Cisco DOCSIS 3.0 Downstream Solution Architecture

This chapter explains the architecture used for the Cisco DOCSIS 3.0 Downstream (DS) Solution in Cisco IOS Releases 12.2(23)BC, Cisco IOS Release 12.3(33)SCB and later releases.

This chapter contains the following topics:

Modular CMTS

The Cisco DOCSIS 3.0 DS Solution, deploys along with the modular CMTS (M-CMTS) architecture. With the M-CMTS architecture, the DS physical layer (PHY) is located in a separate network element called the Edge quadrature amplitude modulation (QAM) (QAM) device, while the packet processing at Layer 2 (DOCSIS) and above is done in the M-CMTS core.

The CableLabs specification for the M-CMTS architecture defines changes to the Edge QAM device, that requires it to be both DOCSIS-aware and synchronized to the DOCSIS subsystem. The Cisco implementation of the M-CMTS architecture meets this requirement by using the DTCC to acquire timing information from the DTI server and then distribute it within the CMTS.

Figure 5-1 shows the M-CMTS architecture used in the Cisco DOCSIS 3.0 DS Solution, with a Cisco uBR-MC3GX60V cable interface line card and a single wideband channel. In this example, eight DS RF channels are bonded together into one wideband channel. The Gigabit Ethernet (GE) switch is optional. The Wideband Gigabit Ethernet Interface can be connected directly to the GE Interface on the Edge QAM.

Figure 5-1 Cisco Cable Wideband M-CMTS Architecture Using the uBR-MC3GX60V Line Card

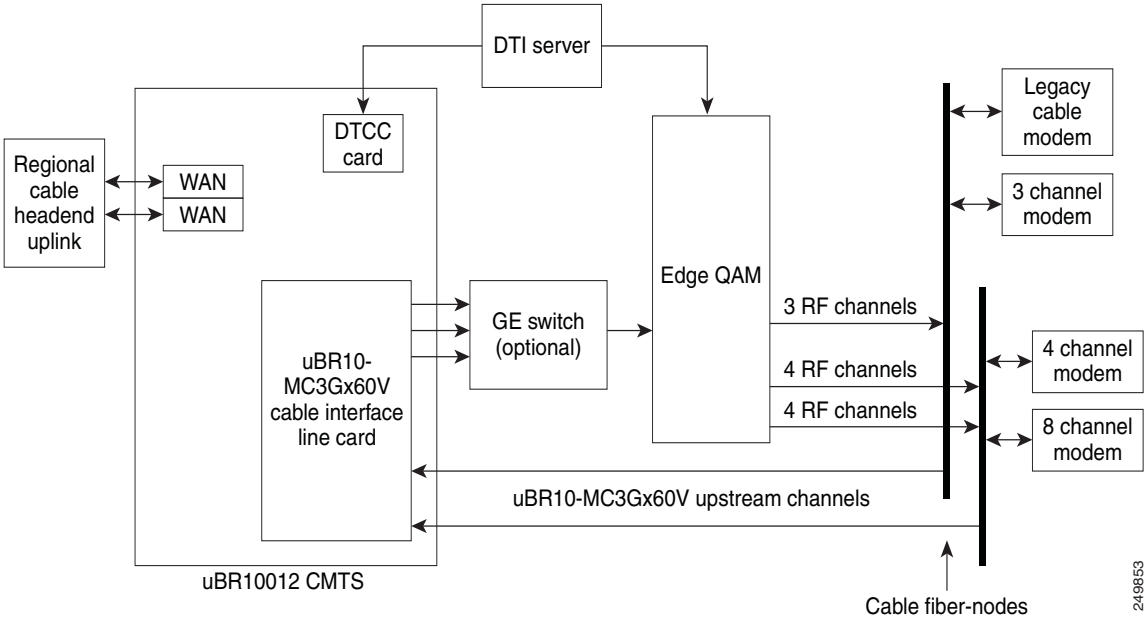
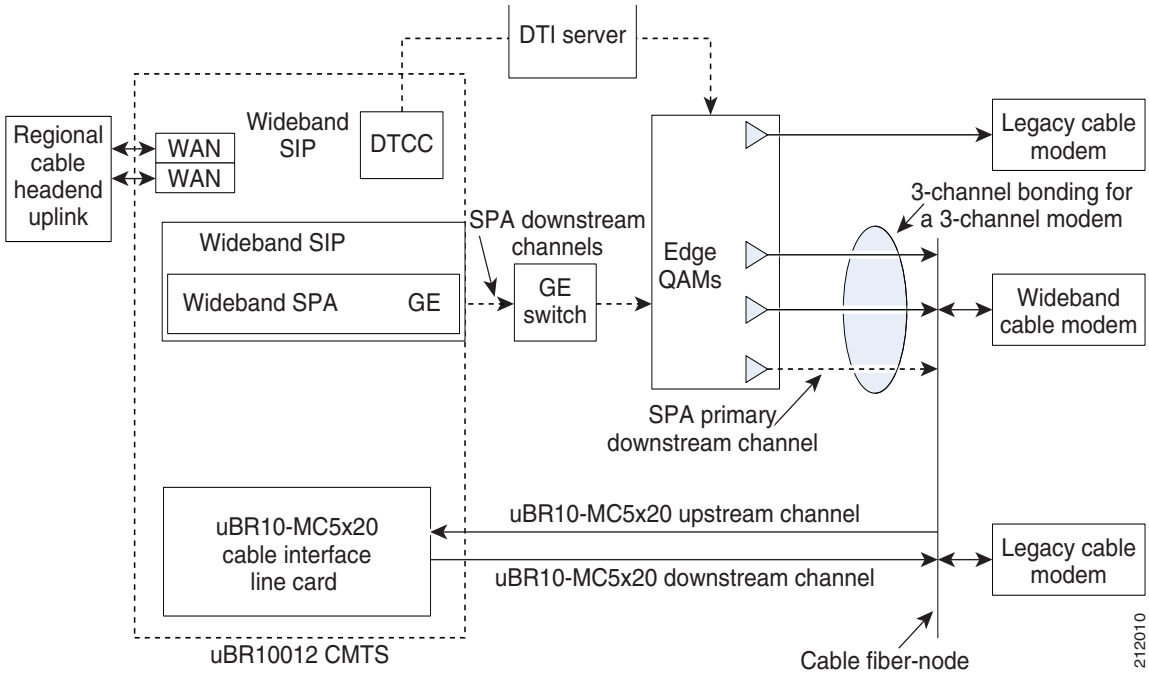


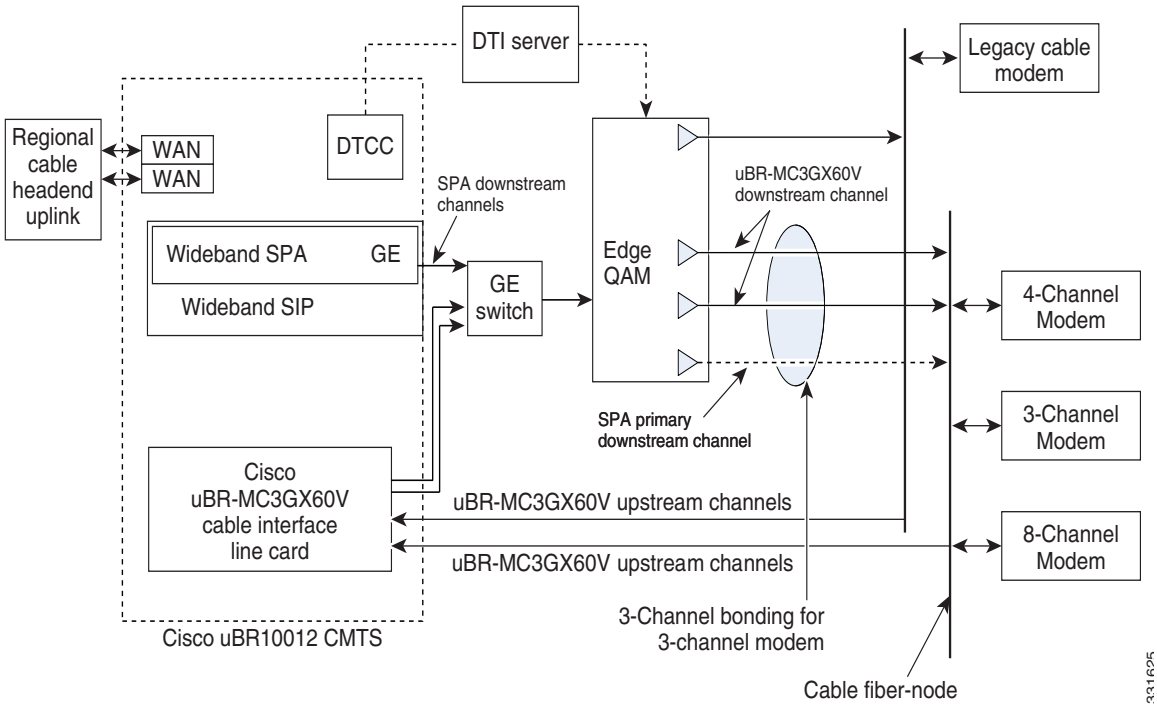
Figure 5-2 shows the M-CMTS architecture used in the Cisco DOCSIS 3.0 DS Solution, with a single wideband channel. In this example, three DS RF channels are bonded together into one wideband channel. The GE switch is optional. The Wideband SPA Gigabit Ethernet Interface can be connected directly to the GE Interface on the Edge QAM.

Figure 5-2 Cisco Cable Wideband M-CMTS Architecture using uBR10-MC5X20 line card



Starting with Cisco IOS Release 12.2(33)SCG, Cisco Wideband SPA and Cisco uBR-MC3GX60V cable interface line card can share DS channels, and therefore can coexist on a single chassis. Figure 5-3 shows the M-CMTS architecture used in the Cisco DOCSIS 3.0 DS solution, with Cisco Wideband SPA and Cisco uBR-MC3GX60V cable interface line card. In this example, three DS RF channels are bonded together into one wideband channel. The GE switch is optional. The Wideband SPA Gigabit Ethernet interface can be connected directly to the GE interface on the Edge QAM.

