**Downstream Interface Configuration**

This document describes how to configure the downstream interfaces on the Cisco cBR Series Converged Broadband Router.

- Finding Feature Information, on page 1
- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 1
- Information About Downstream Interface Configuration, on page 2
- How to Configure Downstream Interfaces, on page 4
- Configuration Examples, on page 9
- Additional References, on page 12
- Feature Information for Downstream Interface Configuration on the Cisco cBR Router, on page 12

**Finding Feature Information**

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

**Hardware Compatibility Matrix for the Cisco cBR Series Routers**

*Note*

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Table 1: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Supervisor:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-RF-PROT-PIC</td>
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<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
<td>• PID—CBR-D30-DS-MOD</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
<td>• PID—CBR-D30-US-MOD</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
<td></td>
</tr>
</tbody>
</table>

Information About Downstream Interface Configuration

Overview

• Each downstream port requires port level configuration and channel level configuration. Port level configuration is optimized with a frequency profile that defines ranges of frequencies available on the port. Channel level configuration is optimized with a QAM profile and channel range configuration block that auto-increments frequency and duplicates annex, modulation, and interleaver.

• Each channel requires a set of parameters: frequency, annex, modulation, interleaver, and DOCSIS channel id.

• Configuration is done in 4 major blocks of configuration:
  • QAM Profile—Example: “cable downstream qam-profile 1”
  • Frequency Profile—Example: “cable downstream freq-profile 2”
  • Port/Controller—Example: “controller Integrated-Cable 3/0/0”
  • RF Channel block—Example: “rf-chan 0 31”
**Downstream RF Port and Channel Management**

The downstream RF port and channel management feature is responsible for the configuration and management of the downstream RF ports and channels. Each downstream RF channel can be provisioned either as a DOCSIS or traditional MPEG video QAM channel.

**QAM Profile**

A QAM profile describes the common downstream channel modulator settings, referred to as physical layer parameters. This includes QAM constellation, symbol rate, interleaver-depth, spectrum-inversion, and annex. The QAM profile is described by CCAP DownPhyParams object. Default QAM profiles are supported and customized for DOCSIS or MPEG Video, which are described as DocsisPhyDefault and VideoPhyDefault objects, respectively.

A maximum of 32 QAM profiles can be defined. There are four system-defined QAM profiles (0 to 3), which cannot be deleted or modified. You can define profiles 4 to 31.

The system defined profiles are:

- **Profile 0 - default-annex-b-64-qam**
  - interleaver-depth: I32-J4
  - symbol rate: 5057 kilo-symbol/second
  - spectrum-inversion: off

- **Profile 1 - default-annex-b-256-qam**
  - interleaver-depth: I32-J4
  - symbol rate: 5361 kilo-symbol/second
  - spectrum-inversion: off

- **Profile 2 - default-annex-a-64-qam**
  - interleaver-depth: I12-J17
  - symbol rate: 6952 kilo-symbol/second
  - spectrum-inversion: off

- **Profile 3 - default-annex-a-256-qam**
  - interleaver-depth: I12-J17
  - symbol rate: 6952 kilo-symbol/second
  - spectrum-inversion: off

**Frequency Profile**

A frequency profile defines the ranges of frequencies available on a port. A maximum of 16 frequency profiles can be defined. There are four system-defined frequency profiles (0 to 3), which cannot be deleted or modified. You can define profiles 4 to 15.

The system defined profiles are:
• Profile 0 - annex-b-low, Frequency range (Hz): 90000000 - 863999999
• Profile 1 - annex-b-high, Frequency range (Hz): 234000000 - 1002999999
• Profile 2 - annex-a-low, Frequency range (Hz): 94000000 - 867999999
• Profile 3 - annex-a-high, Frequency range (Hz): 267000000 - 1002999999

The frequency ranges are defined using lanes and blocks:
• Four lanes per port, each lane can support 216 MHz range.
• Four blocks per lane, each block can support 54 MHz range.
• Lanes and blocks may have overlapping frequency ranges.

How to Configure Downstream Interfaces

This section contains the following:

Configuring the Cisco CMTS Manually Using Configuration Mode

Connect a console terminal to the console port on the I/O controller. When asked if you want to enter the initial dialog, answer no to go into the normal operating mode of the router. After a few seconds the user EXEC prompt (Router>) appears.

Configuring the QAM Profile on the Downstream Channels

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable Example: Router&gt; enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal Example: Router# configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>cable downstream qam-profile Qam_Profile_ID Example: Router(config)# cable downstream qam-profile 3</td>
<td>Defines or modifies a QAM profile.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>annex {A</td>
<td>B</td>
</tr>
</tbody>
</table>
### Configuring the Frequency Profile on the Downstream Channels

**Purpose**

**Command or Action**

**Step 5**
- **description** *LINE*
- **Example:**
  ```
  Router(config-qam-prof)# description qam1
  ```
- Name or description for this profile.

**Step 6**
- **Example:**
  ```
  Router(config-qam-prof)# interleaver-depth I64-J2
  ```
- Defines the interleaver depth. The default is I32 J4 for DOCSIS.

**Step 7**
- **modulation** {256 | 64}
- **Example:**
  ```
  Router(config-qam-prof)# modulation 64
  ```
- Defines the modulation. The default is 256QAM.

**Step 8**
- **spectrum-inversion** {off | on}
- **Example:**
  ```
  Router(config-qam-prof)# spectrum-inversion on
  ```
- Enables or disables spectrum inversion. Default is off.

**Step 9**
- **symbol-rate** *value*
- **Example:**
  ```
  Router(config-qam-prof)# symbol-rate 5057
  ```
- Defines the symbol rate. Value is in kilo-symbol/sec.

**Step 10**
- **exit**
- **Example:**
  ```
  Router(config-qam-prof)# exit
  ```
- Exits from the QAM profile configuration mode.

---

### Configuring the Frequency Profile on the Downstream Channels

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1**
- enable
- **Example:**
  ```
  Router> enable
  ```
- Enables privileged EXEC mode.
  Enter your password if prompted.

| **Step 2**
- configure terminal
- **Example:**
  ```
  Router# configure terminal
  ```
- Enters global configuration mode.

| **Step 3**
- cable downstream freq-profile *DS_frequency_profile_ID*
- **Example:**
  ```
  Router(config)# cable downstream freq-profile 4
  ```
- Defines or modifies a frequency profile.
### Configuring the Controller on the Downstream Channels

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> controller integrated-cable slot/subslot/port</td>
<td>Enters the controller sub-mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# controller Integrated-Cable 3/0/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> base-channel-power value</td>
<td>Sets the base channel power level. If not specified, the default value is calculated based on the number of carriers. Maximum limit is 34 dBmV DRFI. If you configure a value greater than the maximum specified by DRFI, the following message is displayed: Caution: RF Power above DRFI specification. May result in minor fidelity degradation.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-controller)# base-channel-power 26</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> freq-profile number</td>
<td>Specifies the frequency profile for the port.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-controller)# freq-profile 0</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Step 6 max-carrier <em>value</em></td>
<td>Specifies the maximum number of carriers.</td>
</tr>
<tr>
<td>Example: Router(config-controller)#max-carrier 1</td>
<td></td>
</tr>
<tr>
<td>Step 7 mute</td>
<td>Mutes the port. Use the no prefix to unmute the port. Default is &quot;no mute&quot;.</td>
</tr>
<tr>
<td>Example: Router(config-controller)#mute</td>
<td></td>
</tr>
<tr>
<td>Step 8 rf-chan <em>starting_Qam_ID ending_Qam_ID</em></td>
<td>Enters RF channel configuration sub-mode to configure an individual channel or a block of channels.</td>
</tr>
<tr>
<td>Example: Router(config-controller)#rf-chan 0 1</td>
<td></td>
</tr>
<tr>
<td>Step 9 shutdown</td>
<td>Changes the port administration state to down. Use the no prefix to change the port administration state to up.</td>
</tr>
<tr>
<td>Example: Router(config-controller)#shutdown</td>
<td></td>
</tr>
</tbody>
</table>

**Troubleshooting Tips**

**Shutting and No Shutting Downstream Controller Immediately**

**Problem** Shutting down a downstream controller on a cable line card and bringing the controller back up immediately can cause a Queue ID Pending Drain event on the system. This results in traffic disruption to the modems or modems going offline.

**Solution** It is recommended that you wait for a few seconds (>30 secs) before issuing the no shut command on a shut downstream controller. The system also restricts the user from issuing the no shut command immediately by printing this message.

```
Config change could not be applied as a cleanup is pending following shut on controller x/x/x. Please wait for the cleanup to complete before attempting to no shut controller.
```

**Configuring the RF Channel on a Controller**

The RF channel submode is entered from the channel controller configuration submode using the `rf-chan` command as described in the previous section. If an individual channel was specified in the `rf-chan` command, only that channel configuration is changed. If a block of channels was specified in the `rf-chan` command, the configuration change is applied to all channels in the block.
If the user tries to add a video type RF channel to a cable interface, the following message appears to reject the configuration:

\[X/X/X \text{ rf-channel XX is video type channel, it can't be configured as primary DS}\]

If a RF channel is configured under cable interface, when the user tries to change the channel type to video, the following message appears to reject the configuration:

\[X/X/X \text{ rf channel X can't be set to video type.}\]
\[\text{It is configured under Cable1/0/1.}\]
\[\text{Please remove the configuration before change the qam type}\]

---

### Step 1 docsis-channel-id \textit{dcid}

**Example:**

Router(config-rf-chan)#docsis-channel-id 1

Changes the channel DOCSIS channel identifier. In block mode, the value is assigned to the first channel and incremented for successive channels.

### Step 2 frequency \textit{value}

**Example:**

Router(config-rf-chan)#frequency 93000000

Configures the channel's center frequency in Hz. The available frequency range is determined from the port's frequency profile, if configured. If not configured, the available range will be the full port spectrum. In block mode, the frequency will be assigned to the first channel. Successive channels will get the next center frequency for the annex specified in the QAM profile (+6 Hz for Annex B, +8 Hz for Annex A).

### Step 3 mute

**Example:**

Router(config-rf-chan)#mute

Mutes the RF channel. Enter the \textit{no} prefix to unmute the channel. Default is "no mute".

### Step 4 power-adjust \textit{pwr_adj_range}

**Example:**

Router(config-rf-chan)#power-adjust 8.0 - 0.0 dBmV

Adjusts the RF channel's power.

### Step 5 qam-profile \textit{qam_profile_number}

**Example:**

Router(config-rf-chan)#qam-profile 0

Specifies the QAM profile for this channel.

### Step 6 rf-output \textit{value}

**Example:**

Router(config-rf-chan)#rf-output normal
Changes the RF output mode to test the channel.

**Step 7**  
**shutdown**  
**Example:**

```bash
Router(config-rf-chan)#shutdown
```

Changes the channel administration state to down. Use the **no** prefix to change the channel administration state to up. The default is "no shut".

**Step 8**  
**type value**  
**Example:**

```bash
Router(config-rf-chan)#type video
```

Configures the channel QAM type. The default is DOCSIS.

---

**Configuration Examples**

**Downstream Interface Configuration Example**

The example below shows the configuration of:

- QAM Profile—The system defined QAM profile for Annex B and 256 QAM.
- Frequency Profile—The system defined frequency profile annex-b-low.
- Controller and RF channel—Port 0 on slot 3/0 with frequency profile 0; 96 channels with QAM profile 1 and center frequencies starting at 93 MHz.

```bash
cable downstream qam-profile 1
 annex B
 modulation 256
 interleaver-depth I32-J4
 symbol-rate 5361
 spectrum-inversion off
 description default-annex-b-256-qam

 cable downstream freq-profile 0
 lane 1 start-freq 90000000
 block 1 start-freq 90000000
 block 2 start-freq 138000000
 block 3 start-freq 186000000
 block 4 start-freq 234000000
 lane 2 start-freq 282000000
 block 1 start-freq 282000000
 block 2 start-freq 330000000
 block 3 start-freq 378000000
 block 4 start-freq 426000000
 lane 3 start-freq 474000000
 block 1 start-freq 474000000
 block 2 start-freq 522000000
 block 3 start-freq 570000000
 block 4 start-freq 618000000
 lane 4 start-freq 666000000
 block 1 start-freq 666000000
```

---

Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.0
controller Integrated-Cable 3/0/0
max-carrier 128
base-channel-power 34
freq-profile 0
rf-chan 0 95
type DOCSIS
frequency 93000000
rf-output NORMAL
power-adjust 0
docsis-channel-id 1
qam-profile 1

Show Command Examples for Displaying the State

Use the following commands to display the state of any QAM profile, Frequency profile, downstream controller or channel.

QAM Profile Configuration Example

Router#show cable qam-profile 0
QAM Profile ID 0: default-annex-b-64-qam
  annex: B
  modulation: 64
  interleaver-depth: I32-J4
  symbol rate: 5057 kilo-symbol/second
  spectrum-inversion: off
Router#

Frequency Profile Configuration Example

Router#show cable freq-profile 0
Frequency Profile ID 0 annex-b-low:
  Lane 1 start-freq 90000000hz
    Block 1 start-freq 90000000hz
    Block 2 start-freq 138000000hz
    Block 3 start-freq 186000000hz
    Block 4 start-freq 234000000hz
  Lane 2 start-freq 282000000hz
    Block 1 start-freq 282000000hz
    Block 2 start-freq 330000000hz
    Block 3 start-freq 378000000hz
    Block 4 start-freq 426000000hz
  Lane 3 start-freq 474000000hz
    Block 1 start-freq 474000000hz
    Block 2 start-freq 522000000hz
    Block 3 start-freq 570000000hz
    Block 4 start-freq 618000000hz
  Lane 4 start-freq 666000000hz
    Block 1 start-freq 666000000hz
    Block 2 start-freq 714000000hz
    Block 3 start-freq 762000000hz
    Block 4 start-freq 810000000hz
Router#
Controller Configuration Example

Router#show controller Integrated-Cable 3/0/0 rf-port
  Admin: UP  MaxCarrier: 128  BasePower: 34 dBmV  Mode: normal
  Rf Module 0: UP
  Frequency profile: 0
  Free freq block list has 1 blocks:
    666000000 - 863999999
  Rf Port Status: UP
Router#

RF Channel Configuration Example

Router#show controller integrated-Cable 3/0/0 rf-channel 0-3 95
  Chan State Admin Frequency Type Annex Mod srate Interleaver dcid power output
  0 UP UP 93000000 DOCSIS B 256 5361 I32-J4 1 34 NORMAL
  1 UP UP 99000000 DOCSIS B 256 5361 I32-J4 2 34 NORMAL
  2 UP UP 105000000 DOCSIS B 256 5361 I32-J4 3 34 NORMAL
  3 UP UP 111000000 DOCSIS B 256 5361 I32-J4 4 34 NORMAL
  95 UP UP 663000000 DOCSIS B 256 5361 I32-J4 96 34 NORMAL

Router# show controller integrated-Cable 3/0/0 rf-channel 0 verbose
  Chan State Admin Frequency Type Annex Mod srate Interleaver dcid power output
  0 UP UP 93000000 DOCSIS B 256 5361 I32-J4 1 34 NORMAL
    Qam profile: 1
    Spectrum Inversion: Off
    Frequency Lane: 1  Block: 1  index: 1
    Resource status: OK
    License: granted <02:00:04 EDT Jan 2 2012>
    JIB channel number: 0
  Chan EnqQ Pipe RAF SyncTmr Vid Mac Video Primary DqQ TM Mpts Sniff
    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  Grp Prio P Prate Phy0-ctl Phy1-ctl Enable Tun-Id L2TPv3 Ses_id
    0 0 0 1 1 0 TRUE 0 0
  Chan Qos-Hi Qos-Lo Med-Hi Med-Lo Low-Hi Low-Lo
    0 32774 16384 16384 65536 32768
  Chan Med Low TB-neg Qos_Exc Med_Xof Low_Xof Qdrops Pos Qlen(Hi-Med-lo) Fl
    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  DSPHY Info:
    DSPHY Register Local Copy: QPRHI = c0000163, QPRLO = e30d0
    DSPHY Register Local Copy Vaddr = 80000290, qam2max_mapping = 80000000
    DSPHY Register Local Copy: SPR ID = 0, SPR Mapping= c200000a
    Last read from HW: Mon Jan  2 02:02:04 2012
  SPR ID 0, rate value in kbps 0, overflow count 0, underflow count 0

Router# sh controllers Integrated-Cable 7/0/0 counter rf-channel
  Controller RF MPEG MPEG MPEG Sync MAP/UCD User QAM
  Chan Packets bps Mpts Packets Packets Mbps Util
    7/0/0 0 0 0 0 0 0 0 0 0 0
    7/0/0 1 0 0 0 0 0 0 0 0 0
    7/0/0 2 8239954 2475952 02.47 0 0 0.00 0.00 0.00 0.00
    7/0/0 3 85927382 25769779 25.76 0 0 0.00 0.00 0.00 0.00
    7/0/0 4 85927608 25769027 25.76 0 0 0.00 0.00 0.00 0.00
    7/0/0 5 8239088 2475999 02.47 0 0 0.00 0.00 0.00 0.00
    7/0/0 6 8210840 2463770 02.46 0 0 0.00 0.00 0.00 0.00
    7/0/0 7 50103 15040 00.01 0 0 0.00 0.00 0.00 0.00
    7/0/0 8 50103 15040 00.01 0 0 0.00 0.00 0.00 0.00

Router# show cable licenses ds
  Entitlement: Downstream License
Additional References

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
<tr>
<td>documentation and tools for troubleshooting and resolving technical issues</td>
<td></td>
</tr>
<tr>
<td>with Cisco products and technologies.</td>
<td></td>
</tr>
<tr>
<td>To receive security and technical information about your products, you can</td>
<td></td>
</tr>
<tr>
<td>subscribe to various services, such as the Product Alert Tool (accessed from</td>
<td></td>
</tr>
<tr>
<td>Field Notices), the Cisco Technical Services Newsletter, and Really Simple</td>
<td></td>
</tr>
<tr>
<td>Syndication (RSS) Feeds.</td>
<td></td>
</tr>
<tr>
<td>Access to most tools on the Cisco Support website requires a Cisco.com user</td>
<td></td>
</tr>
<tr>
<td>ID and password.</td>
<td></td>
</tr>
</tbody>
</table>

Feature Information for Downstream Interface Configuration on the Cisco cBR Router

Use Cisco Feature Navigator to find information about the platform support and software image support.
Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Table 2: Feature Information for Downstream Interface Configuration

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Interface Configuration</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
<tr>
<td>Feature Name</td>
<td>Releases</td>
<td>Feature Information</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Display QAM Utilization Percentage using the <code>sh controllers Integrated-Cable 7/0/0 counter rf-channel</code></td>
<td>Cisco IOS XE Gibraltar 16.10.1f</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 2

Upstream Interface Configuration

This document describes how to configure the upstream interfaces on the Cisco cBR Series Converged Broadband Router.

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• Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 15
• Information About Upstream Interface Configuration, on page 16
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• Configuration Examples, on page 20
• Additional References, on page 21
• Feature Information for Upstream Interface Configuration on the Cisco cBR Router, on page 21

Finding Feature Information

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Information About Upstream Interface Configuration

The cable interface in the Cisco cBR router supports upstream signals and serves as the radio frequency (RF) interface. This chapter provides an overview of the upstream interfaces on the Cisco cBR Series Converged Broadband Router.

Cisco IOS-XE Fuji 16.9.1 and later releases support 10 Gbps of upstream throughput on the following line cards on the Cisco cBR Series Converged Broadband Router:

- CBR-CCAP-LC-40G
- CBR-CCAP-LC-40G-R

Upstream Channel Management

Upstream Channel Management (UCM) is responsible for the physical (PHY) layer configuration and resource management of upstream channels in the Cisco cBR Series Converged Broadband Router.
Upstream Controller

An upstream port represents a physical upstream RF connector on a cable line card, connected to one or more fiber nodes. An upstream RF port is a container of upstream RF channels, which imposes constraints on both topology and spectrum for the group of RF channels contained in the physical port. An upstream RF port also represents the RF front-end hardware component on a cable line card including the connector, variable gain adjustment (VGA), and A/D converter. This is directly connected to a set of upstream physical channel receivers. The number of upstream physical channels per port is thus constrained by the number of receivers accessible to the port.

Upstream Channel

An upstream RF channel represents DOCSIS physical layer operation on a single upstream center frequency with a particular channel width. It is contained by a single physical port on the CMTS line card hardware.

Upstream Resource Management

The upstream resource management (URM) feature is primarily responsible for the maintenance of the relationship between a physical upstream connector on the line card and the upstream RF channels received on that connector.

How to Configure Upstream Interfaces

This section contains the following:

Configuring the Cisco CMTS Manually Using Configuration Mode

Connect a console terminal to the console port on the I/O controller. When asked if you want to enter the initial dialog, answer no to go into the normal operating mode of the router. After a few seconds the user EXEC prompt (Router>) appears.

Configuring the Modulation Profile and Assigning to an Upstream Channel

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router&gt;</td>
<td>enable</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router#</td>
<td>configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>cable modulation-profile profile mode_of_oper qam_profile</td>
<td>Creates a preconfigured modulation profile, where the burst parameters are set to their default values for each burst type.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Configuring the Upstream Channel with PHY Layer

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> controller upstream-cable slot/subslot/port</td>
<td>Specifies the controller interface line card and enters upstream controller config configuration submode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# controller upstream-cable 1/0/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> us-channel rf-channel frequency freq-val</td>
<td>Assigns frequency to an RF channel on a controller interface.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-controller)# us-channel 1 frequency 20000000</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> us-channel rf-channel docsis-mode mode</td>
<td>Assigns DOCSIS mode to an RF channel on a controller interface.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-controller)# us-channel 1 docsis-mode tdma</td>
<td></td>
</tr>
</tbody>
</table>
**Upstream Interface Configuration**

### Associating Upstream Channels with a MAC Domain and Configuring Upstream Bonding

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td><code>us-channel rf-channel channel-width value</code></td>
<td>Assigns channel width in Hertz to an RF channel on a controller interface.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-controller)# us-channel 1 channel-width 3200000</code></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><code>us-channel rf-channel modulation-profile profile</code></td>
<td>Assigns modulation profile to an RF channel on a controller interface.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-controller)# us-channel 1 modulation-profile 21</code></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><code>no us-channel rf-channel shutdown</code></td>
<td>Enables the upstream channel.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-controller)# no us-channel 1 shutdown</code></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><code>end</code></td>
<td>Exits upstream controller configuration submode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-controller)# end</code></td>
<td></td>
</tr>
</tbody>
</table>

### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><code>interface cable slot/subslot/cable-interface-index</code></td>
<td>Specifies the cable interface line card on a Cisco CMTS router.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# interface cable 7/0/0</code></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><code>downstream integrated-cable slot/subslot/port rf-channel rf-chan [upstream grouplist]</code></td>
<td>Associates a set of upstream channels to the integrated downstream channels.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-if)# downstream integrated-cable 7/0/0 rf-channel 3 upstream 3</code></td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

#### Step 5
`upstream md-us-chan-id`<br>`upstream-cable slot/subslot/port`<br>`us-channel rf-channel`<br>
**Example:**
Router(config-if)# upstream 0 upstream-cable 7/0/0 us-channel 0

**Purpose:** Associates a set of physical upstream channels with the Mac Domain.

#### Step 6
`cable upstream bonding-group id`<br>
**Example:**
Router(config-if)# cable upstream bonding-group 200

**Purpose:** Creates the upstream bonding group on the specified cable interface and enters upstream bonding configuration submode.

#### Step 7
`upstream number`<br>
**Example:**
Router(config-upstream-bonding)# upstream 1

**Purpose:** Adds an upstream channel to the upstream bonding group. A maximum of 16 upstream channels can be configured for each MAC Domain, which are divided into two groups:
- Group 1: upstream channel 0-7
- Group 2: upstream channel 8-15

The **upstream bonding-group** should include all the upstream channels either from Group 1 or Group 2 only.

#### Step 8
`attributes value`<br>
**Example:**
Router(config-upstream-bonding)# attributes eeeeeeee

**Purpose:** Modifies the attribute value for the specified upstream bonding group.

#### Step 9
`end`<br>
**Example:**
Router(config-upstream-bonding)# end

**Purpose:** Exits upstream bonding configuration submode and returns to privileged EXEC mode.

### Configuration Examples

#### Upstream Channel with PHY Layer Configuration Example

```plaintext
...
us-channel 0 frequency 20000000
us-channel 0 channel-width 3200000 3200000
us-channel 0 power-level 0
us-channel 0 docsis-mode tdma
us-channel 0 minislot-size 2
us-channel 0 modulation-profile 21
no us-channel 0 shutdown
...
```

#### Upstream Channels with a MAC Domain Configuration Example

```plaintext
...
```
interface Cable8/0/0
downstream Modular-Cable 8/0/0 rf-channel 0
upstream 0 Upstream-Cable 8/0/0 us-channel 0
upstream 1 Upstream-Cable 8/0/0 us-channel 1
cable mtc-mode
cable upstream bonding-group 1
upstream 0
upstream 1
attributes 80000000

Additional References

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
<tr>
<td>documentation and tools for troubleshooting and resolving technical issues</td>
<td></td>
</tr>
<tr>
<td>with Cisco products and technologies.</td>
<td></td>
</tr>
<tr>
<td>To receive security and technical information about your products, you can</td>
<td></td>
</tr>
<tr>
<td>subscribe to various services, such as the Product Alert Tool (accessed from</td>
<td></td>
</tr>
<tr>
<td>Field Notices), the Cisco Technical Services Newsletter, and Really Simple</td>
<td></td>
</tr>
<tr>
<td>Syndication (RSS) Feeds.</td>
<td></td>
</tr>
<tr>
<td>Access to most tools on the Cisco Support website requires a Cisco.com user</td>
<td></td>
</tr>
<tr>
<td>ID and password.</td>
<td></td>
</tr>
</tbody>
</table>

Feature Information for Upstream Interface Configuration on the Cisco cBR Router

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream Interface Configuration</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
Feature Information for Upstream Interface Configuration on the Cisco cBR Router
CHAPTER 3

DOCSIS Interface and Fiber Node Configuration

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 23
- Overview of DOCSIS Interfaces and Fiber Node Configurations, on page 24
- Configuring DOCSIS Interfaces and Fiber Nodes, on page 25
- Configuring MAC Domain Service Groups, on page 31
- Downstream Bonding Group Configuration, on page 34
- Upstream Bonding Group Configuration, on page 38
- Additional References, on page 41
- Feature Information for DOCSIS Interface and Fiber Node Configuration, on page 41

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Table 5: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
</tr>
</tbody>
</table>

Overview of DOCSIS Interfaces and Fiber Node Configurations

The Interface line card used in the Cisco cBR chassis is an integrated line card that has two downstream modules and one upstream module. The line cards support DOCSIS 3.0 features including downstream bonding groups, and upstream bonding groups.

Downstream Features

Physically, the DS (downstream) modules support eight physical connectors or ports. The DS modules support the following features:

- The DS modules support eight downstream integrated-cable controllers for these eight ports. Each downstream integrated-cable controller is associated with an RF port.
- Each downstream controller supports up to 128 downstream channels (0-127).
- Each downstream controller can be configured with 128 integrated-cable interfaces. Therefore, each line card has 1024 integrated-cable interfaces.
• Each integrated-cable interface has a static mapping to an integrated-cable controller RF channel. For example, Integrated-Cable interface 3/0/0:0 is mapped to RF Channel 0 on Integrated-Cable controller 3/0/0.
• 768 downstream DOCSIS channels may be configured on each line card.
• A total of 512 wideband-cable interfaces (downstream bonding groups) may be configured on each line card.
  • Each wideband-cable interface supports a maximum of 64 downstream channels.
  • 128 of the 512 wideband-cable interfaces (downstream bonding groups) may contain 33 or more channels.

Upstream Features

The Interface line card has one upstream module supporting 16 physical connectors or ports. The upstream features are as follows:
  • The line card supports 16 upstream-cable controllers, each mapping to one upstream connector.
  • 12 upstream channels can be configured per upstream controller.
  • 12 upstream channels can be enabled per pair of upstream controllers.

For more details on the upstream features, see the Downstream Upstream Guide.

MAC Domains (Cable Interfaces)

1. 16 MAC domains (cable interfaces) may be configured per line card.
2. Maximum of 16 upstream channels can be configured in each MAC domain.
3. A maximum of 255 downstream channels may be added to a MAC domain.
4. Maximum number of primary capable downstream channels per MAC Domain is 32. Non Primary downstream channels are added automatically to the MAC domains when the fiber nodes are configured.

Fiber Nodes

512 fiber nodes may be configured for each Cisco cBR-8 chassis.

Configuring DOCSIS Interfaces and Fiber Nodes

Configuring Upstream Channels

Verifying the Controller Configuration

Use the `show controllers upstream-cable` command to verify the configuration of the upstream channels in the controllers. Use the modifier `| include upstream` to see the administrative and operational state of the controllers.

```
Router# show controllers upstream-cable 1/0/0 | include upstream
Controller 1/0/0 upstream 0 AdminState:UP OpState: UP
```
Controller 1/0/0 upstream 1 AdminState:UP OpState: UP
Controller 1/0/0 upstream 2 AdminState:UP OpState: UP
Controller 1/0/0 upstream 3 AdminState:UP OpState: UP
Controller 1/0/0 upstream 4 AdminState:DOWN OpState: DOWN (Reason: Default)
Controller 1/0/0 upstream 5 AdminState:DOWN OpState: DOWN (Reason: Default)
Controller 1/0/0 upstream 6 AdminState:DOWN OpState: DOWN (Reason: Default)
Controller 1/0/0 upstream 7 AdminState:DOWN OpState: DOWN (Reason: Default)

Router#

## Binding Upstream Channels to MAC Domain

By default, a MAC domain does not contain any upstream channels. This section describes the configurations necessary to bind one or more upstream channels to a MAC domain. Each upstream channel is bound to only one MAC domain. The MAC domain and the upstream channel must reside on the same line card (same slot). If required, the upstream channels within the same upstream controller can be bound to different MAC domains.

### Before you begin

**Restrictions**

- A maximum of 8 upstream channels may be bound to one MAC domain.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Enters MAC Domain configuration mode. Values for slot are 0-3 and 6-9, for subslot is always 0, for MD Index is 0-15.</td>
</tr>
<tr>
<td><code>interface cable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong><code>Router# interface cable 1/0/0</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Binds the specified upstream channel to the MAC Domain.</td>
</tr>
<tr>
<td><code>upstream upstream-Cable us-channel</code></td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong><code>Router(config-if)# upstream 4 upstream-Cable 1/0/0 us-channel 7</code></td>
<td></td>
</tr>
</tbody>
</table>
**What to do next**

To verify MAC Domain configurations for upstream, use the `show cable mac-domain` command with `cgd-associations` keyword.

The MD US Binding table shows the upstream channel binding.

```
Router# show cable mac-domain c1/0/0 cgd-associations
Load for five secs: 1%/0%; one minute: 2%; five minutes: 2%
CGD Host Resource DS Channels Upstreams (ALLUS) Active DS
Ca1/0/0 1/0/0 8 0-1 Yes 8
       16 0-1 Yes 16
       24 0-1 Yes 24
       32-33 0-1 Yes 32-33
       40 0-1 Yes 40
```

The MD US Binding:

```
Host MD Controller US channel State
Ca1/0/0 U0 1/0/0 0 UP
Ca1/0/0 U1 1/0/0 1 UP
Ca1/0/0 U2 1/0/0 2 UP
Ca1/0/0 U3 1/0/0 3 UP
Ca1/0/0 U4 1/0/0 0 UP
Ca1/0/0 U5 1/0/0 1 UP
Ca1/0/0 U6 1/0/0 2 UP
Ca1/0/0 U7 1/0/0 3 UP
```

**Configuring Primary Capable Downstream Channels**

**Verifying Downstream Configuration in Controller**

Use the `show controller Integrated-Cable` command to verify the status of the downstream channels configured on an Integrated-cable controller.

```
Router# show controller Integrated-Cable 1/0/0 rf-channel 0-127
Chan State Admin Frequency Type Annex Mod srate Interleaver dcid power output
0 UP UP 381000000 DOCSIS B 256 5361 I32-J4 1 32 NORMAL
1 UP UP 387000000 DOCSIS B 256 5361 I32-J4 2 34 NORMAL
2 UP UP 393000000 DOCSIS B 256 5361 I32-J4 3 34 NORMAL
3 UP UP 399000000 DOCSIS B 256 5361 I32-J4 4 34 NORMAL
```
Configuring Integrated-cable Interface

Configure an integrated-cable interface to prepare a downstream channel for inclusion within a MAC Domain as a primary-capable downstream channel. The interface configuration provides the following advantages:

• It enables the allocation of bandwidth to the downstream channel.
• It enables the control of the administrative state (shut/no shut) of the channel interface.

The time interval required between the shut and no shut administrative states for the same controller is approximately 30 seconds. You must not change the shut and no shut states rapidly without any delay in script or copy-paste. It can generate unexpected errors.

Each integrated-cable interface is mapped statically to an integrated-cable controller RF channel. For example, IC interface 1/0/0:0 is mapped to IC controller 1/0/0 RF channel 0. Similarly, IC interface 1/0/0:1 is mapped to IC controller 1/0/0 RF channel 1.

IC controllers are numbered 0-7 and RF Channels on each controller are numbered 0-127.

Before you begin

Determine the percentage of bandwidth to allocate to a channel. The bandwidth percentage configured is converted to a committed information rate (CIR) value for the interface. The value is used to admit non-bonded service flows on this channel. For more information, see the Dynamic Bandwidth Sharing on the Cisco CMTS Router.

---

**Step 1**

`enable`

**Example:**

```
Router> enable
```

Enables privileged EXEC mode.

Enter your password if prompted.

**Step 2**

`configure terminal`

**Example:**

```
Router# configure terminal
```

Enters global configuration mode.

**Step 3**

`interface integrated-cable`

**Example:**

```
Router(config)# interface integrated-cable 1/0/0:0
```

Enter the integrated-cable interface configuration mode for specified integrated-cable interface.

**Step 4**

`cable rf-bandwidth-percent percentage-number`

**Example:**

```
Router(config-if)# cable rf-bandwidth-percent 30
```

Configures the bandwidth allocation to the specified integrated-cable interface.
Step 5  end

Example:
Router# end

Returns to privileged EXEC mode.

What to do next

The following conditions are used to determine if an IC (Integrated-Cable) interface is up in current software.

- The IC interface is associated to a MD (MAC Domain) interface.
- The MD interface, which the IC interface associated to, is in UP state.
- The IC interface is not configured shutdown.
- The IC interface is configured with bandwidth.
- The associated downstream channel within the IC controller is operationally up.

Use the `show interface Integrated-Cable controller` command to verify the status of the specified integrated-cable interface. The State info table provides information to diagnose issues affecting the operational state of the interface.

Router# show interface Integrated-Cable 1/0/0:0 controller
Integrated-Cable1/0/0:0 is up, line protocol is up
...
State info (DSNB if and its underlying states)
DSNB IF state : UP
RF Chan state : UP
RF Chan frequency : 38100000
Bandwidth configured on DSNB IF : YES
Inject Header/HW flow creation status : DSNB_IF_SM_UP
MD state (9/0/0) : UP
*DSNB i/f Line State : UP

Binding Primary Capable Downstream Channels to a MAC Domain

After a downstream channel has a properly configured Integrated-cable interface, it may be bound to a MAC Domain as a primary capable channel. The Channel Grouping Domain (CGD) configuration allows specified downstream channels to be bound to a MAC Domain as primary capable channels. Optionally, it also allows downstream channels to be associated with a subset of upstream channels within the MAC domain.

Before you begin

Restrictions

- The downstream channel and MAC domain must reside on the same line card (same slot)
- A maximum of 32 primary capable downstream channels may be bound to a single MAC domain
Step 1  enable
Example:
Router> enable
Enables privileged EXEC mode.
Enter your password if prompted.

Step 2  configure terminal
Example:
Router# configure terminal
Enters global configuration mode.

Step 3  interface cable
Example:
Router# interface cable 1/0/0
Enters MAC domain configuration mode.
• slot—Specifies the chassis slot number of the interface line card. Valid values are 0-3 and 6-9
• subslot—Specifies the secondary slot number of the interface line card. Valid subslot is 0.
• MD index—Specifies the MAC Domain index number. Valid values are 0-15.

Step 4  downstream Integrated-Cable slot/subslot/port rf-channels grouplist
Example:
Router# downstream Integrated-Cable 1/0/0 rf-channels 1-6
Configures the downstream primary capable channels.
• grouplist—Specify the range of downstream rf-channels.

Step 5  end
Example:
Router# end
Returns to privileged EXEC mode.

What to do next
To verify the downstream primary capable channels, use the show cable mac-domain command with cgd-associations keyword.

Router#show cable mac-domain cl/0/0 cgd-associations
Load for five secs: 1%/0%; one minute: 2%; five minutes: 2%
Configuring MAC Domain Service Groups

Configuring the Fiber Nodes

A maximum of 512 fiber nodes may be configured per CMTS. A fiber node configured on the CMTS represents one or more matching physical fiber nodes in the HFC plant. The CMTS uses the fiber node configuration to identify the DOCSIS downstream service group (DS-SG) and DOCSIS upstream Service Group (US-SG) of the physical fiber nodes in the plant. The Service Group information is compared with MAC Domain channel configuration to automatically calculate the MAC Domain downstream and upstream service groups (MD-DS-SGs and MD-US-SGs respectively) within the MAC Domains.

The following is required to create a valid fiber node configuration.

- Each fiber node configuration must include at least one downstream controller and one upstream controller.
- Every MAC Domain and Wideband Interface including channels within the fiber node must use the same bundle interface.
- All downstream channels included within the fiber node must be assigned a unique frequency.
- All downstream channels associated with a particular MAC Domain must be assigned a unique DOCSIS channel ID.

If automatic DOCSIS channel ID allocation is preferred over manual DOCSIS channel ID configuration, the `cable downstream-channel-id automatic` command may be used to enable automatic DOCSIS channel ID allocation for the CMTS.

For details, see the Cisco CMTS Cable Command Reference.

Step 1: enable

Example:
Router> enable
Enables privileged EXEC mode.
Enter your password if prompted.

Step 2 configure terminal
Example:
Router# configure terminal
Enters global configuration mode.

Step 3 cable fiber-node id
Example:
Router(config)# cable fiber-node 1
Router(config-fiber-node)#
Enters cable fiber-node configuration mode to configure a fiber node
  * id — cable fiber node ID. The valid range is 1-512.

Step 4 downstream Integrated-Cable slot/subslot/port
Example:
Router(config-fiber-node)# downstream Integrated-Cable 1/0/0
Adds the DOCSIS downstream channels within the controller to the fiber node.

Step 5 upstream upstream-Cable slot/subslot/port
Example:
Router(config-fiber-node)# upstream upstream-Cable 1/0/0
Adds the upstream channels within the controller to the fiber node.

Step 6 end
Example:
Router# end
Returns to privileged EXEC mode.

What to do next
To verify the fiber-node configuration use the show cable fiber-node command.

Router# show cable fiber-node 1
-------------------------------------------------------------------------------
Fiber-Node 1
Description: Feed Mac Domain: Cable1/0/0
Channel(s) : downstream Integrated-Cable 1/0/0: 0-3, 32-35, 64-67, 96-99
The output shows the downstream channel IDs configured on a fiber node. It also shows the status of the upstream-cable configured on the fiber node. Further, it shows the status of MAC Domain Descriptor (MDD) messaging.

Verify MD-DS-SG Channel Membership

Once the fiber node is valid, the MD-DS-SGs within the associated MAC domains will be automatically populated with downstream channels. The MD-DS-SGs will include the active primary downstream channels within the MAC domain as well as non-primary downstream channels automatically associated with the MAC domain through the fiber node configuration. The non-primary channels must be properly configured within the controller (that are operationally up) to be included in MD-DS-SGs.

Use the `show cable mac-domain` command with the `downstream-service-group` option to display the MD-DS-SG channel membership.

To verify that the primary downstream channels are transmitting MAC Management Messages (MMMs) use the `show controller Integrated-Cable counter rf-channel` command.

Verify MD-US-SG Channel Membership

Use the `show cable mac-domain` command with the `upstream-service-group` option to display the MD-US-SG channel membership.
**Downstream Bonding Group Configuration**

### Configuring Wideband-cable Interface (Downstream Bonding Grouping)

A Wideband-Cable interface forwards bonded traffic in the downstream direction. A set of downstream RF channels is configured under the Wideband interface. Each line card will support up to 512 Wideband interfaces. Although there is no real relationship between these wideband interfaces and the 8 controllers (ports), there is a convention of dividing the wideband interfaces into groups per controller.

The 512 wideband interfaces are divided among the 8 controllers - 64 interfaces per controller.

You can create a wideband-cable interface to define a downstream bonding group. A downstream bonding group bonds together a set of downstream RF channels. It can only contain the RF channels from the same line card.

Associations between bonding groups and MAC Domains are automatically created. Associations occur when a bonding group channel set is found to be a subset of a MAC Domain Downstream Service Group (MD-DS-SG) within a MAC Domain. The automatic associations will trigger the creation of an RCC that contains the bonding group’s channel set within the MAC Domain.

**Before you begin**

**Restrictions:**

1. Included downstream channels must be a part of the same line card slot.
2. All the downstream channels must be from the integrated-cable controllers 0-3 or 4-7.

---

**Step 1** enable

**Example:**

```
Router> enable
```

Enables privileged EXEC mode.

Enter your password if prompted.

**Step 2** configure terminal

**Example:**

```
Router# configure terminal
```
Enters global configuration mode.

Step 3  
(interface wideband-Cable
Example:

Router(config)#interface wideband-Cable 1/0/0:1
Router(config-if)#

Enter the wideband-cable interface configuration mode for specified wideband-cable interface.

Step 4  
cable bundle id
Example:

Router(config-if)#cable bundle 1

Configures the cable bundle id for this wideband-cable interface. The configured cable bundle id must match the cable bundle id configured in associated MAC domains.
  • Bundle number — cable bundle number. The valid range is 1-255.

Step 5  
cable rf-channels channel-list grouplist bandwidth-percent percentage-bandwidth
Example:

Router(config-if)#cable rf-channel channel-list 1-3 bandwidth-percent 10

Configures the bandwidth allocation for specified channel-list and includes the channels in the downstream bonding group. Range for channel numbers are 0-127 (<first channel num-last channel num>).
  • grouplist — Specify the range of downstream rf-channels.

Step 6  
cable rf-channels controller controller number channel-list grouplist bandwidth-percent percentage-bandwidth
Example:

Router(config-if)#cable rf-channel controller 1 channel-list 1-3 bandwidth-percent 10

Configures the bandwidth allocation for specified channel-list on downstream controllers and includes the channels in the downstream bonding group. Range for channel numbers are 0-127.
  • controller number — Downstream controller number. The valid numbers are 0-7.
  • grouplist — Specify the range of downstream rf-channels.

Step 7  
end
Example:

Router# end

Returns to privileged EXEC mode.
What to do next
Verify the Bonding Group Interfaces.

Verifying the Bonding Group Interfaces

Use **wideband-channel** option of the **show controllers integrated-Cable** command to display bonding group interfaces:

```
Router# show controllers integrated-cable 1/0/0 wideband-channel
```

```
Load for five secs: 2%/0%; one minute: 2%; five minutes: 2%
Time source is NTP, *17:45:51.964 PST Thu Jan 12 2012
WB                  BG Primary
channel    ID   BG
Wideband-Cable1/0/0:0 12289 Yes
Wideband-Cable1/0/0:1 12290 Yes
Wideband-Cable1/0/0:2 12291 Yes
Wideband-Cable1/0/0:3 12292 Yes
Wideband-Cable1/0/0:4 12293 Yes
Wideband-Cable1/0/0:5 12294 Yes
Wideband-Cable1/0/0:6 12295 Yes
Wideband-Cable1/0/0:7 12296 Yes
Wideband-Cable1/0/0:8 12297 Yes
Wideband-Cable1/0/0:9 12298 Yes
Wideband-Cable1/0/0:10 12299 Yes
Wideband-Cable1/0/0:11 12300 Yes
Wideband-Cable1/0/0:12 12301 Yes
Wideband-Cable1/0/0:13 12302 Yes
Wideband-Cable1/0/0:14 12303 Yes
Wideband-Cable1/0/0:15 12304 Yes
Wideband-Cable1/0/0:16 12305 Yes
Wideband-Cable1/0/0:17 12306 Yes
Wideband-Cable1/0/0:18 12307 Yes
Wideband-Cable1/0/0:19 12308 Yes
Wideband-Cable1/0/0:20 12309 Yes
Wideband-Cable1/0/0:21 12310 Yes
Wideband-Cable1/0/0:22 12311 Yes
Wideband-Cable1/0/0:23 12312 Yes
Wideband-Cable1/0/0:24 12313 Yes
Wideband-Cable1/0/0:25 12314 Yes
```

- To display the RF-channel mapping to wideband channels, use **mapping wb-channel** option.

```
Router# show controllers Integrated-Cable 1/0/0 mapping wb-channel 0
Ctrlr       WB    RF       WB %       WB Rem
1/0/0:0     0     1/0/0:0  40        1
            1     1/0/0:1  40        1
```

- To display the downstream MAC Domain service groups, use the **dsbg-associations** option of the **show cable mac-domain** command.

```
Router# show cable mac-domain c1/0/0 dsbg-associations
Wi1/0/0:0   Wi1/0/0:1
```

Use the **show interface Wideband-Cable controller** command to verify the bonding group configurations. The State info table shows the downstream bonding group state information.
Router# show interface Wideband-Cable 1/0/0:0 controller
Wideband-Cable1/0/0:0 is up, line protocol is up
Hardware is CMTS WB interface, address is c414.3c17.1dcb (bia c414.3c17.1dcb)
MTU 1500 bytes, BW 150000 Kbit/sec, DLY 1000 usec
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation MCNS, loopback not set
Keepalive set (10 sec)
ARP type: ARPA, ARP Timeout 04:00:00
Last input never, output never, output hang never
Last clearing of "show interface" counters never
Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
Conversations 0/0/256 (active/max active/max total)
Available Bandwidth 112500 kilobits/sec
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts (0 multicasts)
0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
0 packets output, 0 bytes, 0 underruns
0 output errors, 0 collisions, 3 interface resets
0 unknown protocol drops
0 output buffer failures, 0 output buffers swapped out

BG controller details
Wi1/0/0:0 BGID: 12289
Member RFIDs:
Config RFIDs: 12288-12291 Count: 4
Active RFIDs: 12288-12291 Count: 4
Attribute mask: 0x80000000

State info (DSBG if and its underlying states)
----------------------------------------------
DSBG IF state : UP
DSBG Member RF chan states : UP (4 out of 4 chans are UP)
DSBG HWID(FCID) : 0x3800
*DSBG i/f Line State : UP
----------------------------------------------
DMP Resources
DMP handle : 0x10000800
----------------------------------------------
DMP BG pool entry details
HW-id BGid BGSize Enabled
0 12289 4 1
----------------------------------------------
Bgid Bgcnt Bgaddr Channels (1023 means invalid/Unused)
0 0 0: 0 1 2 3 1023 1023 1023 1023
BG Rate Neg Pos LastTS CurrCr Pos
0 25000 65535 65535 0 0 N
----------------------------------------------
RFID - JIB chan mapping for active RFIDs: [rfid:jib-chan-no]
[12288:0] [12289:1] [12290:2] [12291:3]

Router#
Upstream Bonding Group Configuration

Restrictions for Upstream Bonding Groups

- Upstream bonding groups are configured within the MAC Domain interface.
- Upstream bonding groups consist of a set of upstream channels that are bonded together.
- A maximum of 16 upstream channels can be configured for each MAC Domain, which are divided into two groups:
  - Group 1: upstream channel 0-7
  - Group 2: upstream channel 8-15

The `upstream bonding-group` should include all the upstream channels either from Group 1 or Group 2 only.

Configuring Upstream Bonding Groups

Before you begin

Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2 configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3 interface cable slot/subslot/MD index</td>
<td>Enters MAC domain configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface cable 1/0/0</td>
<td></td>
</tr>
<tr>
<td>Step 4 cable upstream bonding-group</td>
<td>Creates a static upstream bonding group on a MAC Domain.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
</tbody>
</table>
### Purpose
Command or Action

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| `Router(config-if)#cable upstream bonding-group 7`<br>`Router(config-upstream-bonding)#` | Add upstream channels to an upstream bonding group. A maximum of 16 upstream channels can be configured for each MAC Domain, which are divided into two groups:  
  - Group 1: upstream channel 0-7  
  - Group 2: upstream channel 8-15  
  
  The **upstream bonding-group** should include all the upstream channels either from Group 1 or Group 2 only. |
| `Router(config-upstream-bonding)#upstream 7` | **Step 5**  
  **Example:**  
  `Router(config-upstream-bonding)#upstream 7` |
| `Router(config-upstream-bonding)#end` | **Step 6**  
  **Example:**  
  `Router# end` |

**What to do next**

Use the `show interface cable upstream bonding-group` command to display upstream bonding group information.

```
Router#show interface cable 1/0/0 upstream bonding-group  
Load for five secs: 1%/0%; one minute: 2%; five minutes: 2%  
Time source is NTP, *10:47:17.142 PST Thu Jan 12 2012  
Cable1/0/0: Upstream Bonding Group 1  
  0 packets input, 0 octets input  
  Segments: 0 valid, 0 discarded, 0 lost  
  Reserved Bandwidth Max : 0 bits/sec  
  Reserved Bandwidth : 0 bits/sec  
  Available Bandwidth : 46080000 bits/sec  
  Total Service Flows On This Bonding Group: 0  
Cable1/0/0: Upstream Bonding Group 2  
  0 packets input, 0 octets input  
  Segments: 0 valid, 0 discarded, 0 lost  
  Reserved Bandwidth Max : 0 bits/sec  
  Reserved Bandwidth : 0 bits/sec  
  Available Bandwidth : 46080000 bits/sec  
  Total Service Flows On This Bonding Group: 0  
Cable1/0/0: Upstream Bonding Group 65536  
  0 packets input, 0 octets input  
  Segments: 0 valid, 0 discarded, 0 lost  
  Reserved Bandwidth Max : 0 bits/sec  
  Reserved Bandwidth : 0 bits/sec  
  Available Bandwidth : 15360000 bits/sec  
  Total Service Flows On This Bonding Group: 0  
Cable1/0/0: Upstream Bonding Group 65537  
  0 packets input, 0 octets input  
  Segments: 0 valid, 0 discarded, 0 lost  
  Reserved Bandwidth Max : 0 bits/sec  
  Reserved Bandwidth : 0 bits/sec  
  Available Bandwidth : 15360000 bits/sec  
  Total Service Flows On This Bonding Group: 0  
```

Router#
Verifying Upstream Bonding Groups

Use the show cable upstream bonding-group command.

Router#show interface cable 1/0/0 upstream bonding-group
Load for five secs: 1%/0%; one minute: 2%; five minutes: 2%
Time source is NTP, *10:47:17.142 PST Thu Jan 12 2012

Cable1/0/0: Upstream Bonding Group 1
   0 packets input, 0 octets input
   Segments: 0 valid, 0 discarded, 0 lost
   Reserved Bandwidth Max : 0 bits/sec
   Reserved Bandwidth : 0 bits/sec
   Available Bandwidth : 46080000 bits/sec
   Total Service Flows On This Bonding Group: 0

Cable1/0/0: Upstream Bonding Group 2
   0 packets input, 0 octets input
   Segments: 0 valid, 0 discarded, 0 lost
   Reserved Bandwidth Max : 0 bits/sec
   Reserved Bandwidth : 0 bits/sec
   Available Bandwidth : 46080000 bits/sec
   Total Service Flows On This Bonding Group: 0

Cable1/0/0: Upstream Bonding Group 65536
   0 packets input, 0 octets input
   Segments: 0 valid, 0 discarded, 0 lost
   Reserved Bandwidth Max : 0 bits/sec
   Reserved Bandwidth : 0 bits/sec
   Available Bandwidth : 15360000 bits/sec
   Total Service Flows On This Bonding Group: 0

Cable1/0/0: Upstream Bonding Group 65537
   0 packets input, 0 octets input
   Segments: 0 valid, 0 discarded, 0 lost
   Reserved Bandwidth Max : 0 bits/sec
   Reserved Bandwidth : 0 bits/sec
   Available Bandwidth : 15360000 bits/sec
   Total Service Flows On This Bonding Group: 0

Router#
Additional References

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
</tbody>
</table>

Feature Information for DOCSIS Interface and Fiber Node Configuration

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS Interface and Fiber Node Configuration</td>
<td>Cisco IOS XE Everest 16.6.1</td>
<td>This feature was integrated into Cisco IOS XE Everest 16.6.1 on the cisco cBR Series Converged Broadband Routers.</td>
</tr>
<tr>
<td>Display QAM Utilization Percentage using the <code>sh controllers</code> <code>Integrated-Cable 7/0/0 counter rf-channel</code></td>
<td>Cisco IOS XE Gibraltar 16.10.1f</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
Service Group Based Configuration of the Cisco cBR Router

Service Group Profile Based Configuration

The DOCSIS Interface and Fiber Node Configuration guide describes the interface and fiber node configurations that are required to operationalize the Cisco cBR router. The steps described to accomplish the tasks involved in such configuration are complex.

To simplify and speed up the process of configuring the physical and logical interfaces required to deploy the Cisco cBR router quickly, a service group (SG) profile based approach is adopted. This document describes the simplified SG profile approach.

This approach provides the following advantages:

• Improves and simplifies the deployment of Cisco cBR router.
• Improves and simplifies the configuration of Cisco cBR Router by eliminating duplicate configurations.
• Improves and simplifies troubleshooting of Cisco cBR router.
• Supports faster Converged Cable Access Platform (CCAP) provisioning by using common and quick replication across nodes and regions.

To configure the interfaces and quickly operationalize the Cisco cBR router, a set of common profiles are created and are created and configured into global service group profiles. These global service group profiles may be applied to fiber node interfaces along with a mapping of the service group interfaces to the physical interfaces.

