processor for an application environment, and either an embedded or removable module for Conditional Access. In OpenCable™, this definition refers to the combination of an Advanced Host Device and a CableCARD™.</b>

# Definitions

<b>DSG Server</b>	<b>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.</b>
<b>DSG Agent</b>	<b>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.</b>
<b>DSG Client</b>	<b>The DSG Client is the implementation of the DSG protocol within the Set-top Device. 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.</b>

# Definitions

<b>DSG Tunnel</b>	<b>The DSG Tunnel exists between the DSG Agent in the CMTS and the DSG Client in the Set-top Device. The DSG Tunnel is identified by its DSG Tunnel Address, and it carries one or more IP datagram streams which originated from the DSG Server. Multiple DSG Tunnels may exist on a single downstream DOCSIS channel, and a DSG Tunnel may span one or more downstreams.</b>
<b>DSG Tunnel Address</b>	<b>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.</b>
<b>DSG Channel</b>	<b>Any DOCSIS downstream channel that contains one or more DSG Tunnels.</b>

# Definitions

<b>DSG Client ID</b>	<p>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 Basic Mode, the DSG Client ID is a 6 byte MAC address. In DSG Advanced Mode, the DSG Client ID may additionally be a 2 byte Application ID, a 2 byte CA_system_ID, or a broadcast ID.</p>
<b>Well-Known MAC Address</b>	<p>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 the CableCARD and/or Conditional Access system within the Set-top Device, and has been made known to the MSO for use in configuring the DSG Agent.</p>

# Definitions

<b>Application ID</b>	<b>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.</b>
<b>CA_system_ID</b>	<b>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.</b>

# Definitions

<b>DSG Address Table</b>	<b>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.</b>
<b>DSG Rule</b>	<b>A row entry within the DSG Address Table that assigns a DSG Client ID to a DSG Tunnel Address</b>

# Definitions

<b>DSG Basic Mode</b>	<b>Operation without the DCD message. Address assignment is static. The DSG Tunnel Address is determined by the DSG Client and learned by the DSG Agent through configuration. This mode provides backwards compatibility with earlier versions of the DSG specification.</b>
<b>DSG Advanced Mode</b>	<b>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.</b>



# **DSG Network Components**

***DSG ECR Walk-Through***

# 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 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.
  - Informational 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.

# DSG Agent – Network Side Operation

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- The DSG Agent **MUST** be implemented on a CMTS.
- The CMTS **MUST NOT** send standard DOCSIS MAC Management messages to the DSG Tunnel Address.
- The DSG Agent **MUST NOT** forward frames with Ethertypes other than 0x0800, corresponding to IP, onto the DSG Tunnel.
- If Dynamic Channel Change (DCC) is implemented and used to change downstream channels, then the DSG Agent **MUST** provide a means to ensure that content of the DSG Tunnels are forwarded onto the old and new DOCSIS downstream channels that are impacted by the DCC message.

# DSG Agent – Network Side Operation

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- 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.
- The DSG Agent **MAY** use dedicated links, Secure Sockets Layer (SSL/TSL), 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.

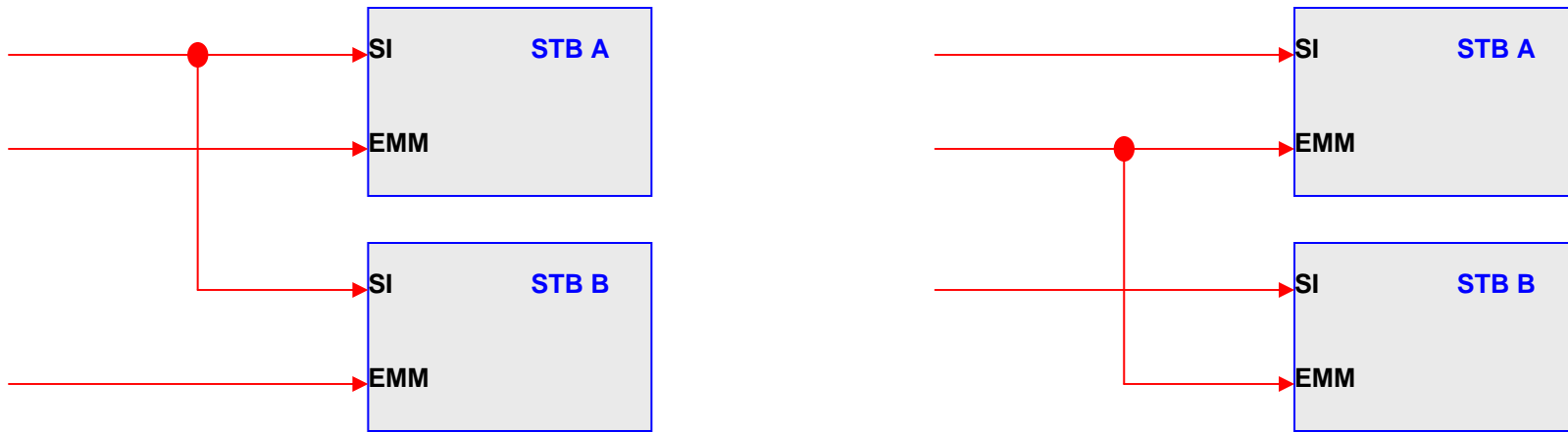
# DSG Agent – RF Side Operation

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- 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 DSG Basic Mode Tunnels and DSG Advanced Mode Tunnels.
- The DSG Agent **MUST** be able to support at least 32 DSG Tunnels per downstream.