Figure 5-3 Cisco Cable Wideband M-CMTS Architecture Using Cisco Wideband SPA and Cisco uBR-MC3GX60V line card



In the M-CMTS architecture used for the Cisco DOCSIS 3.0 DS Solution, traditional Cisco CMTS functionality is divided into three network elements and an interface, as specified below:

- M-CMTS core—Contains the traditional functionality of a CMTS except for the DS PHY. The M-CMTS Core provides CMTS functionality, such as DOCSIS Media Access Control (MAC) and upstream (US) QPSK and QAM demodulation. DOCSIS MAC includes US and DS packet transmission services, and MAC management message exchanges with the cable modems. In the Cisco DOCSIS 3.0 DS Solution, the Cisco uBR10012 router is the M-CMTS core device. The M-CMTS core acquires the required timing from the DTI server using its DTCC, which is connected to the timing server.
- Edge QAM (EQAM) device—Connects to the M-CMTS core as well as the DTI server and contains PHY-related hardware, such as QAM modulators. For input, the EQAM device communicates with the M-CMTS through redundant GE interfaces. For output, the EQAM device has multiple QAM modulators and RF upconverters that connect to a hybrid fiber-coaxial (HFC) network. In the Cisco DOCSIS 3.0 DS Solution, the Harmonic Narrowcast Services Gateway (NSG) 9000 EQAM, the Cisco RF Gateway 1, and Cisco RF Gateway 10 EQAM devices are tested for interoperability with solution components. For more information on EQAM, see Edge QAM Device Functionality, page 5-47.
- DOCSIS Timing Interface (DTI) server—Connects to the M-CMTS core via the DTCC as well as the EQAM device. The DTI server provides DOCSIS clock generation in an M-CMTS architecture. It ensures that the DOCSIS time-stamp and frequency between M-CMTS core, EQAM, and US are synchronized to nanosecond levels. For more information on DTI server, see DOCSIS Timing Interface Server Functionality, page 5-46
- Downstream External PHY Interface (DEPI)—Interface between the M-CMTS core and the EQAM. This interface is an L2TPv3 tunnel between the CMTS DOCSIS MAC and the PHY.

Benefits of M-CMTS Architecture

Some of the benefits of a modular CMTS architecture are described in these sections:

Cost-Effective Architecture

The Cisco DOCSIS 3.0 DS solution can use the existing network of the Multiple Systems Operator (MSO). Deployed Cisco uBR10012 routers, that are used as a DOCSIS 1.x and DOCSIS 2.0 CMTS, can be upgraded to a M-CMTS by adding on hardware (the Cisco uBR-MC3GX60V, or Cisco Wideband SIP and SPA, or both) and upgrading Cisco IOS software. Some existing external QAM array devices used for the Video on Demand (VoD), with a software upgrade may be able to be deployed as the EQAM device. For EQAM devices that have been tested for interoperability, see External Edge QAM Device.

MSOs can repurpose their existing network infrastructure, including existing fiber nodes, for wideband cable. The benefits of the M-CMTS architecture include:

- Lower cost, lower power requirements, and higher density of EQAM devices.
- Less-expensive external QAM arrays for DS channels. This is more cost effective than locating the DS QAM channels in the CMTS chassis.
- Operating cost is saved by avoiding rewiring and moving customers to new systems.

With traditional CMTS architecture, adding DS RF channels for a wideband channel would also mean adding multiple USs. With the M-CMTS SPA architecture, multiple DS RF channels can be added without any additional USs. This independent scaling of DS channels makes the Cisco DOCSIS 3.0 DS Solution more cost effective.

Multiservice Architecture

With the M-CMTS architecture, the use of external EQAM devices allows MSOs to use the same network resources for a VoD network and a Cisco wideband cable network. With updated firmware, some EQAM devices can be used for VoD and for wideband channels, however individual output QAM channels in the device cannot be shared.

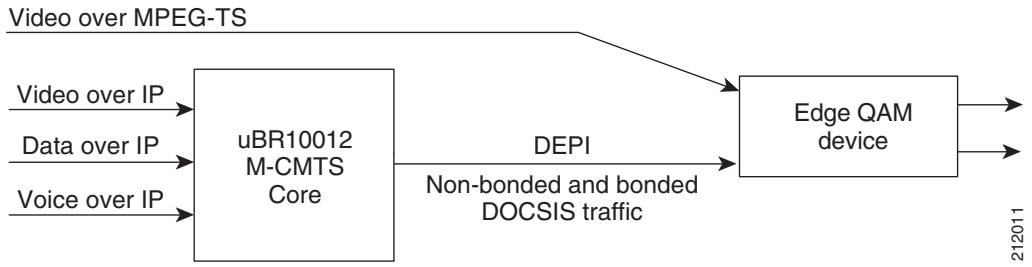
The wideband channel, comprising of one or more RF channels on the EQAM device, is used for DS data traffic. The US channels on the Cisco uBR-MC3GX60V or Cisco uBR10-MC5X20 cable interface line cards are used for US traffic. The DTI server is used for timing signaling messages.

In the Cisco DOCSIS 3.0 DS solution, traditional DOCSIS 1.x and DOCSIS 2.0 services are supported by the Cisco CMTS on either the traditional Cisco uBR10-MC5X20 cable interface DS channels or the edge QAM DS channels.

The DOCSIS 3.0 DS solution also supports multiservice architecture (see Figure 5-4) with converged IP triple play (voice, data, and video services) on wideband channels, which includes support for DOCSIS 3.0 services.

All services use the same IP/DOCSIS network and share the same RF network resources.

Figure 5-4 M-CMTS Multiservice Architecture



GE Switch Functionality

The GE switch is an optional device that receives DS packets from the Cisco uBR-MC3GX60V line card or Cisco Wideband SPA, and passes the packets to the EQAM device. The Gigabit Ethernet switch is used to:

- Concentrate traffic from multiple Gigabit Ethernet links to a smaller number of Gigabit Ethernet links prior to fiber transport to the EQAM devices
- Provide 1+1 or N+1 redundancy for DS Gigabit Ethernet links
- Multiplex wideband DOCSIS traffic and video traffic onto the same EQAM devices

The GE Switch is required, in the M-CMTS DS solution, in the following scenarios:

- If more than two EQAM devices are required for two Wideband SPAs, a GE switch is needed to connect the SPAs to the EQAM devices.
- If VoD traffic and RF channels for wideband channels are mixed on the same EQAM device, a GE switch is required.

When an RF channel for a wideband channel is configured using Cisco IOS commands on the Cisco uBR10012 router, the **rf-channel** command with the **mac-address** keyword option specifies the MAC address for the next-hop interface on the switch if it is a Layer 2 GE switch. The **rf-channel** command with the **ip-address** keyword option specifies the IP address of the Gigabit Ethernet interface on the EQAM device. The MAC address on the switch and the IP address on the EQAM device are used to route DS traffic for the RF channel to the correct destinations.

DOCSIS Timing Interface Server Functionality

The DTI server interfaces with the EQAM devices and DTCC in the M-CMTS. It facilitates communication between M-CMTS, EQAM devices, and the cable modems by synchronizing timing and frequency between the three devices to nanosecond levels, supporting DOCSIS 3.0 standards. The M-CMTS core is synchronized to the EQAM device to schedule, correct, and insert MPEG time stamps for video. A cable modem receives its synchronization from the EQAM device so that it is synchronized to other cable modems to properly transmit to the US burst receiver.

Note When the **cable clock dti** command or its **no** form is used to configure the DTI clock reference mode, the DTCC card on the Cisco uBR10012 router restart and the cable modems may re-initialize or re-register.

Edge QAM Device Functionality

The EQAM device receives wideband traffic as MPEG-TS over IP on its Gigabit Ethernet interfaces, encapsulated with L2TP as DEPI frames. The EQAM device extracts the MPEG-TS packets from the MPEG-TS over IP stream and routes them to the proper QAM RF outputs to the HFC plant for transmission to the wideband cable modem.

The EQAM devices are not involved in the active management of bandwidth or QoS for wideband channels. The EQAM devices are not aware of the IP addressing used by the wideband cable modems.

Each M-CMTS can support numerous EQAM devices if required. The DEPI interfaces with the EQAM device and M-CMTS and is used for encapsulation of frames in the DOCSIS-MPEG Transport mode over IP to forward packets for the QAM channels to a synchronous EQAM. Each DS channel associated with the EQAM is a narrowband channel and is referred to as a modular-cable interface. The modular-cable interface must forward traffic using DEPI.

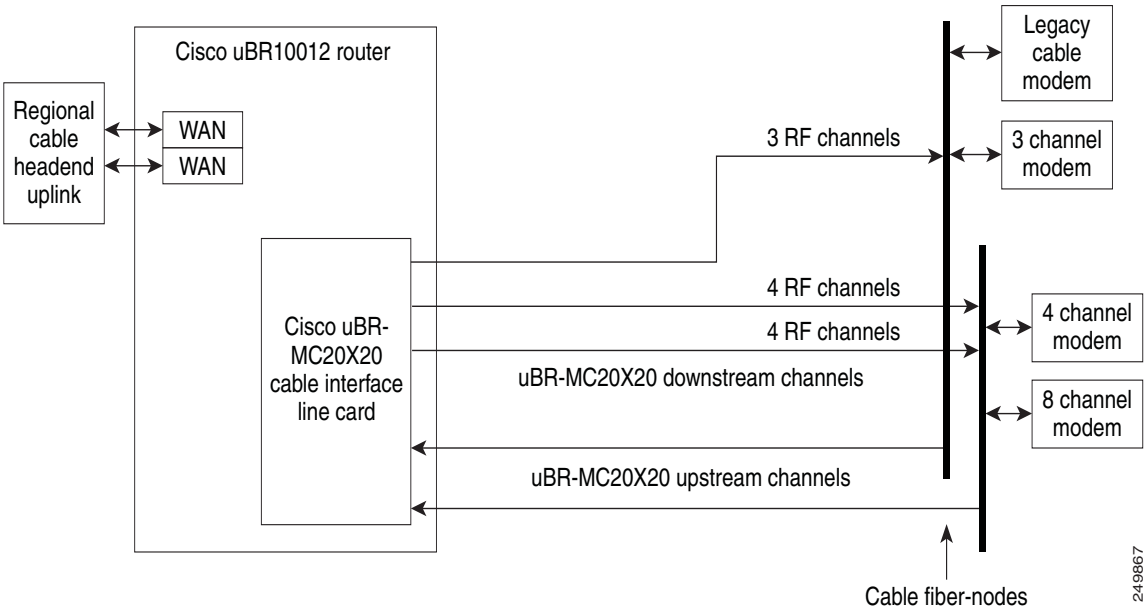
The total bandwidth for a single QAM channel can be statically allocated between one or more wideband and narrowband channels. When a wideband channel is configured on the Cisco CMTS, the wideband channel uses multiple specified logical RF channels on the Cisco Wideband SPA. Each RF channel is associated with a QAM output on the EQAM device. The bandwidth of an RF channel can be divided between one or more wideband channels as long as the total allocated bandwidth for an RF channel (and QAM channel) does not exceed 100 percent. For more information about configuring RF channels, see the *Cisco uBR10012 Universal Broadband Router SIP and SPA Software Configuration Guide*.