Common profiles are profiles which contain configurations for common service group (SG) interfaces like MAC domain, wideband-cable, and primary downstream.

The common profiles and the global SG profiles may be independent of the topology of the network in which they are applied. The SG interface to physical interface mapping defines the behavior of the profiles in the topology that the SG profiles have been applied to.
Limitations:

• A common profile cannot be deleted if it is associated with the fiber nodes. It can be modified by entering the profile configuration mode using the cable profile command.

• A service-group profile cannot be deleted or modified if it is associated with the fiber nodes.

• To associate a new global SG profile to a fiber node, dissociate the currently associated global SG profile from the fiber node.

• To configure for a unique topology, use the full configuration approach provided in DOCSIS Interface and Fiber Node Configuration guide.

• When the secondary line card is in active mode, the following limitations apply:
  • A MAC domain, Wideband-Cable interface, downstream channel, and SG profile cannot be modified when they are associated with the fiber nodes.
  • SG profile cannot be dissociated from the fiber nodes.
  • A MAC domain, Wideband-Cable interface, downstream channel, and SG profile can be created but cannot be associated to the fiber node.
  • To enable the SG operation simplification feature, auto-reset feature must be enabled using the cable wideband auto-reset command.

• Do not support downgrade cBR-8 image from 16.7.x to previous image if the configuration includes mac domain split configuration.

Broadly, the following steps define and deploy the common profiles and the SG profiles:

1. Define and configure the Common profiles: The SG interface profiles or the common profiles contain configuration parameters common to a group of similar interfaces. For example, a profile may contain specific configuration parameters shared by multiple Wideband-Cable interfaces, associated across multiple line cards. A common profile is configured at the global or chassis level. All interfaces associated with a profile will inherit the configuration in the profile. Any common profile may be associated with any global SG profile. Use the cable profile profile-type profile-name command to define the following common profiles:
   • MAC Domain (MD) profile
   • Primary Downstream channel (DS) profile
   • Wideband-cable Interface (WB) profile
   • Global Service Group (SG) profile

2. Complete the following configurations to the fiber node interface using the cable fiber-node command:
   • Define the downstream and upstream ports. Map the appropriate interface-cable using the downstream interface-cable command. Map the appropriate upstream-cable interface using the upstream upstream-cable command.
   • Use the downstream sg-channel command to map the logical downstream SG channels to the physical RF channels and the upstream sg-channel command to map the logical upstream SG channels to the physical upstream channels.
   • Use the service-group profile to associate the global service group profile to the fiber node.
See the use case scenarios for configurations and examples.

Service Profile Configuration for 16x8 with One MAC Domain

This section describes the service group based configurations for a 16x8 service group with one MAC domain.

**Step 1**

**cable profile**  `profile-type`  `profile-name`

For MAC Domain profile, specify `profile-type` as **mac-domain**.

```
Router(config)# cable profile mac-domain MD1
Router(config-profile-md)# cable dynamic-secret mark
Router(config-profile-md)# cable shared-secret 0 cisco
Router(config-profile-md)# cable ip-init ipv4
Router(config-profile-md)# cable mtc-mode
Router(config-profile-md)# cable mrc-mode
Router(config-profile-md)# cable privacy mandatory
Router(config-profile-md)# cable privacy bpi-plus-policy
```

For Primary downstream profile, specify `profile-type` as **downstream**.

```
Router(config)# cable profile downstream DS1
Router(config-profile-ds)# cable rf-bandwidth-percent 20
Router(config-profile-ds)# cable attribute-mask 0x80000000
```

For wideband-cable interface profile, specify `profile-type` as **wideband-interface**.

```
Router(config)# cable profile wideband-interface BG1
Router(config-profile-wb)# cable downstream attribute-mask 0x80000000
```

For global service group profile, specify `profile-type` as **service-group**. In the service group profile, configure the cable bundle associated, mac-domain profile, and the wideband interface profile

```
Router(config)# cable profile service-group SG-16x8-1_1
Router(config-profile-sg)# cable bundle 71
Router(config-profile-sg)# mac-domain 0 profile md1
Router(config-profile-sg-md)# downstream sg-channel 0-7 profile ds1 upstream 0-3
Router(config-profile-sg-md)# upstream 0 sg-channel 0
Router(config-profile-sg-md)# upstream 1 sg-channel 1
Router(config-profile-sg-md)# upstream 2 sg-channel 2
Router(config-profile-sg-md)# upstream 3 sg-channel 3
Router(config-profile-sg-md)# upstream 4 sg-channel 4
Router(config-profile-sg-md)# upstream 5 sg-channel 5
Router(config-profile-sg-md)# upstream 6 sg-channel 6
Router(config-profile-sg-md)# upstream 7 sg-channel 7
Router(config-profile-sg-md-usbg)# us-bonding-group 1
Router(config-profile-sg-md-usbg)# upstream 1
Router(config-profile-sg-md-usbg)# upstream 2
Router(config-profile-sg-md-usbg)# upstream 3
Router(config-profile-sg-md-usbg)# upstream 4
Router(config-profile-sg-md-usbg)# upstream 5
Router(config-profile-sg-md-usbg)# upstream 6
```
Step 2  cable fiber-node

Enter fiber-node configuration mode. Configure the following in fiber-node configuration mode:

- downstream port
- upstream port
- downstream sg-channels to rf-channels mapping
- upstream sg-channels to us-channels mapping
- global service group mapping
- managed MAC domain

Router(config)#cable fiber-node 1
Router(config-fiber-node)#downstream integrated-cable 3/0/0
Router(config-fiber-node)#upstream upstream-cable 3/0/0
Router(config-fiber-node)#downstream sg-channel 0 15 integrated-cable 3/0/0 rf-channel 0 15
Router(config-fiber-node)#upstream sg-channel 0 7 upstream-cable 3/0/0 us-channel 0 7
Router(config-fiber-node)#service-group profile SG-16X8-1_1

What to do next

Use the `show cable fiber-node [id] mapping` and the `show cable fiber-node [id] derived` commands to check the configuration of the interfaces.

Router#show cable fiber-node 1 mapping
Fiber-node 1:
Upstream:
<table>
<thead>
<tr>
<th>Sg chan</th>
<th>Us-chan</th>
<th>Op</th>
<th>state</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3/0/0</td>
<td>Up</td>
<td></td>
</tr>
</tbody>
</table>
Downstream:
<table>
<thead>
<tr>
<th>Sg chan</th>
<th>Ds-rf-chan</th>
<th>Op</th>
<th>state</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3/0/0:0</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3/0/0:1</td>
<td>Up</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3/0/0:2</td>
<td>Up</td>
<td></td>
</tr>
</tbody>
</table>
Router# show cable fiber-node 1 derived
Fiber-node 1:  interface  Assoc succeeded
mac-domain 0  Cable3/0/0  Y
Wideband 1  Wideband-Cable3/0/0:0  Y

Use the show cable mac-domain fiber-node command to verify the interface associations.

Router# show cable mac-domain fiber-node 1 md 0 downstream-service-group
Cable  MD-DS-SG  RF
IF  Id  Resource  Chan  Primary Chan
C3/0/0
Router#

Router# show cable mac-domain fiber-node 1 md 0 upstream-service-group
Cable  MD  3/0/0
Router#

Service Profile Configuration for 16x8 with Two MAC Domains

This section describes the service group based configurations for a 16x8 service group with two MAC domains, split downstream and overlaid upstream channels.

**Step 1**  cable profile  profile-type  profile-name

For MAC Domain profile, specify *profile-type* as *mac-domain*.

Router(config)# cable profile mac-domain MD1
Router(config-profile-md)# cable dynamic-secret mark
Router(config-profile-md)# cable shared-secret 0 cisco
Router(config-profile-md)# cable ip-init ipv4
Router(config-profile-md)# cable mtc-mode
Router(config-profile-md)# cable mrc-mode
Router(config-profile-md)# cable privacy mandatory
Router(config-profile-md)# cable privacy bpi-plus-policy

For Primary downstream profile, specify *profile-type* as *downstream*.
For wideband-cable interface profile, specify `profile-type` as `wideband-interface`.

For global service group profile, specify `profile-type` as `service-group`. In the service group profile, configure the cable bundle associated, mac-domain profile, and the wideband interface profile.

**Step 2**

cable fiber-node

Enter fiber-node configuration mode. Configure the following in fiber-node configuration mode:

- downstream port
- upstream port
- downstream sg-channels to rf-channels mapping
- upstream sg-channels to us-channels mapping
- global service group mapping
- managed MAC domain
Router(config-fiber-node)#service-group profile SG-16X4-1_2
Router(config-fiber-node)#exit
Router(config)#

Router(config)#cable fiber-node 2
Router(config-fiber-node)#downstream integrated-cable 3/0/0
Router(config-fiber-node)#upstream upstream-cable 3/0/1
Router(config-fiber-node)#downstream sg-channel 0 7 integrated-cable 3/0/0 rf-channel 8 15
Router(config-fiber-node)#downstream sg-channel 0 7 integrated-cable 3/0/0 rf-channel 8 15
Router(config-fiber-node)#downstream sg-channel 0 3 upstream-cable 3/0/1 us-channel 0 3
Router(config-fiber-node)#service-group profile SG-16X4-1_2
Router(config-fiber-node)#exit
Router(config)#

**What to do next**

Use the `show cable fiber-node [id] mapping` and the `show cable fiber-node [id] derived` commands to check the configuration of the interfaces.

## MAC-Domain Split Configuration

This section describes the MAC-domain split configurations.

**Note**

- In MAC domain split scenario, we must configure upstream peer-node-us and managed MAC domain.
- After a fiber node managed MAC domain, we will reserve cable interface by `cable managed fiber-node` command.
- If a fiber-node has peer, we can not add managed MAC domain.
- If a fiber-node has peer, we can not modify the configuration of channel mapping and upstream peer-node-us.
- If a fiber-node has managed MAC domain, we can not remove upstream peer-node-us.
- Only both two fiber-nodes are associated with service group profile, mac-domains and wideband interfaces will be generated.
- MAC domain and wideband interfaces will be removed as soon as one fiber-node is unassociated with service group profile.

### Step 1: cable profile mac-domain

Define global common profiles for MAC-domain, bonding group, primary downstream.

Router(config)#cable profile mac-domain MD
MAC-Domain Split Configuration

Router(config-profile-md)#load-interval 30
Router(config-profile-md)#cable dynamic-secret mark
Router(config-profile-md)#cable shared-secret 0 cisco
Router(config-profile-md)#cable ip-init ipv4
Router(config-profile-md)#cable mtc-mode
Router(config-profile-md)#cable mrc-mode
Router(config-profile-md)#cable privacy mandatory
Router(config-profile-md)#cable privacy bpi-plus-policy
Router(config-profile-md)#cable privacy accept-self-signed-certificate
Router(config-profile-md)#cable privacy eae-policy capability-enforcement
Router(config-profile-md)#cable privacy dsx-support
Router(config-profile-md)#cable privacy retain-failed-certificates
Router(config-profile-md)#cable privacy skip-validity-period
Router(config-profile-md)#cable privacy tek life-time 180
Router(config-profile-md)#cable cm-status enable 3
Router(config-profile-md)#cable map-advance dynamic
Router(config-profile-md)#cable upstream 0 attribute-mask FFFFFFFF
Router(config-profile-md)#cable upstream 0 power-adjust continue 5
Router(config-profile-md)#cable downstream balance-scheduling
Router(config)#cable profile downstream DS
Router(config-profile-ds)#cable rf-bandwidth-percent 20
Router(config-profile-ds)#cable attribute-mask 0x80000000
Router(config)#cable profile wideband-interface BG
Router(config-profile-wb)#cable downstream attribute-mask 0x80000000
Router(config-profile-wb)#description BG
Router(config-profile-wb)#load-interval 30

Step 2

In the service group profile, configure the cable bundle associated, mac-domain profile, and the wideband interface profile.

Router(config)#cable profile service-group MD_SPLIT
Router(config-profile-sg)#cable bundle 1
Router(config-profile-sg)#mac-domain 0 profile MD
Router(config-profile-sg-md)#downstream sg-channel 0-15 profile DS
Router(config-profile-sg-md)#upstream 0 sg-channel 0
Router(config-profile-sg-md)#upstream 1 sg-channel 1
Router(config-profile-sg-md)#upstream 2 sg-channel 2
Router(config-profile-sg-md)#upstream 3 sg-channel 3
Router(config-profile-sg-md)#upstream 4 sg-channel 4
Router(config-profile-sg-md)#upstream 5 sg-channel 5
Router(config-profile-sg-md)#upstream 6 sg-channel 6
Router(config-profile-sg-md)#upstream 7 sg-channel 7
Router(config-profile-sg-md)#us-bonding-group 1
Router(config-profile-sg-md-usbg)#upstream 0
Router(config-profile-sg-md-usbg)#upstream 1
Router(config-profile-sg-md-usbg)#upstream 2
Router(config-profile-sg-md-usbg)#upstream 3
Router(config-profile-sg-md-usbg)#attributes 8000000
Router(config-profile-sg-md-usbg)#exit
Router(config-profile-sg)#wideband-interface 0 profile WB
Router(config-profile-sg-bg)#downstream sg-channel 0 7 rf-bandwidth-percent 1
Router(config-profile-sg-bg)#exit
Router(config-profile-sg)#wideband-interface 1 profile WB
Step 3  cable fiber-node

Enter fiber-node configuration mode. Configure the following in fiber-node configuration mode:

- downstream port
- upstream port
- downstream sg-channels to rf-channels mapping
- upstream sg-channels to us-channels mapping
- abstract upstream channel
- managed MAC domain
- global service group mapping

Router(config)#cable fiber-node 67
Router(config-fiber-node)#downstream integrated-cable 6/0/6
Router(config-fiber-node)#upstream upstream-cable 6/0/6
Router(config-fiber-node)#downstream sg-channel 0 15 integrated-cable 6/0/6 rf-channel 0 15
Router(config-fiber-node)#upstream sg-channel 0 3 upstream-cable 6/0/6 us-channel 0 3
Router(config-fiber-node)#upstream sg-channel 4 7 peer-node-us
Router(config-fiber-node)#service-group managed md 0 cable6/0/6
Router(config-fiber-node)#service-group profile MD_SPLIT

Router(config)#cable fiber-node 69
Router(config-fiber-node)#downstream integrated-cable 6/0/6
Router(config-fiber-node)#upstream upstream-cable 6/0/1
Router(config-fiber-node)#downstream sg-channel 0 15 integrated-cable 6/0/6 rf-channel 0 15
Router(config-fiber-node)#upstream sg-channel 4 7 upstream-cable 6/0/1 us-channel 0 3
Router(config-fiber-node)#upstream sg-channel 0 3 peer-node-us
Router(config-fiber-node)#service-group managed md 0 cable6/0/6
Router(config-fiber-node)#service-group profile MD_SPLIT
MAC-Domain Split Configuration
CHAPTER 5

DOCSIS Load Balancing Groups

First Published: April 11, 2015

Support for the restricted load balancing group (RLBG)/general load balancing group (GLBG) is based on DOCSIS 3.0 specifications.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 53
- Prerequisites for DOCSIS Load Balancing Groups, on page 54
- Restrictions for DOCSIS Load Balancing Groups, on page 55
- Information About DOCSIS Load Balancing Groups, on page 56
- How to Configure DOCSIS Load Balancing Groups, on page 62
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Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
## Prerequisites for DOCSIS Load Balancing Groups

DOCSIS Load Balancing Groups including Restricted/General Load Balancing groups with Downstream Dynamic Load Balancing feature has the following prerequisites:

- A RLBG and a DOCSIS 2.0 GLBG should have a load balancing group (LBG) ID.
- A LBG should have a default policy ID.
- During registration, a cable modem (CM) that has been assigned to a LBG must also be assigned a policy ID and priority, through Simple Network Management Protocol (SNMP), the cable modem configuration file, or Cisco Cable Modem Termination System (CMTS) configuration.
- The cable modem must send service type identifier (STID), service class name, and DOCSIS version and capability type/length/value (TLV) settings to the Cisco CMTS for registration if the fields are used by general tagging.

### Prerequisites for DOCSIS Load Balancing Groups

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
</table>
Restrictions for DOCSIS Load Balancing Groups

The DOCSIS Load Balancing Groups (LBG) including RLBG/GLBG Support with DLB Support feature has the following restrictions:

- A maximum of 256 DOCSIS policies and 256 rules per chassis are supported.
- Cross-line card (LC) configuration or moving of cable modems is not supported.
- When deployed with channel restriction features, if the target upstream channel attribute masks are against that of the cable modem, then the cable modem on the higher load upstream will not be load balanced, as the current load balancing moves cable modems only to the target upstream. However, cable modems that do not have an attribute mask can still be load balanced. You should consider the following while deploying the load balancing groups: the target upstream will always be the upstream that has the lowest load. If some other upstreams have the same load, the upstream with the lowest index will be chosen as the target upstream.
- We recommend all LBGs that share channels must use the same LB method.

The DOCSIS LBG with RLBG/GLBG Support and DLB Support feature have the following cross functional restrictions:

- Cable modems operating in the multiple transmit channel (MTC) mode do not register for a RLBG assignment, even if their configuration file contains relevant TLVs, such as STID and LBG ID. However, cable modems operating in the multiple receive channel (MRC) can register for a RLBG assignment.
- The Cisco CMTS can parse a specific TLV encoded in cable modem configuration file, and prohibit any DCC operation on the cable modems.
- DOCSIS MAC domain downstream service group (MD-DS-SG) channels in MDD messages are incorrect when a combination of channels from multiple line card types are placed in the same fiber node.

In a complex fiber node setup, with channels from more than one line card, or downstream channels of one MAC domain in more than one fiber node, some modems may not come w-online (wideband online). If a MAC domain has more than one MD-DS-SG, the MDD will contain more than one MD-DS-SG and cause the modem to perform downstream ambiguity resolution. When the modem analyzes the downstream channels from the other line card, it will not see MDD packets and disqualify the channel and the MD-DS-SG. The modem then sends a requested MD-DS-SG of 0 to the CMTS implying it will not participate in a bonding group.

Use the `show cable mac-domain downstream-service-group` command to see the channels in the same MD-DS-SG.

The DOCSIS LBG with RLBG/GLBG Support and DLB Support feature have the following scaling limitations:

- The total number of RLBGs and DOCSIS 2.0 GLBGs cannot exceed 256.
- The total number of tags in a Cisco CMTS cannot exceed 256.
- The total number of DOCSIS 3.0 GLBGs is bounded by free memory.
- A cable modem reset occurs if a CM moves from one cable interface to another because DCC init-tech 0 resets a cable modem during a LB move. A cable modem also resets if the two cable interfaces have been configured with a mismatched `cable ip-init` command.
Information About DOCSIS Load Balancing Groups

The DOCSIS 2.0 “Autonomous Load Balancing” specification is CM-centric, allowing a channel (US or DS) to be part of multiple RLBGs. Therefore, with the DOCSIS 2.0 specifications, you can decide on which channel the CM can be load balanced.

To configure the Restricted/General Load Balancing and Narrowband Dynamic Bandwidth Sharing with Downstream Dynamic Load Balancing feature, you should understand the following concepts:

Service-Based Load Balancing

Using the DOCSIS 3.0 modem-based load balancing specifications, you can manage the LB activity on a per-modem basis as follows:

1. Modem to RLBG association through STID
2. Modem to RLBG association through LBG ID
3. Per-modem LB policy assignment
4. Per-modem LB priority assignment
5. Per-modem channel restriction

Implementing the DOCSIS 3.0 modem-based LB specifications enables the Cisco CMTS to provide an advanced service-based LB. The service-based LB can be used to alleviate the burden for the modem-based provisioning and provide the operator an ability to selectively control LB activity based on modem service type. For example, for LB purposes modems can be classified based on:

- Device type
- DOCSIS version
- Service class

The results of the classification can then be used to selectively control the modem LB activity by mapping the modem to the following settings:

- LBG
- Policy

With the service-based LB enabled, existing service-based cable modem segregation features and channel restriction become special cases and can be handled within the same LB framework.

Functionality

The Cisco CMTS functions in the following ways for general tagging and service-based LB:

- The Cisco CMTS can classify some modems with user-defined modem classifiers using the STID, service class name, DOCSIS version and capability TLVs and MAC Organization Unique Identifier (OUI).
- Each modem classifier has a unique tag. The Cisco CMTS allows each modem to carry one tag. When multiple tags match one cable modem, the tag that has the least index gets applied on the cable modems.
- The Cisco CMTS classifies a CM and assigns a tag, and if a RLBG with that tag is configured, the CM gets assigned to that RLBG.
- The Cisco CMTS can match multiple tags to a RLBG and a DOCSIS policy.
- On the Cisco CMTS, a user can configure whether the general tagging overrides the RLBG or DOCSIS policy assignment using TLVs in the CM configuration file and SNMP when a conflict occurs.
• When doing autonomous LB, the Cisco CMTS ensures that the target channels are available to a specific CM with regard to admission control, the SF attribute masks, and CM attribute masks.
• The user can configure the number of times that a DCC fails a CM before the CM is removed from dynamic LB on the Cisco CMTS.
• The user can configure DCC initialization techniques or whether to use Upstream Channel Change (UCC) for a LBG or for a particular source and target pair on the Cisco CMTS. However, DCC is not issued to cable modems provisioned in DOCSIS 1.0 mode. By default, the UCC for a LBG is not configured and therefore, all channel changes are done through DCC.
• The Cisco CMTS supports LB on at least one logical channel on a physical US channel that has multiple logical US channels.
• As per the DOCSIS 3.0 specifications, a lower load balancing priority indicates a higher likelihood that a CM will be moved due to load balancing operations.
• You can create a policy to set the lower bandwidth for CMs. the LBG can only move cable modems with throughput that is above the threshold.

Compatibility
Both downstream and upstream autonomous load balancing is supported for single channel cable modems.

RLBG/GLBG Assignment
The user can configure one or more service type IDs for each RLBG. The user can also configure the Cisco CMTS, using CLI or SNMP, to restrict a particular cable modem to a certain STID and RLBG ID. However, if such a configuration is made, both the STID and RLBG ID in the configuration file are ignored by the Cisco CMTS.

When the STID is configured by CLI or SNMP or the STID is present in the cable modem configuration file, the Cisco CMTS selects an upstream and downstream channel, which offers the signaled service type, from a RLBG, if such channels exist. However, if an upstream and downstream channel do not exist that provide the signaled service type the Cisco CMTS assigns an upstream and downstream channel that does not offer the signaled service type.

When the LBG ID is configured by CLI or SNMP or the LBG ID is present in the cable modem configuration file, the Cisco CMTS examines the available choices for upstream and downstream channels and, if they include a channel pair associated with the signaled LBG, the Cisco CMTS assigns the cable modem to the signaled LBG. If these conditions are not met, the Cisco CMTS disregards the LBG ID.

If there are multiple upstream and downstream channels available that meet the requirements of the STID, if present, and the LBG ID, if present, the Cisco CMTS selects an upstream and/or downstream channel that meet the cable modem required and forbidden attribute masks requested in the configuration file. If upstream and downstream channels are not available that meet these criteria, the Cisco CMTS can disregard the cable modem attribute masks and select an alternative upstream and/or downstream channel.

In determining a target channel pair for a cable modem during registration time, the Cisco CMTS tries to find the target channel pair that can actually reach the cable modem by checking the current channel pair, the MD-DS-SG-ID (Media Access Control Domain Downstream Service Group Identifier) of cable modem (CM-DS-SG-ID) and the MD-US-SG-ID (Media Access Control Domain Upstream Service Group Identifier) of cable modem (CM-US-SG-ID), if present, and fiber node (FN) configurations. If the target channel pair is available to the cable modem and is different from the current channel pair, the Cisco CMTS is required to move the CM by means of DCC technique 0 or downstream frequency override (DFO).

When the Cisco CMTS identifies multiple candidate RLBGs for a CM, but cannot determine which fiber node configuration the cable modem is actually wired to, or cannot determine if the wired RLBG is unusable (when
interfaces in the load balance group are disabled or in an administratively down state), the Cisco CMTS assigns the cable modem to the RLBG with the lowest group index. This assignment causes the Cisco CMTS to attempt to move the cable modem to interfaces it is not physically connected to, resulting in service outages for the CM.

The Cisco CMTS enforces fiber node checking during RLBG assignment.

The Cisco CMTS follows the following RLBG assignment rules:

- If there is no fiber node configuration, there is no change in the candidate RLBG list. However, if the fiber node is configured, the fiber node must be configured correctly to reflect the real fiber node connection.
- If the cable modem is inside a fiber node, only those RLBGs that are inside that fiber node are selected.
- If the cable modem is not inside any fiber node, that is, the fiber node configuration does not cover all the channels, only those RLBGs that are not inside any fiber node are selected.
- If an RLBG spans across multiple fiber nodes, it is not considered to be inside any fiber node.
- If no candidate RLBG is found, cable modems are assigned to the GLBG, if the GLBG exists.

Channel Assignment

For cable modems operating in MRC mode, the registration request message can have multiple TLVs to influence the selection of upstream and downstream channels that the Cisco CMTS assigns. To avoid conflicts between the multiple TLVs, the Cisco CMTS follows the precedence order defined below:

1. TLV 56—Channel Assignment
2. TLV 43.11—Service Type Identifier
3. TLV 43.3—Load Balancing Group ID
4. TLVs 24/25.31-33—Service Flow Attribute Masks
5. TLV 43.9—CM Attribute Masks

The Cisco CMTS must follow this TLV precedence order for cable modems not operating in MRC mode:

1. TLV 43.11—Service Type Identifier
2. TLV 43.3—Load Balancing Group ID
3. TLV 43.9—CM Attribute Masks
4. TLVs 24/25.31-33—Service Flow Attribute Masks

Note

When a target for the new receive channel configuration (RCC) and Transmit channel configuration (TCC) is selected, ensure that the service level for cable modems is not decreased. Target total RCCs and TCCs must not be less than the source total RCCs and TCCs so that cable modems can keep their service level unchanged. This may cause some unbalanced results when high capacity cable modems come online, later releases..

The Cisco CMTS also considers the DOCSIS 3.0 cable modem capabilities defined in the registration request message and assigns the maximum number of channels that the CM requests.

The tables below define the load balancing matrix for RLBG and GLBG assignment:

Table 8: RLBG Assignment for DOCSIS Cable Modems

<table>
<thead>
<tr>
<th>Operational Mode</th>
<th>MAC Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS 3.0 CM</td>
<td>DOCSIS 2.x CM</td>
</tr>
</tbody>
</table>

DOCSIS Load Balancing Groups
Table 9: GLBG Assignment for DOCSIS Cable Modems

<table>
<thead>
<tr>
<th>Operational Mode</th>
<th>MAC Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-MRC mode (online)</td>
<td>DOCSIS 3.0 CM Assigned</td>
</tr>
<tr>
<td></td>
<td>DOCSIS 2.x CM Assigned</td>
</tr>
<tr>
<td></td>
<td>DOCSIS 2.0 CM Assigned</td>
</tr>
<tr>
<td></td>
<td>DOCSIS 1.1 CM Assigned</td>
</tr>
<tr>
<td></td>
<td>DOCSIS 1.0 CM Assigned</td>
</tr>
<tr>
<td>MRC mode only (w-online)</td>
<td>DOCSIS 3.0 cable modems are assigned to the DOCSIS 3.0 RLBG</td>
</tr>
<tr>
<td></td>
<td>DOCSIS 3.0 GLBG with MD-DS-SG-ID/MD-US-SG-ID</td>
</tr>
<tr>
<td>MRC/MTC mode (UB-online)</td>
<td>DOCSIS 3.0 cable modems are assigned to the DOCSIS 3.0 RLBG</td>
</tr>
</tbody>
</table>

Table 10: Load Balancing Method to Move Bonded and Non-bonded cable modems

<table>
<thead>
<tr>
<th>Modem Mode</th>
<th>Dynamic Service Charge (Initialization Technique)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Within MAC Domain</td>
</tr>
<tr>
<td>DOCSIS 3.0 cable modems in MTC mode</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 11: Using DCC/DBC to Load Balance Bonded and Non-bonded Cable Modems

<table>
<thead>
<tr>
<th>Channel</th>
<th>CM in MRC, non-MTC Mode</th>
<th>DOCSIS 1.1/DOCSIS 2.0 cable modems with Single US/DS</th>
<th>DOCSIS 1.0 cable modems with Single US/DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream (US)</td>
<td>DCC</td>
<td>DCC</td>
<td>UCC</td>
</tr>
<tr>
<td>Downstream (DS)</td>
<td>NA (within the same MAC domain)</td>
<td>DCC (within the same MAC domain).</td>
<td>Force reinitialize CM</td>
</tr>
<tr>
<td></td>
<td>DCC with initialization technique 0 when moving cable modems across MAC domains.</td>
<td>DCC with initialization technique 0 when moving cable modems across MAC domains.</td>
<td>Force reinitialize CM</td>
</tr>
</tbody>
</table>

Error Handling of Channel Assignment

This restriction is modified. As long as the interface state of the channels is not "administratively down", all channels are available for LBG assignment. For other load balancing operations, such as moving modems
using DCC, UCC, or DBC, the interface state of the channels should be in "initial", "up", "suspicious", or "testing" states.

The following conditions apply when an LBG is disabled:

- cable modems that match all load balancing criteria can be assigned to an LBG.
- cable modem moves for load balancing are disabled, but cable modem moves from outside of the LBG to inside of the LBG are allowed.

### Upstream Load Balancing for DOCSIS 3.0 Cable Modems in Single Upstream Mode

The upstream load balancing functionality enables the Cisco CMTS router to effectively handle upstream traffic for wideband and narrowband cable modems that are in single upstream mode. Single upstream mode (Mx1) means that the modems cannot send upstream traffic on multiple upstream channels. In the event of traffic overload on a single upstream channel of a wideband or narrowband cable modem, the Cisco CMTS router automatically moves the cable modem to another upstream channel in the same load balancing group.

**Note**

A cable modem operating in single upstream mode is assigned to a load balancing group based on the primary channel of the modem. A cable modem in single upstream mode can support multiple receive channel (MRC) mode or narrowband mode. However, a cable modem in single upstream mode cannot support multiple transmit channel mode (MTC).

### Auto-generate DOCSIS 2.0 GLBG

Cisco CMTS does not automatically implement DOCSIS 2.0 GLBG. DOCSIS 2.0 GLBG is configured manually after a new fiber node - MAC domain (FN-MD) pair is added.

This enhancement to automatically generate DOCSIS 2.0 GLBG after adding a new FN-MD pair and resolving a new combination of MAC domain, cable modem, and service group (MD-CM-SG). This enhancement is implemented through a new command `cable load-balance d20 GLBG auto-generate`. The command has options to renew and update DOCSIS 2.0 GLBGs for a fiber node configuration.

### Independent Upstream/Downstream Throughput Rules

Currently, during upstream or downstream load balancing, to move modems in load balancing operations, Cisco CMTS applies the DOCSIS policy throughput rules to both upstream and downstream throughput to upstream or downstream load balancing operations. In other words, for downstream load balancing, both upstream and downstream sets of rules are applied and similarly for upstream load balancing both set of rules are applied. This prevents movement of modems with low upstream or high downstream throughput and high upstream or low downstream throughput.

Upstream or downstream throughput rules are checked independently to corresponding upstream or downstream load balancing operations. During upstream load balancing, only upstream throughput rules are checked, and during downstream load balancing, only downstream throughput rules are checked.

The following important points are implemented for independent upstream/downstream throughput rules:
• If DOCSIS 2.0 load balancing policy configured is us-across-ds, it is recommended to configure a maximum of 16 downstream channels and 8 upstream channels.

• If a load balancing operation involves a change only in the downstream channel of a cable modem without any change to the upstream channel, then only the downstream lower boundary rules are checked.

• If a load balancing operation involves a change only in the upstream channel of a cable modem without any change to the downstream channel, then only the upstream lower boundary rules are checked.

• If a load balancing operation involves a change in both the upstream and downstream channels of a cable modem, then the modem rule check must pass all the rules for that (upstream or downstream) load balancing.

• If the load balancing policy configured is pure-ds-load, then only the downstream rules are checked.

• If the load balancing policy configured is us-across-ds or both us-across-ds and pure-ds-load, then two types of target interfaces occur as follows:
  • Local interface—where the cable modem shares the upstream with the source. Only downstream load balancing operation occurs.
  • Remote interface—where the the cable modem does not share the upstream with the source. The upstream/downstream load balancing is triggered by upstream load.

If the load balancing policy configured is neither us-across-ds nor pure-ds-load, then the load balancing is done based on Mac domain load.

**How to Configure DOCSIS Load Balancing Groups**

The Restricted/General Load Balancing and Narrowband Dynamic Bandwidth Sharing with Downstream Dynamic Load Balancing feature can be configured as follows:

• A user can configure a DOCSIS 2.0 general load balancing group (GLBG) on the Cisco CMTS according to DOCSIS specification. The Cisco CMTS creates a DOCSIS 3.0 GLBG for each Media Access Control Domain Cable Modem Service Group (MD-CM-SG) automatically and checks whether the GLBG contains both upstream and downstream channels.

• A cable modem that is not provisioned to any RLBG and cannot resolve its MD-CM-SG gets assigned to a DOCSIS 2.0 GLBG. However, if the cable modem resolves its MD-CM-SG, it gets assigned to a DOCSIS 3.0 GLBG.

• A user can configure RLBGs and any upstream or downstream channel into multiple RLBGs on the Cisco CMTS. The Cisco CMTS checks whether a RLBG contains both upstream and downstream channels. A RLBG can cross multiple MDs.

• A backward compatibility with existing Cisco LB schemes is maintained. The users can switch between the old and new DOCSIS 3.0 compliant LB schemes.

---

**Note**

When the Cisco IOS system is upgraded, if the docsis-policy configuration of the DOCSIS load balancing groups, is missing in the output of the show running-config command, apply the docsis-policy to the DOCSIS load balancing groups using the docsis-policy policy-id command again.
The following sections describe how to create and configure DOCSIS load balancing groups to enable DOCSIS load balancing on the Cisco CMTS:

## Configuring DOCSIS 3.0 and 2.0 RLBG and DOCSIS 2.0 GLBG

This section describes how to create and configure a DOCSIS load balancing group. There is a separate configuration mode for a DOCSIS load balancing group that is different from the legacy load balancing group.

### Note

UGS/PCMM policy and threshold do not apply on DOCSIS 3.0 LB.

### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td>- Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>cable load-balance docsis-enable</td>
<td>Enables DOCSIS load balancing on the Cisco CMTS.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config)# cable load-balance docsis-enable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 4</td>
<td>cable load-balance docsis-group docsis-group-id</td>
<td>Creates a DOCSIS load balance group on the Cisco CMTS, with the following parameter: The router enters DOCSIS load balancing group configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config)# cable load-balance docsis-group 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 5</td>
<td>init-tech-list tech-list [ucc]</td>
<td>Sets the DCC initialization techniques that the Cisco CMTS can use to load balance cable modems.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config-lb-group)# init-tech-list 1 ucc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 6</td>
<td>downstream {Cable {slot/subslot/port</td>
<td>slot/port}</td>
</tr>
</tbody>
</table>
### Configuring DOCSIS 3.0 and 2.0 RLBG and DOCSIS 2.0 GLBG

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td><strong>Purpose</strong></td>
</tr>
<tr>
<td>Router(config-lb-group)# downstream integrated-Cable 5/0/0 rf-channel 2</td>
<td><strong>Sets upstream channels with the following parameters:</strong></td>
</tr>
<tr>
<td><strong>Step 7</strong> upstream Cable {slot/subslot/port</td>
<td>slot/port} upstream-list</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><strong>Step 8</strong> docsis-policy policy-id</td>
</tr>
<tr>
<td>Router(config-lb-group)# upstream Cable 1/0 2</td>
<td>Selects the restricted group type. By default, the general group type is selected.</td>
</tr>
<tr>
<td><strong>Step 9</strong> restricted</td>
<td><strong>Step 10</strong> init-tech-ovr Cable {slot/subslot/port</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Sets DCC initialization techniques that overrides the physical upstream channel pair. The <code>init-tech-ovr</code> command can also be used to determine whether the UCC can be used for modems during dynamic upstream load balancing.</td>
</tr>
<tr>
<td>Router(config-lb-group)# restricted</td>
<td>The following parameters override the physical upstream channel pair:</td>
</tr>
<tr>
<td><strong>Note</strong> The <code>init-tech-list</code> keyword accepts an upstream that is not added into the load balancing group. The upstream channel pair is invalid until the upstream is added. When the load balancing group is removed, all upstream channel pairs are also removed.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 11</strong> service-type-id string</td>
<td>Adds a service type ID, with the following parameter, that is compared against the cable modem provisioned service type ID, to determine an appropriate restricted load balancing group (RLBG):</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><strong>Step 12</strong> tag tag name</td>
</tr>
<tr>
<td>Router(config-lb-group)# service-type-id commercial</td>
<td><strong>Example:</strong></td>
</tr>
</tbody>
</table>
**DOCSIS Load Balancing Groups**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Router(config-lb-group)# tag t1</code></td>
<td><strong>Step 13</strong> Sets the time interval, the Cisco CMTS waits before checking the load on an interface.</td>
</tr>
<tr>
<td><code>interval &lt;1-1000&gt;</code></td>
<td><strong>Step 14</strong> Selects the method the Cisco CMTS use to determine the load.</td>
</tr>
<tr>
<td>`method {modems</td>
<td>service-flows</td>
</tr>
<tr>
<td>`{us-method {modems</td>
<td>service-flows</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# interval 60</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# method modems us-method modems</code></td>
<td></td>
</tr>
<tr>
<td>`policy {pcmm</td>
<td>ugs</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# policy us-across-ds</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# policy ugs</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# policy pure-ds-load</code></td>
<td></td>
</tr>
<tr>
<td>`threshold {load {minimum &lt;1-100&gt;</td>
<td>&lt;c-100&gt;}}</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# threshold load minimum 10</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# threshold pcmm 70</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# threshold load 10</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-lb-group)# threshold ugs 70</code></td>
<td></td>
</tr>
<tr>
<td><code>exit</code></td>
<td><strong>Step 17</strong> Exits DOCSIS LBG configuration.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# exit</code></td>
<td></td>
</tr>
</tbody>
</table>

**Configuring DOCSIS 3.0 GLBG**

The following sections describe how to configure a DOCSIS 3.0 GLBG and also how to configure default values of DOCSIS 3.0 certification for the DOCSIS 3.0 general group:

**Note**

If a Cable interface on the line card is in "no shut down" state, the associated DOCSIS 3.0 GLBGs are restored in the running-configuration.
# Configuring a DOCSIS 3.0 General Load Balancing Group

This section describes how to configure a DOCSIS 3.0 general load balancing group.

## Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><strong>enable</strong>&lt;br&gt;Example: <code>enable</code>&lt;br&gt;Router&gt; <code>enable</code></td>
<td>Enables privileged EXEC mode.&lt;br&gt;• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><strong>configure terminal</strong>&lt;br&gt;Example: <code>configure terminal</code>&lt;br&gt;Router# <code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><strong>cable load-balance docsis-enable</strong>&lt;br&gt;Example: <code>cable load-balance docsis-enable</code>&lt;br&gt;Router(config)# <code>cable load-balance docsis-enable</code></td>
<td>Enables DOCSIS load balancing on the Cisco CMTS.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>**cable load-balance docsis-group FN fn-id MD cable slot/subslot/port</td>
<td>slot/port**&lt;br&gt;Example: <code>cable load-balance docsis-group FN 1 MD c5/0/0</code>&lt;br&gt;Router(config)# <code>cable load-balance docsis-group FN 1 MD c5/0/0</code></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>init-tech-list tech-list [ucc]</strong>&lt;br&gt;Example: <code>init-tech-list 1 ucc</code>&lt;br&gt;Router(config-lb-group)# <code>init-tech-list 1 ucc</code></td>
<td>Sets the DCC initialization technique list, with the following parameters.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>disable</strong>&lt;br&gt;Example: <code>disable</code>&lt;br&gt;Router(config-lb-group)# <code>disable</code></td>
<td>Disables the load balance group.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>docsis-policy policy-id</strong>&lt;br&gt;Example: <code>docsis-policy 0</code>&lt;br&gt;Router(config-lb-group)# <code>docsis-policy 0</code></td>
<td>Sets the load balance group policy.</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>interval 1-1000</strong>&lt;br&gt;Example: <code>interval 10</code>&lt;br&gt;Router(config-lb-group)# <code>interval 10</code></td>
<td>Sets the interface polling interval.</td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td>**method [modems</td>
<td>service-flows</td>
</tr>
</tbody>
</table>
Purpose

Command or Action | Purpose
--- | ---
Step 10 | Sets load balancing policy.
| policy {pcmm | ugs | us-across-ds | pure-ds-load}
| Example:
| Router(config-lb-group)# policy us-across-ds

Step 11 | Sets the load balancing threshold in percentage.
| threshold {load {minimum 1-100 | 1-100} | pcmm 1-100 | stability 0-100 | ugs 1-100}
| Example:
| Router(config-lb-group)# threshold pcmm 70

Step 12 | Exits the DOCSIS load balancing group configuration mode.
| exit
| Example:
| Router# exit

---

### Configuring Default Values of DOCSIS 3.0 Load Balancing Group

This section describes how to configure default values of DOCSIS 3.0 certification for a DOCSIS 3.0 general group on the Cisco CMTS. A DOCSIS 3.0 general group is automatically created for each MD-CM-SG derived from the fiber node (FN) configuration, and the group parameters are set as default values.

**Note**
The configured default values of DOCSIS 3.0 certification are applicable to the new automatically created DOCSIS 3.0 GLBGs and do not affect the existing DOCSIS 3.0 GLBGs. When a DOCSIS 3.0 GLBG is removed and recreated, its group parameters do not change.

**Note**
The default settings for interface polling interval, load balancing method, policy for modems selection, and threshold usage in percent, can be configured for DOCSIS 3.0 general group. For more information, see the Cisco CMTS Cable Command Reference.

---

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td></td>
</tr>
</tbody>
</table>
| Example:
| Router> enable |
|  | • Enter your password if prompted. |
| Step 2 | Enters global configuration mode. |
| configure terminal | |
| Example:
| Router# configure terminal |
| Step 3 | Disables the default values of the DOCSIS 3.0 general load balance group (GLBG). |
| cable load-balance d30-ggrp-default disable | |
| Example: | |
### Configuring Cable Modems to RLBG or a Service Type ID

This section shows how to configure a list of cable modems that are statically provisioned at the Cisco CMTS to a RLBG or a service type ID.

#### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td>(Router)&gt; enable</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>configure terminal</td>
<td>(Router)# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Assigns a modem or a group of modems with a common MAC mask to a load balancing group or a service type ID.</td>
</tr>
<tr>
<td>cable load-balance restrict modem index mac-addr [mac-mask] {docsis-group docsis-group-id</td>
<td>Assigns a modem or a group of modems with a common MAC mask to a load balancing group or a service type ID.</td>
</tr>
<tr>
<td></td>
<td>service-type-id string}</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Exits the global configuration mode.</td>
</tr>
<tr>
<td>exit</td>
<td>(Router)# exit</td>
</tr>
</tbody>
</table>
Configuring Rules and Policies

This section shows how to create and configure rules and DOCSIS policies to restrict the movement of modems during load balancing. Rules determine whether a modem can be moved and during which time periods. The time periods are measured in seconds with the start time being an offset from midnight measured in seconds. Rules are created individually and can be combined into policies. The user is able to create DOCSIS policies that consist of one or more rules. When more than one rule is part of a DOCSIS policy, all rules apply. Each group has a default DOCSIS policy.

Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong> cable load-balance rule rule-id</td>
<td>Creates a rule to prevent the modem from being moved.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# cable load-balance rule 1</td>
</tr>
<tr>
<td><strong>Step 4</strong> cable load-balance rule rule-id {enabled</td>
<td>disabled}</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# cable load-balance rule 1 disable-period dis-start 40 dis-period 50</td>
</tr>
<tr>
<td><strong>Step 5</strong> cable load-balance docsis-policy policy-id rule rule-id</td>
<td>Associates a particular rule with the DOCSIS policy with the following parameters:</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# cable load-balance docsis-policy 2 rule 1</td>
</tr>
<tr>
<td><strong>Step 6</strong> exit</td>
<td>Exits the global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# exit</td>
</tr>
</tbody>
</table>

Troubleshooting Tips

**Problem** When you disable load balancing and enable it for the next day using the `cable load-balance rule rule-id disable-period dis-start start-time dis-period dis-period` command, the load balancing is enabled at 12.00 am instead of the configured `disable-period`. 
Configuring Load Balancing Parameter for a Cable Modem Movement Failure

This section describes how to configure the number of times a CM can fail before the CM is removed from the dynamic load balancing group.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Configures the number of times a CM can fail before the CM is removed from the dynamic load balancing group.</td>
</tr>
<tr>
<td>cable load-balance modem max-failures 0-100</td>
<td>Configures the number of times a CM can fail before the CM is removed from the dynamic load balancing group.</td>
</tr>
<tr>
<td>Example:</td>
<td>Configures the number of times a CM can fail before the CM is removed from the dynamic load balancing group.</td>
</tr>
<tr>
<td>Router(config)# cable load-balance modem max-failures 10</td>
<td>Configures the number of times a CM can fail before the CM is removed from the dynamic load balancing group.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Exits the global configuration mode.</td>
</tr>
<tr>
<td>exit</td>
<td>Exits the global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Exits the global configuration mode.</td>
</tr>
<tr>
<td>Router# exit</td>
<td>Exits the global configuration mode.</td>
</tr>
</tbody>
</table>

Creating and Configuring TLV type Tag

The tags for TLV type matching rule are created and configured in this section.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td><strong>Purpose</strong></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Creates a tag. Enters the cmts-tag configuration mode.</td>
</tr>
<tr>
<td>cable tag 1-1000</td>
<td>Example: Router(config)# cable tag 1</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Specifies the name of the tag.</td>
</tr>
<tr>
<td>name tag name</td>
<td>Example: Router(cmts-tag)# name CSCO</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>Configures the specified service type ID for the tag.</td>
</tr>
<tr>
<td>[exclude] service-type-id service-type-id</td>
<td>Example: Router(cmts-tag)# service-type-id HSD</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>Configures the specified service class name for the tag.</td>
</tr>
<tr>
<td>[exclude] service-class service-class-name</td>
<td>Example: Router(cmts-tag)# service-class work</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td>Configures the specified DOCSIS version of the cable modem for the tag.</td>
</tr>
<tr>
<td>[exclude] docsis-version docsis version</td>
<td>Example: Router(cmts-tag)# docsis-version docsis20</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td>Configures the specified OUI of the cable modem for the tag.</td>
</tr>
<tr>
<td>[exclude] oui oui of CM</td>
<td>Example: Router(cmts-tag)# oui 00.1a.c3</td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td>Configures the specified TLV type for the tag.</td>
</tr>
<tr>
<td>[exclude] tlv type value</td>
<td>Example: Router(cmts-tag)# tlv mrcs 4</td>
</tr>
<tr>
<td><strong>Step 10</strong></td>
<td>Overrides the TLV or SNMP during load balancing an RLBG.</td>
</tr>
<tr>
<td>override</td>
<td>Example: Router(cmts-tag)# override</td>
</tr>
<tr>
<td><strong>Step 11</strong></td>
<td>Exits the cmts-tag configuration mode.</td>
</tr>
<tr>
<td>exit</td>
<td>Example: Router(cmts-tag)# exit</td>
</tr>
<tr>
<td><strong>Step 12</strong></td>
<td>Creates a DOCSIS load balancing group on the Cisco CMTS. If the DOCSIS load balancing group is already present, the router enters the specified DOCSIS load balancing group configuration mode.</td>
</tr>
<tr>
<td>cable load-balance docsis-group docsis-group-id</td>
<td>Example: Router(config)# cable load-balance docsis-group 1</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 13** | **tag** *tag name*  
**Example:**  
Router(config-lb-group)# *tag CSCO* | Adds a tag to the load balancing group. |
| **Step 14** | **exit**  
**Example:**  
Router(config-lb-group)# *exit* | Exits the DOCSIS load balancing group configuration mode. |
| **Step 15** | **cable load-balance** *docsis-policy policy-id tag tag name*  
[override]  
**Example:**  
Router(config)# *cable load-balance docsis-policy 2 tag CSCO* | Creates a DOCSIS policy and associates a new rule or an existing rule with the policy. |
| **Step 16** | **exit**  
**Example:**  
Router# *exit* | Exits the global configuration mode. |

### Configuration Examples for DOCSIS Load Balancing Groups

This section describes a sample configuration example for configuring DOCSIS Load Balancing Groups including Restricted/General Load Balancing and downstream dynamic load balancing:

#### Example: Configuring a Tag

The following example shows how you can configure the tag to exclude a DOCSIS version, a MAC address, a service class name or a service type ID:

Router# *configure terminal*  
Enter configuration commands, one per line. End with CNTL/Z.  
Router(config)# *cable tag 1*  
Router(config-cable)# *exclude ?*  
Router(config-cable)# *docsis-version ?*  
Router(config-cable)# *docsis-version docsis10*  
Router(config-cable)# *exclude oui ?*  
Router(config-cable)# *exclude oui 00.1a.c3*  
Router(config-cable)# *exclude service-class ?*  
Router(config-cable)# *exclude service-class work*  
Router(config-cable)# *exclude service-type-id ?*
Example: Disabling Load Balancing

Use the following commands to disable DOCSIS 3.0 GLBG:

```
Router(config)# cable load-balance docsis-group FN 1 MD cable 6/0/0
Router(config-lb-group)# disable
```

Use the following commands to disable DOCSIS 3.0 RLBG:

```
Router(config)# cable load-balance docsis-group 1
Router(config-lb-group)# disable
```

How to Configure Load Balancing with Operational Simplification

To configure Load Balancing Groups with Operational Simplification, complete the following steps:

**SUMMARY STEPS**

1. Define the global common Load Balancing profile. Specify the Load Balancing Group configure: method, interval, threshold, policy, and so on.
2. Define the Load Balancing Group under service-group profile. Associate the Load Balancing profile with Load Balancing group. Configure the DS and US channels.
3. Define the physical mapping info for US or DS channels under fiber-mode.
4. Define the service-group profile under Fiber-node.

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> Define the global common Load Balancing profile. Specify the Load Balancing Group configure: method, interval, threshold, policy, and so on.</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>cable profile load-balance lb_1</code></td>
<td></td>
</tr>
<tr>
<td><code>disable</code></td>
<td></td>
</tr>
<tr>
<td><code>method utilization primary-distributed us-method utilization</code></td>
<td></td>
</tr>
<tr>
<td><code>threshold load 2</code></td>
<td></td>
</tr>
<tr>
<td><code>policy pcmm</code></td>
<td></td>
</tr>
<tr>
<td><code>interval 1</code></td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 2** | Define the Load Balancing Group under service-group profile. Associate the Load Balancing profile with Load Balancing group. Configure the DS and US channels.  
*Example:*  
cable profile service-group sq  
load-balance docsis-group 0 profile lb_1  
downstream sg-channel 0-7  
upstream 0 sg-channel 0  
upstream 1 sg-channel 1 |
| **Step 3** | Define the physical mapping info for US or DS channels under fiber-mode.  
*Example:*  
cable fiber-node 1  
downstream sg-channel 0 15 downstream-Cable 6/0/0  
rf-channel 0 15  
upstream sg-channel 0 3 upstream-Cable 6/0/0  
us-channel 0 3 |
| **Step 4** | Define the service-group profile under Fiber-node.  
*Example:*  
cable fiber-node 1  
service-group profile sg |

The Load Balancing Groups are auto-generated when the SG profile is applied.

**Example**

An example of the Load Balancing Groups Operational Simplification configuration, *show run* as is as follows:

```plaintext
cable profile load-balance lb  
method utilization primary-distributed us-method utilization  
threshold load 22  
threshold load lcmdm 33  
policy lcmdm  
policy pure-ds-load  
init-tech-list 1-3  

load-balance docsis-group 0 profile lb  
downstream sg-channel 0 15  
upstream 0 sg-channel 0  
upstream 1 sg-channel 1  
upstream 2 sg-channel 2  
upstream 3 sg-channel 3  
load-balance docsis-group 2 profile RLBG_STB  
downstream sg-channel 0-3 8-11  
upstream 0 sg-channel 0  
```
An example of the Load Balancing Groups Operational Simplification configuration, **show derived** as is as follows:

cable profile load-balance lb
method utilization primary-distributed us-method utilization
threshold load 22
threshold load lcmm 33
policy lcmm
policy pure-ds-load
init-tech-list 1-3

Cable profile service-group sg
  Load-balance docsis-group 0 profile lb
downstream sg-channel 0 15
  upstream 0 sg-channel 0
  upstream 1 sg-channel 1
  upstream 2 sg-channel 2
  upstream 3 sg-channel 3
load-balance docsis-group 2 profile RLBG_STB
downstream sg-channel 0-3 8-11
  upstream 0 sg-channel 0

Cable fiber-node 1
  downstream Downstream-Cable 6/0/0
  upstream Upstream-Cable 6/0/0
  downstream sg-channel 0 15 downstream-Cable downstream-Cable 6/0/0 rf-channel 0 15
  upstream sg-channel 0 3 Upstream-Cable 6/0/0 us-channel 0 3
service-group profile sg

Cable load-balance docsis-group 2
restricted
downstream Downstream-Cable 6/0/0 rf-channel 0 15
  upstream Upstream-Cable 6/0/0 us-channel 0-3
method utilization primary-distributed
threshold load 22
threshold pccmm 33
policy lcmm
policy pure-ds-load
init-tech-list 1-3
cable managed fiber-node 1
cable load-balance-profile lb
cable load-balance docsis-group 3
restricted
downstream Downstream-Cable 6/0/0 rf-channel 0-3 8-11
Upstream Upstream-Cable 6/0/0 us-channel 0
Threshold load 55
Interval 5
Cable managed fiber-node 1
Cable load-balance-profile RLBG_STB
Load Balancing Groups with Operational Simplification

The Cisco IOS XE Gibraltar 16.10.1d supports simplified Load Balancing configuration in the Operational Simplification service group profile. Currently, CMTS supports auto creation of D30 GLBGs based on the existing configuration. Load Balancing would now support creation of RLBGs and D20 GLBGs.