# Sharing of DSG Tunnel

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- **Set-top Device Vendor A and Set-top Device Vendor B might have their own DSG Tunnels A and B, but share a DSG Tunnel from CAS Vendor C.**
  - **DSG Agent sees 3 DSG clients**
  - **Set-top Controller contains 2 DSG Clients**
- **In legacy OOB equipment, the 2 Mbps media matched the 2 Mbps input rate of the Set-top Device. This is no longer true.**

# DSG Tunnels

- **Solution**
  - **DSG Tunnels must be independent**
  - **eCM provides buffering**
  - **Rate shaping should be defined per DSG Tunnel.**
  - **Rate shaping should be a configurable rate.**

# DSG Agent – Rate Shaping

- The DSG Agent **MUST** be capable of rate limiting or rate shaping each DSG Tunnel.
  - 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.
- The buffer capacity contained in the OpenCable™ Advanced Host is limited and data rates in excess of 2.048 Mbps can potentially overflow this buffer.
  - Thus, the maximum sustained traffic rate of the group of DSG Tunnels per Set-top Device in an OpenCable™ environment, when aggregated together, should not exceed 2.048 Mbps

# DSG Agent – Header Rewrite Rules

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- 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 or CMTS **MAY** modify any of the fields of the IP header with the exception of the IP Protocol Type.
- The payload of the IP packet, including the UDP port numbers, **MUST** remain unchanged.



# **IP and MAC Addressing**

***DSG ECR Walk-Through***

# DSG Tunnel Address

- 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 DSG Agent **MUST** also be configurable to instead use a unicast (individual) MAC address as the DSG Tunnel Address.
- It is **recommended** that the DSG Tunnel Address be a multicast (group) MAC address.
- The use of a unicast (individual) MAC address is allowed only to support certain legacy DSG Clients.
  - Otherwise, the use of a unicast MAC address is **explicitly deprecated**.

# DSG Tunnel Address

- A DSG Client operating in DSG Basic Mode **will** identify and receive a DSG Tunnel based solely on the use of a Well-Known MAC Address as the DSG Tunnel Address.
- It is **recommended** that the Well-Known MAC Address be a multicast (group) Ethernet address.
  - That multicast (group) MAC address may be derived by taking a unicast (individual) MAC address with an OUI [OUI] value set to the OUI value of the CableCARD or Conditional Access system manufacturer, 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 [IEEE802.3].
- Alternatively, the Well-Known MAC Address may be a unicast (individual) Ethernet address.
  - **Informational Note:** This last provision is to allow for early deployment of DSG, and is not intended for long term use.

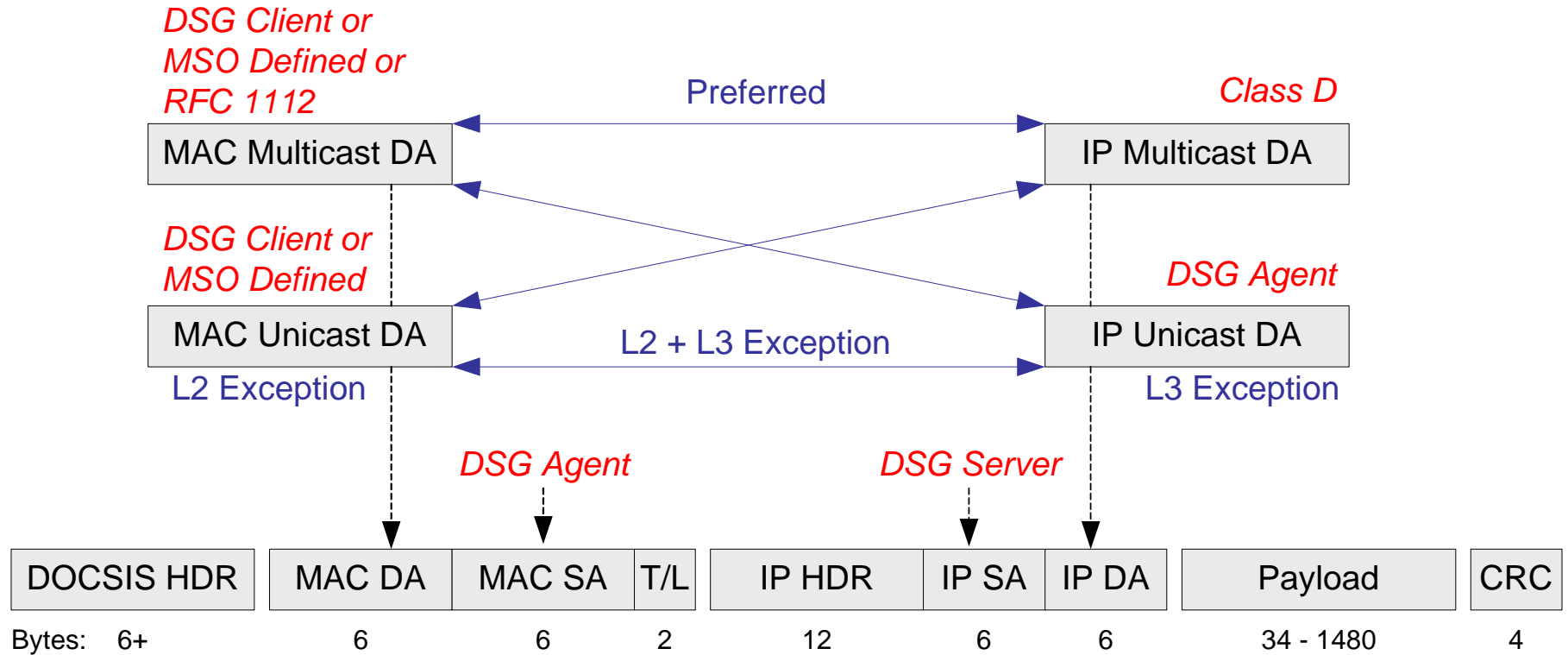
# DSG Tunnel with IP Multicast

- 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.
- 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.
- Note that there is no requirement that the DSG Tunnel Address be generated using the technique of RFC 1112 which is a standard IP Multicast requirement

# DSG Tunnel with IP Unicast

- **If the message stream from the DSG Server to the DSG Agent is IP Unicast, then the DSG Agent **MUST** support that IP Unicast message stream by at least one of the following three methods:**
  - 1. By supporting IP Multicast tunneled over IP Unicast.**
  - 2. By translating the IP Unicast address to an IP Multicast address.**
  - 3. By forwarding the IP Unicast packet directly onto the DOCSIS downstream.**