The QAM channels on the EQAM device do not have to be adjacent channels. If some of the QAM channels have already been assigned for non-DOCSIS purposes, the Cisco DOCSIS 3.0 DS Solution uses the channels that are available. The system does impose certain constraints. For example, if the QAMs are frequency stacked, certain QAMs will have to be adjacent.

Integrated CMTS

Figure 5-5 shows the I-CMTS architecture used in the Cisco DOCSIS 3.0 DS Solution.

Figure 5-5 Cisco Cable Wideband I-CMTS Architecture Using the UBR-MC20X20V Line Card



Benefits of I-CMTS Architecture

Some of the benefits of I-CMTS architecture:

- I-CMTS is a simpler solution than M-CMTS. I-CMTS provides a simpler solution for MSOs upgrading a non-bonding cable plant, based on Cisco uBR10-MC5X20 line cards, to a bonding capable cable plant.
- EQAM is not required for the I-CMTS solution. Therefore I-CMTS solution is easier to maintain as there is one less piece of equipment than in the M-CMTS solution.

Wideband Cable Modem Functionality

The wideband cable modem is a standalone device capable of inter-operation with an industry standard DOCSIS 1.x, DOCSIS 2.0, or DOCSIS 3.0-compatible CMTS, and it also supports wideband operation when used with a wideband CMTS.

The wideband cable modem operates in either of these ways:

- As a DOCSIS 1.x or DOCSIS 2.0 cable modem, it receives all DS traffic as non-bonded traffic on its primary DS.
- As a wideband cable modem, it receives all DS traffic as bonded traffic—a wideband channel consisting of one or more RF DSs.

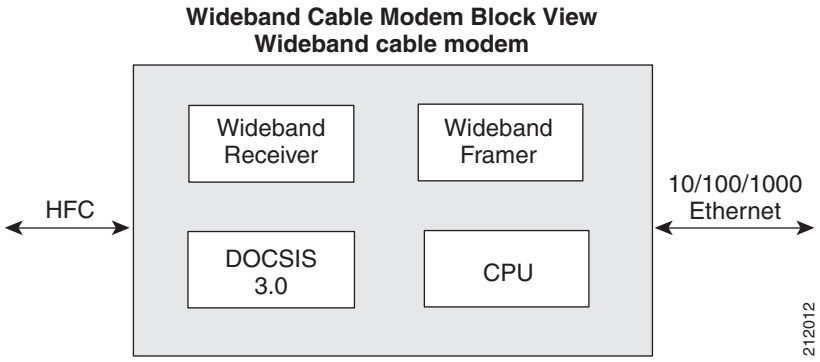
This section focuses on the role of the modem as a wideband cable modem. The explanations in this section are generic and apply to all wideband cable modems supported by the Cisco DOCSIS 3.0 DS Solution.

Wideband cable modem functionality may vary depending on the wideband cable modem vendor. For implementation information on vendor-specific wideband cable modems, see the "Wideband Cable Modem Behavior" section in Chapter 6, "Implementing and Configuring the Solution."

Wideband Cable Modem Design and Operation

The wideband cable modem is backward-compatible with DOCSIS 2.0 and contains a complete DOCSIS 3.0 core. Figure 5-6 shows a simplified block view of the wideband cable modem.

Figure 5-6 Wideband Cable Modem Block View



The wideband cable modem has a wideband receiver that receives the multiple RF channels of a bonded channel. It also has a wideband framer that decodes the signal from the wideband receiver and extracts the packets for the 10/100/1000-Mbps Ethernet home network.

The wideband cable modem identifies itself as being wideband-capable during the configuration process. This allows the DOCSIS Trivial File Transfer Protocol (TFTP) cable modem configuration provisioning server to enable or disable the wideband mode, and to choose the appropriate configuration parameters.

A wideband channel uses the same DOCSIS frame format as a DOCSIS channel uses. The channel just has more bandwidth. For DOCSIS 3.0 DS bonding, a new extended header for wideband has been added to the DOCSIS protocol. The extended header defines the logical wideband channel and a sequence number that the wideband cable modem uses for resequencing the wideband packets.

The CISCO-CABLE-WIDEBAND-MODEM-MIB for the wideband cable modem is supported and is an extension to the existing cable modem MIB.

Cisco DOCSIS 3.0 DS Solution

The Cisco DOCSIS 3.0 DS Solution utilizes either the DOCSIS M-CMTS architecture with the Cisco Wideband SPA and Cisco uBR-MC3GX60V cable interface line card, or the DOCSIS I-CMTS bonding with the Cisco UBR-MC20X20V and Cisco uBR-MC88V cable interface line cards. This enables cable operators to optimize their networks for additional bandwidth. The solution provides support for both narrowband and wideband modems, allowing both types of cable modems to share the same DS channels. The DOCSIS 3.0 DS Solution is backward compatible with DOCSIS 1.x and DOCSIS 2.0 services and networks.

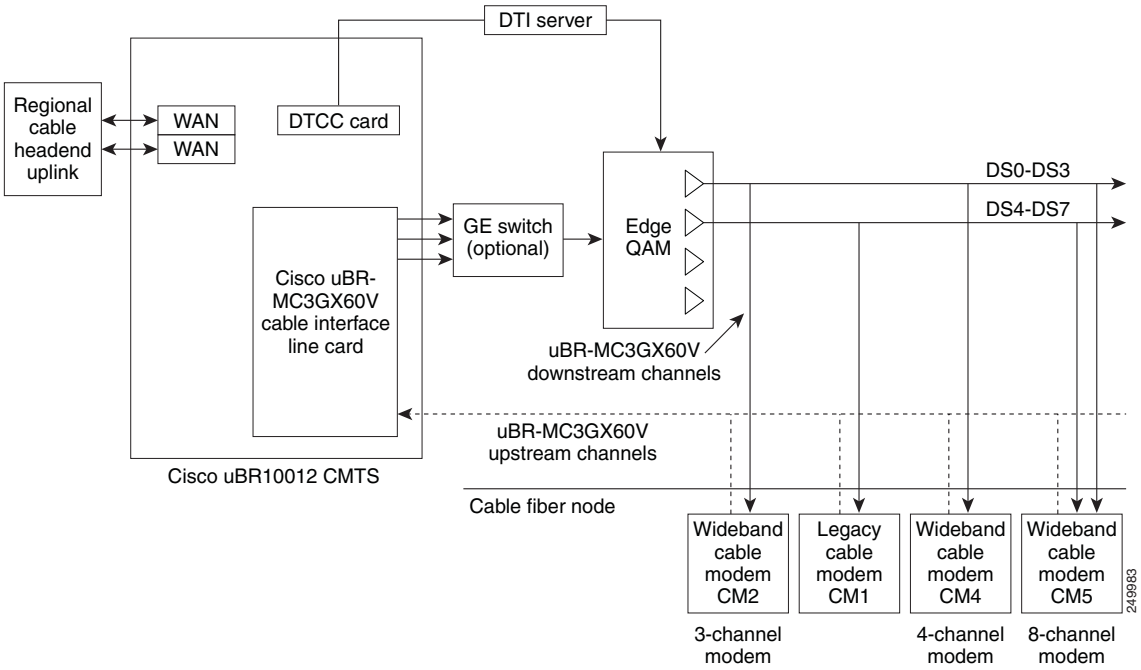
The Cisco DOCSIS 3.0 DS Solution encompasses the following:

- Primary-Capable Downstream Channels
- Extensible MAC Domain Support Through Channel Grouping Domain
- Virtual Bundle Support for Modular Cable Interfaces
- Fiber node

- Enhanced M-CMTS Channel Support
- Load Balancing Support for DOCSIS 1.x or DOCSIS 2.0 Modems on SPA RF Channels
- Legacy Feature Support
- Primary-Capable Downstream Channel Selection
- High Availability Support for Cable Modems on SPA DS Channels

Figure 5-7 illustrates the Cisco DOCSIS 3.0 DS solution using the Cisco uBR-MC3GX60V cable interface line card.

Figure 5-7 Cisco DOCSIS 3.0 DS Solution Using Cisco uBR-MC3GX60V Cable Interface Line Card

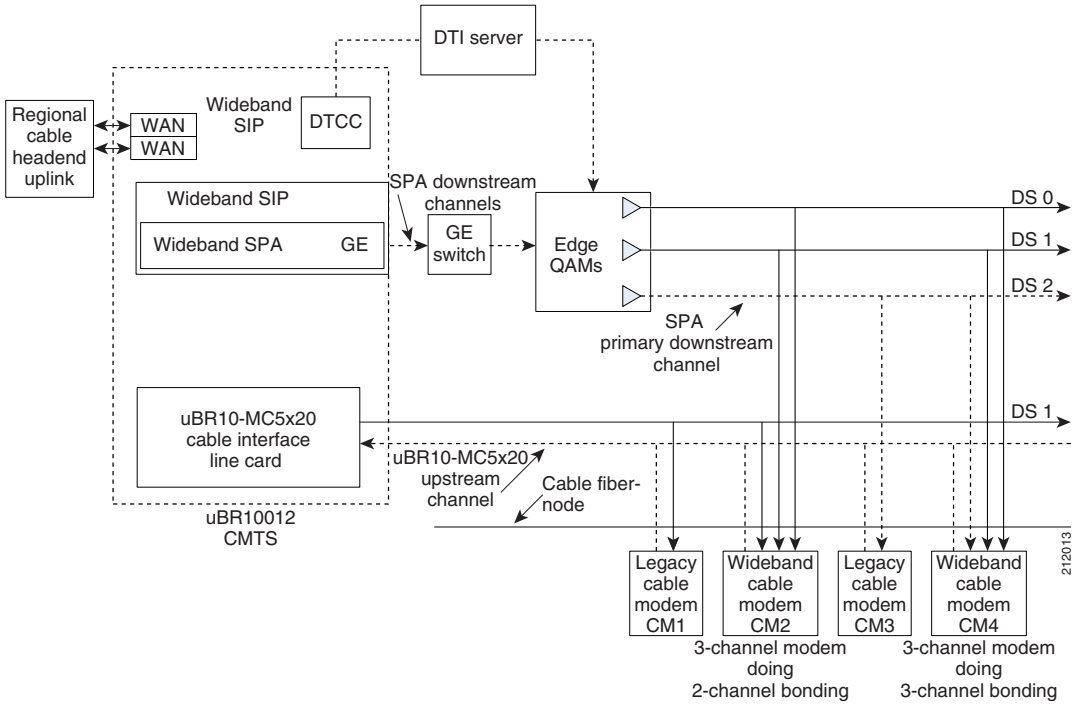


In Figure 5-7:

- Cable Modem 1 (CM1) represents a DOCSIS 1.x or DOCSIS 2.0 modem. This modem uses a DS channel on a Cisco uBR-MC3GX60V cable interface line card as its primary DS channel for both DOCSIS control messages as well as data traffic.
- Cable Modem 2 (CM2) represents a DOCSIS 3.0 modem with three tuners. This modem uses a Cisco uBR-MC3GX60V cable interface line card DS channel as its primary channel for DOCSIS control messages and a 3-DS bonded channel for its data traffic.
- Cable Modem 4 (CM4) represents a DOCSIS 3.0 modem with four tuners. This modem uses one DS channel as its primary channel, and a 4-DS bonded channel (including DS0-DS3 from the EQAM) for its data traffic.
- Cable Modem 5 (CM5) represents a DOCSIS 3.0 modem with eight tuners. This modem uses one DS channel as its primary channel, and a 8-DS bonded channel (including DS0-DS3 and DS4-DS7 from the EQAM) for its data traffic.

Figure 5-8 illustrates the Cisco DOCSIS 3.0 DS solution using the Cisco Wideband SIP/SPA and Cisco uBR10-MC5X20 cable interface line card.

Figure 5-8 Cisco DOCSIS 3.0 DS Solution Using the Wideband SIP/SPA and Cisco uBR10-MC5X20 Cable Interface Line Card.



In Figure 5-8:

- Cable Modem 1 (CM1) represents a DOCSIS 1.x or DOCSIS 2.0 modem. This modem uses a DS channel on a Cisco uBR10-MC5X20 line card as its primary DS channel for both DOCSIS control messages as well as data traffic.
- Cable Modem 2 (CM2) represents a DOCSIS 3.0 modem with three tuners. This modem uses a Cisco uBR10-MC5X20 line card DS channel as its primary channel for DOCSIS control messages and a 2-DS bonded channel for its data traffic.
- Cable Modem 3 (CM3) represents a DOCSIS 1.x or DOCSIS 2.0 modem, but in contrast to CM1, this modem uses the SPA DS channel as its primary channel.
- Cable Modem 4 (CM4) represents a DOCSIS 3.0 modem with three tuners. This modem uses one SPA DS channel (DS2) as its primary channel, and a 3-DS bonded channel (including DS1/DS2/DS3 from the SPA) for its data traffic.

Primary-Capable Downstream Channels

The DS channels from the Cisco uBR-MC3GX60V cable interface line card, Cisco UBR-MC20X20V cable interface line card or Cisco Wideband SPA may serve as a primary-capable channel as defined in DOCSIS 3.0. When configured as a primary-capable channel, the DS channel carries the DOCSIS MAC management messages including time synchronization (SYNC), bandwidth allocation map (MAP), Upstream Channel Descriptors (UCD), and possibly the primary MAC Domain Descriptor (MDD) messages, along with the non-bonded data traffic.

A DS channel, whether primary-capable or not, can always be part of a bonded channel that carries bonded data traffic.

A DS channel is made primary-capable via Channel Grouping Domain (CGD) configuration. The MAP and UCD messages carried by this channel may contain the information of all or a subset of the US channels, as specified by CGD in the MAC domain. CGD provides the flexibility of grouping specific DS with specific USs in any MAC domain.

A DS channel may only be a primary-capable DS channel for a single MAC domain. However, the same DS channel may be part of one or more bonded channels (wideband interface) that serve multiple MAC domains.

Modular-Cable and Integrated-Cable Interfaces

Modular-cable (MC) and Integrated-cable (IC) interfaces are logical representations of the capability of the DS channels to carry non-bonded data traffic on a DS RF channel. MC interfaces are instantiated when a Cisco uBR-MC3GX60V cable interface line card or Wideband SPA is inserted, configuration mode is entered and a configuration is changed in the interface. Similarly, IC interfaces are instantiated when a Cisco UBR-MC20X20V or Cisco uBR-MC88V cable interface line card is inserted and configured. However, for an MC or IC interface to be operational, the underlying DS channel must be configured as a primary-capable channel via the CGD (see Extensible MAC Domain Support Through Channel Grouping Domain, page 5-52). If a DS channel is not primary-capable, then sending non-bonded traffic over this DS is not supported.

RF Channel Bandwidth Allocation

When a DS channel is used by both an MC interface (or IC interface) and Wideband interfaces (WB interface), or when it is used by more than one WB interface, its bandwidth is statically partitioned between both these interfaces. When the bandwidth of a DS channel is not allocated to the corresponding MC interface (or IC Interface), 100 percent of this bandwidth is available for all the WB interfaces. However, if any amount of bandwidth of an RF channel is used for its MC interface, then only 96 percent of the DS channel bandwidth is available for allocation, for both the MC interface and the WB interfaces that use this DS channel. The remaining 4 percent is reserved for DOCSIS MAPs and other MAC Management Messages, because this DS channel could be enabled as a primary-capable channel to carry such messages.

Enhanced Channel Bonding Support

Because of the ability to use the same DS channel as a primary-capable channel and as part of a wideband channel, a DOCSIS 3.0 cable modem may use the same tuner to receive the DOCSIS control traffic and the bonded traffic on that channel. This allows the cable modem to make full use of its tuner capability, allowing *n* channel bonding for an *n*-tuner modem, as long as the primary channel of the modem is also part of an *n*-channel bonding group visible to that modem.

Extensible MAC Domain Support Through Channel Grouping Domain

A CGD is a collection of primary-capable DS channels that are associated with a common set of US channels. A CGD is always specified within the context of a MAC domain to which all the DS and US channels belong. The DS channel local to the MAC domain on the Cisco uBR10-MC5X20 cable interface line card is always primary-capable, but a DS channel of a Cisco Wideband SPA, Cisco UBR-MC20X20V line card, Cisco uBR-MC88V line card , or Cisco uBR-MC3GX60V line card has to be made primary-capable by explicit CGD configuration. A CGD provides the additional flexibility of associating a subset of the US channels within a MAC domain to any of the primary-capable DS channels, including the local DS channels. When an US channel is associated with a DS channel, its

information is included in the MAP and UCD messages sent through that DS channel. By default, all USs of a MAC domain are associated with the DS channels unless otherwise specified in the CGD configuration.

Multiple CGD configurations may be included in the same MAC domain, allowing the flexibility of the MAC domain to include various primary-capable DS channels associated with common or different sets of US channels.

The CGD can be defined in a flexible manner to support a variety of DS-US combinations on a fiber node. Here are a few examples—2 DS x 1 US, 2 DS x 2 US, 3 DS x 1 US, 3 DS x 2 US, and 4 DS x 1 US. The association of USs to primary-capable DS can be controlled to ensure that MAPs for a given USs are sent on the right set of DS instead of being flooded to all DSs in the MAC domain using bandwidth on all DSs.

Figure 5-9 provides an example of how CGD can be used to group channels of a Cisco uBR-MC3GX60V MAC domain. The MAC domain consists of DS channels 0 through 3 of controller 0 and US channels 0 through 3.

Figure 5-9 Flexible US/DS Associations in Cisco uBR-MC3GX60V Line Card

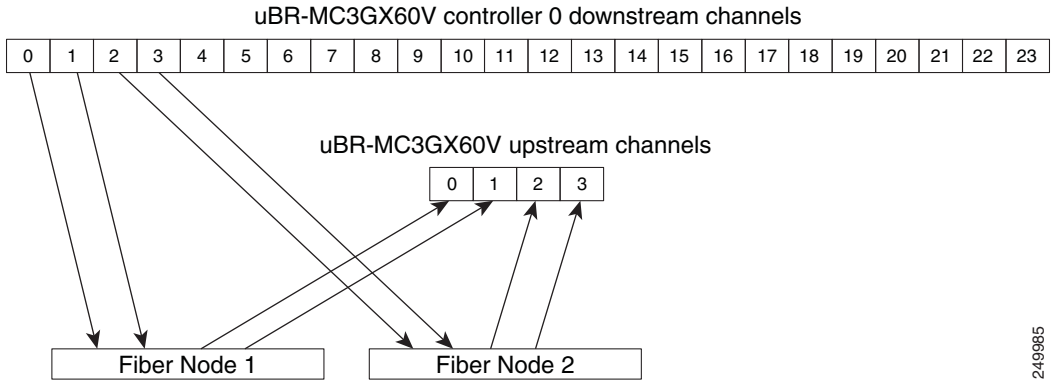


Figure 5-9 shows the fiber nodes served by the frequencies of the US and DS associations listed in Table 5-1

Table 5-1 US/DS Association to Fiber Nodes in the Cisco uBR-MC3GX60V Cable Interface Line Card

CGD1	Fibernode 1	US0, US1, DS0, DS1
CGD2	Fibernode 2	US2, US3, DS2, DS3

In this example, the four US channels and four DS channels are divided into two separate CGDs. Two CGDs are created to associate specific USs and DSs. By doing so, bandwidth on DS0 and DS1 is only required for MAPs and UCDs of US channels US0 and US1, but not US2 and US3. Similarly, bandwidth on DS2 and DS3 is only required for MAPs and UCDs of US channels US2 and US3, but not US0 and US1.

Figure 5-10 provides an example of how the flexible US and DS association may facilitate the distribution of channel frequencies to different fiber nodes. This illustration only represents the US and DS associations of primary-capable DS channels in the Cisco Wideband SPA along with the Cisco uBR10-MC5X20 line card.