Following are the salient features of the feature:

- For D20 GLBG created by Operational Simplification, the Group ID is in range [65024, 65535]. This follows legacy design.

- For RLBG created by Operational Simplification, the Group ID is related to the information of fiber-node id/us channel controller/docsis-group index in service group file. This also follows legacy range [1, 2147483647]. For example: RLBG ID: 12330208. Where '123' is the Fiber node ID, '302' is the Upstream-Cable 6/0/0, and '08' is the docsis-group index in service group profile.

```
cable profile service-group sg
  load-balance docsis-group 8 profile lb_1
  downstream sg-channel 0-7
  upstream 0 sg-channel 0
  upstream 1 sg-channel 1
```

- The default value of Load Balance profile are equal to the value of “cable load-balance d20-ggrp-default xxx”.

- For Load Balancing Groups that are created by Operational Simplification, the user cannot configure them with CLI.

- For one service group profile, a user is only allowed to configure one GLBG load balance.

- A user can configure a maximum of 20 tags into one load balance profile.

- A user can configure a maximum of 15 service-type-ids into one load balance profile.

- Load Balancing Groups by Operational Simplification supports fly modification.

- For Load Balancing Groups created by Operational Simplification, if a user changes the option of Load Balance profile, the OPS would update all the related LBGs automatically. However, the user cannot change the type of LBGs.

For the Load Balancing Groups created by Operational Simplification, the configuration of the groups would not be displayed for the show run or the show run all commands. The Load Balancing Groups would only be displayed using the derived command. This change can simplify the running configuration.

```
clab-cbr-S11K01#show derived-config | sec cable load
cable load-balance docsis-group 1
  restricted
downstream Downstream-Cable 6/0/0 rf-channel 0-7
upstream Upstream-Cable 6/0/0 us-channel 0-1
method utilization primary-distributed
threshold load 2
cable managed fiber-node 1
cable load-balance-profile lb_1
```
### Verifying DOCSIS Load Balancing Groups

This section describes how to use certain show commands to verify the configuration of the Restricted/General Load Balancing and Narrowband Dynamic Bandwidth Sharing with Downstream Dynamic Load Balancing feature.

#### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong> <code>Router&gt; enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>2</td>
<td>`show cable load-balance docsis-group docsis-group-id</td>
<td>FN fn-id MD cable slot/subslot/port slot/port</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong> <code>Router# show cable load-balance docsis-group 1</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router# show cable load-balance docsis-group fn 1 MD c8/1/4</code></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><code>show cable fiber-node fiber-node-id [spectrum]</code></td>
<td>Displays information about a fiber node.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong> <code>Router# show cable fiber-node 3</code></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>`show cable load-balance [group n]</td>
<td>[all</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong> <code>Router# show cable load-balance group 1</code></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>`show cable modem ip-address</td>
<td>mac-address</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong> <code>Router# show cable modem 40.3.160.15 verbose</code></td>
<td></td>
</tr>
</tbody>
</table>

#### Examples

Use the `show cable load-balance docsis-group` command to see the DOCSIS group status and to see the list of modems in the group, use the `show cable fiber-node` command to see the information on fiber nodes, use the `show cable load-balance` command to see information on LBG and DOCSIS channels, and use the `show cable modem` command to see the information on all the CMs.

The following examples show the output of the `show cable load-balance docsis-group` command:

```plaintext
Router# show cable load-balance docsis-group 2
```
Verifying DOCSIS Load Balancing Groups

The output of the `show cable load-balance docsis-group` command is modified to include an additional field MUPFXLR to display more status information on the modems in the DOCSIS groups. For more information, see the Cisco IOS CMTS Cable Command Reference.

The following example shows the modified output of the `show cable load-balance docsis-group` command:

```
Router#show cable load docsis-group fn 1 md c6/0/0 modem-list
Load for five secs: 1%/0%; one minute: 2%; five minutes: 1%
Time source is NTP, 13:39:31.300 PDT Thu Mar 28 2013
Codes: M - Multicast, U - UGS, P - PCMM, F - Max-Failures, X - eXcluded
L - L2vpn, R - RSVP
Primary DS Grp Idx MAC Address RCC-ID Bad Rfid Priority MUPFXLR
In6/0/0:0/UB 40448 (6)
e448.c70c.98af 1 2 -------
e448.c70c.9b76 1 2 -------
e448.c70c.9c15 1 2 -------
e448.c70c.9a92 1 2 -------
e448.c70c.99e4 1 2 -------
e448.c70c.9a35 1 2 -------
In6/0/0:0/0U0 40448 (0)
In6/0/0:0/0U1 40448 (1)
e448.c70c.9915 2 -------
In6/0/0:0/0U2 40448 (0)
In6/0/0:0/0U3 40448 (0)
In6/0/0:1/UB 40448 (5)
e448.c70c.9abc 1 2 -------
e448.c70c.993f 1 2 -------
e448.c70c.9927 1 2 -------
e448.c70c.9b82 1 2 -------
4458.2945.2cb8 1 2 -------
In6/0/0:1/U0 40448 (0)
In6/0/0:1/U1 40448 (0)
In6/0/0:1/U2 40448 (0)
In6/0/0:1/U3 40448 (0)
In6/0/0:2/UB 40448 (5)
e448.c70c.9759 1 2 -------
e448.c70c.9a0e 1 2 -------
e448.c70c.992d 1 2 -------
e448.c70c.9a38 1 2 -------
0025.2ed9.9984 1 2 -------L-
In6/0/0:2/U0 40448 (0)
In6/0/0:2/U1 40448 (0)
In6/0/0:2/U2 40448 (0)
In6/0/0:2/U3 40448 (0)
In6/0/0:3/UB 40448 (5)
e448.c70c.9c00 1 2 -------
```
The following examples show the output of the `show cable fiber-node` command:

```
Router# show cable fiber-node
Fiber-Node Config Status
Fiber-Node 1
  Modular-Cable 1/0/0: 0-1
    FN Config Status: Configured (status flags = 0x01)
    MDD Status: Valid
```

The following examples show the output of the `show cable load-balance` command:

```
Router# show cable load-balance
Group Interval Method DCC Init Threshold
Technique Minimum Static Enforce Ugs PCMM
1 10 service-flows 1 1 2% 2% --- ---
2 10 modems 0 5 10% --- --- ---

DOCSIS LB Enabled: No
Router# show cable load-balance load
Interface State Group Utilization Reserved Modems Flows Weight
Index
Cable5/0/3 (459 MHz) up 1 0%(0%/0%) 0% 7 7 37
Cable5/0/3/U0 up 1 0% 0% 2 2 1.2
Cable5/0/3/U1 up 1 0% 0% 2 2 1.2
Cable5/0/3/U2 up 1 0% 0% 2 2 1.2
Cable5/0/3/U3 up 1 0% 0% 1 1 1.2
Cable5/0/4 (465 MHz) up 1 0%(0%/0%) 0% 7 7 37
Cable5/0/4/U0 up 1 0% 0% 1 1 1.2
Cable5/0/4/U1 up 1 0% 0% 2 2 1.2
Cable5/0/4/U2 up 1 0% 0% 2 2 1.2
Cable5/0/4/U3 up 1 0% 0% 2 2 1.2
Mo1/0/0:0 (555 MHz) down 1 0%(0%/0%) 0% 0 0 0

Router# show cable load-balance fiber-node-validation
DOCSIS LBG ID Match Channel Fiber-node list
1 match Ca5/0/0/U0 (1)
   Ca5/0/0/U1 (1)
   Ca5/0/0/U2 (1)
   Ca5/0/0/U3 (1)
   Mo1/0/0:0 (1)
   Mo1/0/0:1 (1)
2 mismatch Ca5/0/0/U0 (1)
   Ca5/0/0/U1 (1)
   Ca5/0/0/U2 (1)
   Ca5/0/0/U3 (1)
   Ca5/0/0 (1)
```

The following example shows the output of the `show cable modem` command:
Verifying DOCSIS Load Balancing Groups

DOCSIS 3.0 GLBG is generated dynamically by the fiber node configuration, if a valid fiber node is configured.

For example, if the fiber node configuration is:

cable fiber-node 2
  downstream Modular-Cable 1/0/0 rf-channel 0-3
  downstream Cable7/0/0
  upstream Cable 7/0 connector 0-3

The GLBG generated by this fiber node is similar to:

```
Router# show cable load-balance docsis-group fn 2 md cable 7/0/0

DOCSIS 3.0 General LB
MD  FN  Group S Intv DCC mask Policy Mtd MD-CM-SG Threshold
    Index /UCC D/U M/E/U/P/S
Ca7/0/0 2 48129 E 30 0xF8(0)/N 0 m/m 0x3C0101 5/10/70/70/50
```

```
Router# show cable load-balance docsis-group fn 2 md cable 7/0/0 all

DOCSIS 3.0 General LB
MD  FN  Group S Intv DCC mask Policy Mtd MD-CM-SG Threshold
    Index /UCC D/U M/E/U/P/S
Ca7/0/0 2 48129 E 30 0xF8(0)/N 0 m/m 0x3C0101 5/10/70/70/50

Current load:
DOCSIS load-balancing load

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Group Utilization</th>
<th>Rsvd NBCM</th>
<th>WB/UB Flows</th>
<th>Weight</th>
</tr>
</thead>
</table>
| Cable7/0/0    | up    | 48129 0%
| Cable7/0/0/U0 | up    | 48129 0%
| Cable7/0/0/U1 | up    | 48129 0%
| Cable7/0/0/U2 | up    | 48129 0%
| Cable7/0/0/U3 | up    | 48129 0%
| Mo1/0:0/0:0   | up    | 48129 0%
| Mo1/0:0/0:1   | up    | 48129 0%
| Mo1/0:0/0:2   | up    | 48129 0%
| Mo1/0:0/0:3   | up    | 48129 0%
| Mo1/0:0:1     | up    | 48129 0%
| Mo1/0:0:1/U0  | up    | 48129 0%
| Mo1/0:0:1/U1  | up    | 48129 0%
| Mo1/0:0:1/U2  | up    | 48129 0%
| Mo1/0:0:1/U3  | up    | 48129 0%
| Mo1/0:0:2     | up    | 48129 0%
| Mo1/0:0:2/U0  | up    | 48129 0%
| Mo1/0:0:2/U1  | up    | 48129 0%
| Mo1/0:0:2/U2  | up    | 48129 0% |
Verifying DOCSIS Load Balancing Groups

<table>
<thead>
<tr>
<th>Target interface</th>
<th>State</th>
<th>Transfers</th>
<th>Complete</th>
<th>Pending</th>
<th>Retries</th>
<th>Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable7/0/0 (333 MHz)</td>
<td>up</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cable7/0/0/U0</td>
<td>up</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cable7/0/0/U1</td>
<td>up</td>
<td>83</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cable7/0/0/U2</td>
<td>up</td>
<td>48</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cable7/0/0/U3</td>
<td>up</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:0 (501 MHz)</td>
<td>up</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:0/U0</td>
<td>up</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:0/U1</td>
<td>up</td>
<td>46</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:0/U2</td>
<td>up</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:0/U3</td>
<td>up</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:1 (507 MHz)</td>
<td>up</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:1/U0</td>
<td>up</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:1/U1</td>
<td>up</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:1/U2</td>
<td>up</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:1/U3</td>
<td>up</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:2 (513 MHz)</td>
<td>up</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:2/U0</td>
<td>up</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:2/U1</td>
<td>up</td>
<td>3</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Mo1/0/0:0:2/U2</td>
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<td>6</td>
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<td>Mo1/0/0:0:2/U3</td>
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<td>7</td>
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<td>Mo1/0/0:0:3 (519 MHz)</td>
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<td>9</td>
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<td>1</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mo1/0/0:0:3/U1</td>
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<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Mo1/0/0:0:3/U2</td>
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<td>4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>4</td>
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Pending:

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<tr>
<th>Modem</th>
<th>Grp Idx</th>
<th>Primary RF/RCC</th>
<th>MD/TCS</th>
<th>Action</th>
<th>Active Retries</th>
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Additional References

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
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<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
<tr>
<td>documentation and tools for troubleshooting and resolving technical issues</td>
<td></td>
</tr>
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<td>with Cisco products and technologies.</td>
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<tr>
<td>To receive security and technical information about your products, you can</td>
<td></td>
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<tr>
<td>subscribe to various services, such as the Product Alert Tool (accessed from</td>
<td></td>
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<tr>
<td>Field Notices), the Cisco Technical Services Newsletter, and Really Simple</td>
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</tr>
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<td>Syndication (RSS) Feeds.</td>
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<td>Access to most tools on the Cisco Support website requires a Cisco.com user</td>
<td></td>
</tr>
<tr>
<td>ID and password.</td>
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</table>

Feature Information for DOCSIS Load Balancing Groups

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
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<tbody>
<tr>
<td>DOCSIS Load Balancing Groups</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the cisco cBR Series Converged Broadband Routers.</td>
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<tr>
<td>Load Balancing with Operational Simplification</td>
<td>Cisco IOS XE Gibraltar 16.10.1d.</td>
<td>This feature was integrated on the cisco cBR Series Converged Broadband Routers.</td>
</tr>
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</table>
DOCSIS Load Balancing Movements

Cisco CMTS supports static load balancing for MTC/MRC modems and dynamic load balancing for non-MTC and/or non-MRC modems. Support for configuration of load balancing groups (LBGs) that entail multiple interfaces, multiple load balancing policies, and the option to configure multiple additional load balancing parameters are also included.

The load balancing policies can be configured on the Cisco CMTS, indexed by an ID, to limit the movement of cable modems within a Load Balancing Group (LBG). The cable modem will forward TLV43.1 in its registration request (REG-REQ) message, which is then parsed and stored in the Cisco CMTS. A policy defines whether and when cable modems can be moved within their load balancing groups.

During dynamic load balancing, the specified policy of the cable modem is checked to determine whether the cable modem is allowed to move.

Load balancing supports Dynamic Channel Change (DCC). DCC in DOCSIS 1.1, dynamically changes cable modem upstream or downstream channels without forcing a cable modem to go offline, and without re-registration after the change.

Load balancing distributes downstream load balancing with upstream channel loads in the same upstream load balancing group. This improves upon the prior load balancing limitation, in which load balancing was implemented on the basis of the entire downstream channel load.

Load balancing uses rules and policies to decide on moving the cable modems within their LB groups. These policies are created on the Cisco CMTS and chosen on a per-CM basis using type-length-value (TLV) portion (43.1,Policy ID) of REG-REQ. These policies prohibit a modem from being moved or restricted.

A policy contains a set of rules. When the policy is defined by multiple rules, all rules apply in combinations. A rule can be defined as "enabled", "disabled", or "disabled during time period." Each rule can be used by more than one policy.

DOCSIS 3.0 static modem count-based load balancing uses the dynamic bonding change (DBC) to modify the following parameters of DOCSIS 3.0 cable modem with multiple transmit channel (MTC) mode or multiple receive channel (MRC) mode without primary channel change:

- Transmit channel set (TCS)
- Receive channel set (RCS)
- Downstream IDs (DSID) or DSID-associated attributes
- Security association for encrypting downstream traffic

These parameters and additional load balancing schemes are supported on the Cisco CMTS, and described in this document. This document describes all implementations of load balancing on the Cisco CMTS, dependent upon the Cisco IOS release installed and the desired parameters.
Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

• Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 84
• Prerequisites, on page 85
• Restrictions, on page 86
• Information on the Load Balancing on the Cisco CMTS, on page 90
• How to Configure Load Balancing, on page 106
• How to Configure Dynamic Channel Change for Load Balancing, on page 109
• Configuration Examples for Load Balancing, on page 115
• Additional References, on page 119
• Feature Information for DOCSIS Load Balancing Movements, on page 119

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note
The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Table 13: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
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<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
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<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
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<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
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<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
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<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
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<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
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<td>• PID—CBR-CCAP-LC-40G</td>
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<td></td>
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<td>Cisco cBR-8 Downstream PHY Modules:</td>
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<td>• PID—CBR-D30-DS-MOD</td>
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<td>Cisco cBR-8 Upstream PHY Modules:</td>
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<td></td>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
</tr>
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<td></td>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
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Prerequisites

Prerequisites for Load Balancing

The Load Balancing feature has the following prerequisites:

- Load balancing can be done only on upstreams and downstreams that share physical connectivity with the same group of cable modems.

Prerequisites for Dynamic Channel Change for Load Balancing

- DCC can be done only to a cable modem that is physically connected to both source and target upstream or downstream channels, or both.

- Upstreams and downstream channels that share the same physical connectivity must have different center frequencies separated by channel width.
- The difference between the physical layer parameters on the source and target DCC channels must be within the threshold required by the desired DCC initialization technique.
- DOCSIS 1.1 must be enabled for a modem to behave properly for the DCC operation. Note that not all DOCSIS 1.1 certified modems are DCC-capable, as the CableLabs DCC ATP tests need enhancement for complete coverage.

**Prerequisites for Dynamic Bonding Change for DOCSIS 3.0 Static Modem Count-Based Load Balancing**

- Initialization techniques 1 to 4, when used, require the Cisco CMTS to include the upstream channel descriptor (UCD) TLV (TLV46.5) in the DBC-REQ message.
- Bandwidth must be sufficient on the target bonding group to support DBC. This is determined by the admission control APIs.
- Fiber nodes must be configured before configuring DOCSIS 3.0 static modem count-based load balancing.

**Restrictions**

The following sections describe the restrictions applicable for the Load Balancing, Dynamic Channel Change, and Dynamic Bonding Change feature:

**Restrictions for Load Balancing**

The Load Balancing feature has the following restrictions:

- Load balancing can be done only on a per-line card basis—all interfaces in a load balancing group must be provided by the same line card.
- All downstreams and upstreams in a load balancing group must share physical connectivity to the same group of cable modems. All downstreams or all upstreams that have the same RF physical connectivity must be members of the same load balancing group.
- You can create a maximum of 256 load balancing groups on each line card.
- If an upstream port is operational, using the **no shutdown** command, and is not being used and not connected, load balancing attempts to use the port even though there are no cable modems registered on that port. When the upstream port is up, it is put into INIT state and load balancing includes this port as a potential target. However, if the load balancing sees multiple failures moving to this upstream, it is set to DISABLE state and the port is avoided later on in load balancing processes.
- The load balancing algorithms assume a relatively even distribution of usage among modems. In the situation where one cable modem creates the bulk of the load on an interface, the load balancing thresholds should be configured for a value above the load created by that single modem.
- You cannot select particular cable modems to be automatically moved for load balancing, although you can exclude cable modems from load balancing operations altogether on the basis of their MAC address or organization unique identifier (OUI). (You can use the **test cable load-balance** command to manually...
move a particular cable modem among upstreams, but this is done typically to test the configuration of the load balancing groups.)

- If you have configured upstream shared spectrum groups while doing downstream load balancing, the downstream in each MAC domain must not use overlapping upstream groups. For example, the downstream in one MAC domain could use an upstream spectrum band of 10 to 30 MHz, while the downstream in a second MAC domain could use an upstream spectrum band of 30 to 42 MHz. Each MAC domain has its own upstream shared spectrum group, allowing the load balancing group to contain the downstreams for both MAC domains.

- All upstream ports coming from the same splitter must be using different center frequencies that are separated by the channel width. For example, if the upstreams are using a channel width of 3.2 MHz, the center frequencies for all upstreams must be separated by at least 3.2 MHz.

- You can use four initialization techniques for Dynamic Channel Change (DCC).

- If you have configured load balancing, the provisioning system must not assign specific upstream channels or downstream frequencies to individual cable modems in their DOCSIS configuration files. Any cable modems requiring specific upstream channels or downstream frequencies must be excluded from load balancing operations (using the `cable load-balance exclude` command).

- Do not use the utilization method of load balancing on cable interfaces that have a small number of cable modems and where a single modem is responsible for the majority of the interface load. In this condition, the Cisco CMTS could end up continually moving cable modems from one interface to another in an endless attempt to load balance the interfaces. To avoid this, configure the utilization threshold to a value that is higher than what can be caused by any single cable modem.

- When deployed with channel restriction features, if the target upstream channel attribute masks are against that of the cable modem, then the cable modem on the higher load upstream will not be load balanced, as the current load balancing moves cable modems only to the target upstream. However, cable modems that do not have an attribute mask can still be load balanced. You should consider the following while deploying the load balancing groups: the target upstream will always be the upstream that has the lowest load. If some other upstreams have the same load, the upstream with the lowest index will be chosen as the target upstream.

- A TLV in a cable modem configuration file restricts dynamic load balancing on per modem basis.

- If you remove the last rule of a DOCSIS policy, the policy itself will be removed.

- The Cisco CMTS load balancing feature moves a cable modem based on the load of the channels in a load balancing group, without checking if the cable modem supports the extended frequency range (5Mhz-85Mhz). This may result in moving a cable modem that supports standard frequency range (5Mhz-65Mhz) to a channel that has extended frequency configured. To overcome such scenarios, operators should not mix upstreams that have standard and extended frequencies configured into the same load balancing group, unless all modems in the group support extended frequency range.

### Restrictions for Dynamic Channel Change for Load Balancing

- The source and target upstreams and downstreams must share physical connectivity with the modem desired for a DCC transaction.

- Independent downstream change is not supported, and cross-MAC domain upstream changes must occur with the associated downstream changes.
• The source and target downstream interfaces must belong to the same virtual bundle and the same load balancing group if DCC is used for load balancing.

• For DCC initialization techniques 1 to 4, all the configuration variables of the cable modem must remain constant with the exception of the configuration variables that are explicitly changed by the Dynamic Channel Change request (DCC-REQ) messages encoding.

• DCC initialization techniques 2 to 4 must not be used if the propagation delay differences between the old and new channels exceeds the ranging accuracy requirement defined in DOCSIS, for example, ±0.25 usec plus ± symbol time.

  For example, for a symbol rate of 1.28 Msps, the timing offset difference between the source and target upstream channel is ± floor[(0.250 us + 0.5*0.781us)/(1/10.24)] = ± 6.

• The attenuation or frequency response differences between the old and new upstream channels causes the received power at the Cisco CMTS to change by more than 6 dB.

• DCC initialization technique 3 must not be used if the conditions for using technique 2 are not met.

• DCC initialization technique 4 must not be used if the conditions for using technique 2 cannot be met.

• Micro-reflections on the new upstream channel result in an unacceptable BER (greater than 1e-8) with pre-equalization coefficients set to the initial setting.

• DCC is used only for dynamic downstream load balancing on DOCSIS 1.1 and later CMs. Upstream Channel Change (UCC) is always used for dynamic upstream load balancing on DOCSIS 1.x CMs. For DOCSIS 2.x CMs, UCC is used when the ucc option is configured. For DOCSIS 3.x CMs, DCC is used irrespective of whether the ucc option is configured or not.

• Prolonged interruption of the multicast traffic is expected if the cable modem moved by DCC is the first one in a dynamic multicast group on the target interface. The downstream multicast service flow cannot be reestablished until the Cisco CMTS receives an Internet Group Management Protocol (IGMP) join message from the customer premises equipment (CPE) as the result of the Cisco CMTS IGMP query, where the IGMP query interval is set to one minute. This is an IGMPv2 limitation.

• Multiple statically-assigned IP addresses to a CPE can be pinged. However, this works only if all the security features, such as verification of IP addresses for cable modems and CPE devices on the upstream, and other security mechanism are disabled.

• The TCS and RCS assigned to the DOCSIS 3.0 cable modems are restricted by the upstream and downstream bonding groups configured by the Cisco CMTS.

• Load balancing and DCC are not supported for CMs that are enabled for Layer 2 VPN (L2VPN) support.

• When a DCC occurs, the cable modem US and DS counters are reset. The US and DS counters include counters such as data and throughput seen in the show cable modem (mac-address) verbose command output and packets and bytes seen in the show cable modem (mac-address) counters command output.

### DCC Restrictions with N+1 Redundancy and Inter-Card Load Balancing

• Inter-card load balancing is not supported with cable interface line cards using N+1 redundancy. Refer to general DCC restrictions for additional information.

• Dynamic load balancing should not be used together with N+1 redundancy. Cable modems with outstanding DCC transactions go offline after a switchover event.
When cable modems go offline during a switchover event, the load balancing feature activates. Cable modems move in relation to the switchover event. When the cable modems return online, load balancing may need to initiate again.

To facilitate load balancing during a switchover, you can increase the dynamic load balance threshold, if a certain percentage of cable modems that reset during switchover is configured in the system. An alternate method is to use static load balancing with N+1 redundancy. For more information, see the Types of Load Balancing Operations.

Restrictions for DOCSIS 3.0 Static Modem Count-Based Load Balancing

- Static modem count-based load balancing is supported on MTC and MRC-only cable modems. Single-channel, narrowband cable modems will continue to be supported with dynamic load balancing. MRC-only modems are supported by dynamic load balancing on upstream channels.

DOCSIS 3.0 static modem count-based load balancing is not supported on:

- Multiple line cards.
- Load balancing groups and downstream channels shared across multiple line cards.
- DOCSIS 3.0 static modem count-based load balancing does not support service flow method of load balancing.

Restrictions for Dynamic Bonding Change for DOCSIS 3.0 Static Modem Count-Based Load Balancing

- The Cisco CMTS can use only DBC messaging to move modems within a MAC domain and applies only to cable modems operating in MTC mode or MRC-only mode without a primary downstream change.
- The Cisco CMTS moves the MRC-only cable modems with a primary channel change using DCC with initialization technique 0.
- The Cisco CMTS moves cable modems across MAC domains using only DCC with initialization technique 0.
- The Cisco CMTS must ensure minimum interruption to existing QoS services while considering an initialization technique that is suitable for the cable plant conditions.

DOCSIS 3.0 Static Load Balancing uses Initialization Technique 1 to move cable modems for DBC movement.
• Initialization Technique 1—(Broadcast initial ranging) may result in a lengthy interruption of service, which is mitigated by the reservation of QoS resources on the new channel(s). The service interruption can be further reduced if the Cisco CMTS supplies the UCD TLV in the DBC request in addition to providing more frequent initial ranging opportunities on the new channel.

• Initialization Technique 2—(Unicast ranging) offers the possibility of only a slight interruption of service. To use this technique, the Cisco CMTS must include the UCD TLV in the DBC message if the upstream channel is changing.

• Initialization Technique 3—(Broadcast or unicast ranging) offers the possibility of only a slight interruption of service. Use this technique when there is uncertainty when the CM may execute the DBC command and thus a chance that it might miss station maintenance slots. However, the Cisco CMTS should not use this technique if the conditions for using techniques 1 and 2 are not completely satisfied.

• Initialization Technique 4—(Use the new channel directly) results in the least interruption of service.

• For a DOCSIS 3.0 cable modem that in a DOCSIS 3.0 static load balancing group, the multicast join will be dropped before REG-HOLD time elapses.

Restrictions for MRC-Only Cable Modems

• MRC-only cable modems use single channel non-bonded upstreams (similar to narrowband (NB) modems) and multi-channel bonding groups on the downstream.

  Note  The following restrictions apply only to DOCSIS 2.0 and DOCSIS 3.0 cable modems in MRC-only mode.

• cable modems are moved across upstream channels using DCC.

• cable modems are moved to different downstream channels through DBC, if there is a change in the upstream channel and downstream channel bonding group, but not in the primary downstream channel and the upstream channel change is ignored.

  However, if there is a change in the primary downstream channel also, DCC with init tech 0 is used to balance the cable modems.

• MRC-only modems are treated similar to cable modems operating in MTC mode, to move modems across downstream channels. For change in upstream channel, MRC-only cable modems are treated similar to single-channel NB cable modems.

Information on the Load Balancing on the Cisco CMTS

This section describes the operation, concepts, and benefits of the Load Balancing on the Cisco CMTS feature:

Feature Overview

The Load Balancing on the Cisco CMTS feature allows service providers to optimally use both downstream and upstream bandwidth, enabling the deployment of new, high-speed services such as voice and video.
services. This feature also can help reduce network congestion due to the uneven distribution of cable modems across the cable network and due to different usage patterns of individual customers.

By default, the Cisco CMTS platforms use a form of load balancing that attempts to equally distribute the cable modems to different upstreams when the cable modems register.

This feature has been enhanced to make use of DOCSIS policies and rules to limit the movement of cable modems within a Load Balancing Group. A policy defines whether and when cable modems can be moved within their load balancing groups.

A policy consists of a set of rules. Each rule can be defined as “enabled”, “disabled”, or “disabled during time period.” Multiple policies can share a single rule. However, if you remove the last rule of a policy, that will also remove the policy.

Each rule can be used in any number of policies. When it is defined by multiple rules, all rules apply in combinations. Each rule helps to prohibit load balancing using a particular cable modem and to prohibit load balancing using a particular cable modem during certain times of the day.

Following are the general guidelines for the rules and policies:

- The policy or rule is recognized by a 32-bit ID.
- Each cable modem can have one policy only.
- Each rule can be associated to one or more policies.
- Each policy is described by at least one rule, otherwise it cannot be created.
- The zero Policy ID is reserved by Cisco CMTS indicating “Do nothing to LB prohibition.”
- If the policy ID specified by the cable modem configuration file is not configured on Cisco CMTS, no LB prohibition is applied to that CM. However, after the policy with the matched ID is configured, LB prohibition takes effect immediately.

### Methods to Determine When Interfaces Are Balanced

In addition to selecting how interfaces should be balanced (using the static, passive, or dynamic types of load balancing), you can also select one of the following methods that the Cisco CMTS should use to determine when interfaces are balanced:

- **Modems Method**—Uses the number of active cable modems on an interface.
- **Utilization Method**—Uses the current percentage of utilization of an interface.

See the following sections for more information about each method.

### Modems Method

The modem method of load balancing uses the number of active cable modems on an interface to determine the current load. This is a form of distribution-based load balancing, in which the absolute numbers of modems are used to determine whether interfaces are load balanced.

This method does not take into account the amount of traffic flowing through the cable modems, but the system does take into account the relative bandwidth of the channels being used, so that channels with higher bandwidths are allocated higher numbers of cable modems. This means that when interfaces are using different channel widths or modulation profiles, the system can assign different numbers of cable modems to the interfaces to achieve a balanced load. For example:
Utilization Method

- Channel widths— If two upstreams are being load balanced, and one upstream is configured with a channel width of 1.6 MHz and the other upstream is configured for a channel width of 3.2 MHz, the Cisco CMTS allocates twice as many cable modems to the second upstream because its channel width is twice as large as the first upstream channel width.

- Modulation profiles— If one downstream is configured for 64-QAM and the other downstream is configured for 256-QAM, the Cisco CMTS allocates a proportionately larger number of cable modems to the second downstream so as to achieve a balanced load.

When both the channel width and modulation profile are set differently on two interfaces, the system calculates a “weight” value to use as a guide to determine the relative bandwidths of the interfaces.

Tip
In a system with balanced loads, the interfaces will contain the same number of cable modems only when the interfaces are configured with the same channel width and modulation parameters.

Utilization Method

Note
Narrowband cable modems, multiple downstream modems and upstreams of MRC-only cable modems participate in the utilization method.

The utilization method uses an interface’s current percentage of utilization to determine the current load. This method uses the amount of traffic being sent over an interface, in the form of the percentage of total bandwidth being used. The system takes into account the relative throughput and bandwidth (as determined by the modulation profiles and channel widths) of each interface when evaluating the load on those interfaces.

For example, if two upstreams are being load balanced using the utilization method, and the first upstream has twice the bandwidth of the second upstream, the two upstreams are considered balanced when they reach the same percentage of utilization. The first upstream is carrying more traffic than the second upstream because it has a larger capacity for traffic, but the percentage of utilization will be the same.

Wideband Interface Average Utilization and Throughput

The average utilization and average throughput between Wideband interfaces of the same size can be calculated by:

Average Utilization (WB) = \( \sum_{i=1}^{n} r_{fch} - util(r_{f}) / n \)

- \( n \) represents the size of the Wideband interface
- \( \sum_{i=1}^{n} r_{fch} - util(r_{f}) \) represents the sum of rfch - util of QAM channels in Wideband interface.

Average Throughput (WB) = AverageThroughput(WB) in last 30s/\( \sum_{i=1}^{n} BW(r_{f}) \)

- Average Throughput (WB) represents the KB recorded in the last 30 seconds
- \( \sum_{i=1}^{n} BW(r_{f}) \) represents the total bandwidth of Wideband interface.

Note
Use the show cable load-balance load wideband command to view the average utilization and average throughput between Wideband interfaces.
Load Balancing Parameters

You can determine which cable interfaces should participate in load balancing operations. You can also choose which of the following methods should be used to determine the current load on a cable interface, and therefore determine whether cable modems should be moved:

- Number of active cable modems
- Channel bandwidth utilization

You can also specify the threshold values that the Cisco CMTS should use to determine how to assign new cable modems to upstreams and downstreams for both types of load balancing. You can also configure whether cable modems with active Voice-over-IP (VoIP) calls should be moved, and if so, what thresholds should be used. You can also exclude certain cable modems from one or all of the different forms of load balancing.

Configurable Minimum Threshold under Utilization Method

The utilization method does not move cable modems for load balancing until the utilization of at least one of the interfaces reaches minimum threshold. This is done to avoid the unnecessary moving of cable modems due to temporary spikes in an interface's utilization rate.

Minimum utilization threshold can be configured under Utilization Method. The minimum utilization threshold may be configured in a range of 10 to 90 percent. As a result the cable modems will be moved only when the configured minimum utilization threshold is reached on an interface.

To configure the minimum threshold under the Utilization method, use the `cable load-balance method-utilization min-threshold` command in global configuration mode. For more information, refer to `cable load-balance method-utilization min-threshold` command reference.

Single Channel Load Balancing

Error Handling of Channel Assignment

As long as the interface state of the channels is not "administratively down", all channels are available for LBG assignment. For other load balancing operations, such as moving modems using DCC, or UCC, the interface state of the channels should be in "initial", "up", "suspicious", or "testing" states.

Downstream Load Balancing Distribution with Upstream Load Balancing

Downstream load balancing provides equalized load balancing with upstream group members. This enhancement synchronizes the “pending” statistic between different cable interface line cards in the load balancing group. The result is an alternative downstream load balancing scheme that makes use of per-upstream loads rather than total downstream loads.

This enhancement performs downstream load balancing that accounts for upstream channel loads in the same upstream load balancing group, rather than on the basis of the entire downstream channel load. Prior Cisco IOS releases may not have distributed cable modems evenly over individual upstream channels, nor in a way that accounted for downstream and upstream together.

The load balancing enhancement applies when downstream load balancing occurs on a headend system with separate upstream load balancing segments; the upstream segments are spread over multiple downstream segments.

The configuration and operation of making downstream load balancing decisions is enabled as follows:
• The target downstream segment is in the same downstream load balancing group as the source downstream segment.

• The upstream load balancing group can be set for the corresponding channel on which a cable modem is balanced.

• The Cisco CMTS automatically locates the upstream segment for a load balancing group and processes the upstream group status on the source interface that has the lowest load.

• The target downstream segment must have an upstream channel set in the upstream load balancing group.

• The highest target upstream segment must carry less load than any other potential target—the highest upstream segment on other interfaces.

For example, several upstream segments can be configured across multiple downstream segments as follows:

<table>
<thead>
<tr>
<th>U0</th>
<th>U1</th>
<th>U2</th>
<th>U3</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/0</td>
<td>LB10</td>
<td>LB11</td>
<td>LB12</td>
<td>LB13</td>
</tr>
<tr>
<td>4/0</td>
<td>LB10</td>
<td>LB11</td>
<td>LB12</td>
<td>LB13</td>
</tr>
<tr>
<td>5/0</td>
<td>LB10</td>
<td>LB11</td>
<td>LB12</td>
<td>LB13</td>
</tr>
<tr>
<td>6/0</td>
<td>LB10</td>
<td>LB11</td>
<td>LB12</td>
<td>LB13</td>
</tr>
</tbody>
</table>

In this example, a cable modem that comes online on the interface cable 5/0 Upstream 2 could potentially come online on the following interfaces:

• cable 3/0 upstream 2

• cable 4/0 upstream 2

• cable 6/0 upstream 2

The enhancement enables the following advantages and behaviors:

• This enhancement adds support for synchronizing the “pending” statistic between different cable interface line cards and the network processing engine (NPE) so that a better decision can be made about where cable modems should be moved. This function can be used as a normal downstream load balancing implementation, if desired.

• This enhancement adds the `us-groups-across-ds` keyword to the `cable load-balance group` command for configuring downstream load balancing groups with upstream resources.

---

**Note**

You can use the `no cable load-balance docsis20-enable` command to disable DOCSIS 2.0 dynamic downstream and upstream load balance.

---

**Upstream Load Balancing for DOCSIS 3.0 Cable Modems in Single Upstream Mode**

The upstream load balancing functionality enables the Cisco CMTS router to effectively handle upstream traffic for wideband and narrowband cable modems that are in single upstream mode. Single upstream mode (Mx1) means that the modems cannot send upstream traffic on multiple upstream channels. In the event of traffic overload on a single upstream channel of a wideband or narrowband cable modem, the Cisco CMTS router automatically moves the cable modem to another upstream channel in the same load balancing group.
A cable modem operating in single upstream mode is assigned to a load balancing group based on the primary channel of the modem. A cable modem in single upstream mode can support multiple receive channel (MRC) mode or narrowband mode. However, a cable modem in single upstream mode cannot support multiple transmit channel mode (MTC).

**Interaction with Spectrum Management**

Cisco cable interface line cards support a number of features to maximize channel bandwidth and to minimize the impact of ingress noise on cable modem traffic. These features have the following impacts upon load balancing operations:

- **Frequency hopping**—Frequency hopping does not affect the load balancing algorithm, because it does not change either the bandwidth of a channel nor the number of cable modems on an interface.

- **Dynamic modulation changes**—The dynamic modulation feature affects the load balancing algorithm because it typically switches an interface from a higher-bandwidth modulation profile to a lower-bandwidth modulation profile in response to noise conditions on the interface.

  For example, if an upstream is configured for 16-QAM, sufficient noise levels could switch the upstream to a QPSK modulation profile. Depending on the load balancing configuration, this could then result in the movement of cable modems to other channels. Similarly, when the noise conditions improve, and the modulation is returned to the original, higher-bandwidth profile, the cable modems could be moved again to rebalance the upstream channels.

- **Channel width changes**—Cisco cable interface line cards support automatic changes to the channel width in response to noise conditions. Because changing the channel width affects the throughput of a channel, this also affects the load balancing algorithm.

  For example, if noise makes the current channel width unusable, the Cisco cable interface line card reduces the channel width until it finds a usable channel width. Because this reduces the available bandwidth on the channel, the load balancing algorithm moves cable modems to rebalance the upstreams.

  In addition, the Cisco cable interface line card does not automatically restore the original channel width when noise conditions improve. Instead, the card changes the channel width only when it performs a subsequent frequency hop, either in response to additional noise conditions or when an operator performs a manual frequency hop. When the hop occurs, the card then searches for the largest possible channel width, and this could result in another movement of cable modems to rebalance the channels.

**Using Dynamic Channel Change**

DCC in DOCSIS 1.1 dynamically changes cable modem upstream or downstream channels without forcing a cable modem to go offline, and without re-registration after the change. DCC supports five different initialization methods (0-4).

- **Load balancing techniques** allow for moving cable modems with DCC by using configurable initialization techniques.

- **DCC** allows line card channel changes across separate downstream channels in the same cable interface line card, with the DCC initialization techniques ranging from 0 to 4.

- **DCC** transfers cable modem state information from the originating downstream channel to the target downstream channel, and maintains synchronization of the cable modem information between the cable interface line card and the Network Processing Engine (NPE) or Route Processor (RP).
• Applications that are sensitive to delay, such as PacketCable (PC) and PacketCable Multi Media (PCMM), may use DCC initialization technique 4 to retain services while the cable modem is performing DCC.
• If the channel is in mixed or ATDMA-only mode, the primary Service Identifier (SID) must be switched to ATDMA-only mode.

Note
You can use the `no cable load-balance docsis20-enable` command to disable DOCSIS 2.0 dynamic downstream and upstream load balance.

**Multiple Channel Load Balancing**

**Algorithm for Bonded Channel Cable Modem Load Balancing**

During registration of the cable modem, the modem count-based method uses the number of active cable modems on the allowed RCS to determine the current load on each channel. After the modem is assigned an RCS, the Cisco CMTS does not move the cable modem even when traffic conditions change.

When a cable modem sends a registration request, modem count-based method of load balancing ranks the allowed receive channel sets (RCS) based on their modem count and assigns the set with the lowest number of CMs, to the ranging cable modem.

**DOCSIS 3.0 Static Modem Count-Based Load Balancing**

The static modem count-based load balancing supports the following:

• DOCSIS General and Restricted load balancing group assignment to include DOCSIS 3.0 cable modems in MTC and MRC-only modes.

Note
DOCSIS 3.0 static modem count-based load balancing is not supported:

• Across multiple line cards.
• For load balancing groups and downstream channels shared across multiple line cards. However, autonomous load balancing-based CM steering and load balancing group assignment is supported across multiple line cards.

• Use of DCC and DBC in load balancing.
• Use of DBC for MRC-only modems during downstream move.
• Use of DCC with init tech 0 if the primary downstream channel is changed for MRC-only CMs.
• Use of DBC for cable modems in MTC mode for all upstream and downstream modem move.
• Separate counters for NB and wideband (WB)/upstream bonding (UB) CMs. For more information, see the `show cable load-balance docsis-group` command in the Cisco IOS CMTS Cable Command Reference.
• Aggregate logical channels to physical channels for load balancing. Physical channel load is calculated by using average weights among all logical channels.
• Non-primary downstream channels load where utilization of SPA QAM is considered.
When the CM counts across different WB interfaces are within predefined threshold levels, the load is always considered as balanced; no more CM move is initiated by the LB system. No service flow count, whether primary or secondary, is taken into consideration during this LB process.

Note

The attributes considered for the forward interface for the service flow (SF) are attribute mask and available bandwidth, and not the number of service flows on each channel. If a channel is within the new RCS, then irrespective of the type of narrowband SF, (whether primary or secondary, or static or dynamic) the SF continues to use its current channel.

Note

The US Phy Mode counters (scdma, atdma, and tdma) remain 0 for the UB interfaces.

DOCSIS 3.0 static modem count-based load balancing is based on legacy load balancing and supports any type of channel combination (upstream and downstream)—MxN, with 1x1 combination being the subset.

DOCSIS 3.0 static modem count-based load balancing controls dynamic changes to the set of downstream and upstream channels used by a registered CM. It supports the following:

- Multiple channel load balancing operation.
- Load balancing operation based on policies and priorities.
- Load balancing with multicast. DOCSIS 3.0 static modem count-based load balancing does not move any CM with active video sessions.

DOCSIS 3.0 static modem count-based load balancing supports the modem count-based load balancing in a hybrid deployment of DOCSIS 1.x, 2.0 and 3.0 cable modems.

Static modem count-based load balancing is supported only for DOCSIS 3.0 CMs. Single-channel, narrowband cable modems will continue to be supported with dynamic load balancing. MRC-only cable modems are supported by dynamic load balancing on upstream channels.

With DOCSIS 3.0 static modem count-based load balancing, when load balancing related configuration within the LBG is changed as follows, the cable modems are forced to re-register:

- Partial shut or no shut interfaces under the LBG domain
- MRC or MTC mode in cable modems is turned on or turned off
- Change in fiber node for GLBG
- Change in wideband configuration for downstream group
- Change in the upstream bonding group

Use the following commands to force cable modems to re-register:

- clear cable modem delete
- clear cable load state
Primary Channel Load Display for Target RCS

This feature enables the bonded modems to be moved at the time of registration such that the primary channels are distributed evenly among the primary-capable channels apart from the load being balanced on the target DS channels. Modem method ranks the RCS based on their primary loads and assigns the set with the lowest primary load to the ranging cable modem.

An optional keyword primary-load has been added to the show cable load-balance docsis-group command to display the primary load of an RCS. For more information, see the Cisco CMTS Command Reference.

Although the modem count-based method distributes the cable modems fairly as they register, the following conditions may cause a system imbalance:

- A channel or groups of channels fail because of a planned (administrative shutdown) or unplanned event.
- While some cable modems may continue to operate in partial mode, some may re-register because of the failure and are reassigned to the channels that are active.
- When the failed channels become operational again, the cable modems do not re-register and the system is unbalanced.

In this case, the modem count-based method sends an SNMP trap to alert the operator, and the operator can choose to manually intervene to re-balance the cable modems by resetting the MAC domain to force all cable modems to re-register.

For cable modems in MRC and MTC modes, the modem count based load balancing method considers the number of active modems and service flows on the primary channels in the RCS and TCS of the cable modem.

Use no cable load-balance docsis30-enable static command to disable this feature.

Dynamic Load Balancing for DOCSIS 3.0 Cable Modems

The existing Load Balancing (LB) feature is enhanced to cope with the increase in the number of downstream and upstream channels by Multi-Service Operators (MSO) and wider deployment of 16-channel, 24-channel and multiple downstream channel Cable Modems (CMs). This enhancement allows the customer to better utilize their available bandwidth. The enhancements made to the existing LB feature include:

- Utilization based Dynamic downstream LB for DOCSIS 3.0
- Support for DOCSIS 3.0 LB statistics
- Enable or Disable DOCSIS 3.0 LB feature
- Distribute the CM on all the primary channels for the target interface when performing DOCSIS 3.0 LB dynamic movement. This feature is only used on DOCSIS 3.0 LB dynamic movement. It is disabled by default. Use method utilization primary-distributed command in the DOCSIS load balancing group mode to enable this feature. To disable this feature, use no form of this command or method utilization us-method command.
Use `cable load-balance docsis-enable` command to enable this feature. In addition, use `cable load-balance docsis30-enable` and `cable load-balance docsis30-enable dynamic downstream` command to enable dynamic and utilization based dynamic downstream LB for DOCSIS 3.0 Cable Modems.

### Multiple Channel Load Balancing Operation

CMs load balance in MRC and MTC modes. The following rules apply while load balancing CMs operating in these modes:

- For CMs operating in MRC and MTC modes, DBC is used to move CMs across downstreams by changing the RCS of the CM within same MAC domain.

  CMs operating in MRC-only mode can be moved across upstreams only through a DCC request. However, the Cisco CMTS uses DCC with initialization technique 0 (reinitializing the MAC domain) when changing the downstream channel of a CM operating in MRC mode.

- During CM registration, the Cisco CMTS may send a multipart registration response (REG-RSP-MP) message to include a TCC TLV encoding to the CM. This CM is marked as TCC-capable.

  For CMs operating in MRC, non-MTC, non-TCC-capable mode, load balancing uses:

  - DBC to change RCS of the CM
  - DCC to change upstream channel of the CM

- For CMs operating in narrowband mode, DCC is used to move CMs within and across MAC domains.

The tables below provide a snapshot view of the load balancing methods and the operations used to move bonded and non-bonded CMs:

**Table 14: Load Balancing Method to Move Bonded and Non-bonded CMs**

<table>
<thead>
<tr>
<th>Modem Mode</th>
<th>Load Balancing Method</th>
<th>Load Balancing Counters</th>
<th>Channels</th>
<th>Dynamic Service Charge (Initialization Technique)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Within MAC Domain</td>
</tr>
</tbody>
</table>

Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.x
<table>
<thead>
<tr>
<th>Modem Mode</th>
<th>Load Balancing Method</th>
<th>Load Balancing Counters</th>
<th>Channels</th>
<th>Dynamic Service Charge (Initialization Technique)</th>
</tr>
</thead>
</table>
| DOCSIS 3.0 CM in MTC mode | DOCSIS 3.0 static modem count-based load balancing (MCBLB) DOCSIS 3.0 dynamic load balancing | WB/UB | DS | DBC  
Note: When DOCSIS 3.0 LB is enabled, and the MTC CM is outside RLBG, CM is moved inside RLBG. |
| DOCSIS 3.0 static modem count-based load balancing (MCBLB) | WB/UB | US | DBC  
Note: When DOCSIS 3.0 LB is enabled, and the MTC CM is outside RLBG, CM is moved inside RLBG. | DCC init tech 0 |
<table>
<thead>
<tr>
<th>Modem Mode</th>
<th>Load Balancing Method</th>
<th>Load Balancing Counters</th>
<th>Channels</th>
<th>Dynamic Service Charge (Initialization Technique)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS 3.0/D2.x CMs in MRC-only mode</td>
<td>DOCSIS 3.0 static MCBLB DOCSIS 3.0 dynamic load balancing</td>
<td>WB/UB</td>
<td>No change to the primary DS channel</td>
<td>DBC <strong>Note</strong> When DOCSIS 3.0 LB is enabled and CM with all DSs is outside RLBG, CM is moved inside RLBG.</td>
</tr>
<tr>
<td>DOCSIS 3.0 CMs in MRC-only mode</td>
<td>DOCSIS 2.0 static and dynamic MCBLB, dynamic utilization</td>
<td>NB</td>
<td>US</td>
<td>DCC init tech 0 <strong>Note</strong> CM with primary DS outside RLBG moves inside RLBG with DOCSIS 2.0 LB.</td>
</tr>
</tbody>
</table>

**US**

### DOCSIS Load Balancing Movements

#### Multiple Channel Load Balancing Operation

- **Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.x**
<table>
<thead>
<tr>
<th>Modem Mode</th>
<th>Load Balancing Method</th>
<th>Load Balancing Counters</th>
<th>Channels</th>
<th>Dynamic Service Charge (Initialization Technique)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2.x CMs in MRC-only mode</td>
<td>DOCSIS 2.0 static and dynamic MCBLB, dynamic utilization</td>
<td>NB</td>
<td>US</td>
<td>DCC/UCC &lt;br&gt;Note CM outside RLBG moves inside RLBG with DOCSIS 2.0 LB.</td>
</tr>
<tr>
<td>DOCSIS 2.0 /DOCSIS 1.1 CMs in NB mode</td>
<td>DOCSIS 2.0 dynamic MCBLB, dynamic utilization</td>
<td>NB</td>
<td>DS</td>
<td>DCC &lt;br&gt;Note CM outside RLBG moves inside RLBG with DOCSIS 2.0 LB.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>US</td>
<td>UCC &lt;br&gt;Note CM outside RLBG moves inside RLBG with DOCSIS 2.0 LB.</td>
</tr>
</tbody>
</table>
Table 15: Using DCC/DBC to Load Balance Bonded and Non-bonded Cable Modems

<table>
<thead>
<tr>
<th>Channel</th>
<th>CM in MRC, MTC Mode</th>
<th>CM in MRC, non-MTC Mode</th>
<th>DOCSIS 1.1/2.0 CMs with Single US/DS</th>
<th>DOCSIS 1.0 CMs with Single US/DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream (US)</td>
<td>DBC</td>
<td>DCC</td>
<td>DCC</td>
<td>UCC</td>
</tr>
<tr>
<td>Downstream (DS)</td>
<td>DBC (within the same MAC domain)</td>
<td>DBC (within the same MAC domain)</td>
<td>DCC (within the same MAC domain)</td>
<td>Force reinitialize CM</td>
</tr>
<tr>
<td></td>
<td>DCC with initialization technique 0 when moving CMs across MAC domains</td>
<td>DCC with initialization technique 0 when moving CMs across MAC domains</td>
<td>Force reinitialize CM</td>
<td>Force reinitialize CM</td>
</tr>
</tbody>
</table>

Using DBC for DOCSIS 3.0 Load Balancing Movement

As part of the DOCSIS 3.0 specifications, at any time after registration, the Cisco CMTS uses the DBC command to change any of the following parameters in a DOCSIS 3.0 CM:

- Receive channel set
- Transmit channel set
- DSID(s) or DSID associated attributes
- Security association(s) for encrypting downstream traffic
- Service Flow Cluster Assignments

**Note**

Only RCS and TCS are used by the DOCSIS 3.0 load balancing.

Use the `show cable load-balance docsis-group` command to display the current, real-time statistics for load balancing operations. For more information, see the Cisco IOS CMTS Cable Command Reference.

### Using DBC to Change the Receive Channel Set

The Cisco CMTS can add, delete, or change the channels in the RCS of a cable modem by including a RCC in the DBC-REQ.

If an RCS change affects the primary downstream channel of the cable modem, the cable modem is required to re-register on its upstream channels.

If channels are deleted from the RCS, the Cisco CMTS may stop sending traffic on the downstream channel to be removed, which may cause loss of traffic. The Cisco CMTS minimizes packet loss by duplicating traffic on the new and old RCS until it receives a DBC-RSP from the cable modem.

**Note**

For cable modems in MRC-only mode, a downstream channel move is initiated by a DBC message. However, DCC initialization technique 0 is used if there is a change in the primary downstream channel.

### Using DBC to Change the Transmit Channel Set

The Cisco CMTS can add, delete, or replace one or multiple channels in the TCS in a single DBC message. Whenever the TCS of the cable modem changes, the CMTS appropriately modifies the service identifiers (SIDs) associated with the affected service flows.

A change in the TCS is accompanied by a valid initialization technique.

### Using DBC to Change the Downstream ID

Using DBC, the Cisco CMTS can change the following attributes of a downstream ID (DSID):

- Re-sequencing encodings:
  - Downstream re-sequencing channel list—The CMTS can add, delete, and replace channels in the DS re-sequencing channel list.
  - DSID re-sequencing wait time—The CMTS can indicate a change in skew due to network or configuration changes through DSID re-sequencing wait time.

- re-sequencing Warning Threshold
- CM-STATUS Hold-Off Timer for Out-of-range Events
- Multicast Encoding—The CMTS can initiate a DBC transaction to either add, deleted, or change attributes of an existing multicast DSID:
• Client MAC Address
• Multicast cable modem interface Mask
• Group MAC Address

Using DBC to Change the Security Association for Encrypting Downstream Traffic

• The CMTS can initiate a DBC transaction to add or delete Security Associations (SA) used to encrypt downstream traffic.

• The CMTS cannot send a DBC request to a cable modem that is not in the "Authorized" State.

• The CMTS can send a DBC request with an SA that uses a cryptographic suite unsupported by the cable modem. However, if the cable modem receives a DBC request with an SA that it is not capable of using, the cable modem rejects the DBC request.

Using DBC to Change the Service Flow SID Cluster Assignments

The Cisco CMTS uses the Service Flow SID Cluster Assignments TLV in the DBC request to assign new channels to a service flow, remove channels from a service flow, or replace one channel with another for a service flow.

Note

Multiple actions can occur within a single DBC message.

Benefits of Load Balancing

The Load Balancing feature on the Cisco CMTS provides the following benefits to cable service providers and their partners and customers:

• Provides a method that service providers can use for efficient bandwidth utilization, especially when using multiple upstream channels per fiber node.

• Allows service providers to expand their networks in an efficient manner, avoiding the cost of having to install additional fiber optic equipment and further segmenting the physical plant.

• Load balancing on downstream channels enables efficient bandwidth usage when using multiple downstream channels per fiber node to enable Video over IP and other services that require high-bandwidth real-time streams.

• Load balancing of upstream and downstream channels does not require any change to the provisioning servers or to any DOCSIS configuration files.

• Load balancing of upstream and downstream channels does not require any administrator or user intervention (such as manually resetting cable interfaces or manually rebooting cable modems).

• Allows service providers to equally balance their downstreams as cable modems register, so that cable modems do not all attempt to register on the same downstream, resulting in many cable modems failing to register and having to search for a new downstream.

• Cable modems can be moved among downstream and upstream channels without having to change any network parameters in manual fashion, such as IP address.
• Allows service providers to stay ahead of customers’ bandwidth demands by dynamically responding to current load-usage conditions.
• Allows service providers to optimize the load balancing parameters for critical services, such as Voice over IP (VoIP).

Exclude Cable Modems from Load Balancing Groups

Load Balancing Process
The load balancing process has two phases.

• Assignment phase.
  When a modem is coming online in the assignment phase, the modem is moved to the load balance group by assigning it a load balancing group (LBG) ID. The assignment phase occurs only when a modem is coming online.

• Balancing phase.
  In the balancing phase, a modem is re-assigned to an LBG to balance the load.

Excluding Cable Modems from Load Balancing
There are four options that are used to exclude cable modems from an LBG:

• The **assignment** option:
  The **assignment** option is used to exclude a modem during the assignment phase. The modem is not assigned an LBG and LBG ID is not displayed in the output of the `show cable modem verbose` command. The **assignment** option cannot be used when a modem is already online.

• The **static** option:
  The **static** option is used to exclude a modem during the Balancing phase. The modem is assigned to an LBG with an LBG ID. The **static** option is used to exclude a modem during static load balancing.

• The **enforce** option:
  The **enforce** option is similar to the **static** option, except that the **enforce** option is used to exclude a modem during dynamic load balancing.

When a cable modem is excluded from load balancing using the **assignment** option, the cable modem is not available for load balancing using the **static** or the **enforce** options.

• The **strict** option:
  The **strict** option excludes a modem in both the phases of load balancing. When a modem is online already, the **strict** option applies the **static** and the **enforce** options. It applies the **assignment** option only when the modem comes online again.

How to Configure Load Balancing
To configure load balancing groups, and to enable load balancing, refer to the configurations in the *DOCSIS Load Balancing Groups* document. Each task is marked as required or optional, as appropriate.
Enabling Single Channel Load Balancing

To configure Single Channel Load Balancing, see the DOCSIS Load Balancing Groups guide.

Configuring Dynamic Bonding Change for DOCSIS 3.0 Static Load Balancing

Use the cable load-balance docsis30-enabled command in the global configuration mode, to enable DOCSIS 3.0 Static Load Balancing.

---

**Note**

DOCSIS 3.0 Static Load Balancing always uses Modem Count Method for load balancing.

---

**Before you begin**

Configure Load Balancing Groups. For more details, see the DOCSIS Load Balancing Groups guide.

Excluding Cable Modems from a Load Balancing Group

This configuration is optional. This section describes how to exclude a particular cable modem, or all cable modems from a particular vendor, from participating in static or dynamic load balancing operations, and optionally marking the modems for passive load balancing. This task is optional, because, by default, cable modems on an interface participate in whatever load balancing operations have been configured.

---

**Note**

This step might be required for some cable modems that are not DOCSIS-compliant. Such cable modems can go offline for long periods of time when load balancing is attempted using DOCSIS MAC messages. If this is the case, use the cable load-balance exclude command to exclude such cable modems from load balancing operations until the modem can be upgraded to DOCSIS-compliant software.

---

**Tip**

You must exclude cable modems that require specific upstream channels or downstream frequencies. Load balancing cannot be done when cable modems are assigned specific channels or frequencies in their DOCSIS configuration files.

**Support for Excluding Old Devices**

Load balancing for old cable devices like Set Top Boxes (STBs) which do not support load balancing, will fail. In the output for show cable load-balance group command, these devices will show as 'suspicious' and then as 'disabled'. This will disrupt normal operations of other modems in the load balancing group. To exclude these STBs, a cable load-balance exclude command is configured to exclude each STB.
You can configure the **cable load-balance exclude** command once to exclude all the STBs, that do not support load balancing, instead of configuring the command several times with matched MAC addresses. You can also move cable modems that were moved to a load balancing group in assignment phase.

The **cable load-balance exclude** modem command is modified to include the *mask* argument as an optional argument. The MAC address of a cable modem that belongs to the range specified by the MAC address mask, will be excluded by matching the “1” bit in mask. While configuring a new range rule using the *mask* argument, an existent rule with the same range is overwritten.

The **cable load-balance exclude** modem command is modified to include the *assignment* option. This option allows you to exclude a cable modem that was moved into a load balancing group in assignment phase.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td><code>Example:</code></td>
<td></td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><code>Example:</code></td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td><code>cable load-balance exclude</code></td>
<td>Specifies that one or more cable modems should be excluded from load balancing operations.</td>
</tr>
<tr>
<td>`{modem mac-address [mac-mask]</td>
<td>oui oui-value} [assignment</td>
</tr>
<tr>
<td><code>Example:</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config)# cable load-balance exclude oui 00:00:0c</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
</tr>
<tr>
<td><code>exit</code></td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td><code>Example:</code></td>
<td></td>
</tr>
<tr>
<td><code>Router(config)# exit</code></td>
<td></td>
</tr>
</tbody>
</table>

### Distributing Downstream Load Balancing with Upstream Load Balancing

Two commands are used to configure or display the configuration and status of distributed load balancing on the Cisco CMTS:

- `cable load-balance group ds-lb-group-id policy {pcmm | ugs | us-groups-across-ds}

- `show cable load all`

The optional configuration of making downstream load balancing decisions is enabled as follows:
• The target downstream segment is in the same downstream load balancing group as the source downstream segment. This feature finds the target frequency and interface based on the upstream loads within the same upstream group as the source.

• The upstream load balancing group can be set for the corresponding channel on which a cable modem is balanced on the downstream channels.

• The Cisco CMTS automatically locates the upstream segment for a load balancing group and processes the upstream group status on the source interface that has the lowest load.

• The target downstream segment must have an upstream channel set in the upstream load balancing group.

• The highest target upstream segment must carry less load than any other potential target—the highest upstream segment on other interfaces.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Router(config)# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> cable load-balance group ds-lb-group-id policy {pcmm</td>
<td>ugs</td>
</tr>
<tr>
<td>Example: Router(config)# cable load-balance group 1 policy us-groups-across-ds</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> exit</td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td>Example: Router(config)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> show cable load all</td>
<td>Displays load balancing statistics and status of load balancing configurations on the Cisco CMTS, to include distributed upstream-to-downstream load balancing when configured.</td>
</tr>
<tr>
<td>Example: Router# show cable load all</td>
<td></td>
</tr>
</tbody>
</table>

### How to Configure Dynamic Channel Change for Load Balancing

DCC in DOCSIS 1.1 dynamically changes cable modem upstream or downstream channels without forcing a cable modem to go offline, and without reregistration after the change. DCC supports five different initialization methods (0-4), instead of one, as in earlier DOCSIS support.
Dynamic Channel Change (DCC) and DCC for Load Balancing on the Cisco CMTS supports the following:

- Load balancing techniques allow for moving cable modems with DCC by using configurable initialization techniques.
- DCC allows line card channel changes across separate downstream channels in the same cable interface line card, with the DCC initialization techniques ranging from 0 to 4.
- DCC transfers cable modem state information from the originating downstream channel to the target downstream channel, and maintains synchronization of the cable modem information between the cable interface line card and the Network Processing Engine (NPE) or Route Processor (RP).
- Applications that are sensitive to delay, such as PacketCable (PC) and PacketCable MultiMedia (PCMM), may use DCC initialization technique 4 to retain services while the cable modem is performing DCC.
- If the channel is in mixed or ATDMA-only mode, the primary Service Identifier (SID) must be switched to ATDMA-only mode.

### Configuring Dynamic Channel Change for Load Balancing

To configure the DCC feature for load balancing, use the following steps. Values indicated are sample values that may differ from your own.

#### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `cable load-balance docsis-enable`
4. `cable load-balance docsis-group docsis-group-id`
5. `init-tech-list tech-list [ucc]`
6. `policy {pcmm | ugs | us-across-ds | pure-ds-load}]
7. `threshold {load {minimum <1-100> | <1-100>} | pcmm <1-100> | stability <0-100> | ugs <1-100>}`
8. `end`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td><code>cable load-balance docsis-enable</code></td>
<td>Enables DOCSIS load balancing on the Cisco CMTS.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config)# cable load-balance docsis-enable</code></td>
<td></td>
</tr>
<tr>
<td>Step 4</td>
<td>cable load-balance docsis-group docsis-group-id</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# cable load-balance docsis-group 1</td>
<td></td>
</tr>
</tbody>
</table>

**Step 5**

init-tech-list tech-list [ucc]

Sets the DCC initialization techniques that the Cisco CMTS can use to load balance cable modems.

**Example:**