# DSG Tunnel Packet Format



- **DSG Tunnel packet format with the allowed unicast variants for the MAC and IP Addresses.**
  - **The two variants create 4 cases**

# DSG Network Strategy

DSG Server Capability	IP Backbone Capability	Typical Network Strategy
Multicast	Multicast	<ul style="list-style-type: none"><li>• DSG Agent forwards multicast packet</li></ul>
Multicast	Unicast	<ul style="list-style-type: none"><li>• IP Multicast Tunnel between DSG Server and DSG Agent</li></ul>
Unicast	Multicast	<ul style="list-style-type: none"><li>• A router external to the DSG Server does address translation from unicast to multicast, replicates packets, and forwards multicast.</li></ul>
Unicast	Unicast	<ul style="list-style-type: none"><li>• A router external to DSG Server generates an IP Multicast tunnel</li><li>• or DSG Agent forwards IP Unicast pkt</li><li>• or DSG Agent does address translation and forwards multicast packet.</li></ul>

# DSG Tunnel with IP Unicast

## Technique #1: Multicast Tunneling

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- **By supporting 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 DSG Agent would de-encapsulate the IP Unicast tunnel and forward the IP Multicast packet onto a DSG Tunnel.**
- **PRO: This is the most efficient network solution**
- **Uses GRE Tunnels (Generic Route Encapsulation).**
  - **RFC 1701 (1994), RFC 2784 (2000)**
  - **This is how multicast networks are built today when traversing routers or other devices such as firewalls that do not support IP Multicast.**
  - **IP Multicast, ever since the days of MBONE, has always had to solve this problem.**

# DSG Tunnel with IP Unicast

## Technique #1: Multicast Tunneling

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- **DSG Server(s) would deliver IP Multicast to a router(s). The router would use GRE to tunnel the multicast across the network.**
  - **Alternatively, the DSG Server could generate the GRE Tunnels themselves.**
- **Intermediate routers that support multicast could terminate the GRE tunnel and replicate packets into new GRE Tunnels.**
- **Because IP Multicast permits multiple senders, configurations with redundant routers and redundant DSG Servers could be set up to feed a farm of DSG Agents.**
- **SSM (Source Specific Multicast) can be used since a DSG client in DSG Advanced Mode can filter on the IP Source Address of the IP Multicast packet.**
- **This is all part of the standard vision of IP Multicast.**

# DSG Tunnel with IP Unicast Technique #2: Address Translation

- **By translating the IP Unicast address to an IP Multicast address.**
  - **The new multicast packet would be forwarded to a DSG Tunnel.**
- **This is compliant with the DSG Spec since the DSG spec allows almost all fields of the DSG Tunnel to be re-written.**
- **PRO: This allows CMTS manufacturers to leverage existing IP Multicast implementations.**
- **PRO: Prevents the multicasting of IP Unicast packets.**
- **CON: Address translation requires processor support and may not scale well.**

# DSG Tunnel with IP Unicast Technique #3: Forwarding

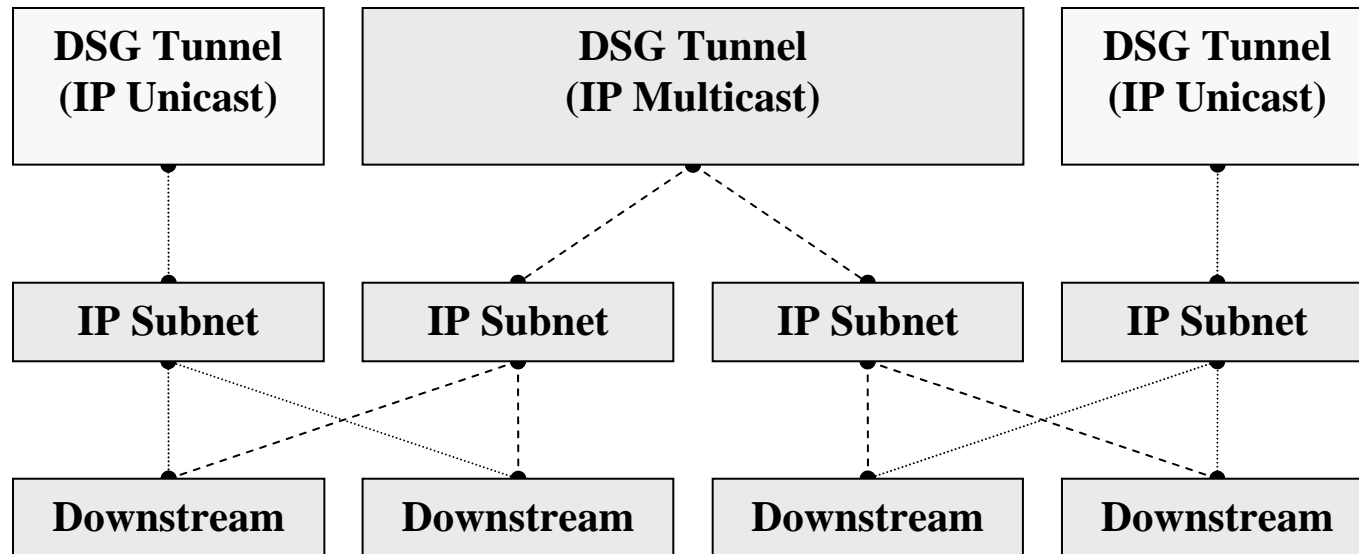
- **By forwarding the IP Unicast packet directly onto the DOCSIS downstream.**
  - **This option may cause an IP Unicast packet with an unicast (individual) MAC address to be multicast on the DOCSIS downstream. (Note that this was the original DSG scheme)**
  - **As such, the forwarding of a packet with an IP Unicast address is allowed only to support certain legacy DSG Clients.**
  - **Otherwise, the forwarding of a packet with an IP Unicast address to a DSG Tunnel is **explicitly deprecated**.**

# DSG Tunnel with IP Unicast Technique #3: Forwarding

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- **PROS:**
  - Supports direct IP Unicast from existing DSG Servers.
  - Simple from a protocol view point. DSG Client does not care about destination IP Address
- **CONS:**
  - Incorrect protocol usage
    - ✓ IP packet forwarded beyond its destination
    - ✓ Multicasting of unicast addresses (IP + MAC)
  - DSG Server has to replicate flows to multiple CMTS.
  - May cause security problems.
  - May cause performance problems.
  - Potential network issue if DSG ever gets forwarded off the DOCSIS network.