Figure 5-10 Flexible US/DS Associations

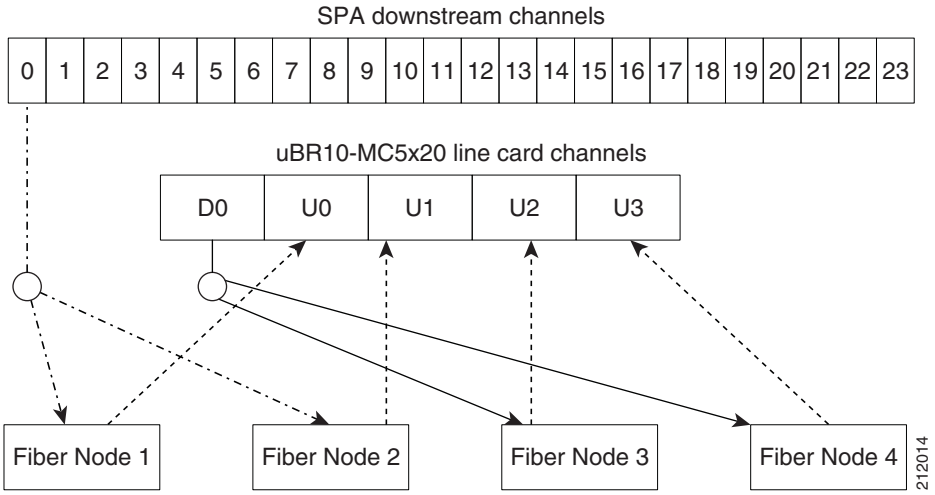


Figure 5-10 shows the fiber nodes served by the frequencies of the US and DS associations listed in Table 5-2.

Table 5-2 US/DS Association to Fiber Nodes in the Cisco Wideband SPA With the Cisco uBR10-MC5X20 Cable Interface Line Card

Fiber Node 1	US0 and SPA DS0
Fiber Node 2	US1 and SPA DS0
Fiber Node 3	US2 and uBR10-5x20 DS0
Fiber Node 4	US3 and uBR10-5x20 DS0

Therefore, in this example, SPA DS0 needs to be associated only with US0 and US1, and Cisco uBR10-MC5X20 DS0 needs to be associated only with US2 and US3.

Virtual Bundle Support for Modular Cable Interfaces

The Cisco CMTS does not allow explicit configuration of the virtual bundles on the MC or IC interfaces. When a CGD configuration within a MAC domain designates a DS channel as a primary-capable channel, the corresponding MC or IC interface is exclusively associated with the MAC domain and this MAC domain is referred to as the "hosting MAC domain" of the MC or IC interface. As a result, the MC interface automatically inherits the bundle membership of its hosting MAC domain, that is, if a Layer 3 virtual bundle includes a particular MAC domain as its member, it also includes all of the MC interfaces hosted by the same MAC domain.

CMTS Interfaces Associated With a Cable Modem

Prior to Cisco IOS release 12.3(23)BC, the Cisco uBR10-MC5X20 cable interfaces were used to manage both the US and DS traffic to cable modems, but with the introduction of the M-CMTS architecture, there is a need to separate this functionality. While the Cisco uBR10-MC5X20 line card DS interfaces are used to manage US traffic, the Cisco uBR10-MC5X20 line card interfaces, the SPA DS channel wideband

cable interfaces, and modular-cable interfaces can be used to manage DS traffic. Therefore, interfaces from the Cisco uBR10-MC5X20 line card, the SPA DS wideband and MC interfaces can be simultaneously involved in the communication with a cable modem.

Here are possible scenarios where interfaces from the Cisco uBR10-MC5X20 line card and the SPA DS can be involved in the communication with a cable modem:

- DOCSIS 1.x or DOCSIS 2.0 modem using a Cisco uBR10-MC5X20 DS channel as its primary channel.

  The Cisco uBR10-MC5X20 cable interface is used for both US and DS traffic.

- DOCSIS 1.x or DOCSIS 2.0 modem using a primary-capable SPA DS channel as its primary channel.

  The Cisco uBR10-MC5X20 cable interface, which is the hosting MAC domain of the modular-cable via CGD is used only for its US traffic, and the modular-cable interface is used for its DS traffic.

- DOCSIS 3.0 modem using a Cisco uBR10-MC5X20 DS channel as its primary channel.

  The Cisco uBR10-MC5X20 cable interface is used for its US traffic and its DS DOCSIS MAC management messages. A wideband interface consisting of the SPA DS channels is used for its DS bonded data traffic.

  Note The cable modem receive tuner tuned to the Cisco uBR10-MC5X20 DS channel cannot participate in channel bonding. Therefore a modem with *n* receive tuners can only achieve *n–1* channel bonding.

- DOCSIS 3.0 modem using a primary-capable SPA DS channel as its primary channel.

  The Cisco uBR10-MC5X20 interface, which is the hosting MAC domain of the MC interface via CGD, is used only for its US traffic. The primary-capable SPA DS channel is used for its DOCSIS MAC management messages, and a wideband interface is used for its DS bonded data traffic.

  – If the primary-capable SPA DS channel is one of the bonding group channels, a modem with *n* receive tuners will be able to achieve *n* channel bonding.

  – If the primary-capable SPA DS channel is not within the bonding group, a modem with *n* receive tuners will only be able to achieve *n–1* channel bonding.

Starting with Cisco IOS Release 12.2(33)SCE, a DOCSIS 1.x, DOCSIS 2.0, or DOCSIS 3.0 cable modem may use Cisco uBR-MC3GX60V line card channels.

Note Starting with Cisco IOS Release 12.2(33)SCG, it is possible to use Cisco uBR-MC3GX60V cable interface line card channels with Cisco Wideband SPA channels. However, it is not possible to share channels between two Cisco uBR-MC3GX60V cable interface line cards. A MAC domain must use DS and US channels from the local line card or Cisco Wideband SPA.

Fiber node

The fiber node configuration on the Cisco CMTS is used to construct the MAC domain service groups, or more specifically, the MAC domain DS service group (MD-DS-SG) as defined in DOCSIS 3.0. This information is used only by DOCSIS 3.0 modems. DOCSIS 1.x or DOCSIS 2.0 modems do not require fiber node configuration.

In HFC networks, all cable modems connected to the same coaxial segment of a fiber node reach the same set of DS and US channels on one or more CMTSs located at the headend.

A cable modem is physically connected to only one fiber node. On the CMTS, the fiber node software configuration defines the set of channels reaching the fiber node, and this configuration mirrors the physical topology of the cable network.

The fiber node must include at least one primary-capable channel for the modems connected to the fiber node to be operational. The fiber node can include one or more primary-capable channels from any of the following line cards:

- Cisco uBR10-MC5X20 line card, or from the primary-capable Cisco Wideband SPA DS channels, or both
- Cisco uBR-MC3GX60V line card, or from the primary-capable Cisco Wideband SPA DS channels, or both
- Cisco UBR-MC20X20V line card, or from the primary-capable Cisco Wideband SPA DS channels, or both
- Cisco uBR-MC88V line card

A fiber node configuration must be valid to be able to construct the MD-DS-SG. For a fiber node to be valid, it must satisfy the following conditions:

- Each DS channel within a fiber node must have been configured with a unique frequency.
- The DS channels within a fiber node must have unique DS channel IDs configured. In the Cisco IOS release 12.3(33)SCE, this can be achieved by enabling the Automatic Downstream Channel ID feature.
- All interfaces, which include the Cisco uBR10-MC5X20 cable interface, modular cable interface, and wideband interface, using any of the DS channels within a fiber node must be within the same virtual bundle.

Enhanced M-CMTS Channel Support

This section discusses the enhancements of the M-CMTS DS channels.

L2TPv3 Encapsulation Support on Downstream External PHY Interface

The Cisco DOCSIS 3.0 DS Solution supports DEPI data plane MPEG Transport Stream (D-MPT) within L2TPv3 encapsulation. The Cisco CMTS supports DEPI on both the Cisco uBR-MC3GX60V cable interface line card and Cisco Wideband SPA. The parameters required by L2TPv3 should be statically configured for each Cisco uBR-MC3GX60V cable interface line card and Cisco Wideband SPA DS channel, and must be consistent between the Cisco CMTS and EQAM.

SYNC Messages

A DEPI DS channel that is configured to be primary-capable requires SYNC insertion in the CMTS line card and SYNC restamping by the EQAM. Because this SYNC message handling is not standardized for legacy MPEG over User Datagram Protocol (UDP) format, configuring DEPI D-MPT/L2TPv3 transport for any SPA DS channel that is primary capable is required.

If a SPA DS channel is not used as a primary-capable channel, the legacy MPEG over UDP format is supported for backward compatibility.

DEPI Control Plane

In the Cisco IOS Release 12.2(33)SCE, the DEPI control plane functionality is supported. This includes DEPI protocol negotiation, DLM, session keepalive, and configuration synchronization between the CMTS and EQAM. For more information about the DEPI control plane, see the *M-CMTS DEPI Control Plane* Guide at the following URL:

http://www.cisco.com/en/US/docs/ios/cable/configuration/guide/m-cmts_depi_control_plane.html

Flexible Connection of DEPI Channels to EQAM Channels

Beginning in Cisco IOS Release 12.3(21)BC, the physical layer parameters including Annex, modulation, and interleave depth are configurable for each individual SPA DS channel. The same configuration applies to Cisco uBR-MC3GX60V channels in the Cisco IOS Release 12.2(33)SCE . This allows the DS channels in the same Cisco uBR-MC3GX60V line card and Cisco Wideband SPA to be tunneled via DEPI to an EQAM where RF channels from the EQAM are configured differently or to different EQAMs, thereby maximizing cable plant flexibility.

The following types of connectivity are supported between the SPA and the EQAM:

- Direct connection
- Connection through a Layer 2 Converged Interconnect Network (CIN)
- Connection through a single Layer 3 switch (for example, Cisco 7600 router)

Load Balancing Support for DOCSIS 1.x or DOCSIS 2.0 Modems on SPA RF Channels

Load balancing (LB) is the ability to assign a cable modem to a specific channel in order to utilize the DS and US bandwidth effectively. DS load balancing on SPA DS channels is restricted to DOCSIS1.x and DOCSIS 2.0 modems. DS-only bonding-enabled modems are eligible for US load balancing without DS channel changes. The MC interfaces inherit DS load balancing group membership from the hosting MAC domain. If the US must be changed due to DS load balancing, the target US channel must be associated to the target DS channel in the CGD configuration, and belong to the same load balancing group as the current US channel of the modem with a lower load.