```plaintext
Router(config-lb-group)# init-tech-list 1 ucc
```

**Step 6**

policy {pcmm | ugs | us-across-ds | pure-ds-load}

Selects the modems based on the type of service flow that are balanced.

**Example:**

```plaintext
Router(config-lb-group)# policy us-across-ds
Router(config-lb-group)# policy ugs
Router(config-lb-group)# policy pure-ds-load
```

**Step 7**

threshold {load [minimum <1-100> | <1-100>] | pcmm <1-100> | stability <0-100> | ugs <1-100>}

Selects the percentage of use beyond which load balancing occurs.

**Example:**

```plaintext
Router(config-lb-group)# threshold load minimum 10
Router(config-lb-group)# threshold pcmm 70
Router(config-lb-group)# threshold load 10
Router(config-lb-group)# threshold stability 50
Router(config-lb-group)# threshold ugs 70
```

**Step 8**

end

Returns to privileged EXEC mode.

**Example:**

```plaintext
Router# end
```

**What to do next**

To test and verify DCC for load balancing, use the following two commands:

- test cable dcc
- show controllers cable

These commands are described in the *Cisco CMTS Cable Command Reference*.

**Verifying Load Balancing Operations**

This section describes how to use certain test and show commands to verify the configuration and operation of the Load Balancing feature or Dynamic Channel Change feature on the Cisco CMTS.
Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

**Step 2** show cable load-balance [group n] [all | load | pending | statistics | target] | Displays real-time statistical and operational information for load balancing operations. If given without any options, this command displays information for the load balancing groups and each cable interface’s current load and load balancing status. You can also specify the following options: |
| Example: Router# show cable load-balance group 1 | |

**Step 3** test cable dcc [mac-addr | ip-addr | cable-if-src sid ] cable-if-target uschan {ranging-tech } | Tests Dynamic Channel Change (DCC) by moving a target cable modem, as specified by MAC address, IP address, or the primary service ID (SID) value. Applies to a cable modem on the source interface to an upstream channel on a target downstream interface using the initialization technique specified. |
| Example: Router# test cable dcc 0000.394e.4e59 | |

Example

This example shows the result of load balancing operations.

```
Router# show cable load all
DOCSIS 2.0 LB Enabled: Yes DOCSIS 3.0 LB Enabled: No
DOCSIS Group Status Interval DCC mask Policy Method Threshold
          /UCC      DS/US M/E/U/P/S
 1  RE  30  0xF8(0)/N 0  m/m  5/10/70/70/50
12345 GE  30  0xF8(0)/N 0  m/m  5/10/70/70/50
12346 RE  30  0xF8(0)/N 0  m/m  5/10/70/70/50
12347 RE  30  0xF8(0)/N 0  m/m  5/10/70/70/50
12348 RE  30  0xF8(0)/N 0  m/m  5/10/70/70/50
12349 RE  30  0xF8(0)/N 0  m/m  5/10/70/70/50

DOCSIS 3.0 General LB
MD FN Group ID S Intv DCC mask Policy Mtd MD-CM-SG Threshold
  /UCC  D/U M/E/U/P/S
Ca8/0/0 1 2147631104 E 30 0x30(2)/N 0  m/m 0x1200301 5/10/70/70/50
Ca8/0/1 3 2147631618 E 30 0x30(2)/N 0  m/m 0x1210301 5/10/70/70/50
Ca8/0/2 5 2147632132 E 30 0x30(2)/N 0  m/m 0x1220401 5/10/70/70/50
Ca8/0/2 6 2147632133 E 30 0x30(2)/N 0  m/m 0x1220402 5/10/70/70/50
Ca8/0/3 7 2147632646 E 30 0x30(2)/N 0  m/m 0x1230501 5/10/70/70/50
Ca8/0/3 8 2147632647 E 30 0x30(2)/N 0  m/m 0x1230502 5/10/70/70/50
Ca8/0/8 2 2147635201 E 30 0x30(2)/N 0  m/m 0x1280201 5/10/70/70/50
Ca8/0/9 4 2147635715 E 30 0x30(2)/N 0  m/m 0x1290201 5/10/70/70/50

Current load:

DOCSIS load-balancing load

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Group</th>
<th>Utilization</th>
<th>Rsvd</th>
<th>NBCM</th>
<th>WB/UB</th>
<th>Weight</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>In8/0/0:0(411 MHz)</td>
<td>initial 1</td>
<td>0%</td>
<td>0% (0%/0%)</td>
<td>0%</td>
<td>0</td>
<td>11</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>In8/0/0:0(411 MHz)</td>
<td>initial 2147631104</td>
<td>0%</td>
<td>0% (0%/0%)</td>
<td>0%</td>
<td>0</td>
<td>11</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Us8/0/0:0</td>
<td>initial 1</td>
<td>0%</td>
<td>0%</td>
<td>31</td>
<td>30.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Us8/0/0:0</td>
<td>initial 2147631104</td>
<td>0%</td>
<td>0%</td>
<td>31</td>
<td>30.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Us8/0/0:1</td>
<td>initial 1</td>
<td>0%</td>
<td>0%</td>
<td>31</td>
<td>30.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Troubleshooting Tips

Problem Packets are dropped when a cable modem moves from one channel to another.

Possible Cause When the test cable dcc command is used to move a cable modem from one channel to another with DCC initialization technique 3:

- If the pre-equalization coefficient is enabled, the cable modem moves and packet drop occurs for 5 seconds.
- If the pre-equalization coefficient is disabled, the cable modem moves and packet drop occurs for less than 1 second.

Possible Cause When the test cable dcc command is used to move a cable modem from one channel to another with DCC initialization technique 4:

- If the pre-equalization coefficient is enabled, the cable modem moves and packet drop occurs for less than 1 second.
- If the pre-equalization coefficient is disabled, the cable modem moves without any packet drop.

Solution No action is required.
Use the `show cable load-balance target` command to display the interfaces being used for load balancing, use the `test cable load-balance` command to test whether a cable modem can move between interfaces, and use the `show cable load-balance statistics` command to display the results of the test.

The following example shows how to test whether a specific cable modem responds to both a UCC request and to an upstream channel override to move from one upstream to another in its load balancing group:

```
Router# show cable load-balance target

Target assignments:
Interface    State Group Target
Cable1/0/0 (669 MHz) up 1
Cable1/0/0/U0 up 1 Cable1/0/0/U1 [enforce]
Cable1/0/0/U1 up 1

Router# show cable load-balance statistics

Statistics:
Target interface State Transfers Complete Pending Retries Failures
Cable1/0/0 (669 MHz) up 15 0 1 0
Cable1/0/0/U0 up 33 0 1 0
Cable1/0/0/U1 up 22 0 2 0

Router# test cable load-balance 0000.394e.4e59

Sending UCC request: Cable1/0/0/U0 --> U1
Waiting for test completion ........
Test results:
  UCC Response: 0.0s
  Initial Ranging: 8.5s
  Ranging Complete: failed.
  Modem replied to DOCSIS ping.
Test summary:
  UCC Response: success rate 100% min 0.0s max 0.0s avg 0.0s
  Initial Ranging: success rate 100% min 8.5s max 8.5s avg 8.5s
Testing US Channel Override: Cable1/0/0/U1 --> U0
Waiting for test completion ...........
Test results:
  Initial Ranging: 8.5s
  Ranging Complete: failed.
  Modem replied to DOCSIS ping.
Test summary:
  UCC Response: success rate 100% min 0.0s max 0.0s avg 0.0s
  Initial Ranging: success rate 100% min 8.5s max 8.5s avg 8.5s

Router# show cable load-balance statistics

Statistics:
Target interface State Transfers Complete Pending Retries Failures
Cable1/0/0 (669 MHz) up 15 0 1 0
Cable1/0/0/U0 up 34 0 1 0
Cable1/0/0/U1 up 23 0 2 0
```

The following example shows how to test whether a specific modem responds to a UCC request to move from one upstream to another in its load balancing group:
Router# show cable load-balance statistics

Statistics:

<table>
<thead>
<tr>
<th>Target interface</th>
<th>State</th>
<th>Transfers</th>
<th>Complete</th>
<th>Pending</th>
<th>Retries</th>
<th>Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable1/0/0 (669 MHz) up</td>
<td>15</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable1/0/0/U0 up</td>
<td>34</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable1/0/0/U1 up</td>
<td>23</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Router# test cable load-balance 0007.0e01.4129 ucc 1

Sending UCC request: Cable1/0/0/U0 --> U1
Waiting for test completion ........
Test results:
  UCC Response: 0.0s
  Initial Ranging: 10.3s
  Ranging Complete: 11.2s
  Modem replied to DOCSIS ping.
Test summary:
  UCC Response: success rate 100% min 0.0s max 0.0s avg 0.0s
  Initial Ranging: success rate 100% min 10.3s max 10.3s avg 10.3s
  Ranging Complete: success rate 100% min 11.2s max 11.2s avg 11.2s

Router# show cable load-balance statistics

Statistics:

<table>
<thead>
<tr>
<th>Target interface</th>
<th>State</th>
<th>Transfers</th>
<th>Complete</th>
<th>Pending</th>
<th>Retries</th>
<th>Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable1/0/0 (669 MHz) up</td>
<td>15</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable1/0/0/U0 up</td>
<td>35</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable1/0/0/U1 up</td>
<td>24</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following example shows information when moving a cable modem to a different upstream channel using DCC initialization technique 1. This example moves the cable modem 0012.17ea.f563 from interface c7/1/0 upstream 1 to interface c7/1/1 upstream 0 using DCC initialization technique 1:

Router# show cable modem

MAC Address | IP Address | I/F | MAC State | Prim RxPwr | Timing | Num BPI | Offset |
---|---|---|---|---|---|---|---|
0012.17ea.f563 | 12.0.0.2 | C7/1/0/U1 | online | 4 | 0.00 | 2449 | 0 N |

Router# test cable dcc 0012.17ea.f563 c7/1/1 0 1

Router# show cable modem

MAC Address | IP Address | I/F | MAC State | Prim RxPwr | Timing | Num BPI | Offset |
---|---|---|---|---|---|---|---|
0012.17ea.f563 | 12.0.0.2 | C7/1/1/U0 | online | 3 | 0.00 | 2451 | 0 N |

Configuration Examples for Load Balancing

This section provides the following configuration examples:
Example: Configuring Dynamic Channel Change for Load Balancing

The following examples illustrate the working of dynamic load balancing working process in DOCSIS 3.0 cable modems.

Verify configuration:

```
Router# show cable load-balance docsis-group 1
DOCSIS LB Enabled: Yes
DOCSIS 2.0 LB Enabled: No
DOCSIS 3.0 LB Enabled: Yes
DOCSIS 3.0 Static LB Enabled: No
DOCSIS 3.0 Dynamic Downstream LB Enabled: Yes
DOCSIS Status Interval DCC mask Policy Method Threshold
Group /UCC DS/US M/E/U/P/S
1 RE 60 0x38(2)/N 0 u/u 1/10/70/70/50
```

Verify channel current load:

```
Router# show cable load-balance docsis-group 1 load wideband
DOCSIS load-balancing wide band load
Interface Size Group Throughput(Kbps)/bw(Mbps) Avg-Util
Wi9/0/0:1 8 1 93324/300 36%
Wi9/0/0:2 8 1 37329/300 39%
Wi9/0/0:3 8 1 74659/300 31%
Wi9/0/0:4 8 1 0/300 13%
Wi9/0/0:5 8 1 9332/300 2%
```

Verify channel overload and target:

```
Router# show cable load-balance docsis-group 1 target wideband
Interface Bg-Id State Group Target
Wi9/0/0:1 28674 up 1 Wi9/0/0:5 ...
Wi9/0/0:2 28675 up 1 Wi9/0/0:5 ...
Wi9/0/0:3 28676 up 1 Wi9/0/0:5 ...
Wi9/0/0:4 28677 up 1 Wi9/0/0:5
Wi9/0/0:5 28678 up 1
```

Verify channel modem-list:

```
Router# show cable load-balance docsis-group 1 modem-list wideband
Codes: M - Multicast, U - UGS, P - PCMM, F - Max-Failures, X - eXcluded
L - L2vpn, R - RSVP
Primary WB MAC Address Primary DS RCC-ID Priority MUPFXLR State
Wi9/0/0:1 (10) c8fb.26a6.c02c In9/0/0:4 1 0 ------- LB_CM_READY
c8fb.26a6.c53a In9/0/0:4 1 0 ------- LB_CM_READY
```

Verify QAM channel utilization:

```
Router# show cable load-balance docsis-group 1 rfch-util
Interface Pstate Pending-In Pending-Out Throughput(Kbps) Util
In9/0/0:4 up No No 6517 17
In9/0/0:5 NA No No 6738 17
In9/0/0:6 NA No No 6250 17
In9/0/0:7 NA No No 6738 17
In9/0/0:8 up No No 8624 22
In9/0/0:9 NA No No 8482 22
In9/0/0:10 NA No No 8353 22
```

Verify channel statistic movement:
The following example of the running configuration illustrates DCC for load balancing.

Router# show cable load all

*Nov 11 15:42:18.955: %SYS-5-CONFIG_I: Configured from console by conscable load all

<table>
<thead>
<tr>
<th>Group</th>
<th>Interval</th>
<th>Method</th>
<th>DCC Init</th>
<th>Threshold</th>
<th>Technique</th>
<th>Minimum</th>
<th>Static</th>
<th>Enforce</th>
<th>Ugs</th>
<th>FCMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>modems</td>
<td>0</td>
<td>5</td>
<td>10%</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Current load:

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Group</th>
<th>Utilization</th>
<th>Reserved Modems</th>
<th>Flows</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 (0 MHz)</td>
<td>initial</td>
<td>1</td>
<td>0%(0%/0%)</td>
<td>0%</td>
<td>0</td>
<td>0 26</td>
</tr>
</tbody>
</table>

Target assignments:

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Group</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 (0 MHz)</td>
<td>initial</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Statistics:

Target interface | State | Complete | Pending | Retries | Failures |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 (0 MHz)</td>
<td>initial</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The following example of the running configuration illustrates DCC for load balancing.

Router# show running configuration

Building configuration...
Current configuration : 11889 bytes
!
version 12.3
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$tEvV$8xICVVbFm10hx0hAB7DO90
enable password lab
!
no cable qos permission create
do cable qos permission update
cable qos permission modems
cable load-balance group 1 threshold load 75 enforce
cable load-balance group 1 threshold stability 75
cable load-balance group 1 policy ugs
cable load-balance group 1 threshold ugs 75
The following example of the show cable load all command illustrates DCC for load balancing.

Router# show cable load all

*Nov 11 15:43:39.979: %SYS-5-CONFIG_I: Configured from conf t
Group Interval Method DCC Init Threshold
Technique Minimum Static Enforce Ugs PCMM
1 10 modems 0 5 75% 75% 75% 75%

Current load:

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Group Utilization</th>
<th>Reserved</th>
<th>Modems</th>
<th>Flows</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 (0 MHz)</td>
<td>initial</td>
<td>1</td>
<td>0%(0%/0%)</td>
<td>0%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Target assignments:

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Group</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 (0 MHz)</td>
<td>initial</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Statistics:

<table>
<thead>
<tr>
<th>Target interface</th>
<th>State</th>
<th>Transfers</th>
<th>Complete</th>
<th>Pending</th>
<th>Retries</th>
<th>Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 (0 MHz)</td>
<td>initial</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Pending:

<table>
<thead>
<tr>
<th>Modem</th>
<th>Group</th>
<th>Source interface</th>
<th>Target interface</th>
<th>Retries</th>
</tr>
</thead>
</table>

The following example illustrates a DCC load balancing group with the default DCC initialization technique. This command configures load balancing group 1:

Router(config)# cable load-balance group 1 threshold load 10 enforce

This configuration creates a dynamic load balancing group with the following default settings:

cable load-balance group 1 method modem
cable load-balance group 1 threshold load 10 enforce
cable load-balance group 1 interval 10
cable load-balance group 1 dcc-init-technique 0

The following example changes this DCC load balancing configuration to initialization technique 4:
Router# cable load-balance group 1 dcc-init-technique 4

Note
By default, UGS and PCMM policies are not turned on, so that CMs with active voice calls or PCMM calls participate in load balancing.

Additional References

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
<tr>
<td>documentation and tools for troubleshooting and resolving technical issues</td>
<td></td>
</tr>
<tr>
<td>with Cisco products and technologies.</td>
<td></td>
</tr>
<tr>
<td>To receive security and technical information about your products, you can</td>
<td></td>
</tr>
<tr>
<td>subscribe to various services, such as the Product Alert Tool (accessed from</td>
<td></td>
</tr>
<tr>
<td>Field Notices), the Cisco Technical Services Newsletter, and Really Simple</td>
<td></td>
</tr>
<tr>
<td>Syndication (RSS) Feeds.</td>
<td></td>
</tr>
<tr>
<td>Access to most tools on the Cisco Support website requires a Cisco.com user</td>
<td></td>
</tr>
<tr>
<td>ID and password.</td>
<td></td>
</tr>
</tbody>
</table>

Feature Information for DOCSIS Load Balancing Movements

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note
The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS Load Balancing Movements</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
Feature Information for DOCSIS Load Balancing Movements
CHAPTER 7

DOCSIS 3.0 Downstream Bonding

The DOCSIS 3.0 Downstream Bonding feature helps cable operators offer new, more bandwidth-intensive services by adding one or more additional downstream quadrature amplitude modulation (QAM) channels to the standard broadband DOCSIS system.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 121
- Information About DOCSIS 3.0 Downstream Bonding, on page 122
- How to Configure RCP and RCC Encoding, on page 124
- How to Configure Attribute Masks, on page 133
- How to Enable Service Flow Priority in Downstream Extender Header, on page 137
- Enabling Verbose Reporting for Receive Channel Profiles, on page 139
- Configuration Example for an RCC Template, on page 140
- Additional References, on page 141
- Feature Information for DOCSIS 3.0 Downstream Bonding, on page 141

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
## Information About DOCSIS 3.0 Downstream Bonding

DOCSIS 3.0 Downstream Bonding enables high-speed broadband access and helps cable operators offer more bandwidth-intensive services by adding one or more additional downstream quadrature amplitude modulation (QAM) channels to the standard broadband DOCSIS system. This new set of downstream channels is grouped into one larger channel, known as a bonded channel.

Channel bonding combines several RF channels into one virtual channel. Data rates in this virtual channel range from hundreds of megabits to potentially gigabits per second, creating more available bandwidth in the network.

### Receive Channel Profile

An RCP is an encoding that represents the receive channels and receive modules of a cable modem. A cable modem communicates to the CMTS one or more RCP encodings within its registration request using either verbose description, which contains complete subtype encoding defined in DOCSIS 3.0, or simple description, which only contains RCP identifiers.

### Table 17: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
</tr>
</tbody>
</table>
The cable modem reporting method is configurable within the MAC domain and communicated to cable modems via the MDD.

You must define an RCP-ID to describe the cable modem's capabilities for that RCP-ID and to input information about cable modems which are not defined on the system. Once configured the RCP-ID is available to the entire system since it is not meant to be card specific or mac-domain specific. The path selection module ensures that the RCP ID is accurately transmitted as part of the RCC profile.

The CableLabs MULPI specification defines standard RCPs which are automatically created by the CMTS.

**Receive Channel Configuration**

A cable modem reports its ability to receive multiple channels with one or more RCP encodings in a REG-REQ or REG-REQ-MP message. Each receive channel profile describes a logical representation of the cable modem’s downstream physical layer in terms of receive channels (RCs) and receive modules (RMs). The CMTS initially configures the cable modem’s receive channels and receive modules with an RCC encoding in the registration response.

This feature supports any arbitrary RCP ID configuration and receive channel configuration on a Cisco cBR Series Converged Broadband Router.

**RCC Template**

You can configure one or more RCC templates for an RCP. An RCC template configures the physical layer components described by an RCP, including receive modules and receive channels to specific downstream frequencies. The template also specifies the interconnections among receive modules, or between a receive module and a receive channel. An RCC template can be associated only to the cable interface (MAC domain).

A cable modem's RCP ID is matched with an RCC, when RCC templates are configured. A cable modem's RCP ID may be matched with an RCC generated by an RCC template when RCC templates are configured. The path selection module ensures that the RCP ID that is transmitted as part of the RCC profile is accurate.

At time of registration, if there are multiple valid RCCs that can be assigned to the CM after going through the sequence of checks outlined in the CableLabs MULPI specifications then the RCC with the most channels will be the one selected. If there are multiple valid RCCs of equal size then the RCC with the least amount of cable modems will be selected.

**Channel Assignment**

The CMTS assigns a receive channel configuration encoding to a DOCSIS 3.0-certified cable modem operating in a Multiple Receive Channel (MRC) mode during cable modem registration.

With the implementation of this feature, the DOCSIS 3.0-certified cable modem reports its receiving capabilities and characteristics using the receive channel profile type, length, value (TLV) list in the registration request message. Based on this report, the CMTS assigns an RCC encoding that is compatible with the reported RCP.

Cable modems operating in MRC mode are assigned an RCC encoding associated with an RCP. RCC encodings may be derived from RCC templates or from a wideband-cable interface configuration.
Downstream Traffic Forwarding

DOCSIS 3.0 introduces the concept of assigning downstream service flows of cable modems, which are operating in an MRC mode, to downstream (DS) channels or bonding groups. Forwarding interfaces assigned to service flows (SFs) can be either DS channel interfaces (integrated cable interfaces) or downstream bonding groups (wideband interfaces).

**Note**
Valid interfaces that are available for SF assignment must be a subset of the cable modem’s assigned RCC encoding.

Service Flow Priority in Downstream Extended Header

The purpose of the feature is to be able to reflect the traffic priority of downstream packets into the DOCSIS extended header. The priority is derived from the service flow that the packet is mapped to. Priority refers to the service flow priority specified in the CM configuration file, or the Cisco CMTS service class configuration.

The service flow priority can be set using cable modem configuration file, or dynamic configuration.

By default, this feature is disabled on Cisco cBR-8 router, user can use `cable service flow priority` command to enable this feature.

How to Configure RCP and RCC Encoding

The following tasks describe how to configure a receive channel profile and configuration encoding for a receive channel profile:

**Configuring the RCP ID**

You must configure the RCP IDs with the cable modem capabilities that are not defined in the CMTS. This is done to supplement the standard MULPI RCP IDs already created by the CMTS.

**Before you begin**

**Restrictions**

The configurations are subject to RCC Templates and RCP Interactions as follows:

- RCC templates can only be created for an RCP that is already defined on the system. By default the system will contain the RCPs that are specified in the MULPI spec.
- When defining RCC templates for a particular RCP, error checking will be done to ensure that the information being configured in the RCC template does not violate the corresponding RCP information. For example, if the RCP information indicates that there are 2 receive modules then the RCC template configuration will not allow the user to configure more than 2 modules.
- Once an RCP is included in an RCC template users will not be allowed to modify the RCP. Only an RCP which is not being used by any RCC template can be modified
- A valid RCP that can be applied to an rcc-template must contain the following:
  - center-frequency-spacing
• At least one module which defines the minimum and maximum center frequency range.
• Rules of inheritance.
  • rcc-template inherit definition from the associated user-defined RCP, such as center-frequency-spacing.
  • rcc-template channel frequencies must fall within the range of the minimum and maximum center frequency per the corresponding RCP module.
• common-module definition is applicable to the rcc-template module referenced with the same index.
• rcc-template module channel frequencies overrides the same channel from the corresponding common-module.

### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# configure terminal</td>
<td></td>
</tr>
</tbody>
</table>
| Step 3 | cable rcp-id rcp-id | Defines the RCC template.  
  • rcp-id - Specifies an RCP ID in Hex. 
  This command changes the input mode to the RCC configuration mode. |
| Example: | Router(config)# cable rcp-id 00 10 00 01 08  
  Router(config-rcp)# | |
| Step 4 | name word | name — Assigns a name ro the RCP ID  
  • word — Use a string to name the RCP ID.  
  Note: Do not include space between words in the name |
| Example: | Router(config-rcp)# name rcp-id_1 | |
| Step 5 | center-frequency-spacing frequency | Assigns a center frequency space to the RCP ID. The valid values are 6 and 8. |
| Example: | Router(config-rcp)#center-frequency-spacing 6 | |
| Step 6 | module module index minimum-center-frequency Hz  
  maximum-center-frequency Hz | Configures a receive module configuration for the selected RCP.  
  • module index - Specifies the module number for the receive module. The valid range is 1 to 12.  
  • minimum-center-frequency - Specifies the minimum center frequency for the channels of the receive module channel.  
  • Hz - Specifies the center frequency value in Hz. The valid range is from 111000000 to 999000000. |
| Example: | Router(config-rcp)# module 1  
  minimum-center-frequency 120000000  
  maximum-center-frequency 800000000 | |
## Configuring the RCP ID

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• <strong>maximum-center-frequency</strong> - Specifies the maximum center frequency for the channels of the receive module channel.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>module</strong> <strong>module index</strong> <strong>number-of-adjacent-channels</strong> &lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-rcp)#module 2&lt;br&gt;number-of-adjacent-channels 10&lt;br&gt;Router(config-rcp)#</td>
</tr>
<tr>
<td></td>
<td>Specifies the frequency band for the receive module. The valid values are 1-255.</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>module</strong> <strong>module index</strong> <strong>connected-module</strong> <strong>module index</strong> &lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-rcp)#module 1 connected-module 0</td>
</tr>
<tr>
<td></td>
<td>Specifies a receive channel configuration for the selected RCP.</td>
</tr>
<tr>
<td></td>
<td>• <strong>connected-receive-module</strong>— (Optional) Specifies a nested receive module in the RCC template. Generally, only one receive module is configured for an RCC template.</td>
</tr>
<tr>
<td></td>
<td>• <strong>module index</strong>—Specifies the module number for the receive module. The valid range is 1 to 12.</td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td><strong>number-of-channels</strong> <strong>Number of channel</strong> &lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-rcp)#number-of-channels 8</td>
</tr>
<tr>
<td></td>
<td>Specifies the number of receive channels in the RCP ID.</td>
</tr>
<tr>
<td><strong>Step 10</strong></td>
<td><strong>primary-capable-channels</strong> <strong>Number of channel</strong> &lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-rcp)#primary-capable-channels 1</td>
</tr>
<tr>
<td></td>
<td>Specifies the number of receive channels that are defined as primary capable channels.</td>
</tr>
</tbody>
</table>

### What to do next

Verify RCP ID configurations using the `show cable rcps` command.

```
Router# show cable rcps
RCP ID : 00 10 00 01 08
    Name : rcp-id 1
    Center Frequency Spacing : 6
    Max number of Channels : 8
    Primary Capable Channel : 1
    Number of Modules : 2
    Module[1]:
        Number of Adjacent Channels: 10
        Minimum Center Frequency-Hz: 111000000
        Maximum Center Frequency-Hz: 999000000
    Module[2]:
        Number of Adjacent Channels: 10
        Minimum Center Frequency-Hz: 120000000
        Maximum Center Frequency-Hz: 800000000
```
Configuring the RCC Templates

You must configure an RCC template with a unique RCP ID for a particular CMTS. A valid RCC template consists of a configured RCP ID, RMAs, and RCs. There is dependency between the RCC templates and the RCP since information present in the RCP configuration is also present in RCC templates.

Each RCC encoding contains all operational DS channels with their channel parameters, including the frequency match RC attribute specified in the RCC template. An RCC template specifies the intended receive channel assignment in the available DS spectrum.

**Note**

If an RCC template is removed from a MAC domain through configuration, the CMTS removes all RCC encodings derived from the RCC template, and all cable modems assigned to the RCC encoding are marked offline.

**Before you begin**

At least one RC must be configured as a primary Receive Channel (RC).

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>cable rcc-templates frequency-based <strong>id</strong></td>
<td><strong>id</strong>—Specifies an RCC template. The valid range is 1-64.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# cable rcc-templates frequency-based 1</td>
<td></td>
</tr>
<tr>
<td>Router(config-rcc-freq-based)#</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step 4</th>
<th>rcp-id id</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-rcc-freq-based)# rcp-id 00 10 00 01 08</td>
</tr>
</tbody>
</table>

**Purpose:**

- **id**—Specifies an RCP ID for the RCC template. The valid range is 00 00 00 00 00 to FF FF FF FF. By default, the RCP ID is set to 00 00 00 00 00.

<table>
<thead>
<tr>
<th>Step 5</th>
<th>common-module module-index channel grouplist start-frequency Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-rcc-freq-based)# common-module 1 channels 0-6 start-frequency 555000000</td>
</tr>
</tbody>
</table>

**Purpose:**

- Specifies module configurations that are common for a selected set of channels assigned to the selected RCP ID.
  - **Module-index**—Specifies the index value for the receive module. The valid range is 1 to 12.
  - **channels**—Specifies the list of channels to which the common configurations apply.
  - **grouplist**—Specifies the list of channels to which a specific list of configurations apply. The range of values are 1-64.
  - **start-frequency**—Specifies the start frequency value in Hz.
  - **Hz**—Specifies the frequency value for the start frequency for the common module. The valid range is 1110000000 to 999000000.

<table>
<thead>
<tr>
<th>Step 6</th>
<th>rcc-template Id</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-rcc-freq-based)# rcc-template 1</td>
</tr>
</tbody>
</table>

**Purpose:**

- Specifies an RCC template ID to configure the selected RCC template.
  - **Id**—Specifies the ID of the RCC template. The valid range is from 1-8.

<table>
<thead>
<tr>
<th>Step 7</th>
<th>cm-attribute-mask value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-rcc-freq-based-tmplt)# cm-attribute-mask 1</td>
</tr>
</tbody>
</table>

**Purpose:**

- (Optional) Configured to be used to match against the cm attribute mask define in CM's configuration file.
  - **value**—The valid range is 00 00 00 00 00 to FF FF FF FF.

<table>
<thead>
<tr>
<th>Step 8</th>
<th>module module-index channel grouplist start-frequency Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-rcc-freq-based)# common-module 1 channels 0-6 start-frequency 555000000</td>
</tr>
</tbody>
</table>

**Purpose:**

- Specifies module configurations that are common for a selected set of channels assigned to the selected RCP ID.
  - **Module-index**—Specifies the index value for the receive module. The valid range is 1 to 12.
  - **channels**—Specifies the list of channels to which the common configurations apply.
  - **grouplist**—Specifies the list of channels to which a specific list of configurations apply. The range of values are 1-64.
  - **start-frequency**—Specifies the start frequency value in Hz.
### Purpose

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Hz * \— Specifies the frequency value for the start frequency for the common module. The valid range is from 111000000 to 999000000.</td>
<td></td>
</tr>
</tbody>
</table>

Repeat Step 3 and Step 7 to configure other frequency based RCC templates.

### What to do next

The following configuration examples show the cable rcc-template configuration:

```plaintext
cable rcc-templates frequency-based 2
rcp-id 00 10 00 01 08
common-module 1 channels 1-4 start-frequency 381000000
rcc-template 1
module 1 channels 5-8 start-frequency 501000000
rcc-template 2
module 1 channels 5-8 start-frequency 669000000
rcc-template 3

cable rcc-templates frequency-based 1
rcp-id 00 10 00 01 08
rcc-template 1
cm-attribute-mask 2
module 1 channels 1-4 start-frequency 381000000
module 2 channels 5-8 start-frequency 501000000
rcc-template 2
module 1 channels 1-4 start-frequency 381000000
module 2 channels 5-8 start-frequency 669000000
rcc-template 3
module 1 channels 1-4 start-frequency 381000000
```

After defining an RCC template, you must assign the template to a cable interface.

### Assigning an RCC Template to a MAC Domain (Cable Interface)

The CMITS derives an RCC or RCCs from the RCC template for each MAC Domain Downstream Service Group (MD-DS-SG).

The following information is required for RCC assignment to cable modems:

- RCC templates assigned to the MAC domain.
- DS channel physical parameters including frequency and connected-receive-module index.
- DS channel primary capable indicator.
- DS channel membership to the MD-DS-SG.
- Cable modem membership to the MD-DS-SG.

This section describes how to assign an RCC template to a MAC Domain.
### Assigning an RCC Template to a MAC Domain (Cable Interface)

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface cable <code>slot / subslot / port</code></td>
<td>Enters MAC domain configuration mode.</td>
</tr>
<tr>
<td>Example: Router(config)# interface cable 1/0/0</td>
<td>- <code>slot</code> — Specifies the chassis slot number of the interface line card.</td>
</tr>
<tr>
<td></td>
<td>- <code>subslot</code> — Specifies the secondary slot number of the interface line card. Valid subslot is 0.</td>
</tr>
<tr>
<td></td>
<td>- <code>MD index</code> — Specifies the MAC Domain index number. Valid values are 0-15.</td>
</tr>
<tr>
<td><strong>Step 4</strong> cable rcc-template frequency-based <code>Id</code></td>
<td>Assigns the RCC template to the specified cable interface.</td>
</tr>
<tr>
<td>Example: Router(config-if)# cable rcc-template frequency-based 1</td>
<td>- <code>Id</code> — Specifies the template you want to assign to the cable interface. The valid range is from 1 to 64.</td>
</tr>
</tbody>
</table>

### What to do next

Verify RCC template binding to MD.

The following example shows the RCC template binding using the `show cable mac-domain rcc` command.

```
Router# show cable mac-domain c1/0/0 rcc
```

<table>
<thead>
<tr>
<th>RCC-ID</th>
<th>RCF</th>
<th>RCS</th>
<th>MD-DS-SG</th>
<th>CMs</th>
<th>WB/RCC-TMPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>00 00 00 00 00 00 00</td>
<td>4 0 0</td>
<td>2</td>
<td>WB (Wi1/0/0:0)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>00 00 00 00 00 00 00</td>
<td>4 0 2</td>
<td>2</td>
<td>WB (Wi1/0/1:3)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>00 00 00 00 00 00 00</td>
<td>4 0 0</td>
<td>0</td>
<td>WB (Wi1/0/1:2)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>00 00 00 00 00 00 00</td>
<td>4 0 0</td>
<td>0</td>
<td>WB (Wi1/0/2:3)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>00 00 00 00 00 00 00</td>
<td>8 5 0</td>
<td>0</td>
<td>RCC-TMPL (1:1)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>00 00 00 00 00 00 00</td>
<td>8 5 0</td>
<td>0</td>
<td>RCC-TMPL (1:2)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>00 00 00 00 00 00 00</td>
<td>8 5 0</td>
<td>0</td>
<td>RCC-TMPL (1:3)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>00 00 00 00 00 00 00</td>
<td>8 5 0</td>
<td>0</td>
<td>RCC-TMPL (2:1)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>00 00 00 00 00 00 00</td>
<td>8 5 0</td>
<td>0</td>
<td>RCC-TMPL (2:2)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>00 00 00 00 00 00 00</td>
<td>8 5 0</td>
<td>0</td>
<td>RCC-TMPL (2:3)</td>
<td></td>
</tr>
</tbody>
</table>

The following example shows the RCC template binding using the `show cable mac-domain rcc` `id` command.

```
Router# show cable mac-domain c1/0/0 rcc 8
```
RCC ID : 8
RCP : 00 10 00 01 08
Created Via : rcc-template - 1:1
CM attribute mask : 0x2
Receive Channels : 8
  Receive Channel : 1
    Center Frequency : 381000000
    Primary Capability : YES
    Receive Module Conn : 1
  Receive Channel : 2
    Center Frequency : 387000000
    Primary Capability : NO
    Receive Module Conn : 1
  Receive Channel : 3
    Center Frequency : 393000000
    Primary Capability : NO
    Receive Module Conn : 1
  Receive Channel : 4
    Center Frequency : 399000000
    Primary Capability : NO
    Receive Module Conn : 1
  Receive Channel : 5
    Center Frequency : 501000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 6
    Center Frequency : 507000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 7
    Center Frequency : 513000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 8
    Center Frequency : 519000000
    Primary Capability : NO
    Receive Module Conn : 2
Receive Modules : 2
Receive Module : 1
  First Frequency : 381000000
Receive Module : 2
  First Frequency : 501000000

Router# show cable mac-domain c9/0/2 rcc 9

RCC ID : 9
RCP : 00 10 00 01 08
Created Via : rcc-template - 1:2
CM attribute mask : 0x0
Receive Channels : 8
  Receive Channel : 1
    Center Frequency : 381000000
    Primary Capability : YES
    Receive Module Conn : 1
  Receive Channel : 2
    Center Frequency : 387000000
    Primary Capability : NO
    Receive Module Conn : 1
  Receive Channel : 3
    Center Frequency : 393000000
    Primary Capability : NO
    Receive Module Conn : 1
  Receive Channel : 4
    Center Frequency : 399000000
    Primary Capability : NO
    Receive Module Conn : 1
  Receive Channel : 5
    Center Frequency : 501000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 6
    Center Frequency : 507000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 7
    Center Frequency : 513000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 8
    Center Frequency : 519000000
    Primary Capability : NO
    Receive Module Conn : 2
Verifying the RCC Configuration

To verify the runtime RCCs on a cable interface, use the `show cable mac-domain rcc` command.

```
Router#show cable mac-domain c1/0/0 rcc

RCC ID : 10
RCP : 00 10 00 01 08
Created Via : rcc-template - 1:3
CM attribute mask : 0x0
Receive Channels : 4
  Receive Channel : 1
    Center Frequency : 381000000
    Primary Capability : YES
    Receive Module Conn : 2
  Receive Channel : 2
    Center Frequency : 387000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 3
    Center Frequency : 393000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 4
    Center Frequency : 399000000
    Primary Capability : NO
    Receive Module Conn : 2
Receive Modules : 1
Receive Module : 2
  First Frequency : 381000000

Router#show cable mac-domain c1/0/0 rcc 10

RCC ID : 10
RCP : 00 10 00 01 08
Created Via : rcc-template - 1:3
CM attribute mask : 0x0
Receive Channels : 4
  Receive Channel : 1
    Center Frequency : 381000000
    Primary Capability : YES
    Receive Module Conn : 2
  Receive Channel : 2
    Center Frequency : 387000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 3
    Center Frequency : 393000000
    Primary Capability : NO
    Receive Module Conn : 2
  Receive Channel : 4
    Center Frequency : 399000000
    Primary Capability : NO
    Receive Module Conn : 2
Receive Modules : 1
Receive Module : 2
  First Frequency : 381000000
```
How to Configure Attribute Masks

DOCSIS 3.0 introduces the concept of assigning service flows to channels or bonding groups based on binary attributes. The attribute masks configured on a cable, modular, integrated or wideband interface are called provisioned attribute masks.

The two types of attributes are as follows:

- Specification-defined attributes—Contain default values based on the characteristics of the channel or bonding group.
- Operator-defined attributes—Default to zero.

The operator can configure a provisioned attribute mask for each channel and provisioned bonding group to assign values to the operator-defined binary attributes. The operator can also assign new values to override the default values of the specification-defined attributes.

The operator can configure a required attribute mask and a forbidden attribute mask for a service flow in the cable modem configuration file. These required and forbidden attribute masks are optionally provided on the DOCSIS 3.0 service flows and are matched with the provisioned attribute masks of the interfaces.

Each service flow is optionally configured with the following TLV parameters:

- Service flow required attribute mask—To configure this, assign a service flow to a channel that has a 1-bit in all positions of its provisioned attribute mask corresponding to the 1-bit in the service flow required attribute mask.
- Service flow forbidden attribute mask—To configure this, assign a service flow to a channel that has a 0-bit in all positions of its provisioned attribute mask corresponding to the 1-bit in the service flow forbidden attribute mask.

Additionally, in a cable modem-initiated dynamic service request, the cable modem can include a required attribute mask and a forbidden attribute mask for a service flow. The CMTS assigns service flows to channels or bonding groups so that all required attributes are present and no forbidden attributes are present in the cable modem configuration file.

The table below lists the supported binary attributes for channels and bonding groups.

<table>
<thead>
<tr>
<th>Channel</th>
<th>RCP or MD-DS-SG Field</th>
<th>RCC Encoding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>00 00 00 00 00</td>
<td>4 0 2</td>
<td>WB (Wi1/0/0:1)</td>
</tr>
<tr>
<td>3</td>
<td>00 00 00 00 00</td>
<td>4 0 0</td>
<td>WB (Wi1/0/1:2)</td>
</tr>
<tr>
<td>4</td>
<td>00 00 00 00 00</td>
<td>4 0 0</td>
<td>WB (Wi1/0/2:3)</td>
</tr>
<tr>
<td>8</td>
<td>00 10 00 01 08</td>
<td>8 5 0</td>
<td>RCC-TMPL (1:1)</td>
</tr>
<tr>
<td>9</td>
<td>00 10 00 01 08</td>
<td>8 5 0</td>
<td>RCC-TMPL (1:2)</td>
</tr>
<tr>
<td>10</td>
<td>00 10 00 01 08</td>
<td>4 5 0</td>
<td>RCC-TMPL (1:3)</td>
</tr>
<tr>
<td>14</td>
<td>00 10 00 01 08</td>
<td>8 5 0</td>
<td>RCC-TMPL (2:1)</td>
</tr>
<tr>
<td>15</td>
<td>00 10 00 01 08</td>
<td>8 5 0</td>
<td>RCC-TMPL (2:2)</td>
</tr>
<tr>
<td>16</td>
<td>00 10 00 01 08</td>
<td>4 5 0</td>
<td>RCC-TMPL (2:3)</td>
</tr>
</tbody>
</table>

Note: A zero (0) value in the RCP or MD-DS-SG field indicates that the RCC encoding is configured directly through a wideband interface configuration and not through any RCC template.
Table 18: Binary Attributes

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 0</td>
<td>Bonded—This bit is zero for all individual channel interfaces and one for all bonding groups.</td>
</tr>
<tr>
<td>Bit 1</td>
<td>Low latency—This bit is set when the interface can provide relatively low latency service.</td>
</tr>
<tr>
<td></td>
<td>This bit is set to zero for all channels, and left up to the operator to define.</td>
</tr>
<tr>
<td>Bit 2</td>
<td>High availability—This bit is set to zero for all channels, and left up to the operator to define.</td>
</tr>
<tr>
<td>Bit 3:15</td>
<td>Reserved—Set to zero.</td>
</tr>
<tr>
<td>Bit 16:31</td>
<td>Operator defined—Set to zero by default.</td>
</tr>
</tbody>
</table>

You can configure provisioned attribute masks for cable, integrated cable, wideband cable, and modular cable interfaces.

Prerequisites

- To assign an interface to a wideband cable modem’s service flow, the interface must be a subset of the cable modem’s RCC.
- To assign a service flow to an integrated cable (IC) channel, the corresponding integrated cable interface must be configured and operational.

Restrictions

- The service flow from a narrowband cable modem is always assigned to the primary interface of the cable modem. No attribute checking is performed in this case.

This section describes the following:

## Configuring Provisioned Attributes for an Integrated Cable Interface

The default provisioned attribute is zero for an integrated cable interface.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>interface integrated-cable {slot/port</td>
<td>slot/subslot/port}:rf-channel</td>
</tr>
<tr>
<td>Example:</td>
<td>• slot—Chassis slot number of the cable interface line card.</td>
</tr>
</tbody>
</table>
Command or Action | Purpose
--- | ---
Router(config)# interface integrated-cable 1/0/0:0 | • subslot—subslot number of the cable interface line card. Valid subslot is always 0.
• port—Downstream port number.
• rf-channel—RF channel number with a range of 0 to 3.

Step 4 cable attribute-mask mask | Specifies the mask for the interface.
Example: Router(config-if)# cable attribute-mask 800000ff

### Configuring Provisioned Attributes for a Wideband Cable Interface

The default provisioned attribute is 0x80000000 for a wideband cable interface, and the zero bit is automatically added to the wideband cable interface whenever an attribute is configured for that interface.

#### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Step 2 configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3 interface wideband-cable {slot/port</td>
<td>slot/subslot/port}:wideband-channel</td>
</tr>
<tr>
<td>Example: Router(config)# interface wideband-cable 1/0/1:4</td>
<td></td>
</tr>
<tr>
<td>Step 4 cable downstream attribute-mask mask</td>
<td>Specifies the mask for the interface.</td>
</tr>
<tr>
<td>Example: Router(config-if)# cable downstream attribute-mask 800000ff</td>
<td></td>
</tr>
</tbody>
</table>

### Verifying the Attribute-Based Service Flow Assignments

To verify the attribute-based assignment of service flows on a cable interface, use the `show interface cable service-flow` or `show interface wideband-cable service-flow` command as shown in the following example:

Router# show interface cable 3/0 service-flow
The table below shows descriptions for the fields displayed by this command:

**Table 18: show interface cable service-flow Field Descriptions**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sfid</td>
<td>Identifies the service flow identification number.</td>
</tr>
<tr>
<td>Note</td>
<td>Primary service flow IDs are displayed even for offline cable modems</td>
</tr>
<tr>
<td></td>
<td>because they are needed for modem re-registration.</td>
</tr>
<tr>
<td>Sid</td>
<td>Identifies the service identification number (upstream service flows only).</td>
</tr>
<tr>
<td>Mac Address</td>
<td>Identifies the MAC address for the cable modem.</td>
</tr>
<tr>
<td>QoS Parameter Index Prov</td>
<td>Identifies the QoS parameter index for the provisioned state of this flow.</td>
</tr>
<tr>
<td>QoS Parameter Index Adm</td>
<td>Identifies the QoS parameter index for the Admitted state of this flow.</td>
</tr>
<tr>
<td>QoS Parameter Index Act</td>
<td>Identifies the QoS parameter index for the Active state of this flow.</td>
</tr>
<tr>
<td>Type</td>
<td>Indicates if the service flow is the primary flow or a secondary service flow.</td>
</tr>
<tr>
<td></td>
<td>Secondary service flows are identified by an “S” (created statically at the</td>
</tr>
<tr>
<td></td>
<td>time of registration, using the DOCSIS configuration file) or “D” (created</td>
</tr>
<tr>
<td></td>
<td>dynamically by the exchange of dynamic service messages between the cable</td>
</tr>
<tr>
<td></td>
<td>modem and CMTS).</td>
</tr>
<tr>
<td>Dir</td>
<td>Indicates if this service flow is DS or US.</td>
</tr>
<tr>
<td>Curr State</td>
<td>Indicates the current run-time state of the service flow.</td>
</tr>
<tr>
<td>Active Time</td>
<td>Indicates the length of time this service flow has been active.</td>
</tr>
<tr>
<td>DS-ForwIf/US-BG/CH</td>
<td>Indicates the bonding group ID or the downstream RFID of the forwarding</td>
</tr>
<tr>
<td>BG/DS</td>
<td>interface assigned to the downstream service flow.</td>
</tr>
</tbody>
</table>
How to Enable Service Flow Priority in Downstream Extender Header

The following tasks describe how to enable service flow priority in downstream extender header:

Enabling Service Flow Priority in Downstream Extender Header

This section describes how to enable service flow priority in downstream extender header on the Cisco cBR-8 routers:

**Procedure**

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>cable service flow priority</td>
<td>Enables the service flow priority in downstream extender header.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable service flow priority</td>
<td></td>
</tr>
</tbody>
</table>

Verifying the Enablement of the Service Flow Priority in Downstream Extended Header

To verify the enablement of the service flow priority in downstream extended header, use the `show running-config | in service flow` or `show cable modem [ip-address | mac-address] verbose` command as shown in the following example:

```plaintext
Router# show running-config | in service flow
cable service flow priority

Router# show cable modem 100.1.2.110 verbose

MAC Address : 0025.2e2d.74f8
IP Address : 100.1.2.110
Dual IP : Y
Prim Sid : 1
Host Interface : C3/0/0/U0
MD-DS-SG / MD-US-SG : N/A / N/A
MD-CM-SG : 0x900000
Primary Downstream : In3/0/0:32 (RfId : 12320, Sc-QAM)
Wideband Capable : Y
```
Verifying the Enablement of the Service Flow Priority in Downstream Extended Header

DS Tuner Capability : 8
RCP Index : 6
RCP ID : 00 00 00 00 00
Downstream Channel DCID RF Channel : 191 3/0/0:32 (SC-QAM)
UDC Enabled : N
US Frequency Range Capability : Standard (5-42 MHz)
Extended Upstream Transmit Power : 0dB
Multi-Transmit Channel Mode : N
Upstream Channel : US0
Ranging Status : sta
Upstream SNR (dB) : 39.8
Upstream Data SNR (dB) : 36.12
Received Power (dBmV) : -1.00
Timing Offset : 1799
Initial Timing Offset : 1799
Rng Timing Adj Moving Avg(0.381 ns) : 0
Rng Timing Adj Lt Moving Avg : 0
Rng Timing Adj Minimum : 0
Rng Timing Adj Maximum : 0
Pre-EQ Good : 0
Pre-EQ Scaled : 0
Pre-EQ Impulse : 0
Pre-EQ Direct Loads : 0
Good Codewords rx : 8468
Corrected Codewords rx : 0
Uncorrectable Codewords rx : 0
Phy Operating Mode : atdma
sysDescr :
Downstream Power : 0.00 dBmV (SNR = ----- dB)
MAC Version : DOC3.0
QoS Provisioned Mode : DOC1.1
Enable DOCSIS2.0 Mode : Y
Service Flow Priority : N
Modem Status : (Modem= online, Security=disabled)
Capabilities : {Frag=Y, Concat=Y, PHS=Y}
Security Capabilities : {Priv=, EAE=N, Key_len=}
L2VPN Capabilities : {L2VPN=N, eSAFE=N}
L2VPN type : {CLT-N, DOCSIS=N}
Sid/Said Limit : {Max US Sids=16, Max DS Saids=15}
Optional Filtering Support : {802.1P-N, 802.1Q-N, DUT-N}
Transmit Equalizer Support : {Taps/Symbol= 1, Num of Taps= 24}
CM Capability Reject : {15,22,23,24,25,26,27,28,29,35,36,38}
Flaps : 3(Oct 8 16:22:23)
Errors : 0 CRCs, 0 HCSes
Stn Mtn Failures : 0 aborts, 2 exhausted
Total US Flows : 1(1 active)
Total DS Flows : 1(1 active)
Total US Data : 294 packets, 25903 bytes
Total US Throughput : 143 bits/sec, 0 packets/sec
Total DS Data : 91 packets, 10374 bytes
Total DS Throughput : 0 bits/sec, 0 packets/sec
LB group ID assigned : 1
LB group ID in config file : N/A
LB policy ID : 0
LB policy ID in config file : 0
LB priority : 0
Tag : d30
Required DS Attribute Mask : 0x0
Forbidden DS Attribute Mask : 0x0
Required US Attribute Mask : 0x0
Forbidden US Attribute Mask : 0x0
Service Type ID :
Service Type ID in config file :
Active Classifiers : 0 (Max = NO LIMIT)
### Enabling Verbose Reporting for Receive Channel Profiles

A receive channel profile is an encoding that represents the receive channels and receive modules of a cable modem. A cable modem communicates to the CMTS one or more RCP encodings within its registration request using either verbose description, which contains complete subtype encodings defined in DOCSIS 3.0, or simple description, which only contains RCP identifiers.

#### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>`interface cable {slot/port</td>
<td>slot/subslot/port}`</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• slot—Chassis slot number of the cable interface line card.</td>
</tr>
<tr>
<td><code>Router(config)# interface cable7/0/0</code></td>
<td>• subslot—subslot number of the cable interface line card. Valid subslot is 0.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
</tr>
<tr>
<td><code>cable rcp-control verbose</code></td>
<td>Enables RCP reporting with verbose description.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if)# cable rcp-control verbose</code></td>
<td></td>
</tr>
</tbody>
</table>
Configuration Example for an RCC Template

The following sample shows an RCP ID configuration:

```
...  
cable rcp-id 00 10 00 01 08  
center-frequency-spacing 6  
module 1 minimum-center-frequency 120000000 maximum-center-frequency 800000000 module 1  
number-of-adjacent-channels 10  
module 2 minimum-center-frequency 120000000 maximum-center-frequency 800000000 module 2  
number-of-adjacent-channels 10  
number-of-channels 8  
primary-capable-channels 1  
```

The following sample shows an RCC template configuration:

```
...  
cable rcc-templates frequency-based 1  
rcp-id 00 10 00 01 08  
rcc-template 1  
cm-attribute-mask 2  
module 1 channels 1-4 start-frequency 381000000  
module 2 channels 5-8 start-frequency 501000000  
rcc-template 2  
module 1 channels 1-4 start-frequency 381000000  
module 2 channels 5-8 start-frequency 669000000  
rcc-template 3  
module 1 channels 1-4 start-frequency 381000000  
```

The following sample shows an RCC template configuration using the `common-module` option:

```
...  
cable rcc-templates frequency-based 2  
rcp-id 00 10 00 01 08  
common-module 1 channels 1-4 start-frequency 381000000  
rcc-template 1  
module 1 channels 5-8 start-frequency 501000000  
rcc-template 2  
module 1 channels 5-8 start-frequency 669000000  
rcc-template 3  
```

The following sample shows the assignment of an RCC template to MAC Domain:

```
...  
configure terminal  
interface c1/0/0  
cable rcc-templates frequency-based 1  
end  
...  
```
Additional References

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
</tbody>
</table>

Feature Information for DOCSIS 3.0 Downstream Bonding

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS 3.0 Downstream Bonding</td>
<td>Cisco IOS XE Everest 16.6.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Router.</td>
</tr>
<tr>
<td>Service Flow Priority in Downstream Extended Header</td>
<td>Cisco IOS XE Everest 16.6.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Router.</td>
</tr>
</tbody>
</table>
CHAPTER 8

DOCSIS 2.0 A-TDMA Modulation Profiles

This document describes the DOCSIS 2.0 A-TDMA services feature, which provides support for DOCSIS 2.1 Advanced Time Division Multiple Access (A-TDMA) upstream modulation profiles on the router. This feature supplements the existing support for DOCSIS 1.0 and DOCSIS 1.1 Time Division Multiple Access (TDMA) modulation profiles.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

• Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 143
• Prerequisites for DOCSIS 2.0 A-TDMA Modulation Profiles, on page 144
• Restrictions for DOCSIS 2.0 A-TDMA Services, on page 145
• Information About DOCSIS 2.0 A-TDMA Services, on page 145
• How to Configure DOCSIS 2.0 A-TDMA Services, on page 148
• Monitoring the DOCSIS 2.0 A-TDMA Services, on page 152
• Configuration Examples for DOCSIS 2.0 A-TDMA services, on page 154
• Additional References, on page 158
• Feature Information for DOCSIS 2.0 A-TDMA Modulation Profile, on page 159

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
### Prerequisites for DOCSIS 2.0 A-TDMA Modulation Profiles

- The cable physical plant must be capable of supporting the higher-bandwidth DOCSIS 2.0 A-TDMA modulation profiles.
- Cable modems must be DOCSIS-compliant. If cable modems go offline, or appear to be online but do not pass traffic when in the mixed TDMA/A-TDMA mode, upgrade the modem software to a DOCSIS-compliant version.
- The following are required to support the DOCSIS 2.0 A-TDMA features:
  - Cable modems must be DOCSIS 2.0 capable.
  - The DOCSIS configuration file for a DOCSIS 2.0 cable modem must either omit the DOCSIS 2.0 Enable field (TLV 39), or it must set TLV 39 to 1 (enable). If you set TLV 39 to 0 (disable), a DOCSIS 2.0 CM uses the TDMA mode.
  - The upstream must be configured for either A-TDMA-only or mixed TDMA/A-TDMA mode. To use the 6.4 MHz channel width, the upstream must be configured for A-TDMA-only mode.
- Complete a basic configuration of the router; this includes, at a minimum, the following tasks:
  - Configure a host name and password for the router.

---

**Table 21: Hardware Compatibility Matrix for the Cisco cBR Series Routers**

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
</table>
• Configure the router to support Internet Protocol (IP) operations.
• Install and configure at least one WAN adapter to provide backbone connectivity.
• Determine a channel plan for the router and all of its cable interfaces.
• Verify that your headend site includes all necessary servers to support DOCSIS and Internet connectivity, including DHCP, ToD, and TFTP servers.
• The system clock on the router should be set to a current date and time to ensure that system logs have the proper timestamp and to ensure that the BPI+ subsystem uses the correct timestamp for verifying cable modem digital certificates.

Restrictions for DOCSIS 2.0 A-TDMA Services

• Does not support virtual channels, as described in DOCSIS 2.0 specification.
• Does not support Synchronous Code Division Multiple Access (S-CDMA) channels.
• Changing the DOCSIS mode of an upstream takes all cable modems on that upstream offline, which forces the cable modems to reregister, so that the CMTS can determine the capabilities of the cable modems on the new channels.

Information About DOCSIS 2.0 A-TDMA Services

DOCSIS 2.0 A-TDMA services improve the maximum upstream bandwidth on existing DOCSIS 1.0 and DOCSIS 1.1 cable networks by providing a number of advanced PHY capabilities that have been specified by the new DOCSIS 2.0 specifications.

DOCSIS 2.0 A-TDMA services incorporate the following advantages and improvements of DOCSIS 2.0 networks:

• Builds on existing DOCSIS cable networks by providing full compatibility with existing DOCSIS 1.0 and DOCSIS 1.1 cable modems. (The registration response (REG-RSP) message contains the DOCSIS version number to identify each cable modem’s capabilities.)
• Upstreams can be configured for three different modes to support different mixes of cable modems:
  • An upstream can be configured for TDMA mode to support only DOCSIS 1.0 and DOCSIS 1.1 cable modems.
  • An upstream can be configured for A-TDMA mode to support only DOCSIS 2.0 cable modems.
  • An upstream can be configured for a mixed, TDMA/A-TDMA mode, to support both DOCSIS 1.0/DOCSIS 1.1 and DOCSIS 2.0 cable modems on the same upstream.

Note

DOCSIS 2.0 A-TDMA cable modems will not register on a TDMA upstream if an A-TDMA or mixed upstream exists in the same MAC domain, unless the CMTS explicitly switches the cable modem to another upstream using an Upstream Channel Change (UCC) message. DOCSIS 1.0 and DOCSIS 1.1 cable modems cannot register on an A-TDMA-only upstream.

• A-TDMA mode defines new interval usage codes (IUC) of A-TDMA short data grants, long data grants, and Unsolicited Grant Service (UGS) grants (IUC 9, 10, and 11) to supplement the existing DOCSIS 1.1 IUC types.
• Increases the maximum channel capacity for A-TDMA upstreams to 30 Mbps per 6 MHz channel.
• A-TDMA and mixed modes of operation provide higher bandwidth on the upstream using new 32-QAM and 64-QAM modulation profiles, while retaining support for existing 16-QAM and QPSK modulation profiles. In addition, an 8-QAM modulation profile is supported for special applications.
• Supports a minislot size of 1 tick for A-TDMA operations.
• Increases channel widths to 6.4 MHz (5.12 Msymbol rate) for A-TDMA operations.
• A-TDMA and mixed modes of operation provide a more robust operating environment with increased protection against ingress noise and other signal impairments, using a number of new features:
  • Uses a symbol (T)-spaced adaptive equalizer structure to increase the equalizer tap size to 24 taps, compared to 8 taps in DOCSIS 1.x mode. This allows operation in the presence of more severe multipath and microreflections, and can accommodate operation near band edges where group delay could be a problem.
  • Supports new QPSK0 and QPSK1 preambles, which provide improved burst acquisition by performing simultaneous acquisition of carrier and timing lock, power estimates, equalizer training, and constellation phase lock. This allows shorter preambles, reducing implementation loss.
  • Increases the forward error correction (FEC) T-byte size to 16 bytes per Reed Solomon block (T=16) with programmable interleaving.

Modes of Operation

Depending on the configuration, the DOCSIS 2.0 A-TDMA Service feature supports either DOCSIS or Euro-DOCSIS operation:

• DOCSIS cable networks are based on the ITU J.83 Annex B physical layer standard and Data-over-Cable Service Interface Specifications (DOCSIS, Annex B) specification, which use 6 MHz National Television Systems Committee (NTSC) channel plans. In this mode, the downstream uses a 6 MHz channel width in the 85 to 860 MHz frequency range, and the upstream supports multiple channel widths in the 5 to 42 MHz frequency range.
• EuroDOCSIS cable networks are based on the ITU J.112 Annex A physical layer standard and European DOCSIS (EuroDOCSIS, Annex A) specification, which use 8 MHz Phase Alternating Line (PAL) and Systeme Electronique Couleur Avec Memoire (SECAM) channel plans. In this mode, the downstream uses an 8 MHz channel width in the 85 to 860 MHz frequency range, and the upstream supports multiple channel widths in the 5 to 65 MHz frequency range.

Note

The table below shows the maximum supported DOCSIS 1.1 data rates.

Table 22: Maximum DOCSIS 1.1 Data Rates

<table>
<thead>
<tr>
<th>Upstream Channel Width</th>
<th>Modulation Scheme</th>
<th>Baud Rate Sym/sec</th>
<th>Maximum Raw Bit Rate Mbit/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 MHz</td>
<td>16-QAM QPSK</td>
<td>2.56 M</td>
<td>10.24 5.12</td>
</tr>
<tr>
<td>1.6 MHz</td>
<td>16-QAM QPSK</td>
<td>1.28 M</td>
<td>5.12 2.56</td>
</tr>
</tbody>
</table>
The table below shows the maximum supported DOCSIS 2.0 (A-TDMA-mode) data rates.

**Table 23: Maximum DOCSIS 2.0 (A-TDMA-mode) Data Rates**

<table>
<thead>
<tr>
<th>Upstream Channel Width</th>
<th>Modulation Scheme</th>
<th>Baud Rate Sym/sec</th>
<th>Maximum Raw Bit Rate Mbit/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.4 MHz</td>
<td>64-QAM</td>
<td>5.12 M</td>
<td>30.72</td>
</tr>
<tr>
<td></td>
<td>32-QAM</td>
<td></td>
<td>25.60</td>
</tr>
<tr>
<td></td>
<td>16-QAM</td>
<td></td>
<td>20.48</td>
</tr>
<tr>
<td></td>
<td>8-QAM</td>
<td></td>
<td>15.36</td>
</tr>
<tr>
<td></td>
<td>QPSK</td>
<td></td>
<td>10.24</td>
</tr>
<tr>
<td>3.2 MHz</td>
<td>64-QAM</td>
<td>2.56 M</td>
<td>15.36</td>
</tr>
<tr>
<td></td>
<td>32-QAM</td>
<td></td>
<td>12.80</td>
</tr>
<tr>
<td></td>
<td>16-QAM</td>
<td></td>
<td>10.24</td>
</tr>
<tr>
<td></td>
<td>8-QAM</td>
<td></td>
<td>7.68</td>
</tr>
<tr>
<td></td>
<td>QPSK</td>
<td></td>
<td>5.12</td>
</tr>
<tr>
<td>1.6 MHz</td>
<td>64-QAM</td>
<td>1.28 M</td>
<td>7.68</td>
</tr>
<tr>
<td></td>
<td>32-QAM</td>
<td></td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>16-QAM</td>
<td></td>
<td>5.12</td>
</tr>
<tr>
<td></td>
<td>8-QAM</td>
<td></td>
<td>3.84</td>
</tr>
<tr>
<td></td>
<td>QPSK</td>
<td></td>
<td>2.56</td>
</tr>
</tbody>
</table>

**Modulation Profiles**

To simplify the administration of A-TDMA and mixed TDMA/A-TDMA modulation profiles, the DOCSIS 2.0 A-TDMA Service feature provides a number of preconfigured modulation profiles that are optimized for different modulation schemes. We recommend using these preconfigured profiles.

Each mode of operation also defines a default modulation profile that is automatically used when a profile is not specifically assigned to an upstream. The default modulation profiles cannot be deleted. The table below lists the valid ranges according to cable interface and modulation type:

**Table 24: Allowable Ranges for Modulation Profiles**

<table>
<thead>
<tr>
<th>Cable Interface</th>
<th>DOCSIS 1.X (TDMA)</th>
<th>Mixed DOCSIS 1.X/2.0</th>
<th>DOCSIS 2.0 (A-TDMA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 CCAP Line Cards</td>
<td>1 to 400 (default is 21)</td>
<td>1 to 400 (default 121)</td>
<td>1 to 400 (default 221)</td>
</tr>
</tbody>
</table>

**Benefits**

The DOCSIS 2.0 A-TDMA Service feature provides the following benefits to cable service providers and their partners and customers:
• Full compatibility with DOCSIS 1.0 and DOCSIS 1.1 cable modems (CMs) and cable modem termination systems (CMTS).
• Additional channel capacity in the form of more digital bits of throughput capacity in the upstream path.
• Increased protection against electronic impairments that occur in cable systems, allowing for a more robust operating environment.

How to Configure DOCSIS 2.0 A-TDMA Services

This section contains the following:

Creating Modulation Profiles

Cisco cable modem termination systems (CMTSs) can handle modulation profiles for the RF configuration of a voice and data cable modem plant. Cisco IOS® Software is designed with a default modulation profile that is optimal in most conditions. Therefore, do not change the default configuration. However, if the modulation needs are different for the customer plant, Cisco IOS Software has the ability to customize and to configure the modulation profiles to suit the customer needs.

Caution

Only an expert, who understands modulation changes and Data-over-Cable Service Interface Specifications (DOCSIS), should modify these parameters. Otherwise, changes can cause disruption or the degradation of services because the commands affect the physical layer.

This section describes how to create modulation profiles for the different modes of DOCSIS operations, using the preconfigured modulation profile options.

Creating a TDMA Modulation Profile

This section describes how to create a modulation profile for the DOCSIS 1.0/DOCSIS 1.1 TDMA mode of operation, using one of the preconfigured modulation profiles.

Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>cable modulation-profile profile tdma {mix</td>
<td>qam-16</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Creating a Mixed Mode Modulation Profile

This section describes how to create a modulation profile for the mixed TDMA/A-TDMA mode of operation, using one of the preconfigured modulation profiles.

**Procedure**

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>cable modulation-profile profile mixed {mix-high</td>
<td>Creates a preconfigured modulation profile, where the burst parameters are set to their default values for each burst type:</td>
</tr>
<tr>
<td></td>
<td>mix-low \ mix-mid \ mix-qam \ qam-16</td>
<td>Note The robust-mix profiles are similar to but more robust than the mix profiles, so that they are more able to deal with noise on the upstream.</td>
</tr>
<tr>
<td></td>
<td>\ qpsk \ robust-mix-high \ robust-mix-mid \ robust-mix-qam}</td>
<td>You can also create custom modulation profiles with the cable modulation-profile command by configuring the values for the individual burst parameters. These parameters, however, should not be modified unless you are thoroughly familiar with how changing each parameter affects the DOCSIS MAC layer. We recommend using the preconfigured default modulation profiles for most cable plants.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable modulation-profile 143 mixed mix-medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable modulation-profile 144 mixed mix-high</td>
<td></td>
</tr>
</tbody>
</table>

**Purpose**

- You can also create custom modulation profiles with the `cable modulation-profile` command by configuring the values for the individual burst parameters. These parameters, however, should not be modified unless you are thoroughly familiar with how changing each parameter affects the DOCSIS MAC layer. We recommend using the preconfigured default modulation profiles for most cable plants.
Creating an A-TDMA Modulation Profile

This section describes how to create a modulation profile for the DOCSIS 2.0 A-TDMA mode of operation, using one of the preconfigured modulation profiles.

Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>enable</td>
<td></td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>configure terminal</td>
<td></td>
</tr>
<tr>
<td>Example: Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>cable modulation-profile profile atdma {mix-high</td>
<td>mix-low</td>
</tr>
<tr>
<td>Example: Router(config)# cable modulation-profile 242 atdma qam-32</td>
<td></td>
</tr>
<tr>
<td>Router(config)# cable modulation-profile 243 atdma qam-64</td>
<td></td>
</tr>
<tr>
<td>Example: cable modulation-profile 45 tdma request 0 16 0 22 qpsk scrambler 152 no-diff 64 fixed</td>
<td></td>
</tr>
<tr>
<td>cable modulation-profile 45 tdma initial 5 34 0 48 16qam scrambler 152 no-diff 256 fixed</td>
<td></td>
</tr>
<tr>
<td>cable modulation-profile 45 tdma station 5 34 0 48 16qam scrambler 152 no-diff 256 fixed</td>
<td></td>
</tr>
<tr>
<td>cable modulation-profile 45 tdma short 3 76 12 22 16qam scrambler 152 no-diff 128 shortened</td>
<td></td>
</tr>
<tr>
<td>cable modulation-profile 45 tdma long 9 232 0 22 16qam scrambler 152 no-diff 128 shortened</td>
<td></td>
</tr>
<tr>
<td>cable modulation-profile 45 tdma initial 5 34 0 48 16qam scrambler 152 no-diff 256 fixed</td>
<td></td>
</tr>
</tbody>
</table>

Note

For Cisco Remote PHY 220, preamble with QPSK modulation must have values—32x2^n (0, 1, 2, 3) bits.

Preamble with 16-QAM modulation must have values—64x2^n (0, 1, 2, 3) bits.

The robust-mix profiles are similar to but more robust than the mix profiles, so that they are more able to deal with noise on the upstream.

You can also create custom modulation profiles with the cable modulation-profile command by configuring the values for the individual burst parameters. These parameters, however, should not be modified unless you are thoroughly familiar with how changing each parameter affects the DOCSIS MAC layer. We recommend using the preconfigured default modulation profiles for most cable plants.

Note

For Cisco Remote PHY 220, preamble with QPSK modulation must have values—32x2^n (0, 1, 2, 3) bits.

Preamble with 16-QAM modulation must have values—64x2^n (0, 1, 2, 3) bits.
### Purpose

**Command or Action**

**Purpose**

<table>
<thead>
<tr>
<th>Step 4</th>
<th>exit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td><code>Router(config)# exit</code></td>
</tr>
<tr>
<td></td>
<td>Exits global configuration mode.</td>
</tr>
</tbody>
</table>

### Configuring the DOCSIS Mode and Profile on an Upstream

This section describes how to configure an upstream for a DOCSIS mode of operation, and then to assign a particular modulation profile to that upstream.

**Note**

By default, all upstreams are configured for ATDMA-only mode, using the default modulation profile.

### Procedure

**Command or Action**

**Purpose**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>enable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td><code>Router&gt; enable</code></td>
</tr>
<tr>
<td></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2</th>
<th>configure terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td><code>Router# configure terminal</code></td>
</tr>
<tr>
<td></td>
<td>Enters global configuration mode.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
<th>controller upstream-Cable slot/subslot/port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td><code>Router(config)# controller upstream-Cable 2/0/1</code></td>
</tr>
<tr>
<td></td>
<td>Enters controller configuration mode for the interface.</td>
</tr>
</tbody>
</table>

| Step 4 | us-channel n docsis-mode {atdma | tdma | tdma-atdma} |
|--------|--------------------------------------------------------|
| Example: | `Router(config-controller)# us-channel 0 docsis-mode atdma` |
| | Configures the upstream for the desired DOCSIS mode of operation. |

<table>
<thead>
<tr>
<th>Step 5</th>
<th>us-channel n modulation-profile primary-profile-number [secondary-profile-number] [tertiary-profile-number]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td><code>Router(config-controller)# us-channel 0 modulation-profile 241</code></td>
</tr>
<tr>
<td></td>
<td>Assigns up to three modulation profiles to the upstream port.</td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>The type of modulation profiles must match the DOCSIS mode configured for the upstream, using the <code>us-channel docsis-mode</code> command.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 6</th>
<th>us-channel n equalization-coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td><code>Router(config-controller)# us-channel 0 equalization-coefficient</code></td>
</tr>
<tr>
<td></td>
<td>(Optional) Enables the use of a DOCSIS pre-equalization coefficient on the upstream port.</td>
</tr>
</tbody>
</table>
### Monitoring the DOCSIS 2.0 A-TDMA Services

This section contains the following:

#### Displaying Modulation Profiles

To display the modulation profiles that are currently defined on the CMTS, use the `show cable modulation-profile` command without any options:

```
Router# show cable modulation-profile
```

<table>
<thead>
<tr>
<th>Mod</th>
<th>Docsis Mode</th>
<th>IUC</th>
<th>Type</th>
<th>Pre Diff</th>
<th>FEC</th>
<th>Scramb</th>
<th>Max Guard</th>
<th>Last Scramb</th>
<th>Pre offst</th>
<th>Pre RS Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>atdma</td>
<td>request 16qam 32 no</td>
<td>0x0</td>
<td>0x10 0x152</td>
<td>0</td>
<td>22</td>
<td>no</td>
<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
<td>1</td>
<td>atdma</td>
<td>initial 16qam 64 no</td>
<td>0x5</td>
<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
<td>no</td>
<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
<td>1</td>
<td>atdma</td>
<td>station 16qam 64 no</td>
<td>0x5</td>
<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
<td>no</td>
<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
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<td>atdma</td>
<td>a-short 16qam 64 no</td>
<td>0x4</td>
<td>0x4C 0x152</td>
<td>7</td>
<td>22</td>
<td>yes</td>
<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
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<td>atdma</td>
<td>a-long 16qam 64 no</td>
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<td>0xE8 0x152</td>
<td>0</td>
<td>22</td>
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<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
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<td>atdma</td>
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<td>0x9</td>
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<td>0</td>
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<tr>
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<td>request 16qam 32 no</td>
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<td>0x10 0x152</td>
<td>0</td>
<td>22</td>
<td>no</td>
<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
<td>2</td>
<td>atdma</td>
<td>initial 16qam 64 no</td>
<td>0x5</td>
<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
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<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
<td>2</td>
<td>atdma</td>
<td>a-short 16qam 64 no</td>
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<td>0x4C 0x152</td>
<td>7</td>
<td>22</td>
<td>yes</td>
<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
</tr>
<tr>
<td>2</td>
<td>atdma</td>
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<td>0xE8 0x152</td>
<td>0</td>
<td>22</td>
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<td>yes</td>
<td>0</td>
<td>qpsk1 no</td>
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<td>a-ugs 16qam 64 no</td>
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<td>0xE8 0x152</td>
<td>0</td>
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<td>0</td>
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</tr>
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<td>21</td>
<td>tdma</td>
<td>request qpsk 36 no</td>
<td>0x0</td>
<td>0x10 0x152</td>
<td>0</td>
<td>22</td>
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<td>yes</td>
<td>0</td>
<td>qpsk na</td>
</tr>
<tr>
<td>21</td>
<td>tdma</td>
<td>initial qpsk 98 no</td>
<td>0x5</td>
<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
<td>no</td>
<td>yes</td>
<td>0</td>
<td>qpsk na</td>
</tr>
<tr>
<td>21</td>
<td>tdma</td>
<td>station qpsk 98 no</td>
<td>0x5</td>
<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
<td>no</td>
<td>yes</td>
<td>0</td>
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<tr>
<td>21</td>
<td>tdma</td>
<td>short qpsk 64 no</td>
<td>0x3</td>
<td>0x4C 0x152</td>
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<td>0</td>
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</tr>
<tr>
<td>21</td>
<td>tdma</td>
<td>long qpsk 64 no</td>
<td>0x9</td>
<td>0xE8 0x152</td>
<td>0</td>
<td>22</td>
<td>yes</td>
<td>yes</td>
<td>0</td>
<td>qpsk na</td>
</tr>
<tr>
<td>121</td>
<td>mixed</td>
<td>request qpsk 36 no</td>
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<td>0x10 0x152</td>
<td>0</td>
<td>22</td>
<td>no</td>
<td>yes</td>
<td>0</td>
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<td>121</td>
<td>mixed</td>
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<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
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<td>yes</td>
<td>0</td>
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<td>121</td>
<td>mixed</td>
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<td>0x22 0x152</td>
<td>0</td>
<td>48</td>
<td>no</td>
<td>yes</td>
<td>0</td>
<td>qpsk na</td>
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<tr>
<td>121</td>
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<td>short qpsk 64 no</td>
<td>0x3</td>
<td>0x4C 0x152</td>
<td>12</td>
<td>22</td>
<td>yes</td>
<td>yes</td>
<td>0</td>
<td>qpsk na</td>
</tr>
</tbody>
</table>
To display a specific modulation profile in detail, specify the profile number with the `show cable modulation-profile` command:

Router# show cable modulation-profile 221

<table>
<thead>
<tr>
<th>Mod</th>
<th>Docsis</th>
<th>IUC</th>
<th>Type</th>
<th>Pre Diff</th>
<th>FEC</th>
<th>FEC Scrmb</th>
<th>Max Guard</th>
<th>Last Scrmb</th>
<th>Pre</th>
<th>Pre RS</th>
<th>Type</th>
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<tr>
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<td>qpsk</td>
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<td>atdma</td>
<td>initial</td>
<td>qpsk</td>
<td>98</td>
<td>no</td>
<td>0x5</td>
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<td>48</td>
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<td>0</td>
<td>qpsk0</td>
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<td>64qam</td>
<td>64</td>
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</tr>
<tr>
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<td>atdma</td>
<td>a-long</td>
<td>64qam</td>
<td>64</td>
<td>no</td>
<td>0x9</td>
<td>22</td>
<td>yes</td>
<td>yes</td>
<td>0</td>
<td>qpsk1</td>
</tr>
</tbody>
</table>

To display how many cable modems of each DOCSIS type are online each upstream, use the `show cable modem mac summary` command:

Router# show cable modem mac summary

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>MAC State</th>
<th>MAC Prim</th>
<th>MAC Ver</th>
<th>MAC QoS</th>
<th>FRag</th>
<th>MAC Concat</th>
<th>MAC PHS</th>
<th>MAC Priv</th>
<th>MAC DS</th>
<th>MAC US</th>
<th>MAC Said</th>
<th>MAC Sids</th>
<th>MAC Priv Sids</th>
</tr>
</thead>
<tbody>
<tr>
<td>1859.334d.7b4c</td>
<td>init(i)</td>
<td>DOC1.0</td>
<td>DOC1.0</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>0</td>
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</tr>
<tr>
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<td>offline</td>
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<tr>
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<td>DOC1.1</td>
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<td>yes</td>
<td>BPI+</td>
<td>15</td>
<td>16</td>
<td></td>
<td></td>
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<td>yes</td>
<td>yes</td>
<td>BPI+</td>
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<td>16</td>
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</tr>
<tr>
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<td>yes</td>
<td>BPI+</td>
<td>15</td>
<td>16</td>
<td></td>
<td></td>
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<tr>
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<td>yes</td>
<td>yes</td>
<td>BPI+</td>
<td>15</td>
<td>16</td>
<td></td>
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<td>yes</td>
<td>yes</td>
<td>BPI+</td>
<td>15</td>
<td>16</td>
<td></td>
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<tr>
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<td>BPI+</td>
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<td>yes</td>
<td>BPI+</td>
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<td>yes</td>
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<td>BPI+</td>
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<td>16</td>
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<td>yes</td>
<td>BPI+</td>
<td>15</td>
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<td>yes</td>
<td>BPI+</td>
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<td>BPI+</td>
<td>15</td>
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</tr>
<tr>
<td>1859.334d.7b84</td>
<td>online(pt)</td>
<td>DOC1.0</td>
<td>DOC1.1</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>BPI+</td>
<td>15</td>
<td>16</td>
<td></td>
<td></td>
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<td>yes</td>
<td>BPI+</td>
<td>15</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To display the capabilities of the online cable modems and how the modems were provisioned, use the `show cable modem mac` command:

Router# show cable modem mac
Configuration Examples for DOCSIS 2.0 A-TDMA services

This section contains the following:

Creating Modulation Profiles Examples

This section contains the following:

Example: DOCSIS 1.0/DOCSIS 1.1 TDMA Modulation Profiles

The following sample configurations show typical modulation profiles for the DOCSIS 1.0/DOCSIS 1.1 TDMA mode of operation:

- Profile 21 is the default profile for TDMA operations.
- Profiles 24 and 25 use the preconfigured 16-QAM and QPSK modulation profiles.
- Profile 26 is a typical QPSK modulation profile using some customized burst parameters.

```plaintext
cable modulation-profile 24 tdma qam-16
cable modulation-profile 25 tdma qpsk
cable modulation-profile 26 tdma request 0 16 0 8 qpsk scrambler 152 no-diff 68 fixed
cable modulation-profile 26 tdma initial 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed
cable modulation-profile 26 tdma station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed
cable modulation-profile 26 tdma short 4 76 12 8 qpsk scrambler 152 no-diff 80 shortened
cable modulation-profile 26 tdma long 8 236 0 8 qpsk scrambler 152 no-diff 80 shortened
```
**Example: Mixed TDMA/A-TDMA Modulation Profiles**

The following sample configurations show typical modulation profiles for the DOCSIS 1.X/DOCSIS 2.0 mixed TDMA/A-TDMA mode of operation:

- Profile 121 is the default profile for mixed mode operations.
- Profiles 122 through 126 use the preconfigured mixed mode modulation profiles.
- Profile 127 is a typical mixed mode modulation profile some customized burst parameters.

```
cable modulation-profile 121 mixed request 0 16 0 8 qpsk scrambler 152 no-diff 64 fixed
  qpsk0 0 18
  cable modulation-profile 121 mixed initial 5 34 0 48 qpsk scrambler 152 no-diff 32 fixed
  qpsk0 0 18
  cable modulation-profile 121 mixed station 5 34 0 48 qpsk scrambler 152 no-diff 32 fixed
  qpsk0 0 18
  cable modulation-profile 121 mixed short 5 75 6 8 qpsk scrambler 152 no-diff 72 shortened
  qpsk0 0 18
  cable modulation-profile 121 mixed long 8 220 0 8 qpsk scrambler 152 no-diff 80 shortened
  qpsk0 0 18
  cable modulation-profile 121 mixed a-short 0 16 15 99 64qam scrambler 152 no-diff 128
  shortened qpsk0 0 18
  cable modulation-profile 121 mixed a-long 0 16 15 200 64qam scrambler 152 no-diff 128
  shortened qpsk0 0 18
```

- Cable modulation-profile 122 mixed mix-high
- Cable modulation-profile 123 mixed mix-low
- Cable modulation-profile 124 mixed mix-medium
- Cable modulation-profile 125 mixed qam-16
- Cable modulation-profile 126 mixed qpsk

```
cable modulation-profile 127 mixed request 0 16 0 8 qpsk scrambler 152 no-diff 68 fixed
  qpsk0 0 18
  cable modulation-profile 127 mixed initial 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed
  qpsk0 0 18
  cable modulation-profile 127 mixed station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed
  qpsk0 0 18
  cable modulation-profile 127 mixed short 6 76 7 8 16qam scrambler 152 no-diff 160 shortened
  qpsk1 1 2048
  cable modulation-profile 127 mixed long 8 231 0 8 16qam scrambler 152 no-diff 160 shortened
  qpsk1 1 2048
  cable modulation-profile 127 mixed a-short 9 76 6 8 32qam scrambler 152 no-diff 160 shortened
  qpsk1 1 2048
  cable modulation-profile 127 mixed a-long 12 231 0 8 64qam scrambler 152 no-diff 132 shortened
  qpsk1 1 2048
```

**Example: DOCSIS 2.0 A-TDMA Modulation Profiles**

The following sample configurations show typical modulation profiles for the DOCSIS 2.0 A-TDMA mode of operation:

- Profile 221 is the default profile for A-TDMA mode operations.
- Profiles 222 through 226 use the preconfigured A-TDMA mode modulation profiles.
- Profile 227 is a typical A-TDMA mode modulation profile customized burst parameters.

```
cable modulation-profile 221 atdma request 0 16 0 8 qpsk scrambler 152 no-diff 64 fixed
  qpsk0 0 18
  cable modulation-profile 221 atdma initial 5 34 0 48 qpsk scrambler 152 no-diff 32 fixed
  qpsk0 0 18
  cable modulation-profile 221 atdma station 5 34 0 48 qpsk scrambler 152 no-diff 32 fixed
  qpsk0 0 18
  cable modulation-profile 221 atdma short 5 75 6 8 qpsk scrambler 152 no-diff 72 shortened
  qpsk0 0 18
  cable modulation-profile 221 atdma long 8 220 0 8 qpsk scrambler 152 no-diff 80 shortened
  qpsk0 0 18
  cable modulation-profile 221 atdma a-short 5 99 10 8 64qam scrambler 152 no-diff 128 shortened
  qpsk0 0 18
  cable modulation-profile 221 atdma a-long 15 200 0 8 64qam scrambler 152 no-diff 128 shortened
  qpsk0 0 18
```
Assigning Modulation Profiles to Upstreams Examples

This section contains the following:

Example: Assigning DOCSIS 1.0/DOCSIS 1.1 TDMA Modulation Profiles

The following sample configuration shows DOCSIS 1.0/DOCSIS 1.1 TDMA modulation profiles being assigned to the upstreams. The TDMA modulation profile (profile 21) is assigned to the upstream controller 2/0/0.

```
cable modulation-profile 222 atdma qam-8

cable modulation-profile 223 atdma qam-16

cable modulation-profile 224 atdma qam-32

cable modulation-profile 225 atdma qam-64

cable modulation-profile 226 atdma qpsk

cable modulation-profile 227 atdma request 0 16 0 8 qpsk scrambler 152 no-diff 68 fixed qpsk0 1 2048

cable modulation-profile 227 atdma initial 0 16 0 0 qpsk no-scrambler no-diff 2 fixed qpsk1 0 18

cable modulation-profile 227 atdma station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed qpsk0 1 2048

cable modulation-profile 227 atdma a-short 9 76 6 8 32qam scrambler 152 no-diff 160 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-long 12 231 0 8 64qam scrambler 152 no-diff 132 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-ugs 3 231 0 8 16qam scrambler 152 no-diff 80 shortened qpsk1 1 2048
```

Assigning Modulation Profiles to Upstreams Examples

Example: Assigning Mixed TDMA/A-TDMA Modulation Profiles

The following sample configuration shows mixed mode TDMA/A-TDMA modulation profiles being assigned to the upstreams. The mixed modulation profile (profile 121) is assigned to the upstream controller 2/0/15.

```
cable modulation-profile 227 atdma request 0 16 0 8 qpsk scrambler 152 no-diff 68 fixed qpsk0 1 2048

cable modulation-profile 227 atdma initial 0 16 0 0 qpsk no-scrambler no-diff 2 fixed qpsk1 0 18

cable modulation-profile 227 atdma station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed qpsk0 1 2048

cable modulation-profile 227 atdma a-short 9 76 6 8 32qam scrambler 152 no-diff 160 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-long 12 231 0 8 64qam scrambler 152 no-diff 132 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-ugs 3 231 0 8 16qam scrambler 152 no-diff 80 shortened qpsk1 1 2048
```

Example: Assigning Mixed TDMA/A-TDMA Modulation Profiles

The following sample configuration shows mixed mode TDMA/A-TDMA modulation profiles being assigned to the upstreams. The mixed modulation profile (profile 121) is assigned to the upstream controller 2/0/15.

```
cable modulation-profile 227 atdma request 0 16 0 8 qpsk scrambler 152 no-diff 68 fixed qpsk0 1 2048

cable modulation-profile 227 atdma initial 0 16 0 0 qpsk no-scrambler no-diff 2 fixed qpsk1 0 18

cable modulation-profile 227 atdma station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed qpsk0 1 2048

cable modulation-profile 227 atdma a-short 9 76 6 8 32qam scrambler 152 no-diff 160 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-long 12 231 0 8 64qam scrambler 152 no-diff 132 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-ugs 3 231 0 8 16qam scrambler 152 no-diff 80 shortened qpsk1 1 2048
```

Example: Assigning Mixed TDMA/A-TDMA Modulation Profiles

The following sample configuration shows mixed mode TDMA/A-TDMA modulation profiles being assigned to the upstreams. The mixed modulation profile (profile 121) is assigned to the upstream controller 2/0/15.

```
cable modulation-profile 227 atdma request 0 16 0 8 qpsk scrambler 152 no-diff 68 fixed qpsk0 1 2048

cable modulation-profile 227 atdma initial 0 16 0 0 qpsk no-scrambler no-diff 2 fixed qpsk1 0 18

cable modulation-profile 227 atdma station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed qpsk0 1 2048

cable modulation-profile 227 atdma a-short 9 76 6 8 32qam scrambler 152 no-diff 160 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-long 12 231 0 8 64qam scrambler 152 no-diff 132 shortened qpsk1 1 2048

cable modulation-profile 227 atdma a-ugs 3 231 0 8 16qam scrambler 152 no-diff 80 shortened qpsk1 1 2048
```
Example: Assigning DOCSIS 2.0 A-TDMA Modulation Profiles

The following sample configuration shows DOCSIS 2.0 A-TDMA modulation profiles being assigned to the upstreams. The A-TDMA modulation profile (profile 221) is assigned to the upstream controller 2/0/10.

controller Upstream-Cable 2/0/10
us-channel 0 channel-width 1600000 1600000
us-channel 0 docsis-mode atdma
us-channel 0 minislot-size 4
us-channel 0 modulation-profile 221
no us-channel 0 shutdown
us-channel 1 channel-width 1600000 1600000
us-channel 1 docsis-mode atdma
us-channel 1 minislot-size 4
us-channel 1 modulation-profile 221
no us-channel 1 shutdown
us-channel 2 channel-width 1600000 1600000
us-channel 2 docsis-mode atdma
us-channel 2 minislot-size 4
us-channel 2 modulation-profile 221
no us-channel 2 shutdown
us-channel 3 channel-width 1600000 1600000
us-channel 3 docsis-mode atdma
us-channel 3 minislot-size 4
us-channel 3 modulation-profile 221
no us-channel 3 shutdown
us-channel 4 channel-width 1600000 1600000
us-channel 4 docsis-mode atdma
us-channel 4 minislot-size 4
us-channel 4 modulation-profile 221
us-channel 4 shutdown
us-channel 5 channel-width 1600000 1600000
us-channel 5 docsis-mode atdma
us-channel 5 minislot-size 4
us-channel 5 modulation-profile 221
us-channel 5 shutdown

!
## Additional References

### Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco CMTS Commands</td>
<td><em>Cisco IOS CMTS Cable Command Reference</em></td>
</tr>
</tbody>
</table>

### Standards

<table>
<thead>
<tr>
<th>Standards</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP-RFIv1.1-I09-020830</td>
<td>Data-over-Cable Service Interface Specifications Radio Frequency Interface Specification, version 1.1</td>
</tr>
<tr>
<td>SP-RFIv2.0-I03-021218</td>
<td>Data-over-Cable Service Interface Specifications Radio Frequency Interface Specification, version 2.0</td>
</tr>
<tr>
<td>SP-OSSIv2.0-I03-021218</td>
<td>Data-over-Cable Service Interface Specifications Operations Support System Interface Specification, version 2.0</td>
</tr>
<tr>
<td>SP-BPI+-I09-020830</td>
<td>Data-over-Cable Service Interface Specifications Baseline Privacy Plus Interface Specification, version 2.0</td>
</tr>
<tr>
<td>RFC 2233</td>
<td>DOCSIS OSSI Objects Support</td>
</tr>
<tr>
<td>RFC 2665</td>
<td>DOCSIS Ethernet MIB Objects Support</td>
</tr>
<tr>
<td>RFC 2669</td>
<td>Cable Device MIB</td>
</tr>
</tbody>
</table>

### MIBs

**MIBs**

- DOCS-BPI-PLUS-MIB
- DOCS-CABLE-DEVICE-MIB (RFC 2669)
- DOCS-CABLE-DEVICE-TRAP-MIB
- DOCS-IF-EXT-MIB
- DOCS-IF-MIB (RFC 2670)
- DOCS-QOS-MIB
- DOCS-SUBMGT-MIB
- IGMP-STD-MIB (RFC 2933)

**MIBs Link**

To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
</tbody>
</table>

Feature Information for DOCSIS 2.0 A-TDMA Modulation Profile

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 25: Feature Information for DOCSIS 2.0 A-TDMA Modulation Profile

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS 2.0 A-TDMA Modulation Profile</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 9

Downstream Resiliency Bonding Group

With more wideband (WB) modems being deployed in cable plants, WB modem resiliency is an important feature. When a comparatively smaller number of cable modems (CMs) observe an impairment on an RF channel, that RF channel stops working. It impacts all the CM using that RF channel, irrespective of whether they reported the impairment on that RF channel. Instead, the solution should be to communicate with the affected cable modems using the good RF channel, without affecting the other cable modems.

The Downstream Resiliency Bonding Group feature allows cable modems with multiple impaired RF channels to be allocated to a dynamically-created wideband interface, which ensures that the performance of the wideband cable modems is not drastically affected.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 161
- Prerequisites for Downstream Resiliency Bonding Group, on page 162
- Restrictions for the Downstream Resiliency Bonding Group, on page 162
- Information About Downstream Resiliency Bonding Group, on page 164
- How to Configure Downstream Resiliency Bonding Group, on page 165
- Verifying Downstream Resiliency Bonding Group Configuration, on page 167
- Troubleshooting the Downstream Resiliency Bonding Group Configuration, on page 171
- Configuration Examples for the Downstream Resiliency Bonding Group, on page 171
- Additional References, on page 175
- Feature Information for Downstream Resiliency Bonding Group, on page 175

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note
The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
### Table 26: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
<td></td>
</tr>
</tbody>
</table>

### Prerequisites for Downstream Resiliency Bonding Group

- Set aside WB interfaces so that new WB interfaces can be dynamically created from the reserved list of WB interfaces.
- Free up RF bandwidth so that those RF channels can be added to a resiliency bonding group (RBG).
- Remove all existing RBG configuration from the WB interface.

### Restrictions for the Downstream Resiliency Bonding Group

- If an existing wideband interface is reserved as a Resiliency Bonding Group (RBG) and later the RBG is removed (through the `no cable ds-resiliency` command), the modems using this RBG go offline and the RBG configuration itself is deleted. Therefore, it is highly recommended that users should not configure an existing BG as an RBG.
• This feature is enabled only when the number of cable modems observing an RF channel impairment is below the resiliency threshold. If the number of cable modems on an impaired RF channel is above the resiliency threshold, the impaired RF channel is temporarily removed from the bonding group.

• A cable modem is assigned to an RBG on a first-come-first-served basis. To handle this feature optimally, it is recommended to set aside more WB interfaces and RF channel bandwidth.

• The Cisco CMTS controls the freeing of unused RBGs, when there is no modem using the RGB. The freeing of the unused RGB may take some time and the RGB, which is not completely free cannot be used by the modems. Irrespective of the number of configured RBGs, if all the old RBGs are not completely set free and if the Cisco CMTS tries to move the cable modem to a new RBG, the Cisco CMTS moves the cable modem to the primary DS channel instead of RBG.

• Only SFs on the WB interface associated with the primary SF are moved to an RBG. SFs on other interfaces will not be moved.

• Static SFs are assigned to an RBG on a best effort quality of service (QoS).

• If the resiliency rf-change-trigger setting does not have the secondary keyword set, only the primary SF is moved to the RBG or a NB interface.

• If the Downstream Resiliency Bonding Group feature is not enabled to use an RBG, only cable modems with impairments on the primary WB interface are moved to the NB interface.

• SFs carrying multicast traffic are not moved.

There may not be enough reserved bonding groups to support all modems facing an impairment at any given time thus the following restrictions must be considered:

• Each RBG has at least two RF channels.

• RBG RF assignments are always a subset of the RF channel assignment of the parent WB interface.

• If an RBG is unavailable for a cable modem, the SF of the CM is moved to a NB interface.

• If a high percentage of cable modems experience an RF impairment and there are no more available bonding group IDs, the impaired RF itself may be removed from the bonding group. Removal of an impaired RF from a parent bonding group is also reflected in the RBG. If an RBG drops to a single RF, all SFs are moved to the NB interface.

The Downstream Resiliency Bonding Group feature has the following cross-functional restrictions:

• All Dynamic service flows, whether they require a committed information rate (CIR) or not, typically voice flows, are created on the NB interface when an RF channel is impaired. Because all SFs assigned to an RBG are best effort only, voice calls may report a quality issue.

• Cable modems participating in the resiliency mode do not take part in load balancing.

• The Downstream Resiliency Bonding Group feature is only supported in the Dynamic Bandwidth Sharing (DBS) mode.
You can set aside unused bonding groups as RBGs. Ensure that each RF channel is assigned at least 1% of the available bandwidth. Use the `cable rf-channel bandwidth-percent` command to configure the RF channel bandwidth.

**Note**

If the bandwidth-percent is set to 100, the Cisco CMTS does not add any RFs to the RBG. In other words, this feature will not be enabled.

The Cisco CMTS controls the assignment and freeing of unused RBGs. If an RF channel is removed from a WB interface, it is also removed from any associated RBGs.

**Note**

If the wideband interface is in standby mode, the Cisco CMTS does not assign or free up the unused downstream bonding group.

A suspended RF channel is restored for all affected wideband interfaces when a specified number of cable modems report (via CM-STATUS) that the channel connectivity is restored. The Wideband Modem Resiliency feature defines the specified number of cable modems as half of the configured count or percentage of rf-change-trigger, or both. For example, if the count is 20 and the percent is 10, then the number of cable modems reporting recovery should reduce the count to 10 and the percent to 5 for the suspended RF channel to be restored.

### Finding a Best-Fit RBG for the Cable Modem

A bonding group is a list of channels that provide a means to identify the channels that are bonded together. The Cisco CMTS assigns a service flow (SF) to an RBG based on the attributes of the SF and the attributes of the individual channels of the bonding group.

In the Downstream Resiliency Bonding Group feature, when a line card receives a CM-STATUS message from the cable modem informing the line card that there is an RF channel impairment, the line card checks for the number of good RF channels and:

- Moves the cable modem to narrowband mode if there is only one available RF channel.
- Moves the cable modem to wideband mode if the cable modem reports all RF channels are in good state.
- Moves the cable modem to an RBG if there are two or more good RF channels, with at least one RF channel impaired, and if the Downstream Resiliency Bonding Group feature is enabled.

When the Cisco CMTS receives a message from the line card to move a cable modem to an RBG, the Cisco CMTS attempts to find an existing RBG or creates an RBG that satisfies the impairment.

**Note**

If two or more RBGs are reserved for the same wideband controller, the Cisco CMTS creates one RBG for each cable modem.
The Cisco CMTS creates more than one RBG from a parent WB interface if the user has set aside more than one WB interface as the RBG and the RF bandwidth does not exceed 100%.