# Subnets and Downstreams



- **DSU Addressing differences between IP Multicast vs IP Unicast**
- **IP Subnets may contain multiple downstreams**
- **Downstreams may contain multiple IP Subnets**



# **The DCD Message**

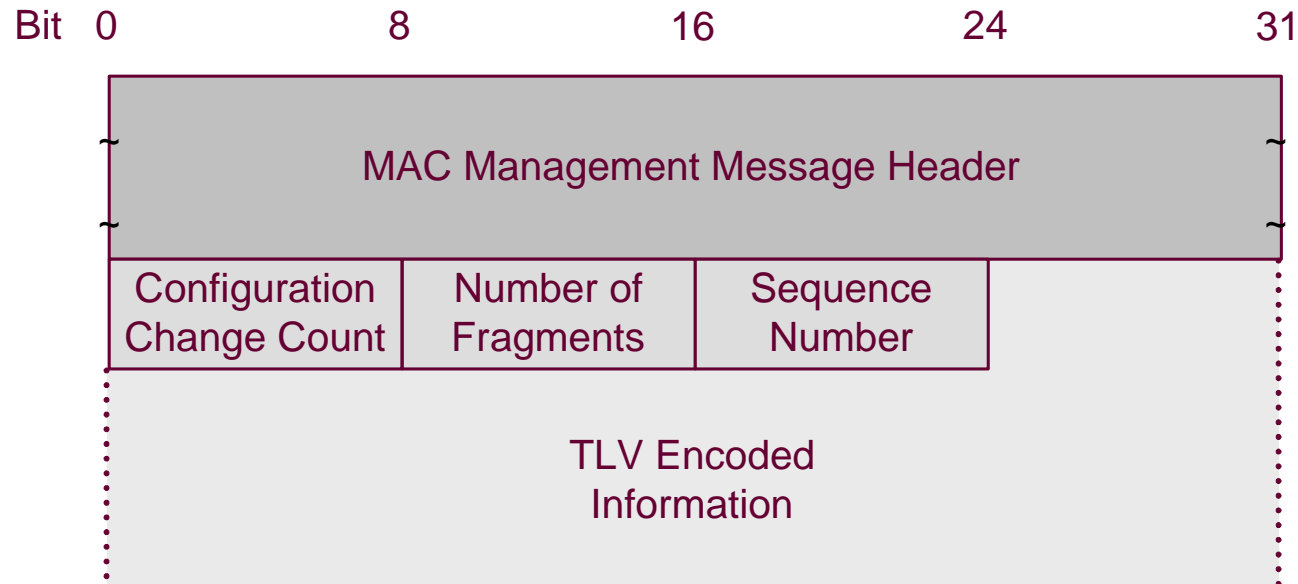
***DSG ECR Walk-Through***

# DCD General Operation

- **A DSG Agent MUST generate DCD.**
  - This means that there is no such thing as a Basic Mode DSG Agent (CMTS), even though DSG Clients can be Basic Mode Only.
- **The DSG Agent MUST include all DSG Tunnels on the current downstream in the DSG Address Table in the DCD message.**
  - One DCD message for all vendors
- **The DCD message is unique per downstream.**
- **The DSG Agent MUST support the DCD TLVs through the MIB.**

# Downstream Channel Descriptor (DCD)

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- **New DOCSIS MAC Management Message**
  - **Type = 32, Version = 3, Max Length = 1522 bytes**
- **Can be used with DOCSIS 1.1 and above**

# DCD 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 fragmented DCD messages.
- If the DCD TLV parameters are changed, the DSG Agent **MUST** increment the configuration change count.
- When the configuration change count is incremented, 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.

# DCD Fragmentation – Number of Fragments

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- **32 DSG Tunnels with 1 DSG Rule and 1 DSG Classifier could be as long as 2500 bytes, not including Vendor Specific Fields.**
- **Fragmentation allows the DCD TLV parameters to be spread across more than one DCD message, thus allowing the total number of DCD TLV parameters to exceed the maximum payload of a single DCD message.**
- **The value of this field represents the number of DCD messages that a unique and complete set of DCD TLV parameters are spread across.**
- **This field is an 8 bit unsigned integer.**
- **The default value for this field is 1.**

# DCD Fragmentation – Sequence Number

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- The value of this field is the sequence of which the DCD message was fragmented.
- Sequence numbers **MUST** start with the value of 1 and increase by 1 for each fragment. Thus, the first DCD message fragment would have a sequence number of 1 and the last DCD message fragment would have a sequence number equal to the Fragmentation Number.
- The DSG Agent **MUST NOT** fragment within any top level or lower level TLVs.
- Each DCD Message is a complete DOCSIS frame with its own CRC.