The load on an US or DS channel can be measured either by:

- The number of active cable modems, which includes wideband modems that use MC interfaces as primary DS channels
- Number of active service flows
- Channel bandwidth utilization

The balanced load can be accomplished by one of the following means:

- During initial ranging (preregistration), the system must determine that a modem should use another DS channel or US channel for balanced load, which is referred to as static load balancing.
- If a need arises, the system may also move online (registered) modems to other DS or US channels, which is referred to as Dynamic Load Balancing.

For Dynamic Load Balancing, Dynamic Channel Change (DCC) is used for changing the DS channel of the modem, Upstream Channel Change (UCC) is used for changing the US channel of the modem. Advanced DCC initialization techniques (DCC initialization technique 1 and above, which keeps modem online during the DCC transaction) can be used for channel changes among the DS channels within a CGD or between the CGDs if the CGD hosting interfaces reside on the same Cisco uBR10-MC5X20 line card. If DCC initialization technique 2 and above (which assumes the timing difference between the source and target channel pairs can be compensated by station maintenance ranging), is desired for channel change between a modular cable interface and a local Cisco uBR10-MC5X20 DS interface, the EQAM timing delay must be calibrated such that the DS PHY processing delay at EQAM is consistent with the DS PHY processing delay on a Cisco uBR10-MC5X20 line card.

For DS channel changes hosted by different Cisco uBR10-MC5X20 line cards, DCC initialization technique 0 will be enforced regardless of DCC initialization configuration in the load balancing group, in which case, the modem will drop offline on the source DS interface and reregister on the target DS interface.

Note For Cisco uBR-MC3GX60V line card, the inter-line card LB groups are not supported, and the DOCSIS LB cannot steer CMs between the Cisco uBR-MC3GX60V line card and another line card. Other legacy and DOCSIS LB features function the same as other line cards.

Legacy Feature Support

The Cisco DOCSIS 3.0 DS Solution supports the following legacy features:

Note For detailed information on legacy features, refer to the *Cisco uBR10012 Universal Broadband Router Software Configuration Guide*.

- Full DOCSIS Quality of Service (QoS)

  The Cisco DOCSIS 3.0 DS Solution supports full DOCSIS QoS, including Committed Information Rate (CIR) support. DS low latency service flows for voice are configurable on all DS interface types.

- Bonded Multicast

  Cisco DOCSIS 3.0 DS Solution supports bonded multicast for DOCSIS 3.0 compatible cable modems.

- DOCSIS Set-Top Gateway (DSG)

  Cisco DOCSIS 3.0 DS Solution supports DSG on DOCSIS 1.x and DOCSIS 2.0 modems. DSG tunnel configuration is performed on the host interface and the modular cable interface inherits all DSG configurations of the host interface.The IP Media Gateway (IPMG) static group is enabled at the physical level of the modular cable interface. After the DSG configurations are added to the host interface, the DC Directories (DCD) are replicated on all modular cable interfaces that are part of the CGD.

- Subscriber Account Management Interface Specification (SAMIS)

  Cisco DOCSIS 3.0 DS Solution supports SAMIS for service flows on Cisco uBR-MC3GX60V line card and SPA DS channels.

- Baseline Privacy Interface/Baseline Privacy Interface+

  Cisco DOCSIS 3.0 DS Solution supports encryption of unicast packets for narrowband modems using Cisco uBR-MC3GX60V and Cisco Wideband SPA DS channels. For SPA deployment, the encryption keys are either generated or renewed in the Cisco uBR10-MC5X20 line card MAC domain and then forwarded to the SPA.

  - Static Multicast BPI

    Cisco DOCSIS 3.0 DS Solution supports static multicast with BPI on modular-cable interfaces.

  - Dynamic Multicast BPI

    Cisco DOCSIS 3.0 DS Solution supports dynamic multicast BPI. The encryption keys for dynamic multicast BPI are generated when an IGMP join is received from the CPE.

- Static Multicast QoS

Cisco DOCSIS 3.0 DS Solution supports static multicast QoS. For a Cisco uBR10-MC5X20 and Wideband SPA combination, the modular-cable interface inherits the QoS parameters from the Cisco uBR10-MC5X20 line card host interface and the cable bundle interface. Service flows are created when the multicast data is received. For modular-cable interfaces, the CMTS assigns unique service flow IDs ranging from 12K to16K.

- Dynamic Multicast QoS

  Cisco DOCSIS 3.0 DS Solution supports dynamic multicast QoS. The CMTS adds a service flow only to the DS interface of the cable modem where the IGMP join originated and the multicast data is only forwarded to that interface which has the service flow.

- Payload Header Suppression (PHS)

  Cisco DOCSIS 3.0 DS Solution supports PHS for narrowband modems on all line cards.

- PacketCable MultiMedia (PCMM)

  Cisco DOCSIS 3.0 DS Solution supports PCMM on wideband and is compliant with PCMM version IO3.

Primary-Capable Downstream Channel Selection

This section describes the primary-capable DS channel selection for wideband, narrowband, and voice-enabled modems.

Primary-Capable Downstream Channel Selection for Downstream Bonding Capable Cable Modems

In order to fully utilize DS bonding capacity, it is necessary to force DS bonding (wideband) capable modems to register on a primary-capable channel that is part of an operational DS bonding group.

A DS bonding capable modem is identified upon cable modem registration. A modem is DS bonding capable if the modem reports a multiple-tuner receive capacity and a Receive Channel Profile (RCP) known by the CMTS in a REG-REQ MP message. A wideband media terminal adapter (MTA) will be treated also as DS bonding-capable modems, therefore subject to the same primary channel selection policy.

In order to select a bonded primary channel (a primary channel that is part of a DS bonding group), the CMTS must know the DS service group information of the modem. If the modem has resolved its MD-DS-SG, the CMTS will select a primary channel that is part of an operational bonding group, which in turn is part of the QAM set corresponding to the MD-DS-SG determined by the modem. The bonded primary channel has to be hosted by an interface on the same Cisco uBR10-MC5X20 line card. A target DS channel will be selected randomly among channels that match the above criteria. If the modem has not resolved the MD-DS-SG, an enforce option is provided through the configuration to allow the CMTS to select a bonded primary channel based on the MAP group associated to the US channel of the modem. It is assumed that in many deployed topologies, an US channel is configured into a single fiber node, so that the CMTS can infer the topology information based on the DS channels associated to the US. If no target primary channel can be found, the modem will be allowed to register on its current primary channel.

The primary channel selection for bonding capable modems can be enabled through the global DS channel selection configuration. By default, if this configuration is not present, DS bonding capable modems will be allowed to operate on a primary channel even it is not included in any load balancing group.

At any time after the system is up, enabling the primary channel selection for bonding capable modems will not affect existing modems in the system. The bonding capable modems have to be manually reset using the **clear cable modem** command either globally or at the per-MAC domain level.

Primary-Capable Downstream Channel Selection for Narrowband Cable Modems

The primary DS channel selection for narrowband modems is intended to provide the operator the flexibility to segregate non-bonding capable modems to specific types of DS channels with the following two options:

- Redirecting modems that access a CMTS with legacy DOCSIS INIT-RNG-REQ at initialization

  This option helps to prevent potential non-bonding capable modems. The modems initialize with legacy initial ranging request message type, INIT-RNG-REQ, by registering to a CMTS that is loaded with bonding capable modems. Although a DOCSIS 3.0 modem may also send INIT-RNG-REQ if it fails to receive the MAC Domain Descriptor (MDD) message, this option allows to filter out and redirect all potential pre-DOCSICS 3.0 non-bonding capable modems at the initial ranging time of the modem without waiting for modem registrations. The target frequency is specified using DS frequency in Hertz. If the target frequency matches one or multiple DS channels on the local CMTS, load balancing will be disabled on these DS channels to prevent modems being moved away from the target channel for load balancing purposes.

- Moving non-bonding capable modems to bonding-disabled primary channels

  This option helps to restrict non-bonding capable modems to non-bonded primary channels on the CMTS. A more stringent method is applied for this option to identify the non-bonding capable modems, by decoding the Multiple Receive Channel Support capability (Type Length Value [TLV] 5.29) and RCP ID (TLV 48.1)of the modem in the registration request. A modem is non-bonding capable if it reports value 1 for TLV5.29 or RCP IDs unknown to the CMTS. With this option, a non-bonding capable modem, identified at registration, will be moved to a non-bonded primary channel through DS frequency override, if its current primary channel is part of a bonding group. The target non-bonded primary channel will be selected among primary capable channels that are associated to the current US channel of the modem, however the non-bonded channel will not be included in any bonding groups associated to any host interfaces on the local line card. When this option is enabled, the bonded primary channels will be taken out of the load balancing group to prevent non-bonding capable modems from being moved back to bonded primary channels for load balancing purposes.

These two options can be enabled through the global DS channel selection configuration. By default, if the configuration is not present, the modem will be allowed to continue the ranging process on its current primary channel. At any time after the system is up, enabling DS channel selection to segregating non-bonding capable modems will not affect existing modems in the system. Additionally, if the frequency specified for the target DS channel is changed, the new frequency setting will only affect new modems trying to initialize after the frequency change. In order to enforce the DS selection policy on existing modems, the non-bonding capable modems must be manually reset using the **clear cable modem** command.

Downstream Channel Selection for Voice-Enabled Cable Modems

This DS channel selection option provides the ability to provide high-availability for voice services by restricting voice-enabled modems to Cisco uBR10-MC5X20 or Cisco UBR-MC20X20V DS channels. Because high-availability is not supported by the Wideband SPA, it is necessary to force voice-enabled modems to use primary channels of line cards that do support high-availability. This includes the Cisco uBR10-MC5X20, Cisco UBR-MC20X20V or Cisco uBR-MC3GX60V line cards.

A voice-enabled cable modem is identified either at registration by decoding the Dynamic Host Control Protocol (DHCP) TLV 122 in the DHCP-ACK of the modem, or at its first voice call if the DHCP TLV 122 is not exchanged. If a voice-enabled modem is detected at registration on a SPA DS channel, it will be moved to the Cisco uBR10-MC5X20 DS channel in the CGD via DS frequency override. If the voice-enabled modem is detected at its first voice call after registration, it will be moved after the call is over to the Cisco uBR10-MC5X20 DS channel in the CGD via DCC using DCC initialization technique

1. If the voice-enabled modem fails to come up on the target Cisco uBR10-MC5X20 DS channel, the CMTS will continue to move the modem until the maximum number of retries (3) has been reached. The modem will be allowed to stay on the SPA DS channel until another set of retries is attempted by the CMTS every 24 hours. A voice-enabled modem on the Cisco uBR10-MC5X20 DS channel will be excluded from being load balanced to a SPA DS channel.