If a matching RBG is not found or cannot be created, the Cisco CMTS looks for an RBG with a subset of the required RF channels and if available, the cable modem is assigned to such an RBG.

However, if no such RBG exists, the Cisco CMTS instructs the line card to move the cable modem to NB mode.

How to Configure Downstream Resiliency Bonding Group

This section contains the following:

Enabling Downstream Resiliency Bonding Group

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: <code>Router&gt; enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: <code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>`cable rf-change-trigger {percent value</td>
<td>count number} [secondary]`</td>
</tr>
<tr>
<td>Example: <code>Router(config)# cable rf-change-trigger percent 50 count 1 secondary</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
</tr>
<tr>
<td><code>cable resiliency ds-bonding</code></td>
<td>Enables the downstream resiliency bonding group.</td>
</tr>
<tr>
<td>Example: <code>Router(config)# cable resiliency ds-bonding</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td></td>
</tr>
<tr>
<td><code>exit</code></td>
<td>Returns to the global configuration mode.</td>
</tr>
<tr>
<td>Example: <code>Router(config)# exit</code></td>
<td></td>
</tr>
</tbody>
</table>
**What to do next**

The result of using the `cable rf-change-trigger` command with the `cable resiliency ds-bonding` command is different from using only the `cable rf-change-trigger` command. For more information, see [Downstream Resiliency Narrowband Mode Versus Resiliency Bonding Group](#), on page 167.

---

### Reserving a Resiliency Bonding Group for a Line Card

This section describes reserving a bonding group or a wideband interface for a line card per controller.

**Restriction**

When you reserve a resiliency bonding group using the `cable ds-resiliency` command, the existing bundle and RF channel configurations on the wideband interface will be removed automatically. Other configurations like admission control, should be removed manually.

After downstream resiliency bonding group is configured, avoid other manual configurations.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: <code>Router&gt; enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: <code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> <code>interface wideband-cable</code></td>
<td>Configures a wideband cable interface.</td>
</tr>
<tr>
<td><code>slot/subslot/port:wideband-channel</code></td>
<td></td>
</tr>
<tr>
<td>Example: <code>Router(config)# interface wideband-cable 1/0/0:7</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> <code>cable ds-resiliency</code></td>
<td>Reserves an individual bonding group or WB interface for usage on a line card, on a per controller basis.</td>
</tr>
<tr>
<td>Example: <code>Router(config-if)# cable ds-resiliency</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> exit</td>
<td>Returns to the global configuration mode.</td>
</tr>
<tr>
<td>Example: <code>Router(config-if)# exit</code></td>
<td></td>
</tr>
</tbody>
</table>
Verifying Downstream Resiliency Bonding Group Configuration

This section contains the following:

Verifying the Downstream Resiliency Bonding Group

To verify if the Downstream Resiliency Bonding Group feature is enabled, use the `show cable modem resiliency` command as shown in the following example:

```
Router# show cable modem resiliency
```

```
Orig BG Curr BG
--- -------------- ---------------------- ----------------------
C7/0/0 0025.2eaf.843e 897 Wi7/0/0:0 4 898 Wi7/0/0:1 3
C7/0/0 0025.2eaf.8356 897 Wi7/0/0:0 4 899 Wi7/0/0:2 3
C7/0/0 0015.d176.5199 897 Wi7/0/0:0 4 720 In7/0/0:0
```

The `Current BG I/F` field indicates whether Downstream Resiliency Bonding Group feature is enabled and if the cable modems are assigned to a WB interface.

Verifying a Reserved Resiliency Bonding Group

To verify if a BG is reserved for a line card, use the `show cable resiliency` command as shown in the following example:

```
Router# show cable resiliency
```

```
BG Resil BG RF
------------- ---- -------------- ----- --------------- ----------
Wi1/0/0:10 10 Free
Wi1/0/0:20 20 Free
Wi7/0/0:1 1 Assigned 3 Nov 3 09:55:49 0 0
Wi7/0/0:2 2 Assigned 3 Nov 3 09:57:09 0 0
```

Downstream Resiliency Narrowband Mode Versus Resiliency Bonding Group

This section provides the sample outputs when using the `cable rf-change-trigger` command with the `cable resiliency ds-bonding` command and using only the `cable rf-change-trigger` command.

**Table 27: Downstream Resiliency Narrowband Mode Versus Resiliency Bonding Group - Scenario 1**

<table>
<thead>
<tr>
<th>Effect on (Using only cable rf-change-trigger command)</th>
<th>Using only cable rf-change-trigger command (Downstream Resiliency NB Mode)</th>
<th>Using cable rf-change-trigger command with cable resiliency ds-bonding (Downstream Resiliency Bonding Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Threshold</td>
<td>Above Threshold</td>
<td>Below Threshold</td>
</tr>
</tbody>
</table>

Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.x
### Effect on
<table>
<thead>
<tr>
<th>Using only cable rf-change-trigger command (Downstream Resiliency NB Mode)</th>
<th>Using cable rf-change-trigger command with cable resiliency ds-bonding (Downstream Resiliency Bonding Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Service Flow</strong></td>
<td>Moves to the primary channel.</td>
</tr>
<tr>
<td><strong>Secondary Service Flows</strong></td>
<td>Remains on the original WB interface.</td>
</tr>
</tbody>
</table>

The following is a sample output for a cable modem when the **cable rf-change-trigger** command is used with the **cable resiliency ds-bonding** command and the number of cable modems observing an RF channel impairment is below the resiliency threshold:

```
Router# show cable modem

+------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>MAC Address</th>
<th>IP Address</th>
<th>I/F</th>
<th>MAC</th>
<th>Prim RxPwr</th>
<th>Timing</th>
<th>Num</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>0023.be83.1ec9e 10.1.11.46</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>922</td>
<td>-0.50</td>
<td>1055</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0023.be83.1eaa 10.1.11.28</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>923</td>
<td>0.00</td>
<td>1043</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0025.2ecf.f1c9 10.1.11.53</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>925</td>
<td>0.00</td>
<td>1057</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.3a30.9fc0 10.1.11.47</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>926</td>
<td>0.00</td>
<td>1055</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>001a.c3ff.e3d4 10.1.11.39</td>
<td>C5/0/0/UB</td>
<td>p-online</td>
<td>927</td>
<td>0.00</td>
<td>1307</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0023.be83.1ec9a 10.1.11.61</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>928</td>
<td>0.00</td>
<td>1057</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.3a30.9fbc 10.1.11.60</td>
<td>C5/0/0/UB</td>
<td>p-online</td>
<td>929</td>
<td>-0.50</td>
<td>1055</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0023.be83.1ec8c 10.1.11.38</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>930</td>
<td>0.00</td>
<td>1061</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>001e.6bfb.1964 10.1.11.63</td>
<td>C5/0/0/UB</td>
<td>p-online</td>
<td>931</td>
<td>0.50</td>
<td>1305</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0025.2ecf.f19e 10.1.11.29</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>932</td>
<td>0.00</td>
<td>1057</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0025.2ecf.f04e 10.1.11.54</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>933</td>
<td>0.00</td>
<td>1054</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.3a30.9fc8 10.1.11.43</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>934</td>
<td>0.00</td>
<td>1056</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0025.2ecf.f190 10.1.11.55</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>935</td>
<td>0.00</td>
<td>1059</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.3a30.9fd0 10.1.11.52</td>
<td>C5/0/0/UB</td>
<td>p-online</td>
<td>936</td>
<td>0.00</td>
<td>1057</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.ce97.8268 10.1.11.31</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>937</td>
<td>-0.50</td>
<td>1056</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.ce97.8281 10.1.11.25</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>938</td>
<td>0.00</td>
<td>1058</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>001a.c3ff.e4ce 10.1.11.44</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>940</td>
<td>-0.50</td>
<td>1304</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.ce9c.839e 10.1.11.32</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>941</td>
<td>-0.50</td>
<td>1305</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.ceac.e768 10.1.11.41</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>942</td>
<td>-1.00</td>
<td>1305</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>0022.ceac.e398 10.1.11.33</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>943</td>
<td>0.00</td>
<td>1306</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>001a.c3ff.e50a 10.1.11.59</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>944</td>
<td>0.00</td>
<td>1304</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>001a.c3ff.e3f8 10.1.11.57</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>945</td>
<td>-1.00</td>
<td>1306</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>001e.6bfb.1a14 10.1.11.37</td>
<td>C5/0/0/UB</td>
<td>w-online</td>
<td>946</td>
<td>0.00</td>
<td>1305</td>
<td>0</td>
<td>N</td>
</tr>
</tbody>
</table>
```

**Note**

p-online indicates that cable modem has reported NP RF failure and it is in downstream partial service mode.

```
Router# show cable resiliency

+-----------------+-----------------+-----------------+-----------------+-----------------+
<table>
<thead>
<tr>
<th>BG</th>
<th>Resil BG</th>
<th>BG</th>
<th>Resil BG</th>
<th>RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/F</td>
<td>ID State</td>
<td>Count Time</td>
<td>Ctrl Num</td>
<td></td>
</tr>
</tbody>
</table>
```

**Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.x**
The following is a sample output for a cable modem under the following conditions:

- **cable rf-change-trigger** command is used with the **cable resiliency ds-bonding** command
- Number of cable modems observing an RF channel impairment is *below* the resiliency threshold
- There is no available WB interface for the resiliency bonding group:
Router# show cable modem resiliency

<table>
<thead>
<tr>
<th>Orig BG</th>
<th>MAC Address</th>
<th>ID</th>
<th>I/F</th>
<th>RPs</th>
<th>Curr BG</th>
<th>RFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5/0/0 0025.2ecf.f19c</td>
<td>257</td>
<td>Wi5/0/0:0</td>
<td>8</td>
<td>259 Wi5/0/0:2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>C5/0/0 0025.2ecf.f196</td>
<td>257</td>
<td>Wi5/0/0:0</td>
<td>8</td>
<td>240 In5/0/0:0</td>
<td>&lt;-- move NB for no available WB interface</td>
<td></td>
</tr>
<tr>
<td>C5/0/0 0022.3a30.9fbc</td>
<td>257</td>
<td>Wi5/0/0:0</td>
<td>8</td>
<td>260 Wi5/0/0:3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>C5/0/0 0022.3a30.9fd0</td>
<td>257</td>
<td>Wi5/0/0:0</td>
<td>8</td>
<td>261 Wi5/0/0:4</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Table 28: Downstream Resiliency Narrowband Mode Versus Resiliency Bonding Group - Scenario 2

<table>
<thead>
<tr>
<th>Effect on</th>
<th>Using only cable rf-change-trigger secondary command (Downstream Resiliency NB Mode)</th>
<th>Using cable rf-change-trigger secondary command with cable resiliency ds-bonding (Downstream Resiliency Bonding Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Threshold</td>
<td>Moves all service flows to the primary channel.</td>
<td>Moves all service flows to the primary channel.</td>
</tr>
<tr>
<td>Above Threshold</td>
<td>Remains on the original bonding group while the impaired downstream channels are not used and are reported as DOWN.</td>
<td>Remains on the original bonding group while the impaired downstream channels are not used and are reported as DOWN.</td>
</tr>
</tbody>
</table>

The following is a sample output for a cable modem when the cable rf-change-trigger secondary command is used with the cable resiliency ds-bonding command and the number of cable modems observing an RF channel impairment is below the resiliency threshold:

Router# show cable modem 0025.2ecf.f196 service-flow

SUMMARY:

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>IP Address</th>
<th>Host</th>
<th>MAC Interface</th>
<th>State</th>
<th>Sid</th>
<th>CPE Downstream</th>
<th>DS</th>
<th>SFid</th>
<th>Dir</th>
<th>Curr</th>
<th>Sid</th>
<th>Sched</th>
<th>Prio</th>
<th>MaxSusRate</th>
<th>MaxBrlst</th>
<th>MinRsVRate</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>0025.2ecf.f196 10.1.11.29</td>
<td>CS/0/0/UB</td>
<td>p-online</td>
<td>955</td>
<td>0</td>
<td>In5/0/0:0</td>
<td>240</td>
<td>1913 US</td>
<td>act</td>
<td>955</td>
<td>BE</td>
<td>0</td>
<td>0</td>
<td>10000000</td>
<td>100000</td>
<td>0</td>
<td>0</td>
<td>425</td>
</tr>
<tr>
<td>1913 US</td>
<td>act</td>
<td>955</td>
<td>BE</td>
<td>0</td>
<td>10000000</td>
<td>100000</td>
<td>0</td>
<td>0</td>
<td>425</td>
<td>1915 US</td>
<td>act</td>
<td>956</td>
<td>RTPS</td>
<td>7</td>
<td>0</td>
<td>3044</td>
<td>100000</td>
</tr>
</tbody>
</table>
Troubleshooting the Downstream Resiliency Bonding Group Configuration

Use the following commands to get information on the WB interface, number of CMs in an impaired state, resiliency bonding groups, their associated bonding groups, available RF channels, and the number of CMS and service flows assigned to them:

- `debug cable wbcmts resiliency`
- `debug cable wbcmts resiliency report`
- `show cable resiliency`
- `show cable modem resiliency`
- `show cable modem wideband rcs-status`
- `show cable modem service-flow verbose`
- `show cable resil-rf-status`
- `show cable modem summary wb-rfs`

Configuration Examples for the Downstream Resiliency Bonding Group

The following is an example of the configuration of the Downstream Resiliency Bonding Group feature:

cable rf-change-trigger count 10 secondary
cable resiliency ds-bonding
!
controller Upstream-Cable 9/0/1
us-channel 0 frequency 13200000
us-channel 0 channel-width 6400000 6400000
us-channel 0 power-level -1
us-channel 0 docsis-mode atdma
us-channel 0 minislot-size 8
us-channel 0 modulation-profile 221
no us-channel 0 shutdown
us-channel 1 frequency 19600000
us-channel 1 channel-width 6400000 6400000
us-channel 1 power-level -1
us-channel 1 docsis-mode atdma
us-channel 1 minislot-size 8
us-channel 1 modulation-profile 221
no us-channel 1 shutdown
us-channel 2 frequency 26000000
us-channel 2 channel-width 6400000 6400000
us-channel 2 power-level -1
us-channel 2 docsis-mode atdma
us-channel 2 minislot-size 8
us-channel 2 modulation-profile 221
no us-channel 2 shutdown
us-channel 3 frequency 32400000
us-channel 3 channel-width 6400000 6400000
us-channel 3 power-level -1
us-channel 3 docsis-mode atdma
us-channel 3 minislot-size 8
us-channel 3 modulation-profile 221
no us-channel 3 shutdown

controller Integrated-Cable 9/0/1
max-carrier 128
base-channel-power 34
rf-chan 0
type DOCSIS
frequency 381000000
rf-output NORMAL
power-adjust -2
docsis-channel-id 1
qam-profile 1
rf-chan 1 3
type DOCSIS
frequency 387000000
rf-output NORMAL
power-adjust 0
docsis-channel-id 2
qam-profile 1
rf-chan 32 35
type DOCSIS
frequency 477000000
rf-output NORMAL
power-adjust 0
docsis-channel-id 33
qam-profile 1
rf-chan 64 67
type DOCSIS
frequency 501000000
rf-output NORMAL
power-adjust 0
docsis-channel-id 65
qam-profile 1
rf-chan 96 99
type DOCSIS
frequency 669000000
rf-output NORMAL
power-adjust 0
docsis-channel-id 97
qam-profile 1
The following is a sample output for the `show cable modem` command to display impaired cable modems below the resiliency threshold value:
Router# **show cable modem**

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>IP Address</th>
<th>I/F</th>
<th>MAC State</th>
<th>Prim RxPwr</th>
<th>Timing</th>
<th>Num I</th>
<th>Sid (dBmv)</th>
<th>Offset</th>
<th>CPE P</th>
</tr>
</thead>
<tbody>
<tr>
<td>e448.c70c.96d5 80.17.150.6</td>
<td>C9/0/1/U2</td>
<td>p-online</td>
<td>1</td>
<td>0.00</td>
<td>1784</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.96f3 80.17.150.14</td>
<td>C9/0/1/U1</td>
<td>w-online</td>
<td>2</td>
<td>-1.00</td>
<td>1797</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68ee.9633.0699 80.17.150.31</td>
<td>C9/0/1/U0</td>
<td>w-online</td>
<td>3</td>
<td>-1.00</td>
<td>2088</td>
<td>1</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.96e7 80.17.150.29</td>
<td>C9/0/1/U3</td>
<td>p-online</td>
<td>4</td>
<td>-0.50</td>
<td>1785</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.982b 80.17.150.18</td>
<td>C9/0/1/U2</td>
<td>w-online</td>
<td>5</td>
<td>0.00</td>
<td>1780</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.9804 80.17.150.13</td>
<td>C9/0/1/U3</td>
<td>w-online</td>
<td>6</td>
<td>-0.50</td>
<td>1788</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.9819 80.17.150.30</td>
<td>C9/0/1/U0</td>
<td>w-online</td>
<td>7</td>
<td>-1.00</td>
<td>1782</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.980d 80.17.150.17</td>
<td>C9/0/1/U0</td>
<td>w-online</td>
<td>8</td>
<td>-1.00</td>
<td>1787</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note**
p-online indicates that the cable modem has reported NP RF failure and it is in downstream partial service mode.

The following is a sample output when RBGs are created:

**Router# show cable resiliency**

<table>
<thead>
<tr>
<th>Resil BG I/F</th>
<th>BG ID</th>
<th>Resil BG RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wi9/0/1:60</td>
<td>28989</td>
<td>Assigned</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**Router# show cable modem resiliency**

<table>
<thead>
<tr>
<th>I/F</th>
<th>MAC Address</th>
<th>Orig BG ID</th>
<th>I/F</th>
<th>RFs ID</th>
<th>Curr BG ID</th>
<th>RFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>C9/0/1</td>
<td>e448.c70c.96d5 80.17.150.6</td>
<td>28929</td>
<td>Wi9/0/1:0</td>
<td>4</td>
<td>28989</td>
<td>Wi9/0/1:60</td>
</tr>
<tr>
<td>C9/0/1</td>
<td>e448.c70c.96e7 80.17.150.29</td>
<td>28929</td>
<td>Wi9/0/1:0</td>
<td>4</td>
<td>28990</td>
<td>Wi9/0/1:61</td>
</tr>
</tbody>
</table>

The following is a sample output of the **show cable modem** command when the impaired cable modems have recovered:

**Router# show cable modem**

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>IP Address</th>
<th>I/F</th>
<th>MAC State</th>
<th>Prim RxPwr</th>
<th>Timing</th>
<th>Num I</th>
<th>Sid (dBmv)</th>
<th>Offset</th>
<th>CPE P</th>
</tr>
</thead>
<tbody>
<tr>
<td>e448.c70c.96d5 80.17.150.6</td>
<td>C9/0/1/U2</td>
<td>w-online</td>
<td>1</td>
<td>0.00</td>
<td>1784</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.96f3 80.17.150.14</td>
<td>C9/0/1/U1</td>
<td>w-online</td>
<td>2</td>
<td>-1.00</td>
<td>1797</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68ee.9633.0699 80.17.150.31</td>
<td>C9/0/1/U0</td>
<td>w-online</td>
<td>3</td>
<td>-1.00</td>
<td>2088</td>
<td>1</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.96e7 80.17.150.29</td>
<td>C9/0/1/U3</td>
<td>w-online</td>
<td>4</td>
<td>-0.50</td>
<td>1785</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.982b 80.17.150.18</td>
<td>C9/0/1/U2</td>
<td>w-online</td>
<td>5</td>
<td>0.00</td>
<td>1780</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.9804 80.17.150.13</td>
<td>C9/0/1/U3</td>
<td>w-online</td>
<td>6</td>
<td>-0.50</td>
<td>1788</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.9819 80.17.150.30</td>
<td>C9/0/1/U0</td>
<td>w-online</td>
<td>7</td>
<td>-1.00</td>
<td>1782</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e448.c70c.980d 80.17.150.17</td>
<td>C9/0/1/U0</td>
<td>w-online</td>
<td>8</td>
<td>-1.00</td>
<td>1787</td>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following is a sample output of the `show cable resiliency` command when the impaired cable modems have recovered:

```
Router# show cable resiliency
BG Resil BG
------------- ----- -------------- ----- --------------- ----------
Wi9/0/1:60 28989 Free 1 Jan 9 07:35:08
Wi9/0/1:61 28990 Free 1 Jan 9 07:36:54
Wi9/0/1:62 28991 Free 0
```

### Additional References

#### Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
</table>

#### Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

### Feature Information for Downstream Resiliency Bonding Group

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

---

**Note**

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Resiliency Bonding Group</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 10

Downstream Channel ID Assignment

First Published: April 17, 2015

The DOCSIS downstream channel ID (DCID) is defined as an 8-bit identifier for recognizing a Downstream Channel within a MAC Domain. All CMTS downstream channels are assigned a DCID by default that may be subsequently changed by configuration. It is used in most DOCSIS downstream packet headers and its valid range is from 1 to 255 (0 is reserved for network management purposes).

Note

All downstream channels in a MAC domain must have a unique DCID within the MAC domain.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

• Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 177
• Information About Downstream Channel ID Assignment on the Cisco CMTS Routers, on page 178
• How to Configure Downstream Channel ID Assignment on the Cisco CMTS Routers, on page 181
• Additional References, on page 184
• Feature Information for Downstream Channel ID Assignment, on page 184

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Information About Downstream Channel ID Assignment on the Cisco CMTS Routers

These are the downstream channel ID assignment features:

- Unique DCIDs are provided for all channels within a single controller by default.

Note

DCID values for downstream channels in the same MAC Domain must be unique. If a MAC Domain only contains channels from a single controller, the default DCID values will be sufficient. If a MAC Domain contains channels from multiple controllers, DCID conflicts may be encountered within the MAC Domain. DCID conflicts may be resolved by changing the DCID value of the conflicting channels within the controller configuration or by enabling the automatic channel ID assignment feature.
• The default DCID value for each downstream channel within a controller is equivalent to rf-chan number plus one. For example, the default value for rf-chan 0 is 1, for rf-chan 1 is 2.

**Manual Downstream Channel ID Assignment**

When using the manual DCID provisioning feature, every downstream channel in the system is assigned a default DCID value equivalent to (controller QAM id + 1). The table below shows the default DCID ranges per downstream controller.

*Table 31: Default Downstream Channel IDs Per Slot/Subslot/Controller*

<table>
<thead>
<tr>
<th>Controller</th>
<th>0/0</th>
<th>1/0</th>
<th>2/0</th>
<th>3/0</th>
<th>6/0</th>
<th>7/0</th>
<th>8/0</th>
<th>9/0</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS Controller 0</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 1</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 2</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 3</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 4</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 5</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 6</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
<tr>
<td>DS Controller 7</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
<td>1-128</td>
</tr>
</tbody>
</table>

The default DCID value can be replaced with a user configurable value. The configuration is available in the downstream controller per channel. The current DCID values for the channels within a downstream controller can be viewed in the dcid column of the `show controller Integrated-Cable rf-chan` command output. The example shows channels with default DCID values. When a DCID value is changed in the configuration, the new value appears in the output below.

*Router#show controllers integrated-Cable 3/0/0 rf-channel 1-127*
Automatic Downstream Channel ID Assignment on the Cisco CMTS Routers

It is possible to automatically assign a unique set of downstream channel IDs to meet all DOCSIS requirements by enabling the Automatic DCID Assignment feature. When enabled, Downstream channel DCIDs will be automatically assigned when the channels are added to a fiber node and associated with a MAC Domain. Therefore, the use of fiber node configuration is a prerequisite for this feature.

Service Impact

Changing the DOCSIS downstream channel ID causes cable modems to re-register. Cable modems receive MAC Domain Descriptor (MDD) and Upstream Channel Descriptor (UCD) messages with a changed DCID in their headers.

- Enabling the automatic DCID assignment displays the following message:

  WARNING: Enabling automatic DCID assignment will cause modems to flap and will apply to all fiber nodes on this CMTS.

- Disabling the automatic DCID assignment displays the following message:

  WARNING: Disabling automatic DCID assignment will no longer enforce channel-id uniqueness at fiber nodes. Channel ID changes may require manual verification to prevent conflicts.

- If there is a DCID conflict with another channel in the MAC Domain, the following error message is displayed:

  ERROR: <slot>/<subslot>/<controller> rf-channel <channel>: The downstream channel id conflicts with interface In<slot>/<subslot>/<controller>:channel. Downstream channel id must be unique in a CGD.

- After automatic DCID assignment is configured, if there is a DCID conflict when a downstream channel that belongs to a fiber node is added to a MAC Domain, the automatic DCID feature tries to resolve the conflict by assigning another automatic DCID and the following message is displayed:

  WARNING: The downstream channel id conflict for <slot>/<subslot>/<controller> rf-channel <channel> was resolved by Automatic DCID Assignment. Please run "interface <md-slot>/<md-subslot>/<md-index>" followed by
"<slot>/<subslot>/<controller> rf-channel <channel>" again in order to add the channel.

To add the channel, use this channel grouping domain (CGD) command again:

cable downstream x/y/z rf-channel channel

• If automatic DCID is configured and the channel does not belong to a fiber node, or if automatic DCID cannot resolve the conflict, the following message is displayed:

WARNING: The downstream channel id conflict for <slot>/<subslot>/<controller> rf-channel <channel> could not be resolved by Automatic DCID Assignment.

To resolve this issue, add the channel to a fiber node.

How to Configure Downstream Channel ID Assignment on the Cisco CMTS Routers

The following sections describe how to configure downstream channel ID assignment.

Configuring Manual Downstream Channel ID Assignment

<table>
<thead>
<tr>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Command or Action</strong></td>
</tr>
<tr>
<td><strong>Step 1</strong></td>
</tr>
<tr>
<td>Example:</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
</tr>
<tr>
<td>Example:</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
</tr>
<tr>
<td>Example:</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
</tr>
<tr>
<td>• Alternatively, use the rf-chan starting downstream QAM ID ending downstream QAM ID command to set the range of downstream channel IDs.</td>
</tr>
<tr>
<td>Example:</td>
</tr>
</tbody>
</table>
### Configuring Automatic Downstream Channel ID Assignment

Automatic DCID assignment should be permanently configured. However, if you need to remove the feature, use the `no` or `default` commands.

#### Note

The `no` or `default` form of the command is not written to startup-config file.

In this case, the DCIDs are retained as computed for all channels, and are not set to the defaults of the channels.

Save the configuration containing the newly-assigned DCIDs to the startup-config file by using the `write memory` command.

When you enable automatic DCID assignment, any DCID conflict arising due to adding a channel to a MAC Domain is resolved automatically.

#### Restriction

- After running the `cable downstream-channel-id automatic` command in the configuration, manually editing the configuration file in an editor to add RF channels to the fiber nodes could cause DCID conflicts. The feature assumes all channels in fiber nodes have unique automatic DCIDs in global configuration mode. If the configuration is manually edited and the feature does not verify the unique DCIDs, the DCIDs of the newly-added channels may conflict with those of the existing channels. To fix any DCID conflicts, undo and re-apply the global automatic DCID configuration.

To avoid DCID conflicts, edit the configuration to configure the fiber nodes, then run the `cable downstream-channel-id automatic` command so all channels have unique automatic DCIDs.

Make additions to the fiber nodes on the Cisco uBR10012 router command line interface with the automatic DCID configured.

- The `cable downstream-channel-id automatic` command should not be manually edited in to the startup-config file, since it does not guarantee unique DCIDs for channels in the fiber node.

#### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
</tbody>
</table>
### Configuring Automatic Downstream Channel ID Assignment

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Example:**  
Router> enable | • Enter your password if prompted. |

**Step 2**  
**configure terminal**  
**Example:**  
Router# configure terminal  
Enters global configuration mode.

**Step 3**  
cable downstream-channel-id automatic  
**Example:**  
Router(config)# cable downstream-channel-id automatic  
Specifies automatic assignment of the DCIDs by the Cisco CMTS.

### Example

This example displays the restriction on manually editing configurations:

Router# show run | include automatic  
cable downstream-channel-id automatic  

router# show cable fiber-node 3

| Fiber-Node 3  
Channel(s) : downstream Integrated-Cable 1/0/2: 0-3, 32-35, 64-67, 96-99  
Channel ID(s): 1 2 3 4 33 34 35 36 65 66 67 68 97 98 99 100  
Upstream-Cable 1/0/2  
FN Config Status: Configured (status flags = 0x01)  
MDD Status: Valid  
Router#  

If you manually edit the startup-config file in an editor to add a downstream controller, for example, 1/0/3, it causes a conflict.

Router> configure terminal  
Router# cable fiber-node 3  
Router# downstream integrated-Cable 1/0/3  

If this downstream controller is added, the automatic DCID assignment feature automatically resolves it. However, since the startup-config file was manually edited to add the downstream controller, the automatic DCID assignment feature is unable to resolve it. This causes a DCID conflict when the edited startup-config file is loaded and invalidates the fiber node.

down Modular-Cable 5/0/0 rf-channel 0  
DS frequency is not unique.  
DS channel id is not unique.  
Warning: D3.0 CMs cannot get w-online with an invalid fiber-node.  
router#  

**What to do next**

Run the `show cable fiber-node` command to view DCIDs assigned to all the channels in the fiber node.
Router# show cable fiber-node 3
Fiber-Node 3
Channel(s): downstream Integrated-Cable 1/0/2: 0-3, 32-35, 64-67, 96-99
Channel ID(s): 1 2 3 4 33 34 35 36 65 66 67 68 97 98 99 100
Upstream-Cable 1/0/2
FN Config Status: Configured (status flags = 0x01)
MDD Status: Valid

**Additional References**

**Technical Assistance**

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

**Feature Information for Downstream Channel ID Assignment**

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

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<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Channel ID Assignment</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Router.</td>
</tr>
</tbody>
</table>
Upstream Channel Bonding

The Upstream Channel Bonding (USCB) feature helps cable operators offer higher upstream (US) bandwidth per cable modem (CM) user by combining multiple radio frequency (RF) channels to form a larger bonding group at the MAC layer.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

• Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 185
• Prerequisites for Upstream Channel Bonding, on page 186
• Restrictions for Upstream Channel Bonding, on page 186
• Information About Upstream Channel Bonding, on page 187
• How to Configure Upstream Channel Bonding, on page 196
• Configuration Example for Upstream Channel Bonding, on page 211
• Verifying the Upstream Channel Bonding Configuration, on page 213
• Additional References, on page 214
• Feature Information for Upstream Channel Bonding, on page 215

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Table 33: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
</tr>
</tbody>
</table>

Prerequisites for Upstream Channel Bonding

- Enable downstream channel bonding before configuring the Upstream Channel Bonding feature on a Cisco cable modem termination system (CMTS) router.
- Ensure that the CM is registered in Multiple Receive Channel (MRC) mode before configuring upstream channel bonding on a Cisco CMTS router.
- Ensure that the CM is DOCSIS 3.0 certified.

Restrictions for Upstream Channel Bonding

The following are the general restrictions for the Upstream Channel Bonding feature:

- Only the static bonding groups are supported.
- Only the upstream channels belonging to the same MAC domain can be added to an upstream bonding group.
A maximum of 16 upstream channels can be configured for each MAC Domain, which are divided into two groups:

- Group 1: upstream channel 0-7
- Group 2: upstream channel 8-15

The `upstream bonding-group` should include all the upstream channels either from Group 1 or Group 2 only.

- Committed information rate (CIR) oversubscription is not supported on USCB groups.

Cisco CMTS allows oversubscription of the available bandwidth for individual upstream channels. However, oversubscription of bandwidth is not supported for USCB groups.

An individual upstream may get oversubscribed due to static CIR service flows created for voice traffic. This may cause the DOCSIS 3.0 CMs with USCB to come online on single channel US bonding group (also known as default bonding group).

This problem is mainly encountered in the voice deployments using static service flows. It is, therefore, recommended to choose from the following voice deployments such that the CIR is allocated (or released) when a voice call is attempted (or dropped):

1. Dynamic Quality of Service (DQoS) Lite
2. Packet Cable (PC) DQoS
3. Packet Cable Multimedia (PCMM)

These deployments avoid the individual upstream oversubscription and CMs come online on expected bonding groups.

---

**Information About Upstream Channel Bonding**

DOCSIS 3.0-based upstream channel bonding is a method for increasing upstream bandwidth up to a maximum of 120 Mbps raw throughput per CM user in a cable communications system that includes a Cisco CMTS router and multiple CMs. The upstream channel bonding method enables a CM to transmit data to a Cisco CMTS router on multiple upstream channels simultaneously.

Channel bonding is a method by which smaller bandwidth upstream channels are bonded together to create a larger upstream bonding group in the MAC domain. A MAC domain is a logical sub-component of a Cisco CMTS router and is responsible for implementing all DOCSIS functions on a set of downstream and upstream channels.

The Upstream Channel Bonding feature supports upstream traffic in Multiple Transmit Channel (MTC) mode for data and video services as these services require more bandwidth than voice-based services. Voice-based services either use the traditional single upstream channel or a single upstream channel bonding group configuration. Any traffic contract that exceeds 30 Mbps requires upstream channel bonding as the physical capacity of a single RF channel in DOCSIS cannot exceed 30 Mbps.

The Upstream Channel Bonding feature is supported on the Cisco cBR-8 router. Upstream data from the subscriber comes through the upstream ports (US0-US19) that are automatically configured on the cable interface line card. The cable interface line card processes the data and sends it across the backplane to the WAN card and out to the Internet.
The table below lists the downstream and upstream frequency supported on the cable interface line card.

### Table 34: Downstream and Upstream Frequency

<table>
<thead>
<tr>
<th>Line Card</th>
<th>Downstream Frequency</th>
<th>Upstream Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 CCAP</td>
<td>55-999 MHz(^1)</td>
<td>The upstream frequency range for the Cisco cBR-8 CCAP line card is from 5 to 85 MHz irrespective of the region and Annexure configuration.</td>
</tr>
</tbody>
</table>

\(^1\) This frequency range is subjected to the frequency restriction of the attached EQAM device.

### Multiple Transmit Channel Mode

Multiple Transmit Channel mode is a CM capability that enables CMs to send upstream traffic on multiple upstream channels. You can enable the MTC mode on a cable interface line card:

- MTC mode for all CMs in a MAC domain—The MTC mode for all CMs in a MAC domain is enabled by default on an upstream bonding capable cable interface line card.

### Multiple Receive Channel Mode

MRC mode is a CM capability that enables CMs to receive downstream traffic on multiple downstream channels. The MRC mode is enabled by default on an upstream bonding capable cable interface line card. You can enable or disable the MRC mode in the MAC domain during or after the CM registration using the `cable mrc-mode` command.

### Dynamic Range Window and Transmit Power Levels for Upstream Channel Bonding

The dynamic range window functionality is based on the CableLabs DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification and DOCSIS 3.0 Specification. This requires a DOCSIS 3.0 CM to have upstream transmit channel power level within a 12 dB range for all channels in its transmit channel set (TCS). DOCSIS 1.x or 2.0 CMs operating with a single upstream channel, in non-MTC mode, have a higher maximum transmit power level than DOCSIS 3.0 CMs operating in the MTC mode with two or more upstream channels. That is, the maximum transmit power level per channel is reduced in the MTC mode.

When the upstream attenuation exceeds the maximum transmit power level, a DOCSIS 3.0 CM attempting to register in the MTC mode may fail to come online, or register in partial mode. The CM fails to register when the transmit power level of all upstream channels in its TCS exceeds the maximum transmit power level. If the CM has some upstream channels that are within the maximum transmit power level, the CM may come online in partial mode. However, the upstream channels that exceed the maximum transmit power level are marked as down and cannot be used for upstream traffic.

To verify the transmit power levels on a CM, use the `show cable modem` command with the `verbose` keyword. This command displays the following transmit power values for each assigned upstream channel:

- Reported Transmit Power—This is the reported transmit power level by the CM for each upstream channel.
- Minimum Transmit Power—This is the minimum transmit power level that the CM in the MTC mode could transmit at for the upstream channel.
Peak Transmit Power—This is the maximum transmit power level that the CM in the MTC mode could transmit at for the upstream channel.

To support upstream channel bonding, the minimum transmit power must be less than or equal to the reported transmit power, and the reported transmit power must be less than or equal to the peak transmit power. The peak transmit power and minimum transmit power levels are derived from the CM TCS assignment and each individual upstream channel configuration.

If the minimum transmit power is higher than the reported transmit power, or the reported transmit power is higher than the peak transmit power, the CM may not come online or may register in partial mode.

You can troubleshoot this transmit power problem in the following two ways:

- Insert an additional amplifier to reduce the upstream attenuation so that the upstream transmit power falls within the allowed transmit power range (12 dB).
- Disable the MTC mode. To switch the CM from the MTC mode to non-MTC mode, disable the bonded-bit (bit-0) in type, length, value (TLV) 43.9.3 using the CM configuration file.

Extended Transmit Power

During the early deployment of DOCSIS 3.0 CMs, additional power is required from the CMs in order to compensate for the attenuation in the upstream path. CMs should transmit at extended power level than that defined in DOCSIS. This scenario is generally observed when USCB is enabled at the Cisco CMTS and the DOCSIS 3.0 CMs are operating in MTC mode.

Additional upstream power provides the operator with a power margin that helps overcome the upstream signal loss, reduces the cable plant operational cost, and enables rapid deployment of DOCSIS 3.0 CMs.

The Cisco CMTS supports the following features with which the CMs can transmit data at an extended power:

- Cisco Extended Transmit Power Feature
- DOCSIS Extended Transmit Power Feature

Cisco Extended Transmit Power Feature

The Cisco Extended Transmit Power feature supports DOCSIS 3.0 CMs operating in MTC mode to transmit at a higher power level than the power level specified in the DOCSIS 3.0 Specification. This feature is supported only with Cisco DPC3000 CMs.

The Cisco Extended Transmit Power feature enables cable operators to have better control on the cable modems that register in 4-channel or 2-channel MTC mode or in non-MTC mode to transmit at a higher power level than the DOCSIS-defined maximum power level. The cable operator can configure extended transmit power using the `cable tx-power-headroom` command in global configuration mode.

DOCSIS Extended Transmit Power Feature

The DOCSIS Extended Transmit Power feature supports extended upstream transmit power capability as defined in the DOCSIS3.0 Specification. This feature allows the CMs to transmit at a high extended power level to counter the attenuation in the US channel.

The table below lists the new TLVs supported by the DOCSIS Extended Transmit Power feature.
### Reduced Transmit Channel Set

The Reduced Transmit Channel Set feature enables the Cisco CMTS router to reduce upstream channel set assignment based on the total power budget of the CM. For example, a reduction from four to two upstream channels gains 3 dB headroom. Further reduction from two channels to a single channel gains another 3 dB headroom, and the CM starts operating in non-MTC mode.

In order to take advantage of the reduced upstream channel set, the corresponding static bonding groups must be configured. For example, a MAC domain is configured with a bonding group having four channels. A CM with the reduced channel set of two is unable to match to the 4-channel bonding group, and can only be matched to a bonding group with two channels or less.

The Reduced Transmit Channel Set feature is helpful when a DOCSIS 3.0 CM is required to increase its total transmit power by 3 dB. For example, a DOCSIS 1.0 or 2.0 CM supports a maximum transmit power of 58 dBmV for Quadrature Phase Shift Keying (QPSK) modulation, while a DOCSIS 3.0 CM supports a maximum transmit power of 61 dBmV. In this case, the DOCSIS 3.0 CM operating in 4-channel MTC mode has a reduction in the maximum transmit power per upstream channel. This feature enables the Cisco CMTS router to support reduced input power level by 6 dB to prevent upstream path attenuation.

### T4 Multiplier

T4 multiplier is the T4 timeout multiplier value of the default T4 timeout values as defined in for cable modems that are in the MTC mode. The default value is derived from the number of channels in the modem transmit channel set. You can change the default T4 multiplier value using the cable upstream ranging-poll command in cable interface configuration mode.

---

**Table 35: TLVs for DOCSIS Extended Power Feature**

<table>
<thead>
<tr>
<th>TLV Name</th>
<th>Type</th>
<th>Length</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended Upstream Transmit Power Support</td>
<td>16</td>
<td>1</td>
<td>0—Extended Upstream Transmit Power Support Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1—Extended Upstream Transmit Power Support On</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2-255—Reserved</td>
</tr>
<tr>
<td>Extended Upstream Transmit Power CM Capability</td>
<td>5.40</td>
<td>1</td>
<td>0, 205-244 (units of one-quarter dB)</td>
</tr>
</tbody>
</table>

The Cisco CMTS sends TLV16 to inform the CM if the DOCSIS Extended Transmit Power feature is enabled. The CM in turn, sends TLV5.40 to the Cisco CMTS to communicate its extended power capability. After the negotiations are complete, the CM can transmit at an extended power.

DOCSIS Extended Transmit Power feature is enabled by default. Use the cable upstream ext-power command to enable or disable this feature. For more information on how to enable or disable DOCSIS Extended Power feature, see Configuring DOCSIS Extended Transmit Power Feature, on page 211.

**Note**

DOCSIS Extended Transmit Power feature takes precedence, if both Cisco Extended Transmit Power feature and DOCSIS Extended Transmit Power feature are configured.
The T4 timeout multiplier values range is from 1 to 10. If the T4 multiplier value is equal to 1, the cable modem will T4 time out in 30 seconds (that is, 1 x 30 = 30). If you change the T4 multiplier to 4, then the new T4 timeout value will be 120 seconds (that is, 4 x 30 = 120).

If the T4 timeout multiplier is not configured from the range (1 - 10), then the CMTS uses the T4 timeout value of modem as T4 timeout value. For example, if the T4 timeout of the modem is 90 seconds, then the CMTS applies 3 as the T4 multiplier.

In the MTC mode, you can increase the T4 timeout value in order to reduce the router overhead associated with processing of ranging request (RNG-REQ) slots and ranging response messages. If an RNG-RSP message does not contain a T4 timeout multiplier value, then the CM uses the default T4 timeout value.

Fiber Node Configuration for Upstream Channel Bonding

The fiber node configuration on a Cisco CMOTs router is used to define MAC domain downstream service groups (MD-Ds-SGs) and MAC domain upstream service groups (MD-US-SGs) as defined in DOCSIS 3.0. Only the DOCSIS 3.0 certified modems use this information.

In hybrid fiber coaxial (HFC) networks, all CMs connected to the same coaxial segment of a fiber node reach the same set of downstream and upstream channels on one or more Cisco CMTS routers located at the headend. A CM is physically connected to only one fiber node. The fiber node must include at least one primary-capable controller for the CM connected to the fiber node to be operational.

New TLVs for Upstream Channel Bonding

The table below lists the new CableLabs defined type, length, values (TLVs) for the Upstream Channel Bonding feature.

<table>
<thead>
<tr>
<th>TLV Name</th>
<th>Type</th>
<th>Length</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM vendor ID</td>
<td>43.8</td>
<td>3</td>
<td>Per vendor definition</td>
</tr>
<tr>
<td>Cable modem attribute mask</td>
<td>43.9</td>
<td>n</td>
<td>Cable modem attribute mask subtype encodings</td>
</tr>
</tbody>
</table>

A Cisco CMTS can have multiple upstream channel bonding groups (USBG) configured. Each of these bonding groups can include upstream channels with different upstream frequencies. Some bonding groups can include channels with frequencies within the extended frequency range (see Table 34: Downstream and Upstream Frequency, on page 188). An HFC network consists of several types of CMs, each supporting standard or extended upstream frequencies.

When you register a CM, the Cisco CMTS does not assign bonding groups based on the upstream frequency range supported by that CM. The assignment of the bonding groups is done to balance the CM count on each of the bonding groups. This may lead to assignment of a bonding group, in the extended frequency range, to a CM that lacks the extended frequency support. As a result, the CM will not be able to register. This scenario is generally observed in the Cisco cBR-8 CCAP line card deployment (containing a mix of CMs), which supports frequency as high as 85MHz (see Table 34: Downstream and Upstream Frequency, on page 188).
If the Cisco CMTS assigns a USBG with a channel within the extended frequency range to a CM limited to the standard frequency range, that CM may not be able to register on that upstream bonding group. Use the TLV 43.9.3 (CM US Required Attribute Mask) or TLV 43.9.4 (CM US Forbidden Attribute Mask) as a workaround. These TLVs enable the Cisco CMTS to assign CM to a USBG, which is in the upstream frequency range supported by that CM.

The default attributes (in hexadecimal) on a CM Attribute Mask (TLV 43.9) are “80 00 00 00”, which means by default the mask is all zeroes with the bonding bit enabled. The first four bytes are pre-defined while the last four bytes are user defined. In order to enable Cisco CMTS to assign bonding groups based on the frequency range supported by CMs, complete these steps:

1. Configure a mask, using TLV 43.9.3 or TLV 43.9.4, by modifying the last four bytes. The mask should be configured such that a unique attribute is assigned to each of the bonding groups.

2. Apply this mask to the CM configuration file. CMs supporting extended frequency, can register with any USBGs, irrespective of the configured frequency range of the USBG. CMs supporting standard frequency, can only register with USBGs that are configured with standard frequency range.

Apply the mask you have configured above, to the CMs that support standard or extended frequency ranges. However, the ONLY CMs that need to employ the attribute mask are the ones with the standard frequency range, since they will not be able to register with the USBG configured with extended upstream frequency range. No attribute mask on the extended frequency supporting CMs means that these modems will be assigned any USBG.

The Cisco CMTS uses this mask, received in the CM configuration file during registration, to decide which USBG should be assigned to the CM.

### Upstream Weighted Fair Queuing

The upstream weighted fair queuing (WFQ) is a quality of service (QoS) feature that enables the Cisco CMTS router to allocate optimum bandwidth to upstream service flows based on the WFQ parameter configurations. To enable upstream WFQ, you must configure either the class-based or activity-based WFQ on a cable interface.

The following WFQ parameter configurations are supported:

#### Class-Based Weighted Fair Queuing

In the class-based weighted fair queuing configuration, allocation of available bandwidth is dependent on the service flows that are active in a service class. A service class is a group of queuing attributes configured on the Cisco CMTS router. The class must have at least one active service flow. The class receives its portion of the available bandwidth based on the weight of the class. By default, each class (0 to 7) has a weight of “class + 1.” For example, the class 0 has a weight of 1, and class 1 has a weight of 2.

#### Activity-Based Weighted Fair Queuing

In the activity-based weighted fair queuing configuration, allocation of available bandwidth is based on the service class and the total number of service flows that are active in a map for the service class. A service class with higher number of service flows receives the larger percentage of bandwidth.

#### Custom Weight for Service Flow Priorities

The weighted fair queuing functionality helps the Cisco CMTS router share the available bandwidth based on the weight of the service flow priorities specified for outstanding requests from an upstream service flow. Priority refers to the service flow priority specified in the CM configuration file, or the Cisco CMTS service
class configuration. By default, the weight of a priority is equal to “priority+1.” For example, priority 0 has a weight of 1, and priority 1 has a weight of 2. A higher priority provides more weight to the outstanding request. The custom weight can be specified for a total of eight priorities (0 to 7) in a service class.

The priority parameter refers to the priority of traffic in a service flow ranging from 0 (the lowest) to 7 (the highest). In the upstream traffic, all of the pending high priority service flows are scheduled for transmission before low priority service flows. You can configure the weight for priorities based on how much weight is appropriate per priority.

The table below lists the default weight for each service flow priority.

<table>
<thead>
<tr>
<th>Service Flow Priority</th>
<th>Default Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

**Upstream Scheduler and Service Flows**

A DOCSIS-qualified Cisco CMTS router can provide varied upstream scheduling modes for different packet streams or applications using upstream service flows. A service flow represents either an upstream or a downstream flow of data. A unique service flow ID (SFID) identifies each service flow. Each service flow can have its own quality of service (QoS) parameters, such as maximum throughput, minimum guaranteed throughput, and priority. In the case of upstream service flows, you can also specify a scheduling mode.

Scheduling is a process that enables the Cisco CMTS router to receive bandwidth requests and grant timeslots to CMs for the upstream traffic. The Cisco CMTS router periodically creates a grant map for each enabled upstream channel. The map grants individual timeslots to enable CMs to place packets on the upstream channels.

DOCSIS 3.0 describes a method by which a CM creates an upstream service flow. The following scheduling types enable the Cisco CMTS router to allocate bandwidth for upstream service flows:

- Unsolicited grant service (UGS)
- Solicited grant service

The unsolicited grant service is primarily used for voice. In the case of UGS, the CM does not have to explicitly request grants from the Cisco CMTS router whereas in the solicited grant service the CM has to explicitly request grants from the Cisco CMTS router. The solicited grant service is primarily used for best effort (BE) services.
Unlike DOCSIS 2.0, DOCSIS 3.0 allows multiple outstanding requests per service flow. For more information about the upstream scheduler, see the Upstream Scheduler Mode for the Cisco CM Ter Routers feature guide at the following URL:


**Upstream Service Flow Fairness**

The service flows in the same class receive approximately the same amount of bandwidth. Fairness resolves the bandwidth distribution disparity among various service flows including:

- non-bonded service flow vs bonded service flows
- Service flows on modems of different vendors, i.e Intel/TI vs Broadcom
- Service flows associated with different sized bonding groups, i.e. 1,2,4 channels

The upstream scheduler supports flow based queuing. When Upstream Service Flow Fairness is configured, the upstream scheduler determines the order and amount of BW a service flow should receive based on its current consumption relative to other flows in the flows in the same class.

Use the **cable upstream qos fairness** command to configure the Upstream Service Flow Fairness feature. Use this command in interface configuration mode (or MAC Domain configuration mode).

**Distribution of Traffic across all Channels in a USBG**

When upstream channel bonding (USCB) is enabled, the Distribution of Traffic across all Channels in a USBG feature can be used to balance the bandwidth utilization across upstream channels on one upstream bonding group.

This feature balances the utilization only if there is one upstream channel bonding group configured per MAC domain.

**Restrictions:**

- This feature is supported only on one upstream bonding group under a MAC domain. When multiple upstream bonding groups are configured under a MAC domain, the utilization is unfair.
- All the channels must be configured in one upstream bonding group under the same MAC domain.
- This feature is used only for UB-online cable modems.

The USCB Balancing Scheduler may be enabled or disabled using the **cable upstream balance-scheduler** command in the interface (config-if) configuration mode.

**DOCSIS 3.0 Load Balancing with USBG Smaller than Cable Modem Capabilities**

When using USC in a service group with USBGs containing fewer upstream channels than the total upstream channel set with DOCSIS 3.0 load balancing enabled, the CMTS can assign a Transmit Channel Set (TCS) to DOCSIS 3.0 cable modems for potential use which falls outside of the configured USBG. The CMTS will try to bind smaller UBGs and default single channel bonding groups into a bigger channel set in order to increase the cable modem services. For example, a DOCSIS 3.0 cable modem receiving the larger TCS can use these additional channels for dynamic service flow addition. The DOCSIS 3.0 Load Balancing feature can also move cable modems to upstream channels that are not explicitly configured with USBGs as a result of the larger TCS.
If you activate DOCSIS 3.0 Load Balancing while using upstream bonding, ensure that the upstream bonding group configuration is embedded and aligned by performing the following:

- Configure USBGs, which is matched to cable modem capabilities within the service group, such as a 4 channel USBG, 2 channel USBG, and 3 channel USBG as applicable.

- Ensure that configured USBGs are optimal for the upstream channel set based on modem capabilities within the service group. For example, if four upstream channels are available, channels 0+1 and 2+3 should each be an USBG to avoid dynamic TCS creating sub optimal bonding scenarios.

- Alternatively, you can choose to shut down any upstream channels that is not configured in USBGs which is not be used for bonding.

**Cisco cBR-8 CCAP Line Card Rate Limiting**

The rate limiting functionality enables you control the aggregated rate and CPU consumption of upstream traffic for DOCSIS 3.0 bonded service flows on the Cisco cBR-8 CCAP line card. The rate limiting functionality is configured by default on the Cisco cBR-8 CCAP line card. However, the default configuration can be modified using the `cable upstream rate-limit-ccf` command.

The rate limiting functionality uses the following two rate limiting methods:

- Aggregated rate limiting—This is based on Peripheral Component Interconnect (PCI) bus aggregated throughput. The throughput is per line card for all bonded service flows. You can modify the default throughput and burst rate configuration. The maximum allowed throughput is 115 Mbps.

- CPU-based rate limiting—This method controls the CPU consumed by Continuous Concatenation and Fragmentation (CCF) and ensures that the line card functions properly when traffic is overloaded with bonded service flows. The default configuration allocates 50 per cent of CPU to CCF. You can modify the default CPU threshold value and burst rate as required.

**SID Tracking**

The service ID (SID) tracking functionality enables you to track events related to upstream bandwidth requests and processing of grants. The SID tracker module can track events for a maximum of two service flows per MAC domain. The SID tracker module tracks up to 40,000 events per service flow on a cable interface line card.

You can enable SID tracking for the following types of events:

- DOCSIS 2.0 bandwidth request
- DOCSIS 3.0 bandwidth request
- Grant
- Pending grant (due to traffic congestion)
- Pending grant (due to shaping)

You can enable SID tracking using the `track` keyword along with the `debug cable interface sid` command. To verify SID tracking, use the `show interface cable upstream debug` command in privileged EXEC mode.

**Service ID Clusters**

A Cisco CMTS router can assign one or more service ID clusters to the upstream bonded service flows (upstream service flows assigned to an upstream bonding group) at the time of service flow creation. A SID
How to Configure Upstream Channel Bonding

Note
Before configuring the Upstream Channel Bonding feature, ensure that the fiber node is configured. The fiber node must be configured in accordance with the physical plant topology.

The following tasks describe how to configure Upstream Channel Bonding on the Cisco cBR-8 router:

Enabling MTC Mode on a Cisco CMCTS Router

To section explains how to enable the MTC mode on a Cisco CMCTS router.

Default MTC Mode Configuration on a Cisco CMCTS Router

By default, the MTC mode is configured on a cable interface line card. With this default configuration, the Cisco CMCTS router enables the MTC mode on a per MAC domain basis depending on the configuration file of each CM. When the CM configuration file has the bonded-bit (bit-0) enabled in TLV 43.9.3 (cable modem upstream required attribute mask), the Cisco CMCTS router enables the CM to come online in the MTC mode. If the CM configuration file does not have the bonded-bit on, the CM comes online in non-MTC mode.