# DCD Fragmentation – Sequence Number

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- **Other than the Sequence Number, the framing of one DCD message is independent of the framing of another DCD message.**
- **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.**

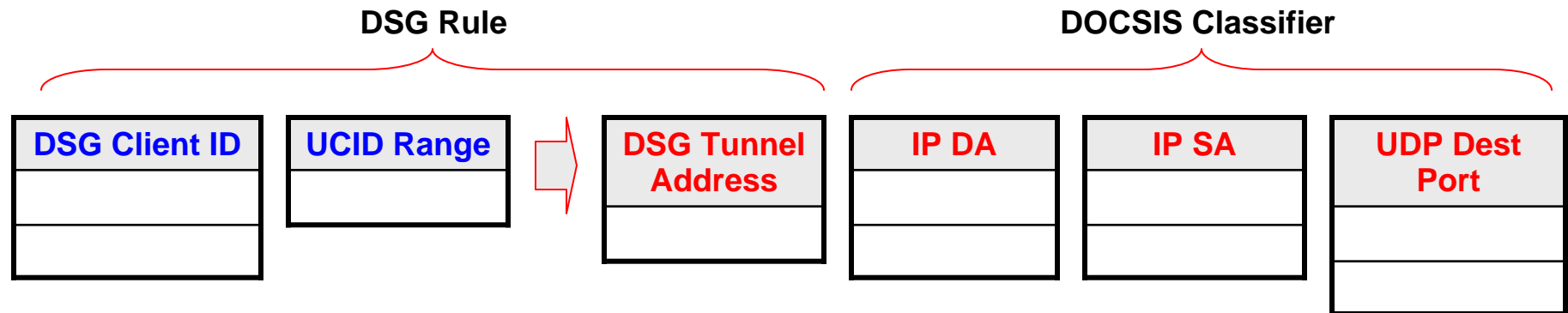
# DCD & Keep Alive

- **DCD provides a consolidated keep-alive mechanism for all DSG Tunnels on a particular downstream, even if the IP network has been interrupted.**
  - **For Basic Mode, the DSG Server provided this service**
- **The DSG Agent **MUST** insert a DCD message sequence at least once per second on each DOCSIS downstream that contains a DSG Tunnel.**
- **The DSG Agent **MAY** insert a DCD message sequence with a DSG Channel List TLV at least once per second on each DOCSIS downstream that does not contains a DSG Tunnel.**
  - **Used for DSG Channel List, not for keep-alive**
- **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.**
  - **No keep-alive if the DSG Tunnel is not listed.**

# DCD Contents

- **DSG Classification Parameters: (Type = 23)**
  - **The DSG Classifier is used to provide additional layer 3 and layer 4 filtering for the DSG Tunnel.**
- **DSG Rules: (Type = 50)**
  - **These parameters are used by the DSG Client to determine which DSG Tunnel to receive and if there are any DSG Classifiers to apply.**
- **DSG Client Configuration: (Type = 51)**
  - **These include various operating parameters for the DSG Client, including timer values for the DSG Client state machines and a list of the downstream frequencies containing DSG Tunnels.**

# DSG Address Table



- 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 Client uses its DSG Client ID and its UCID (if present) as an index into the DSG Address Table to discover which DSG Tunnel to receive and which DSG Classifier to apply.

# DSG Classifiers

Type	Length	Name	DSG Agent	DSG Client
23	-	Downstream Packet Classification Encoding	√	√
23.2	2	Classifier Identifier	√	√
23.5	1	Rule Priority	√	√
23.9	-	IP Packet Classification Encodings	√	√
23.9.3	4	Source IP Address	√	√
23.9.4	4	Source IP Mask	√	√
23.9.5	4	Destination IP Address	√	√
23.9.6	4	Destination IP Mask	√	√
23.9.7	2	Destination TCP/UDP Port Start		√
23.9.8	2	Destination TCP/UDP Port End		√

- **The definitions of the TLV values are defined in section “Packet Classification Encodings” in Annex C of DOCSIS-RFI.**
- **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.**

# DSG Classifiers

- The DSG Classifier parameters are set through the DSG MIB.
  - They are not intended to be configured via a CM Configuration File.
  - When DSG Classifiers are configured, the DSG Agent **MUST** include the DSG Classifier encodings in the DCD messages on the downstream channels to which the Classifiers apply.
  - 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.

# DSG Rules

Type	Length	Name	DSG Agent	DSG Client
50	-	DSG Rule		√
50.1	1	DSG Rule Identifier		√
50.2	1	DSG Rule Priority		√
50.3	2	DSG UCID Range		√
50.4	-	DSG Client ID		√
50.4.1	0	DSG Broadcast		√
50.4.2	6	DSG Well-Known MAC Address		√
50.4.3	2	CA System ID		√
50.4.4	2	Application ID		√
50.5	6	DSG Tunnel Address	√	√
50.6	2	DSG Classifier Identifier	√	√
50.43	-	DSG Rule Vendor Specific Parameters		√

- **Inputs: DSG UCID Range, DSG Client ID**
- **Variables: DSG Rule ID, DSG Rule Priority**
- **Outputs: DSG Tunnel Address, DSG Classifier, DSG Rule VSP**

# DSG Rules

- The DSG Agent **MUST** support all DSG Rule TLVs.
- A DSG Rule **MUST** contain the DSG Rule Identifier TLV and **MAY** contain any of the other DSG Rule TLVs.
- Unless otherwise stated, each TLV within the DSG Rule **MUST NOT** appear more than once.
  - The DSG Client ID TLV may have multiple entries.
  - The DSG Classifier ID TLV may be repeated.
- 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.
- 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 Range (if present).

# DSG Client ID

- 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 is to accept all the DSG Rules while taking the DSG priority field into account.
- The DSG Agent **MUST** support all ID types.

# DSG Client ID – DSG Broadcast ID

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- **A DSG Client ID of this type is received by all Set-top Devices.**
- **This is a short TLV that only contains a Subtype and Length field. There is no Value field.**
- **The DSG Broadcast ID provides a means for the MSO to send content to all Set-top Devices from all manufactures at once.**

# DSG Client ID – Well-Known MAC Address

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- **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 to the DSG Client at the time of manufacture.**
- **This is the typical DSG Client ID that will get used.**
- **This provides backwards compatibility with DSG Basic Mode.**

# DSG Client ID – CA System ID

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- **A DSG Client ID of this type is received by a DSG Client that has been assigned a CA\_system\_ID as defined by ITU Recommendation H.222.0 and assigned by DVB.**
- **All Conditional Access Vendors today have been assigned this ID (about 13 manufacturers).**
- **This ID might get used for the DSG Tunnel which carries CAS information.**