The DS channel selection option to support high availability for voice-enabled modems can be enabled via global DS channel selection configuration. By default, if this configuration is not present, voice-enabled modems are allowed to operate on both the Cisco uBR10-MC5X20 DS channel and SPA DS channels in the CGD. If this option is enabled at any time after the system is up, voice-enabled modems that have been identified on the SPA DS channel without active voice calls will be gradually moved to the Cisco uBR10-MC5X20 or Cisco UBR-MC20X20V DS channel in the CGD at the rate of one modem per five seconds.

High Availability Support for Cable Modems on SPA DS Channels

Cisco High Availability is enables network-wide resilience to increase IP network availability. This feature is supported for PRE redundancy, N+1 redundancy for the Cisco uBR10-MC5X20 line cards, and N+1 failover of the modular host line card. A Cisco Wideband SPA does not support high-availability operations by itself and uses a modular host line card for these high-availability operations. The higher system availability feature is implemented using the HCCP and the high availability infrastructure for the N+1 redundancy and PRE redundancy, allowing the cable modems to stay online in certain failure scenarios.

When a narrowband cable modem uses a SPA RF DS channel and a Cisco uBR10-MC5X20 MAC domain host, and if the Cisco uBR10-MC5X20 MAC domain host to which the SPA RF channel belongs fails, the modem stays online because of N+1 redundancy of the Cisco uBR10-MC5X20 line card. The same is true if the MAC domain host line card is a Cisco UBR-MC20X20V line card.

In a scenario where a wideband cable modem SPA uses a Cisco uBR10-MC5X20 cable interface line card as a modular host (which is different from the MAC domain of the modem, as defined by the CGD), if the modular host Cisco uBR10-MC5X20 cable interface line card fails, the modem stays w-online because of the N+1 redundancy support for the modular host on the Cisco uBR10-MC5X20 cable interface line card. Similarly, if the host MAC domain line card fails and has a protect card, wideband cable modems will stay w-online.

For more information about the modular host line card, refer to the **modular-host subslot** command in the *Cisco CMTS Cable Command Reference*.

Table 5-3 summarizes the scenarios in which the modems are functional during specific component failures.

Table 5-3 High Availability for Cable Modems

Component Failure	Narrowband Cable Modems Using Cisco uBR10-MC5X20 Downstream Channels	Narrowband Cable Modems Using the SPA Downstream Channels	Wideband Cable Modems Using Cisco uBR10-MC5X20 Channels as Primary Downstream Channels	Wideband Cable Modems Using SPA Channels as Primary Downstream Channels
Cisco uBR10-MC5X20 MAC domain host	Online	Online	Online	Online
Cisco uBR10-MC5X20 modular host line card for the SPA	Not Applicable	Online	Online	Online
Cisco uBR10-MC5X20 MAC Domain host serving also as the uBR10-MC5X20 modular host line card for the SPA	Not Applicable	Online	Online	Online
PRE	Online	Online	Online	Online

Note The Cisco UBR-MC20X20V line card provides equivalent functionality as the Cisco uBR10-MC5X20 line card specified in Table 5-3.

Note Beginning with Cisco IOS Release 12.2(33)SCE1, the N+1 redundancy feature including DEPI redundancy is supported on the Cisco uBR-MC3GX60V cable interface line card.

High Availability for Voice Modems

The Cisco DOCSIS 3.0 DS Solution provides higher system availability for voice services by providing the ability to restrict voice services only to Cisco uBR10-MC5X20 or Cisco UBR-MC20X20V line cards. This allows the CMTS to make an attempt to move the voice modems to a MAC domain host line card with DS channels in the same load balancing group.

DOCSIS 3.0 Wideband Channel Support

The Cisco DOCSIS 3.0 DS Solution is an industry-standard DOCSIS 3.0 implementation of channel bonding. The Cisco Wideband SPA, Cisco UBR-MC20X20V, Cisco uBR-MC88V, and Cisco uBR-MC3GX60V line cards are all bonding capable line cards. With channel bonding, the bandwidth is increased by combining or bonding multiple RF channels to create a wideband channel. The Cisco DOCSIS 3.0 DS Solution extensions affect the CMTS and the cable modem and the

provisioning and network management systems. For example, a 3-channel cable modem that performs 3-channel bonding must be able to access three RF channels of which at least one RF channel must be a primary-capable channel that is used for modem registration.

The core of the DOCSIS 3.0 DS Solution is the sending of DOCSIS packets for a given service flow across multiple RF channels, offering significant increases in the peak DS data rate that can be provided to a single cable modem. The transmit framer in the Cisco DS bonding line cards "strips" the DOCSIS packets for a given flow and transmits them across the multiple RF channels of the wideband channel. When the packets are received at the wideband cable modem, the receiver framer of the modem uses a sequence number embedded in each DOCSIS packet to reassemble the packets into the original flow.

The Cisco DOCSIS 3.0 DS Solution defines a *wideband channel* as a unique combination of DS RF channels from the same SPA or DOCSIS 3.0 cable interface line card. The wideband CMTS manages up to 32 wideband channels per Wideband SPA, 30 wideband channels per Cisco UBR-MC20X20V line card, 12 wideband channels per Cisco uBR-MC88V line card, and 96 wideband channels per Cisco uBR-MC3GX60V. A wideband cable modem can use one or more wideband channels. Many wideband cable modems can share the same wideband channel.

In the M-CMTS network architecture, the Cisco uBR-MC3GX60V or Wideband SPA on the Cisco uBR10012 router provides DOCSIS 3.0 channel bonding for DOCSIS network processing. In the Cisco DOCSIS 3.0 DS Solution, for the wideband DS channel, these two cards use one or more Gigabit Ethernet ports to send data traffic to the EQAM device. This EQAM device uses one or more QAM output channels, depending on how the wideband channel is configured, to send stripped packets to the wideband cable modem.

In Cisco DOCSIS 3.0 DS Solution, channel bonding is used only for DS wideband channels. A DS wideband channel can combine up to eight RF channels for a total bandwidth of up to 292 Mbps in the Annex B mode.

Channel bonding is used only for DS wideband channels with a:

- Cisco/Scientific Atlanta DPC3010, a DS wideband channel can combine up to eight RF channels for a total bandwidth of up to approximately 292 Mbps. This modem can also bond in the US direction on all four of its US channels.
- Cisco/Scientific Atlanta DPC3000, a DS wideband channel can combine up to four RF channels for a total bandwidth of up to approximately 146 Mbps. This modem can also bond in the US direction on all four of its US channels
- Linksys WCM300-NA modem, a DS wideband channel can combine up to eight RF channels for a total bandwidth of up to approximately 292 Mbps (at 6 MHz and 256 QAM).
- Scientific Atlanta DPC2505 modem, a DS wideband channel can combine up to three RF channels for a total bandwidth of over 100 Mbps (at 6 MHz and 256 QAM).

Figure 5-11 shows the a Cisco uBR-MC3GX60V line card having eight bonded channels on the EQAM device.

Figure 5-11 Cisco uBR10-MC3GX60V Channel Bonding to Create a Wideband Channel

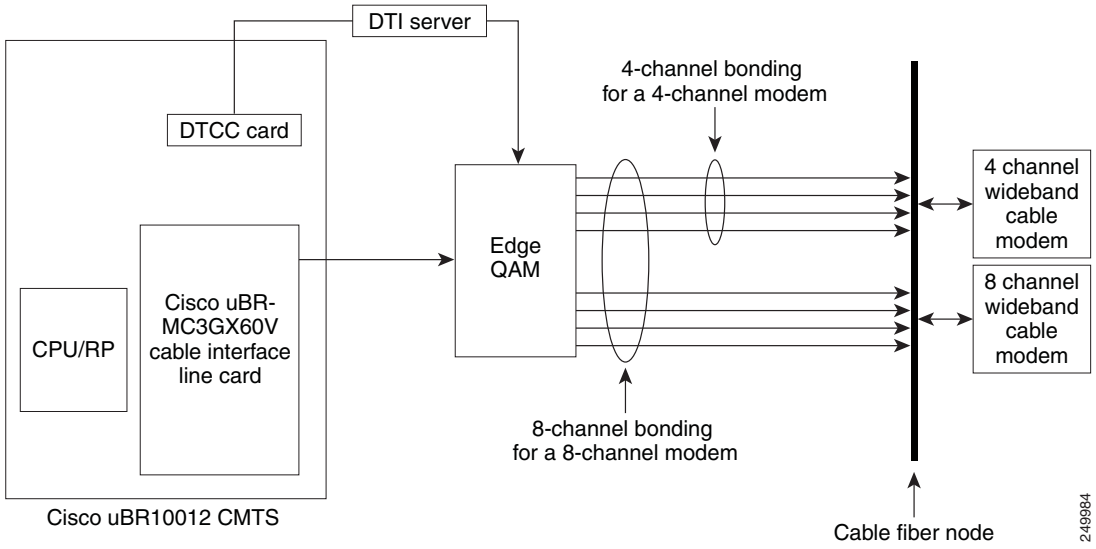
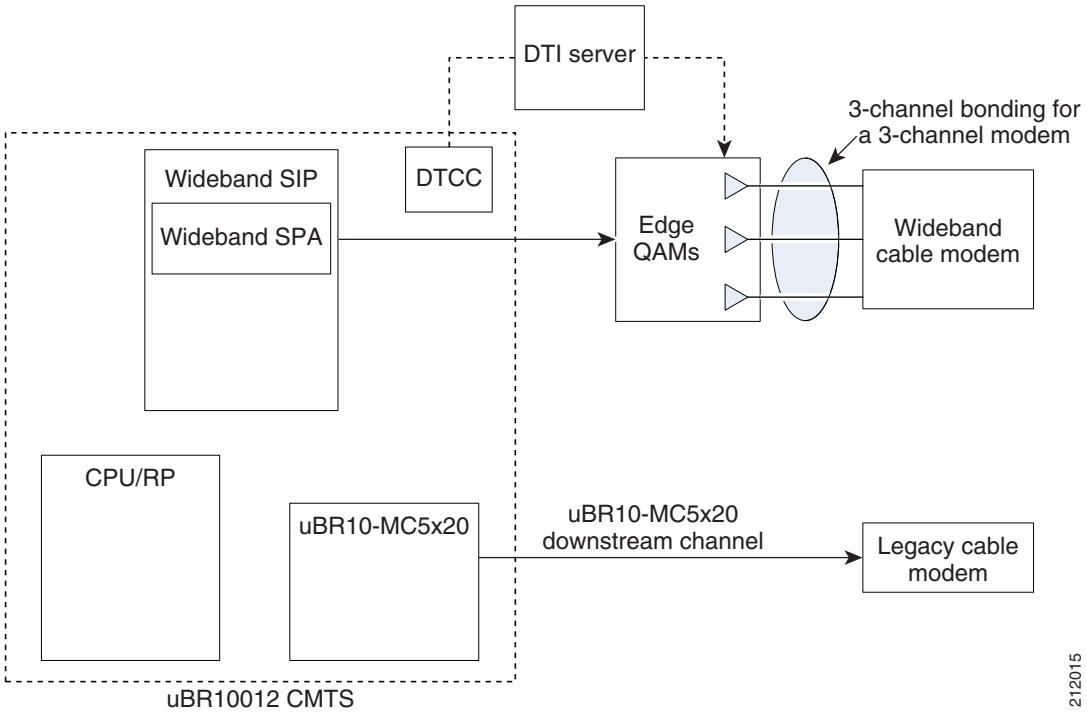