For more information on how to add the required attribute in the CM configuration file, see Example: Enabling MTC Mode for a Single CM Using the CM Configuration File, on page 213.

Enabling MTC Mode for All CMs

Note
- For DOCSIS 3.1 cable modems, the CMTS router must be configured to use MTC mode.
- This MTC mode configuration supersedes the default MTC mode configuration (per CM basis) with the required attribute. To disable the MTC mode for all CMs in a MAC domain, use the no form of the cable mtc-mode command. If the MTC mode is enabled and the forbidden mask of the upstream bonding in TLV 43.9.4 is disabled, the CM does not support the Upstream Channel Bonding feature.
### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
</tbody>
</table>

Example:

```
Router> enable
```

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
</tbody>
</table>

Example:

```
Router# configure terminal
```

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 3</strong></td>
<td>Specifies the cable interface line card on a Cisco CMTS router.</td>
</tr>
</tbody>
</table>

Example:

```
Router(config)# interface cable 7/0/0
```

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 4</strong></td>
<td>Enables MTC mode at the MAC interface for all CMs.</td>
</tr>
</tbody>
</table>

Example:

```
Router(config-if)# cable mtc-mode
```

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 5</strong></td>
<td>Exits cable interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>

Example:

```
Router(config-if)# end
```

### Configuring UCSB Required Attribute

If the CM configuration file has TLV 43.9.3 (CM upstream required attribute mask) configured and bonded bit is set to 1, then the modem comes UB-online on a MAC domain basis. If the CM configuration file has no TLV 43.9.3 or the bonded bit is not set to 1, then the modem comes online with a single upstream channel on a MAC domain basis.

#### Note

Without this configuration, the modem comes UB-online on the MAC domain regardless of whether the TLV 43.9.3 is configured in the modem configuration file.
### Creating a Bonding Group

An upstream bonding group is created by combining multiple upstream channels together on a cable interface line card.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface cable [slot/subslot/port</td>
<td>slot/subslot/cable-interface-index</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface cable 7/0/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> cable upstream bonding-group id</td>
<td>Creates the bonding group on the specified cable interface.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# cable upstream bonding-group 200</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step  5</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>end</code></td>
<td>Exits cable interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>

#### What to do next

After creating an upstream bonding group, you must add upstream channels to the bonding group.

### Adding Upstream Channels to a Bonding Group

#### Restriction

DOCSIS 3.0-certified CMs support only four upstream channels on an upstream bonding group. These CMs do not accept additional upstream channels that are added to a bonding group.

#### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router&gt; <code>enable</code></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# <code>configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>`interface cable {slot/subslot/port</td>
<td>slot/subslot/cable-interface-index</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# <code>interface cable 7/0/0</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td><code>cable upstream bonding-group id</code></td>
<td>Creates the bonding group on the specified interface.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-if)# <code>cable upstream bonding-group 200</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><code>upstream number</code></td>
<td>Enters upstream bonding configuration submode and adds an upstream channel to the upstream bonding group.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Purpose

**Command or Action**

Router(config-upstream-bonding)# upstream 1

**Purpose**

**Note**

Upstream channel needs to be bonded to mac-domain first before adding it to the bounding group. For detailed configuration steps of the upstream channel bonding, please refer to **Configuration Example for Upstream Channel Bonding**

A maximum of 16 upstream channels can be configured for each MAC Domain, which are divided into two groups:

- Group 1: upstream channel 0-7
- Group 2: upstream channel 8-15

The **upstream bonding-group** should include all the upstream channels either from Group 1 or Group 2 only.

### Step 6

**end**

**Example:**

Router(config-upstream-bonding)# end

Exits upstream bonding configuration submode and returns to privileged EXEC mode.

---

### Adding Upstream Channel Ports to a Fiber Node

You must add upstream channel controllers to a fiber node in order to complete the basic upstream channel bonding configuration on a cable interface line card. The fiber node must contain all upstream and downstream controllers reached by the CMs.

#### Restriction

- Configuration of a fiber node is valid only if all upstream channels inside the fiber node have different upstream frequencies.
- For any two upstream channels mapped to the upstream cable controllers in the same fiber node where a spectrum group is assigned to one upstream channel, and a frequency is assigned to the other upstream channel, any overlap between any bands associated with the spectrum group of the upstream channel and the frequency of the upstream channel will result in an invalid fiber node configuration. That is a fixed frequency cannot overlap with another upstream channel’s available spectrum group bands.

#### Note

The fiber node configuration must be done in accordance with the physical plant topology.

#### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>
Upstream Channel Bonding

### Purpose

- **Command or Action**: `configure terminal`  
  **Example**: `Router# configure terminal`

- **Purpose**: Enters global configuration mode.

### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 2** | `configure terminal`  
  **Example**: `Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | `cable fiber-node fiber-node-id`  
  **Example**: `Router(config)# cable fiber-node 2` | Enters fiber node configuration mode. |
| **Step 4** | `upstream Upstream-Cable slot/subslot/port`  
  **Example**: `Router(config-fiber-node)# upstream Upstream-Cable 7/0/1` | Specifies the upstream channel ports for a fiber node. |
| **Step 5** | `end`  
  **Example**: `Router(config-fiber-node)# end` | Exits fiber node configuration mode and returns to privileged EXEC mode. |

---

### Configuring the Class-Based Weighted Fair Queuing

In the case of a class-based configuration, allocation of available bandwidth is dependent on the service flows that are active in a service class.

#### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** | `enable`  
  **Example**: `Router> enable` | Enables privileged EXEC mode.  
  Enter your password if prompted. |
| **Step 2** | `configure terminal`  
  **Example**: `Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | `interface cable {slot/subslot/port | slot/subslot/cable-interface-index | slot/port | slot/cable-interface-index}`  
  **Example**: `Router(config)# interface cable 7/0/0` | Specifies the cable interface line card on a Cisco CMTS router. |
| **Step 4** | `cable upstream qos wfq class`  
  **Example**: `Router(config-if)# cable upstream qos wfq class` | Enables class-based weighted fair queuing. |
Configuring the Activity-Based Weighted Fair Queuing

In the activity-based configuration, allocation of available bandwidth is based on the service class and the total number of service flows that are active in a map for the service class.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
Example:  
Router> enable |
| **Step 2** configure terminal | Enters global configuration mode.  
Example:  
Router# configure terminal |
| **Step 3** interface cable {slot/subslot/port | slot/subslot/cable-interface-index | slot/port | slot/cable-interface-index} | Specifies the cable interface line card on a Cisco CMTS router.  
Example:  
Router(config)# interface cable 7/0/0 |
| **Step 4** cable upstream qos wfq activity | Enables activity-based weighted fair queuing.  
Example:  
Router(config-if)# cable upstream qos wfq activity |
| **Step 5** end | Exits cable interface configuration mode and returns to privileged EXEC mode.  
Example:  
Router(config-if)# end |

Configuring Custom Weights for Service Flow Priorities

The WFQ functionality helps the Cisco CMTS router share the available bandwidth based on the weight of the service flow priorities specified for outstanding requests from an upstream service flow.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
</tbody>
</table>
### Command or Action

**Example:**

Router> enable

- **Purpose:** Enter your password if prompted.

**Step 2**

configure terminal

**Example:**

Router# configure terminal

- **Purpose:** Enters global configuration mode.

**Step 3**

interface cable (slot/subslot/port | slot/subslot/cable-interface-index | slot/port | slot/cable-interface-index)

**Example:**

Router(config)# interface cable 7/0/0

- **Purpose:** Specifies the cable interface line card on a Cisco CMTS router.

**Step 4**

cable upstream qos wfq weights priority0-priority7

**Example:**

Router(config-if)# cable upstream qos wfq weights 10 20 30 40 50 60 70 80.

- **Purpose:** Enables custom weight configuration for all the service flow priorities in a service class.

  **Note:** You must specify custom weight values for all the eight service flow priorities (0 to 7) when you modify the default weights of priorities. The valid range is from 1 to 255.

**Step 5**

end

**Example:**

Router(config-if)# end

- **Purpose:** Exits cable interface configuration mode and returns to privileged EXEC mode.

---

**Configuring the SID Cluster**

This section explains how to configure and assign a SID cluster to an upstream bonded service flow.

---

**Note**

Configure the **cable sid-cluster-group num-of-cluster 2** command to achieve desired upstream bonded speeds. Alternatively, use a large upstream Max Traffic burst value in the cable modem file (such as 30 kB). The Max Concat burst value in the cable modem file need not be changed because DOCSIS 3.0 uses continuous concatenations and fragmentation (CCF) and can therefore use the default value of 3044 in the Max Concat field.

---

**Note**

If the **cable sid-cluster-group** command is not used, the router accepts the default SID cluster configuration. By default, only one SID cluster is configured. Similarly, if the **cable sid-cluster-switching** command is not used, the router accepts the default SID cluster switchover criterion. That is, only one request can be made using the SID cluster.
## Configuring the SID Cluster

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** | `enable` | Enables privileged EXEC mode.  
Example: Router> `enable`  
Enter your password if prompted. |
| **Step 2** | `configure terminal` | Enters global configuration mode.  
Example: Router# `configure terminal` |
| **Step 3** | `interface cable {slot/subslot/port | slot/subslot/cable-interface-index | slot/port | slot/cable-interface-index}` | Specifies the cable interface line card on a Cisco CMTS router.  
Example: Router(config)# `interface cable 7/0/0` |
| **Step 4** | `cable sid-cluster-group [dynamic | req-multiplier value | num-of-cluster number]` | Creates a SID cluster group.  
Example: Router(config-if)# `cable sid-cluster-group dynamic`  
Router(config-if)# `cable sid-cluster-group req-multiplier 12`  
Router(config-if)# `cable sid-cluster-group num-of-cluster 2` |
| **Step 5** | `cable sid-cluster-switching [max-outstanding-byte value | max-request value | max-time seconds | max-total-byte value]` | Specifies SID cluster switchover criteria.  
Example: Router(config-if)# `cable sid-cluster-switching max-outstanding-byte 4444`  
Router(config-if)# `cable sid-cluster-switching max-request 222`  
Router(config-if)# `cable sid-cluster-switching max-time 444`  
Router(config-if)# `cable sid-cluster-switching max-total-byte 67890` |
| **Step 6** | `end` | Exits cable interface configuration mode and returns to privileged EXEC mode.  
Example: Router(config-if)# `end` |
What to do next

Use the `show running-config all` command to verify the SID cluster configuration. Following is a sample output of the command:

```
Router# show running-config all
.
.
cable sid-cluster-group num-of-cluster 1
cable sid-cluster-group dynamic
cable sid-cluster-group req-multiplier 4
```

Configuring the Channel Timeout for a Cable Modem

The channel timeout configuration allows you to specify the maximum time that a CM can spend performing initial ranging on the upstream channels described in the Registration Response (REG-RSP) and REG-RSP-MP messages. The default channel timeout value (60 seconds) is automatically configured.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
</tbody>
</table>

| **Step 2** | Enters global configuration mode. |
| `configure terminal` | |
| **Example:** | |
| `Router# configure terminal` | |

| **Step 3** | Specifies the cable interface line card on a Cisco CMTS router. |
| `interface cable slot/subslot/port | slot/subslot/cable-interface-index | slot/port | slot/cable-interface-index` | |
| **Example:** | |
| `Router(config)# interface cable 7/0/0` | |

| **Step 4** | Specifies the maximum time that a CM can spend performing initial ranging on the upstream channels. |
| `cable init-channel-timeout value` | |
| **Example:** | |
| `Router(config-if)# cable init-channel-timeout 160` | |

| **Step 5** | Exits cable interface configuration mode and returns to privileged EXEC mode. |
| `end` | |
| **Example:** | |
| `Router(config-if)# end` | |

Configuring Cable Upstream Resiliency

The cable upstream resiliency module ensures that a CM remains operational if one or more non-primary upstream service flows of the CM enter temporary or persistent error states. This module enables a Cisco CMTS router to handle various events and maintain the transmit channel set of each CM.
In the event of the primary upstream service flow failure, the upstream resiliency module forces the CM to go offline.

For a Multiple Transmit Channel (MTC) modem, the (NRTPS), Real-time Polling Service (RTPS), (UGS), and (UGS-AD) upstream service flows on an impaired upstream channel is moved to another good upstream channel in the cable modem without resetting the cable modem.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>enable</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

| **Step 2**        | Enters global configuration mode. |
| configure terminal|         |
| **Example:**      |         |
| Router# configure terminal |         |

| **Step 3**        | Configures the polling interval for data-burst resiliency in seconds. The range is from 5 to 3600. The default configuration for polling-interval is 60. |
| cable upstream resiliency data-burst polling-interval number | |
| **Example:**      |         |
| Router(config)# cable upstream resiliency data-burst polling-interval 60 | |

| **Step 4**        | Specifies the cable interface line card on a Cisco CMTS router. |
| interface cable   |         |
| {slot/subslot/port |         |
| slot/subslot/cable-interface-index | slot/port |         |
| slot/cable-interface-index |         |
| **Example:**      |         |
| Router(config)# interface cable 7/0/0 | |

| **Step 5**        | Configures upstream resiliency for bonded upstream service flows. |
| cable upstream resiliency {channel-down-detect number |         |
| | data-burst snr number ufec number cfec number hysteresis number | modem-offline-detect number | on-failure {disable-channel | extended-ranging | reset-modem | on-failure disable-channel | sf-move {NRTPS | RTPS | UGS | UGS-AD} | }
| **Example:**      |         |
| Router(config-if)# cable upstream resiliency channel-down-detect 68 | |
| Router(config-if)# cable upstream resiliency modem-offline-detect 16 | |
| Router(config-if)# cable upstream resiliency on-failure disable-channel | |
| Router(config-if)# cable upstream resiliency sf-move NRTPS | |
| Router(config-if)# cable upstream resiliency sf-move RTPS | |
Configuring Rate Limiting on the Cisco cBR-8 CCAP Line Card

The rate limiting functionality is configured by default on the Cisco cBR-8 CCAP line card. However, the default configuration can be modified using the `cable upstream rate-limit-ccf` command.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable</td>
</tr>
<tr>
<td>Example:</td>
<td>Router&gt; enable</td>
</tr>
<tr>
<td></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>`cable upstream rate-limit-ccf [aggregated-burst value</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# cable upstream rate-limit-ccf aggregated-burst 25000</td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable upstream rate-limit-ccf aggregated-throughput 540000</td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable upstream rate-limit-ccf cpu-burst 30</td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable upstream rate-limit-ccf cpu-threshold 60</td>
</tr>
<tr>
<td></td>
<td>Configures rate limiting parameters for upstream bonded service flows on a cable interface line card.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>end</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# end</td>
</tr>
<tr>
<td></td>
<td>Exits global configuration mode and returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>
Enabling Upstream Related Events for CM Status Reports

You can enable upstream related CM status events only on a cable interface line card. You can enable the following upstream related CM status events per interface using the cable cm-status enable command:

- T4 time-out
- T3 re-tries exceeded
- Successful ranging after T3 re-tries exceeded

For details on how to enable upstream and downstream related CM status events, see the Wideband Modem Resiliency feature guide at the following URL:


Modifying the Bonding Group Attributes

Bonding group attributes are automatically configured for each upstream bonding group. You can modify them using the attributes command in upstream bonding configuration mode.

<table>
<thead>
<tr>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Command or Action</strong></td>
</tr>
<tr>
<td><strong>Step 1</strong> enable</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong> interface cable {slot/subslot/port</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# interface cable 7/0/0</td>
</tr>
<tr>
<td><strong>Step 4</strong> cable upstream bonding-group id</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-if)# cable upstream bonding-group 200</td>
</tr>
<tr>
<td><strong>Step 5</strong> attributes value</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-upstream-bonding)# attributes eeeeeeeee</td>
</tr>
<tr>
<td><strong>Step 6</strong> end</td>
</tr>
</tbody>
</table>
Modifying the Ranging Poll Interval on Upstream Channels

You can change the default ranging poll interval (20 seconds) on upstream channels using the `cable upstream ranging-poll` command in cable interface configuration mode. You can also specify the T4 timeout multiplier value using this command.

For information on T4 Multiplier, see [T4 Multiplier, on page 190](#).

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>enable</td>
</tr>
<tr>
<td>Example:</td>
<td>Router&gt; enable</td>
</tr>
<tr>
<td></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>configure terminal</td>
</tr>
<tr>
<td>Example:</td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>interface cable { slot/subslot/port</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# interface cable 7/0/0</td>
</tr>
<tr>
<td></td>
<td>Specifies the cable interface line card on a Cisco CMTS router.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>cable upstream ranging-poll [interval value</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-if)# cable upstream ranging-poll interval 24000 t4-multiplier 4</td>
</tr>
<tr>
<td></td>
<td>Specifies the ranging poll interval for upstream channels.</td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>If <code>t4-multiplier timeout_value</code> is not configured, then the CMTS uses the the T4 timeout of the modem. For example, if the T4 timeout of the modem is 90 seconds, then the CMTS will apply 3 as T4 multiplier for the modem.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>end</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config-if)# end</td>
</tr>
<tr>
<td></td>
<td>Exits cable interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>
Configuring the Reduced Channel Set Assignment

You need to configure the transmit power offset budget to enable the Cisco CMTS router to reduce upstream channel set assignment based on the total power budget of the CM.

**Note**

The threshold value specified for the power budget offset (max-channel-power-offset) must be less than the power threshold value (power-adjust continue) that determines the value of the Ranging Status field in the Ranging Response (RNG-RSP) messages that the Cisco CMTS router sends to the CM. You can specify the power threshold value using the `cable upstream power-adjust` command.

**Before you begin**

- Configure extended transmit power using the `cable tx-power-headroom` command in global configuration mode.
- Ensure that corresponding static bonding groups are configured.

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>`interface cable {slot/subslot/port</td>
<td>slot/subslot/cable-interface-index</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config)# interface cable 7/0/0</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
</tr>
<tr>
<td><code>cable upstream max-channel-power-offset dB-value</code></td>
<td>Specifies the power offset value for upstream channels.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if)# cable upstream max-channel-power-offset 2</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td></td>
</tr>
<tr>
<td><code>end</code></td>
<td>Exits cable interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if)# end</code></td>
<td></td>
</tr>
</tbody>
</table>
Configuring DOCSIS Extended Transmit Power Feature

The DOCSIS Extended Transmit Power feature is enabled by default on the Cisco CMTS. However, the default configuration can be modified using the cable upstream ext-power command.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
</tr>
<tr>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
<tr>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
</tr>
<tr>
<td>interface cable (slot/subslot/port</td>
<td>slot/subslot/cable-interface-index</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface cable 7/0/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
</tr>
<tr>
<td>cable upstream ext-power</td>
<td>Enables the DOCSIS Extended Transmit Power feature on the Cisco CMTS.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Using the no form of this command disables the DOCSIS Extended Transmit Power feature.</td>
</tr>
<tr>
<td>Router(config-if)# cable upstream ext-power</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td></td>
</tr>
<tr>
<td>end</td>
<td>Exits interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# end</td>
<td></td>
</tr>
</tbody>
</table>

### Troubleshooting Tips

The following debug commands help you troubleshoot an improper upstream channel bonding configuration and its related features:

- **debug cable cm-status**—Provide debugging information about CM status messages on the Cisco CMTS routers.
- **debug cable mdd**—Provides debugging information about MAC domain descriptor (MDD).
- **debug cable md-sg**—Provides information about service group debugging messages.
- **debug cable ubg**—Provides debugging information about upstream bonding groups.

### Configuration Example for Upstream Channel Bonding

The following example shows how to configure the basic upstream channel bonding on the Cisco cBR-8 CCAP line card interface 7/0/0 on the Cisco cBR-8 router:
controller Upstream-Cable 7/0/0
us-channel 0 frequency 10000000
us-channel 0 channel-width 3200000 3200000
us-channel 0 ingress-noise-cancellation 50
us-channel 0 docsis-mode atdma
us-channel 0 minislot-size 2
us-channel 0 modulation-profile 221
us-channel 0 equalization-coefficient
no us-channel 0 shutdown
us-channel 1 frequency 16400000
us-channel 1 channel-width 6400000 6400000
us-channel 1 ingress-noise-cancellation 50
us-channel 1 docsis-mode atdma
us-channel 1 minislot-size 1
us-channel 1 modulation-profile 221
us-channel 1 equalization-coefficient
no us-channel 1 shutdown
us-channel 2 frequency 22800000
us-channel 2 channel-width 6400000 6400000
us-channel 2 docsis-mode atdma
us-channel 2 minislot-size 1
us-channel 2 modulation-profile 221
us-channel 2 equalization-coefficient
no us-channel 2 shutdown
us-channel 3 frequency 29200000
us-channel 3 channel-width 6400000 6400000
us-channel 3 docsis-mode atdma
us-channel 3 minislot-size 1
us-channel 3 modulation-profile 221
us-channel 3 equalization-coefficient
no us-channel 3 shutdown
us-channel 4 channel-width 1600000 1600000
us-channel 4 docsis-mode tdma
us-channel 4 minislot-size 4
us-channel 4 modulation-profile 21
us-channel 4 shutdown
us-channel 5 channel-width 1600000 1600000
us-channel 5 docsis-mode atdma
us-channel 5 minislot-size 4
us-channel 5 modulation-profile 221
us-channel 5 shutdown
!
interface Cable7/0/0
load-interval 30
downstream Integrated-Cable 7/0/0 rf-channel 0
downstream Integrated-Cable 7/0/0 rf-channel 8
downstream Integrated-Cable 7/0/0 rf-channel 16
upstream 0 Upstream-Cable 7/0/0 us-channel 0
upstream 1 Upstream-Cable 7/0/0 us-channel 1
upstream 2 Upstream-Cable 7/0/0 us-channel 2
upstream 3 Upstream-Cable 7/0/0 us-channel 3
no cable upstream 0 equalization-error-recovery
no cable upstream 1 equalization-error-recovery
no cable upstream 2 equalization-error-recovery
no cable upstream 3 equalization-error-recovery
cable upstream 7 attribute-mask 1FF
cable upstream bonding-group 1
upstream 0
upstream 1
upstream 2
attributes 80000000
cable bundle 1
cable map-advance static 2000  
cable sync-interval 121  
cable reduction-mode mta-battery enable  
cable privacy accept-self-signed-certificate  
end  
cable fiber-node 1  
description Feed Mac Domain: Cable7/0/0  
downstream Integrated-Cable 7/0/0  
upstream Upstream-Cable 7/0/0  

Note  
Bonded channels are typically from the same connector; however, channels from different connectors in the same MAC domain can also be bonded together. A single MAC domain can support multiple channel bonding groups.  

Note  
Up to 8 frequencies can be stacked to one upstream-cable controller. Once the upstream-cable controller has 8 frequencies stacked, no more frequency left for the adjacent upstream-cable controller.  

Example: Enabling MTC Mode for a Single CM Using the CM Configuration File

The following example shows how to enable the MTC required attribute using the CM configuration file:

03 (Net Access Control) = 1  
Unknown Type 005 = 01 01 01  
18 (Maximum Number of CPE) = 4  
24 (Upstream Service Flow Encodings)  
S01 (Service Flow Reference) = 1  
S06 (QoS Parameter Set Type) = 7  
S10 (Min Reserved Traffic Rate) = 500000  
25 (Downstream Service Flow Encodings)  
S01 (Service Flow Reference) = 2  
S06 (QoS Parameter Set Type) = 7  
S10 (Min Reserved Traffic Rate) = 1000000  
29 (Privacy Enable) = 0  
43 (Vendor Specific Options)  
S08 (Vendor ID) = ff ff ff  
S009 (Unknown sub-type) = 03 04 80 00 00 00  

Verifying the Upstream Channel Bonding Configuration

Use the following show commands to verify the upstream channel bonding configuration:

- show cable mac-domain upstream-service-group  
- show cable fiber-node  
- show interface cable upstream  
- show interface cable service-flow  
- show cable modem
To verify the runtime statistics of the upstream service group on a cable interface line card, use the `show cable mac-domain upstream-service-group` command.

To verify the configuration of a fiber node, use the `show cable fiber-node` command.

To verify the bonding groups configured on a cable interface line card, use the `show interface cable upstream` command.

To verify upstream bonding information on a cable interface line card, use the `show interface cable service-flow` command.

To verify the transmit power levels on a CM, use the `show cable modem` command.

### Verifying Weighted Fair Queuing for Upstream Service Flows

To verify WFQ parameters configured for upstream service flows on a cable interface line card, use the `show interface cable mac-scheduler` command.

### Verifying Rate Limiting for Upstream Bonded Service Flows

To verify the rate limiting criteria configured on the Cisco cBR8 CCAP line card for upstream bonded service flows, use the `show cable rate-limit-ccf` command.

**Note**
The `show cable rate-limit-ccf` command is applicable only to the Cisco cBR8 CCAP cable interface line card.

### Verifying Extended Power Transmission

To verify that a CM is transmitting at a higher power level, use the `show cable modem` command.

To list all the CMs that are transmitting at higher power level, use the `show cable modem extended-power` command.

### Additional References

The following sections provide references related to the Upstream Channel Bonding feature.
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></td>
</tr>
</tbody>
</table>

Feature Information for Upstream Channel Bonding

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream Channel Bonding</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Router.</td>
</tr>
</tbody>
</table>
CHAPTER 12

Dynamic Bonding Group

This document describes how to configure Dynamic Bonding Group that helps manage resource of all downstream bonding groups by automatically creating bonding groups.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 217
- Information About Dynamic Bonding Group, on page 218
- Overview of Dynamic Bonding Group, on page 218
- How to configure Dynamic Bonding Group, on page 219
- Feature Information for Dynamic Bonding Group, on page 229

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
### Information About Dynamic Bonding Group

Dynamic Bonding Group (DBG) helps manage the resource of all downstream bonding groups, including automatically creating and reclaiming the downstream bonding groups.

### Overview of Dynamic Bonding Group

To reduce the effort required in configuring and managing RCC, the DBG feature implements the automatic creating and reclaiming of the downstream bonding groups. DBG creates the bonding group automatically depending on the channel’s load usage. With DBG, the modem is assigned the downstream bonding group without any static RCC configuration. The load balancing feature leverages DBG to balance traffic among all channels. DBG also accommodates primary channel and CM capacity distributions automatically.

DBG also accommodates primary channel and CM capacity distributions automatically.

Dynamic Bonding Group supports the following:

- Support 896 bonding groups per CLC for CYLONS card.

---

### Table 39: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Downstream PHY</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>Modules:</td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
<td>Cisco cBR-8 Upstream PHY</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Upstream PHY</td>
<td>Modules:</td>
</tr>
<tr>
<td></td>
<td>Modules:</td>
<td>• PID—CBR-D30-US-MOD</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
<td>• PID—CBR-D31-US-MOD</td>
</tr>
</tbody>
</table>

---
• Support creating DBGs and reclaiming DBG.
• Support DOCSIS 3.0 and DOCSIS 3.1 channel types.
• Support DOCSIS 3.0 and DOCSIS 3.1 load balance.
• Supports DBG interoperation — Modem registration and load balancing.
• Enhance dynamic load balance — Fixed primary channel movement.
• Enhance raider FPGA SQF — Fairness in channel utilization.

How to configure Dynamic Bonding Group

Enable Dynamic Bonding Group

To enable DBG, run the following commands:

```
ROUTER# config t
Enter configuration commands, one per line. End with CNTL/Z.
ROUTER(config)# cable dynamic-bonding-group
ROUTER(config)# end
ROUTER# show running-config | in dynamic-bonding
```

cable dynamic-bonding-group

Enable DS-Resiliency and Configure Resiliency Bonding Group

To make sure that the modem remains w-online with maximum downstream capability when several rf channels are impaired, enable ds-resiliency feature by running the following commands:

```
Router# config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# cable resiliency ds-bonding
Router(config)# end
Router# show running-config | in resiliency
cable resiliency ds-bonding
Router#
Router# config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# interface wideband-Cable 3/0/1:30
Router(config-if)# cable ds-resiliency
```

Wideband-Cable 3/0/1:30 is set to WB resiliency bonding group.

Remove any existing bundle and rf-channel configuration.

```
Router(config-if)# end
Router#
Router# show running-config interface wideband-Cable 3/0/1:30
Building configuration...
Current configuration : 61 bytes
!
interface Wideband-Cable3/0/1:30
    cable ds-resiliency
```
Enable ACFE

Enable ACFE feature to make sure that modem registration is not blocked because of QoS failures:

Router# config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# cable acfe enable
Router(config)# end
Router# show running-config | in acfe
cable acfe enable

Configure Interface Mac-Domain and Fiber-Node

The recommended size of service group is 32 or 48. The recommended primary channel distribution is one primary channel for contiguous four channels, such as 0, 4, 8, 12, 16, 20, 24, 28 and so on.

To set up interface mac-domain and fiber-node, run the following commands:

Router# show running-config interface c3/0/1
Building configuration...
Current configuration : 963 bytes
!
interface Cable3/0/1
downstream Integrated-Cable 3/0/1 rf-channel 0
downstream Integrated-Cable 3/0/1 rf-channel 4
downstream Integrated-Cable 3/0/1 rf-channel 8
downstream Integrated-Cable 3/0/1 rf-channel 12
downstream Integrated-Cable 3/0/1 rf-channel 16
downstream Integrated-Cable 3/0/1 rf-channel 20
downstream Integrated-Cable 3/0/1 rf-channel 24
downstream Integrated-Cable 3/0/1 rf-channel 28
upstream 0 Upstream-Cable 3/0/1 us-channel 0
upstream 1 Upstream-Cable 3/0/1 us-channel 1
upstream 2 Upstream-Cable 3/0/1 us-channel 2
upstream 3 Upstream-Cable 3/0/1 us-channel 3
upstream 4 Upstream-Cable 3/0/1 us-channel 4
upstream 5 Upstream-Cable 3/0/1 us-channel 5
upstream 6 Upstream-Cable 3/0/1 us-channel 6
upstream 7 Upstream-Cable 3/0/1 us-channel 7
cable upstream bonding-group 1
upstream 0
upstream 1
attributes 80000002
cable upstream bonding-group 2
upstream 2
upstream 3
attributes 80000000
cable bundle 255
end

Router# show cab
Router# show cable fib
Router# show cable fiber-node 1
Fiber-Node 1
  Channel(s) : downstream Integrated-Cable 3/0/1: 0-31
  Channel ID(s): 1 2 3 4 5 6 7 8 9 10 11 12 13 14
                     15 16 17 18 19 20 21 22 23 24 25 26 27 28
Enable Load Balancing for DOCSIS 3.0 and DOCSIS 3.1

To enable DOCSIS load balancing, run the cable load-balance docsis-enable command. When DOCSIS load balancing is enabled, run the cable load-balance docsis30-enable command to enable load balancing for DOCSIS 3.0 and DOCSIS 3.1.

The **cable load-balance docsis30-enable** command enables load balancing for DOCSIS 3.0 and DOCSIS 3.1.
Enable DOCSIS 3.0 and DOCSIS 3.1 Static Load Balance

To balance the load of primary channels, enable static load balance by running the following commands:

```
Router# config t
Enter configuration commands, one per line. End with CNTL/Z.
ROUTER(config)# cable load-balance docsis30-enable static
ROUTER(config)# end
ROUTER# show cable load-balance
DOCSIS LB Enabled: Yes
DOCSIS 2.0 LB Enabled: Yes
DOCSIS 3.0 LB Enabled: Yes
DOCSIS 3.0 Static LB Enabled: Yes
DOCSIS 3.0 Dynamic Downstream LB Enabled: No
```

Enable DOCSIS 3.0 and DOCSIS 3.1 General Load Balance Group

To enable general load balance group, run the following commands:

```
Router# config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# cable load-balance docsis-group fn 1 md c3/0/1
Router(config-lb-group)# no disable
Router(config-lb-group)# end
Router# show cable load-balance
DOCSIS LB Enabled: Yes
DOCSIS 2.0 LB Enabled: No
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DOCSIS 3.0 LB Enabled: Yes
DOCSIS 3.0 Static LB Enabled: Yes
DOCSIS 3.0 Dynamic Downstream LB Enabled: Yes
DOCSIS 3.0 Dynamic Upstream LB Enabled: Yes
DOCSIS Status Interval  DCC mask  Policy  Method  Threshold
MD  FN  Group ID  S Intv  DCC mask  Policy  Mtd  MD-CM-SG  Threshold
M/E/U/P/S
Ca3/0/1 1 2147557888 E 90 0x80(0)/N 0 u/u 0x91010B 5/10/70/70/50
```

Enable Dynamic Load Balance and Fixed-Primary Channel Movement

To reduce service outage while enabling dynamic load balancing, enable fixed primary channel movement.

`Note`

To balance the load of all of downstream channels based on utilization, enable dynamic load balance by running the following commands:

```
Router# config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# cable load-balance docsis30-enable dynamic downstream
Router(config)# end
Router# show cable load-balance
DOCSIS LB Enabled: Yes
```
Verifying Dynamic Bonding Group Configuration

To verify that the DBGs are created:

Check the modem’s primary wideband interface by using the `show cable modem wideband channel` command:

```
Router# show cable modem 4800.33ee.ebee wideband channel
MAC Address   IP Address   I/F       MAC State   DSxUS  Primary WB
4800.33ee.ebee 30.132.15.246 C3/0/1/UB w-online 32x2 W13/0/1:3
```

Check the modem’s downstream tuner capability by using the `show cable modem verbose | in DS Tuner` command.

```
Router# show cable modem 4800.33ee.ebee verbose | in DS Tuner
DS Tuner Capability : 32
```

Check the related RCC by using the `show cable mac-domain rcc` command:

```
Router# show cable mac-domain c3/0/1 rcc
RCC-ID  RCP  RCs  MD-Ds-SG  CMs  WB/RCC-TMPL  D3.0  D3.1
32 00 00 00 00 00 8 0 11 WB (W13/0/1:1) Y Y
33 00 00 00 00 00 32 0 6 WB (W13/0/1:3) Y Y
34 00 00 00 00 00 8 0 7 WB (W13/0/1:2) Y Y
35 00 00 00 00 00 8 0 7 WB (W13/0/1:4) Y Y
36 00 00 00 00 00 8 0 7 WB (W13/0/1:5) Y Y
```

Check the dynamically created bonding groups, use the `show cable dynamic-bonding-group summary` command as shown in the example below:

```
Router# show cable dynamic-bonding-group summary
Dynamic bonding group: Enable
BG ID  BG Name  BG Size  CMs  ServFlows  Create Time         Create Client  BG State
        RFid list
24834 W13/0/1:1 8 11 11  Sep 14 14:36:35.194 MODEM_ONLINE OPERATIONAL
24832-24839
24836 W13/0/1:3 32 6 6  Sep 14 14:43:24.144 MODEM_ONLINE OPERATIONAL
```
### Table 40: Dynamic Bonding Group States

<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE_WAITING_SUP</td>
<td>Line card sends request to create DBG and waits for SUP to create the bonding group.</td>
</tr>
<tr>
<td>HOLD</td>
<td>DBG is created from SUP, or bonding group reverts from reclaim to ready for use.</td>
</tr>
<tr>
<td>OPERATIONAL</td>
<td>If modem is used on the bonding group after the HOLD state times out, the DBG state changes to OPERATIONAL.</td>
</tr>
<tr>
<td>RECLAIM_HOLD</td>
<td>Ready for reclaim. If no modem is used on the bonding group or match the reclaim in two minutes, the bonding group is reclaimed. The DBG state changes to RECLAIM_HOLD.</td>
</tr>
<tr>
<td>RECLAIM_MODEM_MOVING</td>
<td>Ready for reclaim. The modem is moved out of the bonding group.</td>
</tr>
<tr>
<td>RECLAIM_WAITING_SUP</td>
<td>Line card sends DBG reclaim request and waits for SUP to reclaim the BG.</td>
</tr>
</tbody>
</table>

To show the detailed channel list information of dynamic bonding group, use the `show derived-config interface wideband` command.

```
Router# show derived-config interface wideband-Cable 3/0/1:1
Building configuration...
Derived configuration: 113 bytes
   interface Wideband-Cable3/0/1:1
cable bundle 255
cable rf-channels channel-list 0-7 bandwidth-percent 1
end
```

Check the usage of bonding group resource by using the `show cable dynamic-bonding-group quota summary | slot | controller` command.

```
Router# show cable dynamic-bonding-group quota controller 3/0/1
slot/subslot/ctrlr: 3/0/1
Total BG number: 128
Used BG number (static/dynamic): 6(1/5) Available BG number: 122
Available BG list port: 0, 6-29, 31-127
```
128 BGs can be configured on one controller, but only 896 BGs are supported per CLC. All controllers share the 896 BG resources.

Check the reclaimed bonding group by using the `show cable dynamic-bonding-group reclaim-history summary` command:

```
Router# show cable dynamic-bonding-group reclaim-history summary
BG ID  BG Name  BG Size  Create Time  Create Client  Reclaim Time  Reclaim Client  RFid  
24835  Wi3/0/1:2  16       Sep 14 14:40:27  MODEM_ONLINE  Sep 14 14:44:27  DBG_INTERNAL  
```

**Verifying Static Load Balancing Configuration**

To verify if static load balancing is configured:

Check the load of all primary channels by using the `show cable load-balance docsis-group fn 1 md cable load | in In` command.

```
Router# show cable load-balance docsis-group fn 1 md c3/0/1 load | in In
Interface  State  Group  Utilization  Rsvd NBCM  WB/UB  Weight  
In3/0/1:0(573 MHz)  initial  2147557888  0%(0%/0%)  0%  0  17  37  
In3/0/1:4(597 MHz)  initial  2147557888  0%(0%/0%)  0%  0  17  37  
In3/0/1:8(621 MHz)  initial  2147557888  0%(0%/0%)  0%  0  13  37  
In3/0/1:12(645 MHz) initial  2147557888  0%(0%/0%)  0%  0  13  37  
In3/0/1:16(669 MHz) initial  2147557888  0%(0%/0%)  0%  0  13  37  
In3/0/1:20(693 MHz) initial  2147557888  0%(0%/0%)  0%  0  13  37  
In3/0/1:24(717 MHz) initial  2147557888  0%(0%/0%)  0%  0  13  37  
In3/0/1:28(741 MHz) initial  2147557888  0%(0%/0%)  0%  0  13  37  
```

This command output lists all primary channels and shows the number of cable modems used with these channels. NBCM is the number of narrow band modems used with a channel while WBCM (WB/UB) is the number of wideband modems used with a channel. The total number of WBCMs should be balanced among all the channels.

The difference between the total number of WBCMs used with any two channels is smaller or equal to the threshold load minimum. The default value of the threshold load minimum is 5.

Check the load of all rf channels by using the `show cable load-balance docsis-group fn 1 md rfch-util` command.

```
Router# show cable load-balance docsis-group fn 1 md c3/0/1 rfch-util
Interface  Pstate  Pending-In  Pending-Out  Throughput(Kbps)  Util  NBCM  WBCM  
In3/0/1:0  up  No  No  0  0%  0  17  
In3/0/1:1  NA  No  No  0  0%  0  17  
In3/0/1:2  NA  No  No  0  0%  0  17  
In3/0/1:3  NA  No  No  0  0%  0  17  
In3/0/1:4  up  No  No  0  0%  0  17  
In3/0/1:5  NA  No  No  0  0%  0  17  
In3/0/1:6  NA  No  No  0  0%  0  17  
In3/0/1:7  NA  No  No  0  0%  0  17  
In3/0/1:8  up  No  No  0  0%  0  13  
In3/0/1:9  NA  No  No  0  0%  0  13  
In3/0/1:10 NA  No  No  0  0%  0  13  
In3/0/1:11 NA  No  No  0  0%  0  13  
```
This command lists the load information about the primary and secondary channels. WBCM is the number of wideband modems used with a channel.

Check the cable modem’s internal state in load balancing using the `show cable load-balance docsis-group fn 1 md modem-list wideband` command.

```plaintext
Router# show cable load-balance docsis-group fn 1 md c3/0/1 modem-list wideband

Codes: M - Multicast, U - UGS, P - PCMM, F - Max-Failures, X - eXcluded
L - L2vpn, R - RSVP, S - DS-Resiliency

<table>
<thead>
<tr>
<th>Primary WB MAC Address</th>
<th>Primary DS</th>
<th>RCC-ID</th>
<th>Priority</th>
<th>MUPFXLRS State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wi3/0/1:0 (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>c8fb.2631.0e56</td>
<td>In3/0/1:20</td>
<td>41</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
<tr>
<td>37</td>
<td>c8fb.26a6.c3dc</td>
<td>In3/0/1:16</td>
<td>41</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
<tr>
<td>43</td>
<td>c8fb.2631.0d7e</td>
<td>In3/0/1:16</td>
<td>41</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
<tr>
<td>Wi3/0/1:1 (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>c8fb.2631.0c80</td>
<td>In3/0/1:0</td>
<td>32</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>32</td>
<td>c8fb.2631.0ca0</td>
<td>In3/0/1:0</td>
<td>32</td>
<td>LB_CM_STATIC_READY</td>
</tr>
<tr>
<td>33</td>
<td>c8fb.2631.0db0</td>
<td>In3/0/1:24</td>
<td>42</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>34</td>
<td>c8fb.2631.0c10</td>
<td>In3/0/1:28</td>
<td>42</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>35</td>
<td>c8fb.2631.0d80</td>
<td>In3/0/1:16</td>
<td>41</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>36</td>
<td>c8fb.2631.0d26</td>
<td>In3/0/1:24</td>
<td>41</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>37</td>
<td>a4a2.4a2d.b4aa</td>
<td>In3/0/1:20</td>
<td>41</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>38</td>
<td>c8fb.2631.0e5c</td>
<td>In3/0/1:0</td>
<td>32</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>Wi3/0/1:2 (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>c8fb.2631.0d2a</td>
<td>In3/0/1:12</td>
<td>34</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
<tr>
<td>28</td>
<td>c8fb.2631.0e5a</td>
<td>In3/0/1:12</td>
<td>34</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>29</td>
<td>c8fb.2631.0bfe</td>
<td>In3/0/1:8</td>
<td>34</td>
<td>LB_CM_STATIC_MOVING</td>
</tr>
<tr>
<td>Wi3/0/1:3 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4800.33ea.54be</td>
<td>In3/0/1:28</td>
<td>33</td>
<td>LB_CM_DYNAMIC_READY</td>
</tr>
<tr>
<td>2</td>
<td>4800.33ee.ebe6</td>
<td>In3/0/1:20</td>
<td>33</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
<tr>
<td>Wi3/0/1:4 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>c8fb.2631.0e44</td>
<td>In3/0/1:24</td>
<td>42</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
<tr>
<td>4</td>
<td>c8fb.2631.0a44</td>
<td>In3/0/1:28</td>
<td>42</td>
<td>LB_CM_HOLD_EXPIRE_IN</td>
</tr>
</tbody>
</table>
```

Dynamic Bonding Group

Verifying Static Load Balancing Configuration

<table>
<thead>
<tr>
<th>Channel</th>
<th>Status</th>
<th>Priority</th>
<th>MAC Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>In3/0/1:12</td>
<td>up</td>
<td>0</td>
<td>0% 0 13</td>
</tr>
<tr>
<td>In3/0/1:13</td>
<td>NA</td>
<td>0</td>
<td>0% 0 13</td>
</tr>
<tr>
<td>In3/0/1:14</td>
<td>NA</td>
<td>0</td>
<td>0% 0 13</td>
</tr>
<tr>
<td>In3/0/1:15</td>
<td>NA</td>
<td>0</td>
<td>0% 0 13</td>
</tr>
</tbody>
</table>

Average: 0.0

Variance: 0.0

Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.x
### Table 41: Cable Modem States

<table>
<thead>
<tr>
<th>CM state</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB_CM_STATIC_READY</td>
<td>Modem is ready for static load balance movement.</td>
</tr>
<tr>
<td>LB_CM_STATIC_MOVING</td>
<td>Modem is in movement triggered via static LB.</td>
</tr>
<tr>
<td>LB_CM_HOLD_EXPIRE_IN</td>
<td>Modem is in hold for the next movement. The default hold time is 600 seconds.</td>
</tr>
<tr>
<td>LB_CM_DYNAMIC_READY</td>
<td>Modem is ready for dynamic load balance movement.</td>
</tr>
<tr>
<td>LB_CM_DYNAMIC_MOVING</td>
<td>Modem is in movement triggered via dynamic LB.</td>
</tr>
<tr>
<td>LB_CM_DISABLED</td>
<td>Modem is not ready for movement. If the modem failure movement count reaches max-failure threshold, then set the modem in LB_CM_DISABLED to avoid further movement.</td>
</tr>
</tbody>
</table>

### Verifying Dynamic Load Balancing Configuration

Check the utilization of all rf channels by using `show cable load-balance docsis-group fn 320 md rfch-util` command.

```
Router# show cable load-balance docsis-group fn 320 md c3/0/0 rfch-util

Interface   Pstate Pending-In Pending-Out Throughput(Kbps) Util NBCM WBCM
Do3/0/0:0   up   No   No   11754     31%  0   308
Do3/0/0:1   up   No   No   11754     31%  0   296
Do3/0/0:2   up   No   No   11754     31%  0   333
Do3/0/0:3   up   No   No   11754     31%  0   296
Do3/0/0:4   up   No   No   11754     31%  0   297
Do3/0/0:5   up   No   No   11754     31%  0   331
Do3/0/0:6   up   No   No   11754     31%  0   299
Do3/0/0:7   up   No   No   11753     31%  0   268
Do3/0/0:8   up   No   No   11754     31%  0   302
Do3/0/0:9   up   No   No   11754     31%  0   331
Do3/0/0:10  up   No   No   11753     31%  0   308
Do3/0/0:11  up   No   No   11754     31%  0   305
Do3/0/0:12  NA   No   No   12862     34%  0   258
Do3/0/0:13  NA   No   No   12862     34%  0   258
Do3/0/0:14  NA   No   No   12862     34%  0   258

......

Average: 30.416
Variance: 1.701
```

The traffic among all rf channels is considered balanced when the difference between any two rf channel utilization is under the threshold load. The default value of threshold load is 10%.

To check the potential target bonding group for each of the source bonding group, use the `show cable load-balance docsis-group fn md cable target dbg` and the `show cable load-balance docsis-group fn md target wide command`.  

```
Router# show cable load-balance docsis-group fn 320 md c3/0/0 target dbg

Interface Bg-Id Size Group Target
W13/0/0:0 24577 4 2147557695
W13/0/0:3 24580 4 2147557695
```

---

Cisco cBR Converged Broadband Routers Layer 2 and DOCSIS 3.0 Configuration Guide for Cisco IOS XE Gibraltar 16.10.x
Verifying Dynamic Load Balancing Configuration

Router# show cable load-balance docsis-group fn 5 md c1/0/4 target wide

If no target bonding groups are displayed, no bonding groups are created to balance traffic among rf channels.

A sample output with DOCSIS 3.1 modems with configured threshold of 14% is shown below. For utilization based load balancing to start on DOCSIS 3.1 modems, the OFDM channel must be 100% utilized and traffic must flow on SC-QAM. The utilization based load balancing balances the traffic flowing on the SC-QAM channels in a D31 modem.

Router# show cable load-balance docsis-group fn 5 md c1/0/4 rfch-util
Feature Information for Dynamic Bonding Group

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 42: Feature Information for Dynamic Bonding Group

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Bonding</td>
<td>Cisco IOS XE</td>
<td>This feature was introduced on the Cisco cBR Series</td>
</tr>
<tr>
<td>Group</td>
<td>Fuji 16.7.1</td>
<td>Converged Broadband Routers.</td>
</tr>
</tbody>
</table>

In1/0/4:59    NA  No  No  6645  17%  0  6
In1/0/4:60    NA  No  No  6646  17%  0  6
In1/0/4:61    NA  No  No  6646  17%  0  6
In1/0/4:62    NA  No  No  6647  17%  0  6
In1/0/4:63    NA  No  No  6647  17%  0  6
In1/0/4:159   NA  No  No  1819685 100%  0  47
CHAPTER 13

Spectrum Management and Advanced Spectrum Management

This chapter describes the spectrum management features supported for the Cisco Cable Modem Termination System (CMTS) routers. Spectrum management support is divided into two main groups:

- Guided and scheduled spectrum management features (supported in software)
- Intelligent and advanced spectrum management features (supported in hardware only on specific cable interfaces)

- Finding Feature Information, on page 231
- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 232
- Prerequisites for Spectrum Management, on page 232
- Restrictions for Spectrum Management, on page 233
- Information About Spectrum Management, on page 235
- How to Configure Spectrum Management, on page 250
- Monitoring Spectrum Management, on page 267
- Configuration Examples, on page 273
- Additional References, on page 280
- Feature Information for Spectrum Management and Advanced Spectrum Management, on page 281

Finding Feature Information

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.
Hardware Compatibility Matrix for the Cisco cBR Series Routers

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td><strong>Cisco IOS-XE Release 16.5.1 and Later Releases</strong></td>
<td><strong>Cisco IOS-XE Release 16.5.1 and Later Releases</strong></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Cisco cBR-8 CCAP Line Cards:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-LC-8D30-16U30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-LC-8D31-16U30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-RF-PIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-RF-PROT-PIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Cisco cBR-8 Downstream PHY Modules:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Cisco cBR-8 Upstream PHY Modules:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
<td></td>
</tr>
</tbody>
</table>

Prerequisites for Spectrum Management

Ensure that your network is designed to support reliable broadband data transmission. At minimum, your network must include:

- A Dynamic Host Configuration Protocol (DHCP) server to assign IP addresses to cable modems or set-top boxes on the hybrid fiber-coaxial (HFC) network. This can be a Cisco CMTS router that has been configured to act as the DHCP server.
• If you are not using cable interface line cards with integrated upconverters, you must install the appropriate IF-to-RF external upconverter between the Cisco CMTS router and the combiner.

Note The term “combiner” refers to all cables, amplifiers, and taps at the headend or cable distribution center that connect the Cisco CMTS router to the HFC network.

• Diplex filters installed in the downstream RF path between the cable modems and the cable interface cards in the router. RG-59 headend coaxial cable with the maximum braid available (60 percent + 40 percent braid), double foil, and the correct connector for this cable.

• Avoid frequencies with known ingress problems such as amateur radio bands or short-wave bands.

• Avoid hostile spectrums below 20 MHz.

• When designing your channel plan, allow extra bands for frequency hopping.

• Use the receive power level setting to perform slight equalization adjustments.

• Due to the nature of CATV technology, upstream noise management is a significant issue. We recommend that you follow the rigorous North American plant maintenance procedures documented in the NCTA Supplement on Upstream Transport Issues (available from the National Cable and Telecommunications Association, https://www.ncta.com) to adjust return amplifiers and lasers.

Restrictions for Spectrum Management

This section describes the restrictions for the following spectrum management features:

Shared Spectrum Groups

• Advance spectrum management does not support inter-line-card shared spectrum groups.

• Guided spectrum management does support inter-line-card shared spectrum groups.

Dynamic Upstream Modulation

• The Cisco CMTS router has one preconfigured (primary) modulation profile that defines a typical profile for quadrature phase-shift keying (QPSK) modulation. To use the Dynamic Upstream Modulation feature, you must create a secondary modulation profile that has a higher modulation scheme than the preconfigured profile. The Three Step Dynamic Modulation feature allows you to create and use a third modulation profile. However, the third modulation profile is optional.

• Upstream modulation profiles are assigned to upstream ports and affect all cable modems on those upstream ports.

• Modulation profiles affect the physical layer of the cable network, so only trained technicians who are familiar with the Data-over-Cable Service Interface Specifications (DOCSIS) specifications should create modulation profiles.
• When using the Dynamic Upstream Modulation feature with Voice over IP (VoIP) services, frequent changes to the upstream modulation or channel width could briefly impact the quality of voice calls.

Fixed-Frequency Spectrum Groups with Advanced Spectrum Management

Do the following to configure fixed-frequency spectrum groups:

```
Router(config)#controller upstream-cable 9/0/15
Router(config-controller)#us-channel 0 spectrum-group n
Router(config-controller)#us-channel 0 channel-width 1600000
```

Limitations on Upstream Modulation Parameters for PacketCable VoIP Calls

We recommend the use of a channel width that is 1.6Mhz, 3.2Mhz, or 6.4Mhz while configuring upstreams for PacketCable operations and VoIP calls. (All DOCSIS channel widths and upstream parameter combinations are supported, but not optimum when offering VoIP.)

N+1 Redundancy Support

N+1 redundancy requires the working and protect cable interface line cards to be identical. This ensures that the protect interface supports the same exact configuration as the working interface.

When protecting cards that support intelligent and advanced spectrum management, a switchover preserves the spectrum management configuration, and the protect interface initially uses the same upstream frequency as the working interface. The protect interface does not begin using the advanced spectrum management features until the system stabilizes to avoid any unnecessary frequency hops or channel width changes.

Intelligent and Advanced Spectrum Management Support

• Cable interfaces use standard DOCSIS, EuroDOCSIS, and the extended Japanese frequency ranges (5 to 85 MHz for upstream interfaces) to support the intelligent and advanced spectrum management features.

• Intelligent and advanced spectrum management features are supported only in the DOCSIS 1.0 and DOCSIS 1.1 Time Division Multiple Access (TDMA) mode of operation. These features cannot be used when a cable interface is operating in the DOCSIS 2.0 mixed, Advanced TDMA (A-TDMA), and Synchronous Code Division Multiple Access (S-CDMA) modes of operation. Similarly, these features are also not available when the cable interface is configured to use multiple logical channels. However, these restrictions do not apply for guided spectrum management.

• Upstream channels must meet the carrier-to-noise plus interference ratio (CNR [CNR]), and carrier-to-ingress power ratio values given in the DOCSIS specifications. The minimum value for both parameters is 25 dB in the 5 to 65 MHz frequency range.

• The intelligent and advanced spectrum management features do not support inter-line card shared spectrum groups. Spectrum management features require that upstream ports on different line cards have their own RF domain (a unique set of non-overlapping frequencies).