# DSG Client ID – 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 would be taken from a private address space managed by the MSO.**
- **The Application ID is assigned to the DSG Client from a table contained within the DSG Broadcast Tunnel.**
  - **The typical table type used will be the Source Name Subtable (SNS) as defined in SCTE-65.**
- **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.**
- **This is an ideal DSG Tunnel for sending content to middleware applications that would normally not have a MAC address.**

# DSG UCID Range

- The values of the field specify the matching parameters for the Upstream Channel ID (UCID) for which the DSG Rule applies.
  - A DSG Client with UCID value “ucid” matches this parameter if  $\text{ucid-low} \leq \text{ucid} \leq \text{ucid-high}$ .
- 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.
- If this TLV is included, then an additional DSG Rule would have to be written for DSG Clients that do not have a UCID available to them because they are 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.
- **The UCID Range is primarily used for Regionalization**

# DSG Client Configuration

Type	Length	Name	DSG Agent	DSG Client
51	-	DSG Client Configuration		√
51.1	4	DSG Channel List		√
51.2	1	DSG Initialization Timeout		√
51.3	1	DSG Operational Timeout		√
51.4	1	DSG Two-Way Retry Timer		√
51.5	1	DSG One-Way Retry Timer		√
51.43	-	DSG Client Config Vendor Specific Parameters		√

- **This group of TLVs contains parameters for configuration and operation of the DSG Client.**
- **The state machines of the embedded Cable Modem in the Set-top Device, as defined in [OC-CFR], 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.**

# DSG Channel List

- **A DSG Channel is a downstream channel that contains one or more DSG Tunnels.**
  - **A DSG Channel List is therefore a list of downstreams that contain DSG Tunnels.**
  - **This is intended to reduce the Set-top Device initial scan time.**
- **Set-top Devices are responsible for picking a DSG Channel from the DSG Channel List based upon some criteria that they own.**
  - **The DSG Channel List is not intended to indicate which Set-top Device should go on which downstream.**

# DSG Channel List

- **Typically,**
  - **the DSG Channel List will contain a list of all the DSG Channels, and**
  - **the DSG Channel List will be advertised on all DOCSIS downstream channels, regardless if the DOCSIS downstream channel is a DSG Channel.**
- **This typical scenario has exceptions.**
  - **Each DOCSIS downstream serves different physical areas of the plant.**
  - **A single CMTS may actually span two regions of the plant which have different frequencies for their DOCSIS downstreams.**
  - **Thus, the DSG Channel List would be different for each of those regions.**



# **DSG Service Class & Security**

***DSG ECR Walk-Through***

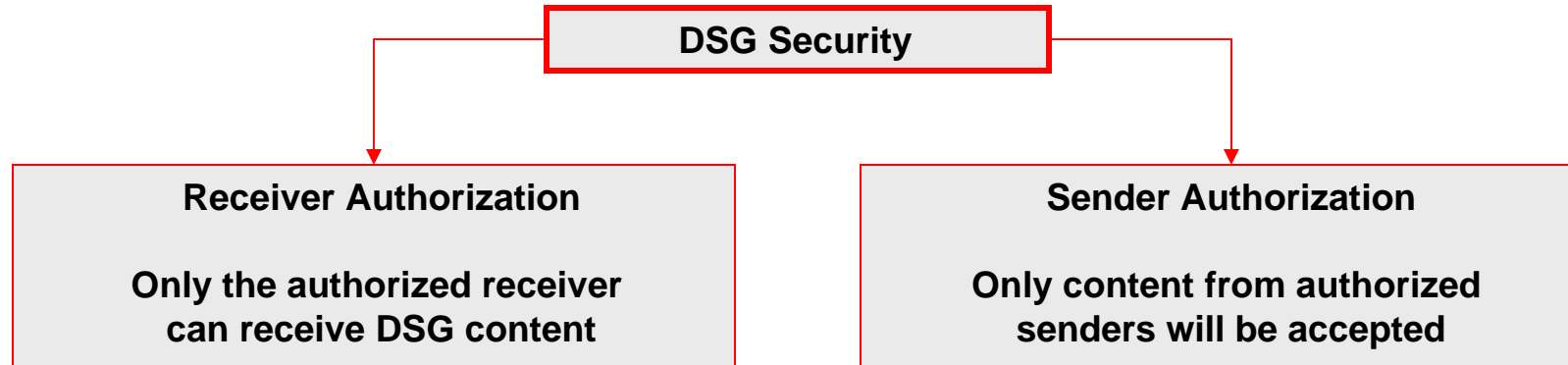
# DSG Service Class

- **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.**
  - **The DSG Service Class parameters are not intended to be included in the DCD message or the CM Configuration File.**
- **Multiple DSG Tunnels may reference the same DSG Service Class.**
- **Each DSG Tunnel MUST only have one Service Class reference.**

# DSG Service Class

- The DSG Agent **MUST** recognize the following DSG Service Class Parameters. These parameters are defined 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

# DSG Security



## Options

1. CM must know MAC address
2. BPI Link layer encryption (two way plant only)
3. Application layer encryption by CAS Vendor (Recommended)

## Options

1. CMTS blocks any traffic from upstream and screens signaling messages
2. CMTS protects WAN side with IP source verification.
3. CMTS protects WAN side with IP Sec tunnels
4. CAS Vendor signs content and Set-top Device verifies signature (Recommended)



**Applications**

**DOCSIS Set-Top Gateway**

# Regionalization – Basic Mode

- **An operator may want to send different content to different Set-top Devices from the same manufacturer on different HFC network segments.**
- **In DSG Basic Mode, this requires placing the different DSG Tunnels on different IP subnets.**
  - **This is because packets are switched between downstreams within an IP subnet based upon their destination MAC address.**
  - **Thus, it is impossible to have different DSG Tunnels with the same DSG Tunnel Address within an IP subnet with DSG Basic Mode.**
- **Since in practice IP subnets tend to span an entire CMTS, regionalization in DSG Basic Mode also tends to be done per CMTS.**