Figure 5-12 shows a wideband channel consisting of three bonded RF channels on the EQAM device. These RF channels are asynchronous and carry only bonded traffic.

Figure 5-12 Cisco uBR10-MC5X20 Channel Bonding to Create a Wideband Channel



For information on configuring wideband channels, see the *Cisco uBR10012 Universal Broadband Router SIP and SPA Software Configuration Guide*.

Security

A wideband channel uses Baseline Privacy Plus (BPI+) for its link level encryption. BPI+ provides cable modem users with data privacy across the cable network by encrypting traffic flows between the wideband cable modem and the wideband CMTS. BPI+ also provides MSOs with protection against theft of service.

The wideband cable modem uses the same BPI+ keys on its wideband channels as it does on its DOCSIS 1.x or DOCSIS 2.0 channels. The wideband cable modem uses the BPI+ keys negotiated on the primary service flow of the DOCSIS 1.x or DOCSIS 2.0 DS channel for the service flows on the wideband channel.

Quality of Service

For a modem that uses a wideband interface or MC interface as its DS data forwarding interface, its service flows will be associated with the Wideband or MC interface. The bandwidth for the WB or MC interfaces may vary due to configured bandwidth partitioning. The traditional support for cable QoS is otherwise unchanged.

Support for Cisco SIP-600 and Gigabit Ethernet SPAs

The Cisco 10000 Series SPA Interface Processor-600 (referred to as the Cisco SIP-600) is a high-performance, feature-rich SIP that functions as a carrier card for shared port adapters (SPAs) on the Cisco uBR10012 router. The SIP is compatible with the following platform-independent SPAs in Cisco IOS Release 12.2(33)SCB and later releases:

- Cisco Wideband SPA
- 5 port Gigabit Ethernet Shared Port Adapter
- 1 port 10-Gigabit Ethernet Shared Port Adapter (supported only with PRE4 configuration)

With a PRE2 configuration, the Cisco SIP-600 can support up to four Cisco Wideband SPAs, with a PRE4 configuration, the SIP can support up to six Cisco Wideband SPAs, and with a PRE5 configuration, the Cisco SIP-600 can support up to four Cisco 3 Gbps Wideband Shared Port Adapters and Cisco 6 Gbps Wideband Shared Port Adapters.

The Cisco SIP-600 is a full-height line card that occupies two physical slots in a Cisco uBR10012 router. Each chassis supports a maximum of two SIPs that can be inserted in the following slots:

- Slot 1
- Slot 3

The Cisco SIP-600 supports four bays (subslots) for the installation of SPAs. The SPA bays are numbered from 0 to 3 on a Cisco uBR10012 router. The number for each SPA bay is indicated by a small numeric label on the SIP faceplate.

SPAs on a Cisco uBR10012 router use an addressing format that specifies the physical location of the SIP, SPA, and interface in the format *slot/bay/port*, where:

- *slot*—Specifies the chassis slot number where the SIP is installed.

- *bay*—Specifies the secondary slot (subslot) of the SIP where the SPA is installed.
- *port*—Specifies the interface number that you want to select on the SPA.

For more information about the Cisco SIP-600 and supported SPAs, see the *Cisco uBR10012 Universal Broadband Router SIP and SPA Hardware Installation Guide* and *Cisco uBR10012 Universal Broadband Router SIP and SPA Software Configuration Guide*.

Wideband Modem Resiliency

Introduced in Cisco IOS Release 12.2(33)SCB, the Wideband Modem Resiliency feature enables the Cisco uBR10012 router to interact with DOCSIS 3.0-compliant cable modems in order to provide the best possible service in the event of non-primary RF channel disruptions such as loss of QAM, forward error correction (FEC) locks, and MDD time-outs. If a cable modem loses connectivity to the Cisco CMTS on one or all of its non-primary RF channels, the Cisco CMTS does not force the cable modem to perform a MAC reset and enables the cable modem to remain operational.

A DOCSIS 3.0-qualified CMTS transmits data to one or more DOCSIS 3.0-compliant cable modems using multiple RF channels. For a cable modem , one of the RF channels is used as the primary RF channel, and the rest of the channels are considered non-primary channels. The primary RF channel is defined as the DS RF channel where the cable modem receives DOCSIS MAC messages needed for US timing and synchronization.

This Wideband Modem Resiliency feature enables the CMTS to collect and analyze data related to RF channel disruptions per cable modem and identify the impairment. The MDD messages, sent on both primary capable and non-primary capable channels, informs the modem what status to report on a per-RF channel basis. The modem sends DOCSIS CM-STATUS messages in the US direction which the CMTS in turn analyzed for status indicating channel impairment. The CMTS is capable of determining if a subset of RF channels in a wideband channel are impaired, and temporarily dropping those channels out of the wideband channel for the modem to continue to receive bonded traffic. In this state, the modem is in wideband *partial* mode. When the impairment clears, the CMTS will automatically re-enable the RF channels.

For more information on how the Wideband Modem Resiliency feature enables the Cisco uBR10012 router to interact with DOCSIS 3.0-compliant cable modems, see the *Wideband Modem Resiliency* feature guide.

Dynamic Bandwidth Sharing

Dynamic bandwidth sharing (DBS) is the dynamic allocation of bandwidth for wideband (WB) and modular cable (MC) interfaces sharing the same DS channel. The bandwidth available to each WB, MC, or narrowband channel is not a fixed value—it depends on the configuration and the traffic load on the WB or MC.

DBS is achieved using a new type of modality called a link queue. Link queues represent a specific share of bandwidth on a particular channel. Link queues are used only to calculate the effective bandwidth of a channel, and such link queues are activated and deactivated according to the state of activity on a specific channel. DBS and static bandwidth allocations are configured at the WB or MC interface level. By default, bandwidth for a WB or MC channel is statically allocated. When DBS is enabled on an interface, the static bandwidth percentage is converted to a committed information rate (CIR) value for the corresponding link queue. The interface CIR value represents the guaranteed portion of the interface bandwidth and is used for admission control of the service flows with minimum reserved rate. When

DBS is enabled, you can also specify the remaining ratio value of the excess bandwidth for the link queue. If DBS is enabled and no bandwidth percentage is specified, no bandwidth is reserved for the WB or MC interface and the interface is effectively in protocol down state where link queues are not created.

DBS does not preclude static bandwidth configuration. If a static portion of bandwidth is configured on any RF channel that one or more DBS-enabled channel utilizes, that portion is subtracted from the CIR of the RF link. Therefore, such a portion is always reserved and is not available to dynamic WB or MC interfaces. The DBS feature continues working across line card and Performance Routing Engine (PRE) switchovers with no loss of functionality.

For more information on dynamic allocation of bandwidth for WB modems and MC interfaces, see the *Dynamic Bandwidth Sharing on the Cisco CMTS Router* feature guide.

DOCSIS WFQ Scheduler

The DOCSIS Weighted Fair Queuing (WFQ) Scheduler feature is an output packet scheduler that provides output scheduling services on both WAN uplink interfaces and DOCSIS DS interfaces.

In Cisco IOS Release 12.2(33)SCB, the DOCSIS WFQ scheduling engine is used to provide output packet scheduling services including absolute priority queueing, weighted fair queueing, minimum rate guarantee, shaping, and DOCSIS bonding group DBS on the Cisco uBR10012 router. It replaces the existing Versatile Traffic Management System (VTMS) scheduler.

For more details on the DOCSIS WFQ Scheduler, see the *DOCSIS WFQ Scheduler on the Cisco CMTS Routers* feature guide.

Voice Support on Wideband Modems

CMTS supports voice services on voice-enabled wideband (WB) cable modems. Committed information rate (CIR) DS service flows on WB interfaces are supported. You can reserve up to 90% of the wideband interface bandwidth. If multiple MAC domains (MDs) are sharing a WB interface, the available link rate is distributed evenly between all MDs that share the WB interface. If the MDs that share the WB interface are on the same line card, they share the CIR pool.

To display the reserved and available bandwidth, you can use the **show hw-module bay all association wideband** command for the Wideband SPA, or the **show controllers** command with the **association** keyword for the DOCSIS3.0 cable interface line cards. To display the reserved and available bandwidth for wideband interfaces, you can use the **show interface wideband-cable** command. For more information on these commands, see the *Cisco IOS CMTS Cable Command Reference Guide*.

Note In the Cisco IOS Release 12.2(33)SCB, new commands have not been introduced for this feature. However, you must first enable PacketCable or multimedia PacketCable to enable the voice support feature.

DOCSIS 3.0 Downstream Bonding for Bronze Certification

The DOCSIS 3.0 DS Bonding for Bronze Certification feature enables high-speed broadband access (100 Mbps) and helps offer more bandwidth-intensive services by adding one or more additional DS QAM channels to the standard broadband DOCSIS system. This new set of DS channels is grouped into a larger channel, known as a bonded channel.

For more information on the DOCSIS 3.0 DS Bonding for Bronze Certification, see the *DOCSIS 3.0 Downstream Bonding for Bronze Certification* feature guide.