# Regionalization – Per Downstream

- **In DSG Advanced Mode, a DSG Tunnel Address substitution may be made on a per downstream basis.**
  - **For example, there could be multiple IP flows from the DSG Server to the DSG Agent.**
  - **These flows may be intended for the same function – such as EAS information – but the content differs across downstreams within the same subnet.**
- **Each of these flows would get mapped to a different DSG Tunnel Address on each downstream (or group of downstreams, depending upon geographical requirements).**
- **Each downstream would have a unique DCD message which would contain the same DSG Client ID, but would contain the unique DSG Tunnel Address.**
- **This is demonstrated in Figure 5-2, Example #2.**

# Regionalization – Per Upstream

- **On a two-way HFC plant, the DSG Client can use the Upstream Channel ID (UCID) for further granularity.**
- **One approach is to write a separate DSG Rule for each range of UCIDs that are within a region.**
  - **Each DSG Rule would be for a separate DSG Tunnel.**
  - **In this scenario, multiple DSG Rules would have the same DSG Client ID, but a different DSG Tunnel Address and a different UCID Range.**
- **This is demonstrated in Figure 5-2, Example #3.**
- **Regionalization with different DSG Tunnels for different content is useful when the number of content streams is low and the content per stream is high.**

# Regionalization – With UDP Ports

- **A second approach which would use fewer DSG Tunnels is for the DSG Server to place the regionalized content onto different destination UDP ports.**
  - **Each destination UDP port would then be associated with a different range of UCIDs.**
  - **In this scenario, multiple DSG Rules would have the same DSG Client ID and the same DSG Tunnel Address, but a different UCID Range.**
- **In both approaches, at least one DSG Rule would include the default DSG Tunnel for DSG Clients which could not register and obtain a UCID.**
  - **This rule would have a lower Rule Priority than the other DSG Rules.**
- **Regionalization with one DSG Tunnel and UDP ports is useful when the number of content streams is high and the content per stream is low.**

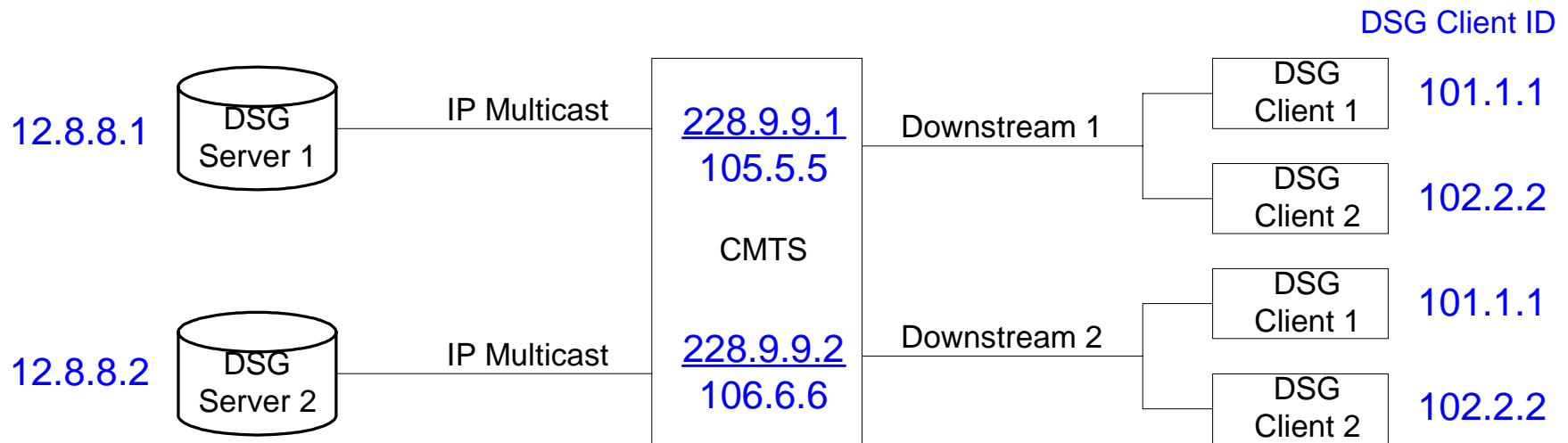


**Examples**

**DOCSIS Set-Top Gateway**

# Example #1

## Example #1: Two DSG Tunnels with MAC DA substitution.



Destination IP Address  
DSG Tunnel Address

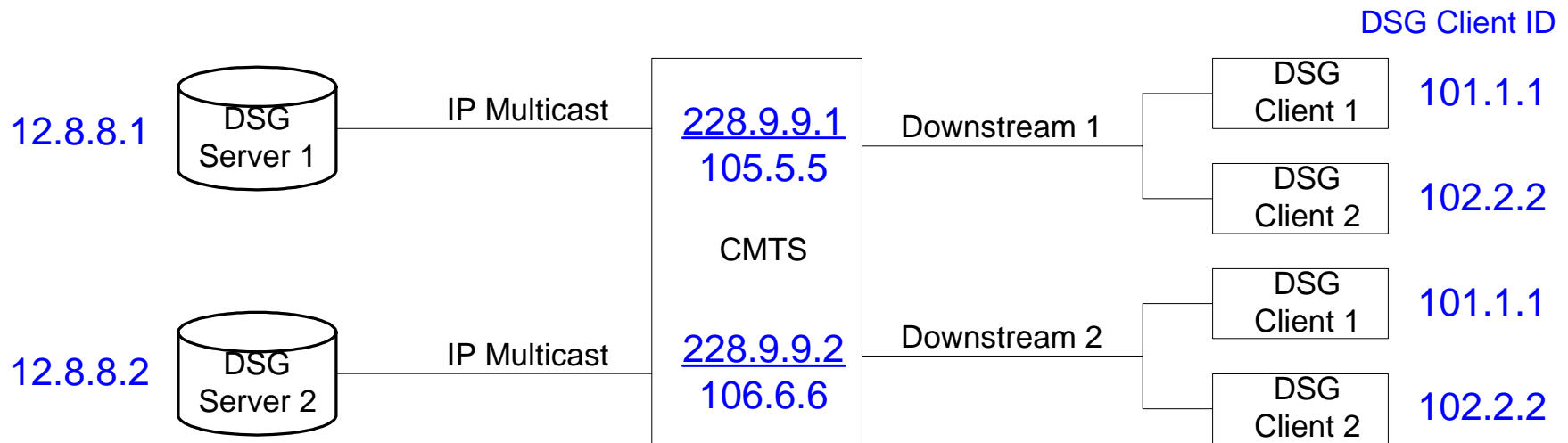
Note: 105.5.5 is short for 0105.0005.0005

DSG Rule (DS1 & DS2)	
DSG Rule ID	1
DSG Client ID	101.1.1
DSG Tunnel Address	105.5.5

DSG Rule (DS1 & DS2)	
DSG Rule ID	2
DSG Client ID	102.2.2
DSG Tunnel Address	106.6.6

# Example #2: Regionalization per Downstream

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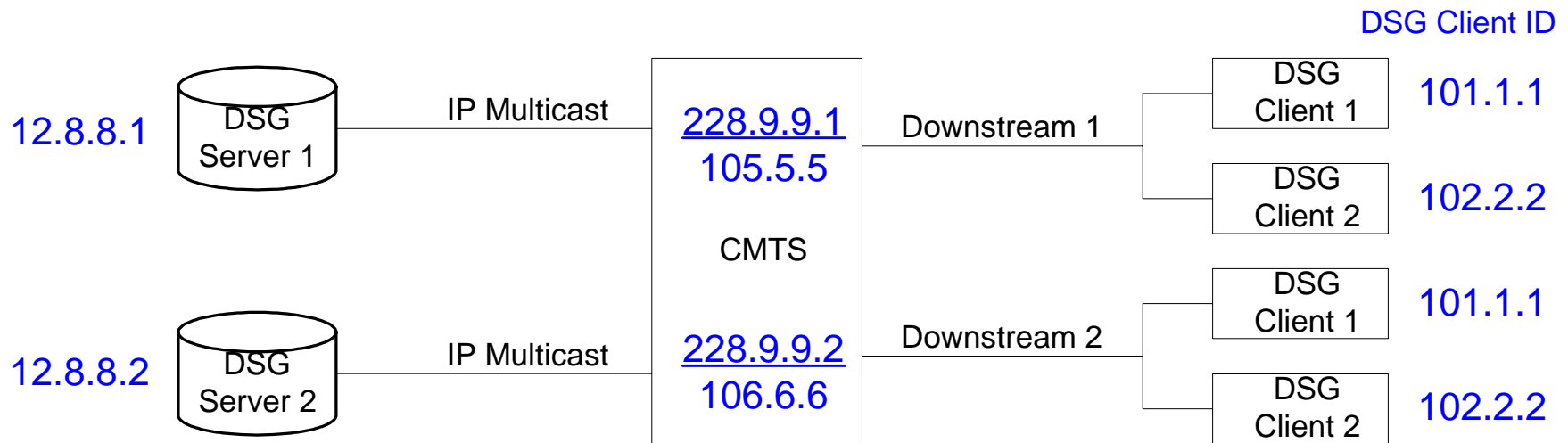
Destination IP Address  
DSG Tunnel Address

Note: 105.5.5 is short for 0105.0005.0005

DSG Rule (DS1)	
DSG Rule ID	1
DSG Client ID	101.1.1
DSG Tunnel Address	105.5.5

DSG Rule (DS2)	
DSG Rule ID	1
DSG Client ID	101.1.1
DSG Tunnel Address	106.6.6

# Example #3: Regionalization per Upstream



Destination IP Address  
DSG Tunnel Address

Note: 105.5.5 is short for 0105.0005.0005

DSG Rule ID	1
DSG Client ID	101.1.1
DSG UCID Range	0-2
DSG Tunnel Address	105.5.5

DSG Rule ID	2
DSG Client ID	101.1.1
DSG UCID Range	3-5
DSG Tunnel Address	106.6.6

# Example #4

## Example #4: Two DSG Tunnels with Full Classifiers with MAC DA substitution.

DSG Rule (DS1 & DS2)	
DSG Rule ID	1
DSG Client ID	101.1.1
DSG Tunnel Address	105.5.5
DSG Classifier ID	10

DSG Rule (DS1 & DS2)	
DSG Rule ID	2
DSG Client ID	102.2.2
DSG Tunnel Address	106.6.6
DSG Classifier ID	20

DSG Classifier	
DSG Classifier ID	10
IP SA	12.8.8.1
IP DA	228.9.9.1
UDP DP	8000

DSG Classifier	
DSG Classifier ID	20
IP SA	12.8.8.2
IP DA	228.9.9.2
UDP DP	8000

# Example #5

**Example #5: One DSG Tunnel, supporting both IP Multicast flows from multiple DSG Servers (many-to-one) to multiple DSG Clients (one-to-many) with full classification and MAC substitution.**

<b>DSG Rule (DS1 &amp; DS2)</b>	
DSG Rule ID	1
DSG Client ID	101.1.1 102.2.2
DSG Tunnel Address	105.5.5
DSG Classifier ID	10 20

<b>DSG Classifier</b>	
DSG Classifier ID	10
IP SA	12.8.8.1
IP DA	228.9.9.1
UDP DP	8000

<b>DSG Classifier</b>	
DSG Classifier ID	20
IP SA	12.8.8.2
IP DA	228.9.9.2
UDP DP	8000



**Summary**

**DOCSIS Set-Top Gateway**

# Summary

## **“DSG is like IP Multicast – except when it is not”**

- **The exceptions are:**
  - **A unicast IP address is explicitly deprecated – but permitted**
  - **A unicast MAC address is explicitly deprecated – but permitted**
  - **The multicast MAC address does not have to be RFC 1112 compliant**
  - **IGMP is not used.**
- **But:**
  - **DSG can forward an IP Multicast stream from the DSG Server to the DSG Client, and manage the session.**



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