• N+1 redundancy is not supported on any cable interface line card that has defined spectrum groups, which typically is the normal configuration for advanced spectrum management.
• The intelligent and advanced spectrum management feature is activated by assigning spectrum groups on cards with built-in spectrum analyzer.

Information About Spectrum Management

Spectrum management allows a Cisco Cable Modem Termination System (CMTS) to sense upstream plant impairments, report them to a management entity, and automatically correct them where possible. The spectrum management feature performs these functions without reducing throughput or latency and without creating additional packet overhead on the radio frequency (RF) plant.

In particular, because the cable interfaces on the router receive upstream packets, it can directly detect upstream transmission errors. The router can also indirectly monitor the condition of the plant by keeping a record of modem state changes, such as the number and frequency of cable modems that are “flapping” (modems that either miss a station maintenance message or that go offline and then come back online).

Note

For more information about the cable modem flapping and how to monitor the cable modem flap list, see the Flap List Troubleshooting for the Cisco CMTS Routers.

Spectrum management can prevent long-term service interruptions caused by upstream noise events in the cable plant. It is also used for fault management and troubleshooting the cable network. When cable modems are detected to go online and offline by flap detectors, the cable operators can look at the flap list and spectrum tables to determine the possible causes.

Because of the nature of cable television (CATV) technology, upstream noise management is a significant issue. Frequency bands must have a sufficient CNR (CNR) and carrier-to-ingress power ratio to support the transmission of QPSK and quadrature amplitude modulation (QAM) data. The DOCSIS sets the minimum value for both of these ratios to 25 dB in the 5 to 65 MHz frequency range. If the CNR (CNR) drops below 25 dB on a particular channel due to noise, the cable modem on that channel degrades and can drop off the hybrid fiber-coaxial (HFC) network.

This overview contains the following subsections:

• Spectrum Management Measurements, on page 236—Provides an overview of fundamental concepts and terms that are used in spectrum management.

• Upstream Signal Channel Overview, on page 239—Describes how signals are sent and how changes occur in upstream channels.

• Upstream Segments and Combiner Groups, on page 240—Describes sparse and dense segments and combiner groups.

• Frequency Management Policy, on page 241—Describes the types of noise impairments and how to counteract ingress noise with spectrum groups and frequency hopping.

• Guided and Scheduled Spectrum Management, on page 243—Describes the following guided and scheduled spectrum management features: frequency hopping capabilities, dynamic upstream modulation (signal-to-noise ratio-based), and input power levels.

• Intelligent and Advanced Hardware-Based Spectrum Management, on page 248—Describes spectrum management features that are supported by a number of cable interface line cards that have onboard
spectrum management hardware. These features include a real-time spectrum analyzer, CNR-based, proactive frequency hopping, and a more robust dynamic upstream modulation.

- Benefits, on page 248—Describes the spectrum management features provided on the Cisco CMTS router platforms.

**Spectrum Management Measurements**

Measuring the signal-to-noise ratio (SNR [MER]) and carrier-to-noise ratio (CNR [CNiR]) are the major ways of determining the quality of a downstream or upstream signal. The following sections provide an overview of these two ratios, as well as explaining the differences between them, and some additional values that might be useful:

**Signal and Carrier Noise Ratios**

Measuring the Modulation Error Ratio (MER [SNR]) and CNR (CNiR) of a downstream or upstream is the first step in determining the quality of the signal, and whether spectrum management needs to be performed to correct any errors. The following are brief descriptions of these two values:

- Modulation Error Ratio (MER [SNR])—This is an estimate of the signal strength on the upstream after ingress noise cancellation is performed. This means that the MER (SNR) takes into account a variety of modulation impairments, including frequency response distortions (such as in-channel amplitude tilt and ripple), group delay, microreflections, and phase noise. The MER (SNR) is a good gauge of the overall end-to-end quality of the cable network, because it includes the impact that the transmitter circuitry, receiver circuitry, and transmission media have on the upstream signal.

- Carrier-to-Noise Ratio (CNR)—This is an ratio of the measured modulated power, in dB, on the upstream (before ingress noise cancellation is done) that compares the channel power to the noise power.

The term CNiR is part of the CableLabs nomenclature for the CNR measurement. Therefore these two terms, CNR and CNiR, can be used interchangeably.

The CNR (CNiR) measurement is usually provided only by an external spectrum analyzer, but the cable interface line cards that support intelligent and advanced hardware spectrum management features also provide CNR (CNiR) measurement.

The following two types of CNR (CNiR) measurements are supported on the Cisco CMTS:

- CNR (CNiR) measured for a particular upstream—This is the overall CNR (CNiR) for all of the cable modems on an upstream, which is determined by measuring the RF power of the upstream receiver at the cable interface. This value is always just a snapshot in time for a particular upstream. The cable interface measures the RF power at a time when no bursts are expected from the cable modems, but it can be skewed by a small number of cable modems that are experiencing or creating signal problems.

- Per-modem CNR (CNiR)—This is the CNR (CNiR) for a particular cable modem, which is signal strength of the burst transmissions of the modem at the upstream receiver of the cable interface. The per-modem CNR (CNiR) measurement is a very accurate measure of a particular cable modem’s signal, but you should not use a single modem’s CNR (CNiR) to make assumptions about other cable modems on that upstream or about the upstream itself. However, you can get a good picture of the upstream’s signal quality by polling the CNR (CNiR) for a number of cable modems over a representative time period.
Changing the channel width has a direct impact on the CNR (CNiR). Doubling the channel width (for example, from 400 KHz to 800 KHz) decreases the CNR (CNiR) for an upstream by approximately 3 dB. Cutting the channel width in half (for example, from 3.2 MHz to 1.6 MHz) increases the CNR (CNiR) for an upstream by approximately 3 dB.

**Tip**

In a perfect network, such as a test lab where the only impairment is additive white Gaussian noise (AWGN), you can expect the CNR (CNiR) and MER (SNR) values to be comparable throughout all of the allowable power levels and frequency ranges. In a live network, however, it is expected that the MER (SNR) value should be a few dB lower than the CNR (CNiR) value, given that the MER (SNR) value takes into account noise impairments and distortions that are not accounted for by the CNR (CNiR) power measurements.

In general, when the CNR (CNiR) value is in the 15 to 25 dB range, you can expect the MER (SNR) value to have a comparable value. The difference between the MER (SNR) and CNR (CNiR) values is expected to be larger when the CNR (CNiR) value falls outside of the 15 to 25 dB range.

The table below provides a comparison between the MER (SNR) and CNR (CNiR) values, listing the major reasons for why the MER (SNR) and CNR (CNiR) values might diverge on an active network that is passing live traffic:

**Table 44: Comparison of MER (SNR) and CNR (CNiR) in a DOCSIS Cable Network**

<table>
<thead>
<tr>
<th>Signal-to-Noise (SNR)</th>
<th>Carrier-to-Noise (CNR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-detection measurement of the RF signal.</td>
<td>Pre-detection measurement of the RF signal.</td>
</tr>
<tr>
<td>Measurement of the baseband domain.</td>
<td>Measurement of the RF frequency domain.</td>
</tr>
</tbody>
</table>
**Signal-to-Noise (SNR)**

Includes the effect of signal distortions and impairments on the signal. These include:

- Group delay in the channel such as occurs during operation near the diplexer band edge.
- Channel amplitude variation and echoes.
- Data collisions.
- Microreflections.
- Narrow band ingress in the channel.
- Non-linearities in the cable plant.
- Phase noise.
- Poor selection of the preamble.
- Poor symbol fidelity in the transmission of a a cable modem, despite a good MER (SNR) value.
- Unrecoverable carrier offsets.
- Unrecoverable symbol timing offsets.

**Carrier-to-Noise (CNR)**

Measures only the RF modulated carrier power versus noise power.

<table>
<thead>
<tr>
<th><strong>Additional Measurements</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>In addition to MER (SNR) and CNR (CNIr) values, you should be aware of and monitor the following indicators of signal quality:</td>
</tr>
</tbody>
</table>
• MER—This is the measure of RF signal quality, in dB, which is equivalent to SNR and similar to CNR (CNiR) under additive white Gaussian noise (AWGN) impairments. However, MER is preferred for data networks, because it also includes additional factors that affect the signal, such as analog-to-digital and digital-to-analog conversions, rounding errors, distortions, and signal impairments such as phase noise, group delay, and jitter. For this reason, the DOCSIS 2.0 RF specification adds a requirement for the minimum MER value for a signal, supplementing the existing CNR (CNiR) minimum requirements.

A simple formula for calculating the MER value for an upstream is:

\[ \text{MER} = 20 \times \log \left( \frac{\text{RMS error magnitude}}{\text{Average symbol magnitude}} \right) \]

You can also calculate the Error Vector Modulation (EVM) to find the equivalent value expressed as a percentage of noise on an upstream:

\[ \text{EVM} = \frac{\text{Average error magnitude}}{\text{Max symbol magnitude}} \times 100 \]

See the DOCSIS 2.0 specification for more complete information on calculating and using the MER value.

• FEC Counters—These are counters that keep track of how many correctable and uncorrectable FEC errors occur on the upstream. The FEC error counters are useful for tracking fast transient errors such as impulse noise that are not usually reflected in MER (SNR) or CNR (CNiR) values.

A correctable error count of more than 1 percent can be used as a warning sign of possible physical plant or cable modem problems that might be developed. An uncorrectable error count of more than 1 percent can indicate an existing problem that is blocking traffic on the upstream. Cable interface line cards that support the intelligent and advanced spectrum management features can use the FEC counters as one of the indicators to be monitored to determine whether an upstream must change frequencies so as to correct noise problems.

• Microreflections—Additional copies of a signal that arrive at the receiver, usually at different times and attenuated by different amounts, causing the receiver to misidentify the incoming signal’s true phase and amplitude. Microreflections typically are caused by impedance mismatches in the physical cable plant, and can indicate either equipment that has been degraded by weather or other causes, or equipment that has not been installed correctly.

**Upstream Signal Channel Overview**

The upstream channel is characterized by many cable modems transmitting to the CMTS. These signals operate in a burst mode of transmission. Time in the upstream channel is slotted. The CMTS provides time slots and controls the usage for each upstream interval. The CMTS periodically broadcasts Upstream Channel Descriptor (UCD) messages to all cable modems. The UCD message contains the upstream frequency and transmission parameters associated with an upstream channel. These messages define upstream channel characteristics including the upstream frequencies, symbol rates and modulation schemes, forward error correction (FEC) parameters, and other physical layer values.

Cisco supports all DOCSIS error-correction encoding and modulation types and formats. Upstream signals are demodulated using QPSK or QAM. QPSK carries information in the phase of the signal carrier, whereas QAM uses both phase and amplitude to carry information.

Sending data reliably in the upstream direction is an issue. Because upstream spectrum varies greatly between cable plants, select upstream parameters based on your cable plant’s return paths. Select or customize upstream
profiles for the maximum trade-off between bandwidth efficiency and upstream channel robustness. For example, QAM-16 requires approximately 7 dB higher CNR (CNR) to achieve the same bit error rate as QPSK, but it transfers information at twice the rate of QPSK.

Note

The above specifications are based on predetermined sets of frequencies that may or may not have an adequate CNR (CNR) at any given time.

Upstream frequencies can be assigned as follows:

- **Fixed**—Configuring a spectrum group disables the fixed upstream frequency setting.
- **Single subband**—The CMTS administrator can define a center frequency and symbol rate such that the boundaries of the upstream carrier stay within the subband. The frequency and symbol rate can change within the boundary in response to noisy line conditions, based on the defined upstream parameters.
- **Multiple subbands**—The data carrier can remain in a particular subband for a duration of time and then hop to another subband based on the defined upstream parameters.

Tip

Measurement of noise power levels with a spectrum analyzer should be part of the procedure in initially selecting and setting up frequency allocations. We recommend having fixed frequency settings during early deployment, at least until amplifier cascade adjustments or plant repair have become infrequent enough that they no longer significantly affect the nodes connected to the upstream port.

Upstream Frequency Changes

As stated in the DOCSIS radio frequency interface (RFI) specification, RF channel migration or upstream frequency change occurs when a change in the UCD message is broadcast to all cable interfaces.

The speed of channel migration via the UCD message is typically less than 20 milliseconds (ms). During this time, upstream transmission is interrupted until the cable interface transmitter adjusts to its new frequency. Data is stored in the cable interface buffers during this time and is sent when the frequency hop is complete.

Station maintenance intervals are used to perform per modem keepalive polling. The CMTS polls each cable modem at least once every 30 seconds, with the default being once every 20 seconds. When ingress noise causes loss of keepalive messages from a configurable percentage of all cable interfaces, resulting in missed polls, a new frequency is selected from the allocation table and a UCD update is performed. The migration time is 2 msec for any upstream UCD update. After the UCD is updated, the hop occurs. The system must wait until a hop threshold time interval has elapsed before it can change the UCD a second time.

Upstream Segments and Combiner Groups

The Cisco routers divide a cable plant into downstream channels. Downstream channels contain upstream segments. Each upstream segment typically serves more than one fiber node. Upstream segments can be defined as one of the following:

- **Sparse segment**—Containing one upstream channel per upstream segment.
- **Dense segment**—Containing multiple upstream channels per upstream segment; frequencies must be different.
A cable interface line card can support sparse or dense segments, or both.

Defining sparse segments allows the cable operator to share upstream bandwidth among fiber nodes with fewer subscribers. Defining dense segments allows the cable operator to provide larger upstream bandwidth to fiber nodes with many subscribers.

The figure below illustrates sparse versus dense segments.

*Figure 1: Sparse Versus Dense Segment Illustrations*

As shown in the figure above, the downstream segment can contain multiple upstream segments. Two fiber nodes can be in one downstream segment but in different upstream segments.

The return path of several fiber nodes can be combined at a single point to form a single RF frequency domain called a combiner group. The CMTS software allows a frequency hop table called a spectrum group to be associated with a combiner group.

A combiner group refers to an RF topology point. A spectrum group refers to the frequency hop table associated with a combiner group.

**Frequency Management Policy**

Spectrum management applies a common frequency-management policy to a set of upstream ports to ensure that data is delivered reliably over the cable plant. Cable plant operators must make noise measurements and determine the cable plant’s spectrum management policy. Different modulation schemes, upstream frequency techniques, and symbol rates are used based on the cable plant characteristics and the cable interface line card in the chassis.
See the following sections for more information about these topics:

### Noise Impairments

Upstream noise impairments such as signal degradation on cable networks can negatively affect service to subscribers. Two-way digital data signals are more susceptible than one-way signals to stresses in the condition of the HFC network. Degradation in video signal quality might not be noticeable in one-way cable TV service, but when two-way digital signals share the network with video signals, digital signals can be hampered by:

- **Impulse and electrical signal ingress**—Noise can enter the network from electrical sources within a residence or from high-voltage lines that run near cable television cabling. Two types of ingress noise include broadband and narrowband. Broadband noise is generally of lower frequency (below 10 MHz) and results in harmonic rolloff. Narrowband noise is a more significant interference source. Cable equipment and infrastructure often pick up noise from amateur radio transmissions, citizen band radios, or high-power shortwave broadcast signals. Implement a signal leakage maintenance program to locate and repair areas of signal ingress.

- **Amplifier noise**—Amplifiers add noise to the HFC network that typically goes unnoticed in video signals, but degrades digital data signals if amplifiers are improperly configured. The larger the network, the higher the probability of amplifier noise affecting signals.

- **Noise funnelling**—The upstream data path to the headend is susceptible to interference from the entire network. All upstream noise ultimately ends up at the headend because the cumulative nature of noise becomes concentrated at the headend. As a network serviced by a single RF receiver increases in size, the probability of noise funnelling also increases.

- **Variable transmit levels**—Temperature affects signal loss over coaxial cable. This can cause variations of 6 to 10 dB per year.

- **Clipping**—The lasers in fiber-optic transmitters can stop transmitting light when input levels are excessive. Excessive input levels introduce bit errors in both the upstream and downstream transmissions. If a laser is overdriven as briefly as a fraction of a second, clipping can occur.

To adjust your return amplifiers and lasers, follow rigorous plant maintenance procedures documented in the NTSC Supplement on Upstream Transport Issues or appropriate cable plant standard.

### Spectrum Groups and Frequency Hopping

We recommend that CMTS administrators configure upstream frequency hopping to counteract long-term, narrowband noise. Cisco CMTS routers support a combination of guided frequency hopping and time-scheduled frequency hopping.

The frequency hop to proactively avoid noise ingress is sometimes called frequency agility. Frequency agility is configured and activated using spectrum groups. Spectrum management supports the creation of a number of cable spectrum groups, allowing multiple upstream ports in a single spectrum group. Each spectrum group defines the table of frequencies to be used in a specific frequency plan. Upstream frequencies can be a fixed single frequency, a single continuous range of frequencies (band), or multiple ranges (or bands) of frequencies.

The cable interface does not operate until you assign a frequency to the upstream, which can be done either by configuring and assigning a spectrum group or assigning a fixed frequency. The spectrum group takes precedence, so if you configure both a spectrum group and a fixed frequency on an upstream, the spectrum group overrides the fixed upstream frequency setting.

From the interface point of view, a spectrum group also represents the set of upstreams connected to the same group of fiber nodes. The spectrum manager software in Cisco routers examines all the RF parameters that
have been configured on an upstream to determine whether the upstream frequencies need to be managed together. For example, if you configure a spectrum group with several fixed frequencies, but those frequencies are all within the configured channel width, the spectrum manager software combines the frequencies into a single band.

The upstream ports use the spectrum group to determine which frequencies are available if frequency hopping is needed to deal with noise or other path impairments. The types of frequency hopping techniques are guided, time-scheduled, and combined guided and time-scheduled. See the Frequency Hopping Capabilities, on page 243 for more information on the types of frequency hopping techniques.

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**Guidelines for Spectrum Management**

In general, when defining your spectrum, use the following guidelines:

- Avoid frequencies with known ingress problems, such as amateur radio bands or short-wave bands.
- Avoid a hostile spectrum below 20 MHz.
- Allow extra bands for frequency hopping.
- Take the possible channel widths into account when creating frequency bands. The range of frequencies being used must be able to hop between at least two different frequencies when using the channel width that is configured on the upstream.
- Place upstream ports in the same combiner group in a shared spectrum group.
- Use the receive power level setting to perform slight equalization adjustments.
- If you combine multiple upstream ports to provide increased bandwidth, you must avoid overlapping frequency bands. Each port should be using a discrete band of frequencies that does not overlap the bands being used by other ports in the group. We recommend adding at least 20 KHz between the ending frequency of one band and the starting frequency of the next band, to ensure that the bands do not overlap.

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**Guided and Scheduled Spectrum Management**

Guided and scheduled spectrum management constitutes a set of basic features for all currently supported cable interface line cards. These features are considered basic because they are available for all cable interfaces, and constitute the elementary, cornerstone features upon which the intelligent and advanced spectrum management features are built.

See the following sections for more information about each feature:

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**Frequency Hopping Capabilities**

Noise in the upstream transmission line, that is from the consumer to the service provider, can degrade data transmission from the subscriber’s home. If the noise impairment is of substantial duration, it may cause the cable modem to temporarily lose communication with the headend facility. As a contingency plan, the multiple service operators (MSOs) can reserve multiple channels or upstream frequencies for their subscribers. If one channel suffers too much interference, the CMTS requests that the cable modems “hop” to another channel.
To provide frequency hopping capability, Cisco CMTS routers contain a spectrum manager that continuously monitors the noise in unused upstream channels. If the CNR (CNiR) reaches an unacceptable level on a particular channel, the spectrum manager automatically assigns a new upstream channel to the cable modem using that channel.

Cisco CMTS routers support the following techniques for upstream frequency hopping when the frequency band in use is not clean:

• Guided frequency hopping—in guided frequency hopping (also known as blind hopping), the spectrum manager automatically assigns a new upstream channel frequency when a configurable threshold of station maintenance (keepalive) messages fails. Failed station maintenance messages represent an impairment of the upstream channel due to noise, plant, or equipment failure. Explicit frequency subbands and associated input power levels are assigned in a spectrum group in guided frequency hopping.

• Time-scheduled frequency hopping—Frequency reassignment is scheduled by the time of day or by a specific day of the week.

• Combined guided and time-scheduled frequency hopping.

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**Note**

Frequency hopping is not effective against broadband noise phenomena such as impulse noise.

Time-scheduled and guided hopping techniques are independent concepts:

• The spectrum is controlled by a script, not a frequency table.

• The available spectrum is time-scheduled as an option.

• A guided hopping frequency is selected from the available spectrum at the current time.

You can configure and activate frequency hopping by using spectrum groups. You can create up to 40 cable spectrum groups, each containing multiple upstream ports. The configured channel width is used for each upstream frequency.

After you have created one or more spectrum groups for your cable network, you can add characteristics to them, providing you with more definitive control over frequency usage and frequency hopping.

You can configure hopping thresholds. For example, the frequency hop threshold percentage method prevents a single failing cable modem from affecting service to other working cable modems. As long as a high enough threshold is configured, the system does not hop endlessly due to a single cable modem failing to respond to 90 percent of its station maintenance (keepalive) messages.

You can also configure the minimum period between frequency hops, with a default setting of 30 seconds. If the destination channel is expected to be impaired, you can reduce the minimum period between frequency hops to a small value, such as 10 seconds. This allows the frequency hop to continue more rapidly until a clear channel is found. If excessive frequency hop is an issue, you can increase the minimum period between hops.

To configure different techniques of frequency hopping, see the Creating and Configuring Spectrum Groups, on page 251.

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**Note**

Spectrum management is not supported for one-way (telco return) cable modems, because spectrum management capabilities focus on the upstream path over an HFC network.
After the spectrum-band is changed, the spectrum management does not rearrange the frequency for each US channel if the previous frequency belongs to the range of new spectrum-band, which means that the US frequency will not be changed; if the previous frequency is out of range of new spectrum-band, those US channels will not get frequencies.

Time-Scheduled Frequency Hopping

You can specify upstream channel frequency reassignment based on a configured time of every day or of a specific day of the week. If your cable plant has an upstream noise characteristic on a weekly cycle, use time-scheduled spectrum allocation. With a time-scheduled policy, a single frequency becomes valid at any given time.

Dynamic Upstream Modulation (MER [SNR]-Based)

This section describes the operation of this feature, which is based on evaluating the MER (SNR) of an upstream.

A more advanced version of dynamic upstream modulation, which uses the carrier-to-noise ratio (CNR [CNiR]), is supported on the cards that support intelligent and advanced spectrum management.

Feature Overview

Cisco cable interface line cards monitor the MER (SNR) values and the forward error correction (FEC) counters in the active return path of each upstream port. The Dynamic Upstream Modulation feature determines whether upstream channel signal quality can support the modulation scheme configured, and adjusts to the most robust modulation scheme when necessary. When return path conditions improve, this feature returns the upstream channel to the higher modulation scheme that includes the modulation profile.

A modulation profile is a collection of burst profiles that are sent out in a UCD message to configure modem transmit parameters for the upstream. The Dynamic Upstream Modulation feature adjusts the modulation profiles of an upstream channel based on upstream signal quality.

The Dynamic Upstream Modulation feature is configured on interfaces with fixed upstream frequencies or on interfaces with assigned spectrum groups.

The following examples show two different configurations of the Dynamic Upstream Modulation feature, using two and three modulation profiles.

Example Showing Dynamic Upstream Modulation Using Two Modulation Profiles

You can configure the Dynamic Upstream Modulation feature on the Cisco CMTS router using the following primary and secondary modulation profiles:

- The primary modulation profile uses 64-QAM or 16-QAM, which is a more bandwidth-efficient modulation scheme and has a higher throughput than a QPSK profile.

- The secondary modulation profile uses QPSK, which uses a more robust modulation scheme, but is not bandwidth-efficient.
We recommend that the primary profile use 64-QAM or 16-QAM modulation and the secondary use QPSK. However, this is optional as both modulation profiles can either be QPSK or QAM. It is not mandatory for one profile to be QAM and the other QPSK, but modulation profile switchover is tied to the QAM and QPSK thresholds.

**Example Showing Dynamic Upstream Modulation Using Three Modulation Profiles**

You can configure the Dynamic Upstream Modulation feature on the Cisco CMTS router using the following primary, secondary, and tertiary modulation profiles:

- The primary modulation profile uses 64-QAM, which is a more bandwidth-efficient modulation scheme and has a higher throughput than a 16-QAM profile.
- The secondary modulation profile uses 16-QAM, which is a more bandwidth-efficient modulation scheme and has a higher throughput than a QPSK profile.
- The tertiary modulation profile uses QPSK, which uses a more robust modulation scheme, but is not bandwidth-efficient.

We recommend that the primary profile use 64-QAM modulation, the secondary profile use 16-QAM, and the tertiary profile uses QPSK. However, this is optional as the modulation profiles can either be QPSK or QAM. It is not mandatory that one is QPSK and the other two are QAM, but modulation profile switchover is tied to the QAM and QPSK thresholds.

**Criteria for Switching Modulation Profiles**

The Dynamic Upstream Modulation feature uses the following criteria to determine whether it should switch from the primary modulation profile (the more bandwidth-efficient, but less robust profile) to the secondary modulation profile (more robust, but less bandwidth-efficient profile) or to the (optional) tertiary modulation profile (most robust, but less bandwidth-efficient profile):

The modulation switch from the primary profile (high performance) to the secondary profile (mid-level performance) uses the following criteria:

- The upstream MER (SNR) is less than or equal to MER (SNR) threshold one and the percentage of correctable FEC (cFEC) errors is greater than or equal to the correctable FEC error threshold or the percentage of uncorrectable FEC (uFEC) errors is greater than or equal to the uncorrectable FEC error threshold.

Before switching back to the primary profile from the secondary profile, the following criteria must be satisfied:

- The upstream MER (SNR) is greater than or equal to the sum of MER (SNR) threshold one and the hysteresis value and the percentage of correctable FEC errors is less than or equal to the correctable FEC error threshold and the percentage of uncorrectable FEC errors is less than or equal to the uncorrectable FEC error threshold and the hop period equals to the default value of 15 seconds.

The modulation switch from the secondary profile (mid-level performance) to the tertiary profile (most robust) uses the following criteria:

- The upstream MER (SNR) is less than or equal to MER (SNR) threshold two and the percentage of correctable FEC (cFEC) errors is greater than or equal to the correctable FEC error threshold or the percentage of uncorrectable FEC (uFEC) errors is greater than or equal to the uncorrectable FEC error threshold.

Before switching back to the secondary profile from the tertiary profile, the following criteria must be satisfied:
• The upstream MER (SNR) is greater than or equal to the sum of MER (SNR) threshold two and the hysteresis value and the percentage of correctable FEC errors is less than or equal to the correctable FEC error threshold and the percentage of uncorrectable FEC errors is less than or equal to the uncorrectable FEC error threshold.

The modulation switch from the primary profile to the tertiary profile uses the following criteria:

• The upstream MER (SNR) is less than or equal to MER (SNR) threshold two and the percentage of correctable FEC (cFEC) errors is greater than or equal to the correctable FEC error threshold or the percentage of uncorrectable FEC (uFEC) errors is greater than or equal to the uncorrectable FEC error threshold.

Before switching back to the primary profile from the tertiary profile, the following criteria must be satisfied:

• The modulation switch from the tertiary profile to the primary profile is a two-step process:
  1. The modulation switch happens from tertiary profile to the primary profile, when the upstream MER (SNR) is greater than or equal to the sum of MER (SNR) threshold one and the hysteresis value.
  2. After a 15-second (non-configurable) delay, the modulation switch occurs from secondary profile to the primary profile, when the upstream MER (SNR) remains greater than or equal to the sum of MER (SNR) threshold one and the hysteresis value.

If the only problem is that the upstream is experiencing a large number of uncorrectable errors, then a situation could occur where the router continues to switch back and forth between profiles. The uncorrectable errors occur with the primary profile, so the router switches to the secondary profile. The secondary profile does not experience any problems, so the router switches back to the primary profile. But the uncorrectable errors reoccur and the router switches back to the secondary profile, and this cycle continues indefinitely.

To avoid this problem, make sure that the cable plant is capable of supporting the modulation scheme being used in the primary profile (for example, 64-QAM). If you cannot guarantee successful operation on an upstream using this modulation scheme, then you should select a primary profile that uses a more bandwidth-efficient set of burst parameters (such as QPSK). The Cisco IOS software includes predefined modulation profiles that can be used for the primary, secondary, and tertiary profiles.

### Input Power Levels

The input power level, `power-level-dBmV`, is an option in the `cable spectrum-group` command. The option allows you to specify the expected upstream input power levels on the upstream receivers on the CMTS when the cable modems are hopping from one fixed frequency to another or from one band to another. Each upstream channel width has an associated upstream input power level in dBmV. The power level is the modem transmit power that each spectrum group can use when an upstream frequency change is necessary. The input power level may be set at the time of the frequency hop.

Specifying an input power level is done so that the cable modems do not have to increase or decrease their transmit power with every hop. The cable operator can perform minor power equalizations as a function of frequency. The valid range is –10 to 10dBmV. The power level value should be changed only if you want to change the power level as part of spectrum management. Some cable plants may want to change only the input power level, and not the frequency, on a daily time schedule.
Intelligent and Advanced Hardware-Based Spectrum Management

Several cable interface line cards include hardware-based spectrum management features that provide enhancements to the basic features supported by the other Cisco cable interface line cards.

Intelligent Spectrum Management Enhancements

The following features are part of the intelligent spectrum management feature set:

• Integrates a DOCSIS cable interface line card with an onboard spectrum analyzer that continuously analyzes the upstream spectrum quality in the DOCSIS frequency range of 5 to 42 MHz.

• Includes hardware-assisted frequency hopping, providing for more intelligent and faster frequency selection than software-only solutions.

• Reduces the response time to ingress noise that could cause modems to drop offline.

• Eliminates blind frequency hopping by initiating frequency hops to known clean channels.

• Improves frequency agility to help eliminate dropped packets and thereby maintain full upstream data rates.

• Supports frequency agility in dense-mode combining environments across a shared spectrum.

• Restricts frequency hopping to a set of discrete fixed frequencies or to a range of frequencies, as desired.

• Allows frequency hop conditions to be customized for specific plant environments and requirements.

• Optionally schedules frequency hops to take advantage of known usage patterns or plant conditions.

• Optionally dynamically reduces channel width to allow cable modems to remain online, even in noisy upstream conditions.

Benefits

The spectrum management features provided on the Cisco CMTS router platforms provide several key system benefits:

• Improves response time to ingress noise impairments that appear in the upstream return path.

• Boosts the percentage of modems online.

• Mitigates the impact of ingress to subscriber services.

• Saves time and effort by MSO staff when troubleshooting minor plant outages.

• Increases cable plant reliability.

• Maximizes spectrum utilization.

Guided and Scheduled Spectrum Management Benefits

The following summarizes the specific benefits of the guided and scheduled spectrum management features that are supported for all Cisco CMTS router platforms.
**Input Power Levels**

Allows the cable plant operator to perform minor power level equalization as a function of frequency.

**Frequency Hopping Capabilities**

Proactively countermeasures upstream noise impairments by assigning a new upstream channel to the cable modem. MSOs can take advantage of this feature especially when they have less than an optimal carrier-to-noise ratio in the upstream frequencies or when their cable plants exhibit random bursts of ingress noise that affect reliability.

**Dynamic Upstream Modulation**

- Reduces the risk associated with transitioning to QAM-16 modulation in the return path and provides assurance that subscribers remain online and connected during return path impairments.
- Checks that the active upstream signal quality can support the configured modulation scheme and proactively adjusts to the more robust modulation scheme when necessary.
- Eliminates the necessity to hop channels for cable modems to stay online by automatically switching from the primary modulation profile to the secondary modulation profile.

**Intelligent and Advanced Spectrum Management Benefits**

The following summarizes the specific benefits of the advanced spectrum management features that are supported on Cisco CMTS routers using supported cable interface line cards.

**Dynamic Channel Width Change**

- Improves the DOCSIS upstream channel availability by finding the maximum possible channel width for an upstream when noise conditions make the current channel width unusable.
- Provides the maximum RF spectrum utilization efficiency for current plant conditions.
- Customizable range of channel widths that can be used to respond to noise problems.

**Intelligent Frequency Hopping**

- Proactively changes upstream frequency for an interface before noise conditions become severe enough to force cable modems offline.
- Dedicated hardware intelligent frequency hopping performs “look-ahead” to choose new upstream frequency to find a stable channel.
- Flexible priority configuration allows hopping decision criteria to be tailored to the individual cable plant environment.
- Improves responsiveness to ingress impairments, by matching the hopping decision criteria to the fluctuating plant conditions.
- Pinpoints CNR (CNiR) variations with per-modem accuracy to isolate problematic cable modems.
- Sustains or even improves subscriber online percentages through user-programmable proactive channel management techniques.
**Dynamic Upstream Modulation**

- Reduces the risk associated with switching between QPSK and QAM-16 modulation in the upstream to respond to ingress noise, so that subscribers remain online and connected.
- Checks the current upstream signal to ensure that it can support the configured modulation scheme, and proactively adjusts to the secondary more robust modulation scheme when necessary.
- Improves DOCSIS upstream channel availability and provides maximum RF spectrum utilization efficiency.
- Eliminates unnecessary frequency hopping by switching modulation profiles to one that allows cable modems to remain online while using the currently assigned upstream.
- Provides assurance that subscribers remain online and connected during periods of return path impairments.

**SNMP Interface**

- Provides a way to remotely obtain the current status of noise on an upstream. This information can then be inserted into third-party or custom reporting and graphing applications.
- Provides visibility to ingress and impulse noise under the carrier frequency on a per-port basis.
- Provides an easy-to-use, distributed method to remotely gather real-time display of the DOCSIS upstream spectrum for individual cable modems and set-top boxes (STBs).
- Reduces the reliance on costly spectrum analyzers at every headend or hub.
- Quickly provides spectrum views through an intuitive interface, without the complicated setup time of a spectrum analyzer.
- Allows the technician to troubleshoot the network remotely, as opposed to having to be physically present to connect and use a spectrum analyzer.

**Default Hop Priority**

For Intelligent and Advanced Spectrum Management feature, the default hop priority is as given below:

- Frequency, modulation, and channel width (when using spectrum groups on spectrum cards).
- Modulation, guided frequency hop, and channel width (when using analyzer cards with spectrum groups).
- Modulation only (when not using spectrum groups [fixed frequency]).

**How to Configure Spectrum Management**

This section describes the configuration tasks that are most commonly performed when using the spectrum management features on the Cisco CMTS platforms. See the following sections for the configuration tasks that are appropriate for your platform and cable interface line cards.
Guided and Scheduled Spectrum Management Configuration Tasks

The following tasks configure the guided and scheduled spectrum management features that are supported on all Cisco CMTS platforms:

Creating and Configuring Spectrum Groups

A spectrum group defines the frequencies that an upstream is allowed to use when frequency hopping is done, as well as other parameters that control the frequency hops. When creating and configuring spectrum groups, you can specify the following parameters:

- Frequencies that are assigned to the group. The cable interface uses these frequencies to determine what frequencies are available to use when frequency hopping is needed. You can specify either a list of fixed frequencies or a band of frequencies, or both. The Cisco CMTS uses the following rules when adding frequencies to a spectrum group:
  - When specifying a fixed frequency, the Cisco CMTS assumes it is a center frequency with a 6.4-MHz channel width to allow that frequency to operate at all possible channel widths. For example, specifying a frequency of 17,700,000 Hz is equivalent to specifying a frequency band from 14,500,000 Hz to 20,900,000 Hz (a band that is 6.4 MHz wide).
  - If you configure multiple fixed frequencies or bands of frequencies that overlap, the spectrum group combines them into one band. For example, if you specify a fixed frequency of 17,700,000 Hz and a band from 15,800,000 Hz to 25,200,000 Hz, the spectrum group is configured with one band from 14,500,000 Hz to 25,200,00 Hz.
  - If you want more control over a spectrum group’s frequencies, configure bands of frequencies with the same width as the desired channel width. For example, if you want to use a center frequency of 17,700,000 Hz with a 3.2-MHz channel width, specify a band that ranges from 16,100,000 Hz to 19,300,000 Hz. To ensure you configure non-overlapping bands, separate the bands by a minimum of 20 KHz.
  - Upstream input power level—(Optional) Power level, in dBmV, that the upstream should use when hopping to a new frequency. (Some cable plants might want to change only the input power level, and not the frequency, on a daily time schedule.)
  - Hop threshold—(Optional) Percentage of cable modems that start missing station maintenance messages before a frequency hop can occur. Configure the hop threshold percentage as needed to prevent a single failing cable interface from affecting service to other good cable interfaces. This ensures that the system does not hop endlessly because one cable modem is generating 90 percent of the errors and 90 percent of the traffic.
  - Hop period—(Optional) Minimum time period that must elapse between frequency hops. This allows you to specify a time period long enough to allow an upstream to stabilize before another frequency hop can be performed.
  - Scheduled hop time—(Optional) Time of day at which a frequency hop should be scheduled.

Tip

Before adding a list of upstream frequencies (or frequency hop tables), start by determining which upstream ports are assigned to a combiner group. Refer to the Example: Determining the Upstream Ports Assigned to a Combiner Group, on page 274 for an example.
To create and configure a spectrum group, use the following procedure.

## Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><code>cable spectrum-group group-number time [day hh:mm:ss] frequency up-freq-Hz [power-level-dBmV]</code></td>
<td>Creates the spectrum group (if it does not already exist), and adds the specified fixed frequency to the group.</td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# cable spectrum-group 4 time Monday 12:00:00 frequency 40000000</code></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><code>cable spectrum-group group-number time [day hh:mm:ss] band up-freq-Hz up-freq2-Hz [power-level-dBmV]</code></td>
<td>Creates the spectrum group (if it does not already exist), and adds the specified band of frequencies to the group.</td>
</tr>
<tr>
<td></td>
<td><em>Note:</em> Repeat Step 4 and Step 6 as needed for each fixed frequency and frequency band that should be a member of this spectrum group. You must assign at least two fixed frequencies, or a frequency band that contains at least two center frequencies, to a spectrum group before frequency hopping can occur.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# cable spectrum-group 4 band 20000000 24000000 13</code></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><code>cable spectrum-group group-number hop period seconds</code></td>
<td>Specifies the minimum time, in seconds, between frequency hops.</td>
</tr>
<tr>
<td></td>
<td><em>Note:</em> We recommend a configuration of 30 seconds when using a Cisco uBR-MC5X20S/U/H BPE.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# cable spectrum-group 4 hop period 60</code></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><code>cable spectrum-group group-number hop threshold [percent]</code></td>
<td>Specifies the frequency hop threshold for a spectrum group.</td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# cable spectrum-group 4 hop threshold 25</code></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><code>cable spectrum-group group-number</code></td>
<td>(Optional) Specifies that the upstream ports in a spectrum group should use a unique upstream frequency.</td>
</tr>
<tr>
<td></td>
<td><em>Example:</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# cable spectrum-group 4</code></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><code>end</code></td>
<td>Exits global configuration mode and returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>
Assigning a Spectrum Group to One or More Upstream Ports

After a spectrum group has been created and configured, you must assign it to one or more upstream ports before the group’s frequency spectrum is used for frequency hopping.

To assign a spectrum group to one or all upstream ports on a controller interface, use the following procedure.

### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>enable</td>
<td>Enters privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>controller upstream-cable slot/subslot/port</td>
<td>Enters controller configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# controller upstream-cable 9/0/15</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>us-channel us-channel_num spectrum-group spectrum-group-num</td>
<td>Assigns the specified spectrum group as the default group for all upstream on this controller interface.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-controller)# us-channel 0 spectrum-group 1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>us-channel us-channel_num channel-width value</td>
<td>Configures the channel-width for the specified upstream channel spectrum group.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-controller)# us-channel 0 channel-width 1600000</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>end</td>
<td>Exits controller interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-controller)# end</td>
<td></td>
</tr>
</tbody>
</table>

### What to do next

To verify the spectrum group configuration, use the `show cable spectrum-group` command in privileged EXEC mode.
Configuring Shared Spectrum Groups (Fiber Node Groups) for DOCSIS 3.0

This feature supports shared spectrum groups that cross multiple cable interface line cards on the Cisco CMTS router, and shared spectrum groups within a single cable interface line card.

For additional information about configuring fiber node groups on the Cisco CMTS, see:


Configuring Dynamic Upstream Modulation (MER [SNR]-Based)

To use the Dynamic Upstream Modulation feature on cable interface line cards that support only the MER (SNR) version of this feature, you must do the following:

1. Create a primary modulation profile. This typically is a more bandwidth-efficient but a less robust profile.
2. Optionally create a secondary modulation profile. This typically is a less bandwidth-efficient but a moderately robust profile.
3. Optionally create a tertiary modulation profile. This typically is a less bandwidth-efficient but a more robust profile.
4. Assign the profiles to the desired cable interfaces and upstreams.

Tip

When creating the modulation profiles, we recommend that you use the predefined modulation profiles, as opposed to manually specifying each burst parameter for each modulation profile.

Restriction

- The Dynamic Upstream Modulation feature is supported only for DOCSIS 1.0 or DOCSIS 1.1 TDMA-only modulation profiles for advanced spectrum management.
- The DOCSIS 2.0 mixed-mode or ATDMA-only mode modulation profiles are supported only for basic spectrum management (MER [SNR]-based) and not for advanced spectrum management.
- The Three Step Dynamic Modulation feature supports only basic spectrum management features. It does not support modulation profile changes based on CNR (CNRiR) thresholds and CNR (CNRiR) measurements.
- The Dynamic Upstream Modulation feature is not enabled for single modulation profile configurations.
- You can configure only two modulation profiles when an upstream is already assigned to a spectrum group for frequency hopping. The spectrum group here implies advanced spectrum management and/or the use of CNR (CNRiR).
- A single profile is automatically removed from the configuration if three modulation profiles are assigned to an upstream interface before assigning spectrum group, based on the following conditions:
  - The robust profile is dropped if the upstream port is using a high performance profile.
  - The high performance profile is dropped if the upstream port is using a mid-level or robust profile.
<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>`cable modulation-profile profile {mixed</td>
<td>tdma</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# cable modulation-profile 3 mixed</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong></td>
<td>Repeat this command to create the secondary and tertiary profile for use on a DOCSIS 1.0 or DOCSIS 1.1 TDMA or A-TDMA upstream.</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong></td>
<td>You can also create custom modulation profiles with the <code>cable modulation-profile</code> command by configuring the values for the individual burst parameters. These parameters, however, should not be modified unless you are thoroughly familiar with how changing each parameter affects the DOCSIS MAC layer. We recommend using the preconfigured default modulation profiles for most cable plants.</td>
</tr>
<tr>
<td>4</td>
<td><code>controller upstream-cable slot/subslot/port</code></td>
<td>Enters controller configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config)# controller upstream-cable 9/0/15</code></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><code>us-channel n modulation-profile primary-profile-number [secondary-profile-number] [tertiary-profile-number]</code></td>
<td>Assigns a primary modulation profile, and the optional secondary and tertiary modulation profiles, to the specified upstream port.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-controller)# us-channel 0 modulation-profile 21 121 221</code></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Use one of the following commands:</td>
<td>(Optional) Specifies the MER (SNR) threshold in dB.</td>
</tr>
<tr>
<td></td>
<td>• <code>us-channel n threshold snr-profiles threshold1-in-db threshold2-in-db</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• <code>us-channel n m threshold snr-profiles threshold1-in-db threshold2-in-db</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Router(config-controller)# us-channel 0 threshold snr-profiles 25 15</code></td>
<td></td>
</tr>
</tbody>
</table>
### Purpose

Command or Action | Purpose |
--- | --- |
**Step 7** Use one of the following commands: | (Optional) Specifies the allowable number of correctable FEC errors for the upstream. |
- `us-channel n threshold corr-fec corr-fec` | |
- `us-channel n m threshold corr-fec corr-fec` | |
**Example:** | |
Router(config-controller)# us-channel 0 threshold corr-fec 20 | |

**Step 8** Use one of the following commands: | (Optional) Specifies the allowable number of uncorrectable FEC errors for the upstream. |
- `us-channel n threshold uncorr-fec uncorr-fec` | |
- `us-channel n m threshold uncorr-fec uncorr-fec` | |
**Example:** | |
Router(config-controller)# us-channel 0 threshold uncorr-fec 10 | |

**Step 9** `us-channel n threshold hysteresis hysteresis-in-db` | (Optional) Specifies the hysteresis value to be used in conjunction with the dynamic modulation upgrade thresholds. |
**Example:** | |
Router(config-controller)# us-channel 0 threshold hysteresis 10 | |

**Step 10** `end` | Exits controller interface configuration mode and returns to privileged EXEC mode. |
**Example:** | |
Router(config-controller)# end | |

### What to do next

**Tip**

See the Dynamic Upstream Modulation (MER [SNR]-Based), on page 245 for a complete description of the Dynamic Upstream Modulation feature.

### Verifying Frequency Hopping

You can verify frequency hopping on the CMTS by using the command-line interface (CLI).

**Verifying Frequency Hopping Using CLI Commands**

To verify frequency hopping using CLI commands, use the following procedure:

**Step 1** Verify that the interface being tested is up, using the `show interfaces cable` command in privileged EXEC mode. The first line of the output shows whether both the interface and line protocol are up.

**Example:**

Router# show interfaces cable 9/0/0

Hardware is CMTS MD interface, address is c414.3c16.cf8f (bia c414.3c16.cf8f)
MTU 1500 bytes, BW 26000 Kbit/sec, DLY 1000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation MCNS, loopback not set

**Step 2**
Verify that the upstream being tested is up, using the `show interfaces cable upstream` command. The first line shows whether the upstream is up.

**Example:**
```
Router# show interfaces cable 9/0/0 upstream 0
```

MAC domain upstream impairment report: 0x0
Cable9/0/0: Upstream 0 is up
Description: UC9/0/0:U0
Received 5 broadcasts, 0 multicasts, 26 unicasts
0 discards, 0 errors, 0 unknown protocol
31 packets input
Codewords: 348 good 0 corrected 0 uncorrectable

**Step 3**
Use the `show cable hop upstream-cable` command to display the frequency that the upstream is currently using:

**Example:**
```
Router# show cable hop upstream-cable 9/0/0
```

**Step 4**
Use the `show cable hop upstream-cable history` command to display the frequency change, modulation change, and channel width change action history of the upstreams:

**Example:**
```
Router# show cable hop upstream-cable 9/0/0 history
```

**Step 5**
Use the `show cable hop upstream-cable threshold` command to display the user-defined thresholds and current CNR, MER (SNR), correctable FEC percentage, uncorrectable FEC percentage, and missed station maintenance percentage values of the upstreams:

**Example:**
```
Router# show cable hop upstream-cable 6/0/0 threshold
```
Step 6  Use the **test cable hop** command to force the desired upstream to perform a frequency hop. A few seconds after giving the command, a console message should appear informing you of the hop. Repeat the command as needed to verify that the upstream hops through all the frequencies that have been assigned to the upstream’s spectrum group.

**Example:**

Router# `test cable hop cable 6/0 upstream 5`

2w0d: %UBR7200-5-USFREQCHG: Interface Cable6/0 Port U5, frequency changed to 15.760 MHz

Router# `test cable hop cable 6/0 upstream 5`

2w0d: %UBR7200-5-USFREQCHG: Interface Cable6/0 Port U5, frequency changed to 26.832 MHz

Step 7  Use the **test cable channel-width** command to force the desired upstream to perform a channel-width change. A few seconds after giving the test command, use the show cable hop command to verify the channel-width change.

**Example:**

Router# `test cable channel-width cable 7/0/0 upstream 0`

Channel width changed to 1600000 Hz for Cable7/0/0 U0

Router# *Sep 17 17:06:46.882: %UBR10000-5-USCWCHG: Interface Cable7/0/0 U0, channel width changed to 1600 kHz SLOT 7/0: Sep 17 17:06:46.898: %UBR10000-5-USCWCHG: Interface Cable7/0/0 U0, channel width changed to 1600 kHz

Router# Sep 17 17:06:46.898: %Interface Cable7/0/0 U0 With channel width 1600 kHz, the minislot size is now changed to 4 ticks.

Router# `show cable hop cable 7/0/0 upstream 0 history`

<table>
<thead>
<tr>
<th>Port</th>
<th>Time</th>
<th>Code</th>
<th>From</th>
<th>Chg</th>
<th>Chg</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca7/0/0/U0</td>
<td>Sep 17 17:06:46</td>
<td>C</td>
<td>3.2</td>
<td>1.6</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:06:02</td>
<td>M</td>
<td>222</td>
<td>222</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:06:00</td>
<td>M</td>
<td>222</td>
<td>222</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:03:21</td>
<td>M</td>
<td>222</td>
<td>222</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:03:19</td>
<td>M</td>
<td>222</td>
<td>222</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:01:44</td>
<td>F</td>
<td>26.358</td>
<td>19.742</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:01:17</td>
<td>F</td>
<td>21.528</td>
<td>26.358</td>
<td>Test command enforced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 17 17:00:24</td>
<td>C</td>
<td>1.6</td>
<td>3.2</td>
<td>Configuration changed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 14 19:38:55</td>
<td>F</td>
<td>41.117</td>
<td>21.528</td>
<td>Interface state changed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 14 19:38:55</td>
<td>F</td>
<td>0.000</td>
<td>41.117</td>
<td>Interface state changed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep 14 19:38:24</td>
<td>M</td>
<td>21</td>
<td>221</td>
<td>Configuration changed</td>
<td></td>
</tr>
</tbody>
</table>

Router#

Step 8  Use the **test cable freq-hop** command to force the desired upstream to perform a dynamic frequency change. A few seconds after giving the test command, use the **show cable hop** command to verify the frequency change.

**Example:**

Router# `test cable freq-hop cable 7/0/0 upstream 0`
Step 9 Use the `test cable modulation-change` command to force the desired upstream to perform a dynamic modulation change. A few seconds after giving the test command, use the `show cable hop` command to verify the modulation change.

Example:

```
Router# test cable modulation-change cable 7/0/0 upstream 0
```

Troubleshooting Spectrum Group Characteristics

To troubleshoot the configuration, make sure that you entered a valid spectrum group number, time, frequency, and input power level. Also, when defining your spectrum, use the following guidelines:

- Avoid frequencies with known ingress problems, such as amateur radio bands or short-wave bands.
- Avoid a hostile spectrum below 20 MHz.
- Allow extra bands for frequency hopping.
- Place upstream ports in the same combiner group in a shared spectrum group.
- Use the receive power level setting to perform slight equalization adjustments.
Intelligent and Advanced Spectrum Management Configuration Tasks

The following sections describe the configuration tasks that are needed to configure a Cisco uBR7200 series or Cisco uBR10012 universal broadband router for the intelligent and advanced spectrum management features that are available with the Cisco cable interface line cards.

Configuring and Assigning Spectrum Groups

You must create and configure a spectrum group before you can use the intelligent and advanced spectrum management features. These procedures are the same as those used for guided and scheduled spectrum management, which are given in the following sections:


After the spectrum groups have been configured and assigned to upstreams, the Cisco IOS software automatically uses the advanced frequency hopping algorithms on the cable interface line cards that support it.

Note

For efficient use of the intelligent and advanced spectrum management features, we recommend configuring only frequency bands, and not fixed frequencies, when creating spectrum groups. A spectrum group must contain a frequency band that is wide enough for the cable interface to find at least two center frequencies at the configured channel width, before frequency hopping can occur.

Configuring Dynamic Upstream Modulation (CNR-Based)

Configuring the CNR-based version of the Dynamic Upstream Modulation feature is similar to configuring the MER (SNR)-version of this feature:

1. Create a primary modulation profile. This typically is a more bandwidth-efficient but a less robust profile.
2. Create a secondary modulation profile. This typically is a less bandwidth-efficient but a more robust profile.

Tip

When creating the modulation profiles, we recommend that you use the predefined modulation profiles, as opposed to manually specifying each burst parameter for each modulation profile.

3. Assign the profiles to the desired cable interfaces and upstreams.

After the modulation profiles have been created and assigned to upstreams, the Cisco IOS software automatically uses the advanced CNR-based version of the Dynamic Upstream Modulation feature on the cable interface line cards that support it.
The Dynamic Upstream Modulation feature is supported only for DOCSIS 1.0 or DOCSIS 1.1 TDMA-only modulation profiles. It is not supported for DOCSIS 2.0 mixed-mode or A-TDMA-only mode modulation profiles.

- Three Step Dynamic Modulation is not supported on the CNR-based version of dynamic upstream modulation.

- The CNR-based Dynamic Upstream Modulation feature does not support A-TDMA modulation profiles. However, A-TDMA is supported in the MER (SNR)-based Dynamic Upstream Modulation feature.

To assign the primary and secondary profiles to an upstream, use the following procedure.

### Restriction

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> cable modulation-profile <em>profile</em> {mix</td>
<td>qam-16</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# cable modulation-profile 3 mix</td>
<td></td>
</tr>
<tr>
<td><strong>Note</strong> Repeat this command to create the secondary profile for use on a DOCSIS 1.0 or DOCSIS 1.1 TDMA upstream. Typically, the secondary profile is either robust-mix or qpsk.</td>
<td></td>
</tr>
<tr>
<td><strong>Note</strong> You can also create custom modulation profiles with the cable modulation-profile command by configuring the values for the individual burst parameters. These parameters, however, should not be modified unless you are thoroughly familiar with how changing each parameter affects the DOCSIS MAC layer. We recommend using the preconfigured default modulation profiles for most cable plants.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> controller upstream-cable <em>slot/subslot/port</em></td>
<td>Enters controller configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# controller upstream-cable 9/0/15</td>
<td></td>
</tr>
</tbody>
</table>
Configuring Proactive Channel Management

The cable interface line cards that support the advanced spectrum management features can be configured with the following parameters to fine-tune the operation of proactive channel management on the upstreams of the cards:

- Priority of the corrective actions to be taken when noise on an upstream exceeds the threshold for its modulation profile.
- CNR (CNiR) and MER (SNR) threshold and FEC values for the upstream and its two modulation profiles.
- Allowable range of channel widths that can be used if frequency hopping or modulation switching cannot avoid the upstream problems.

These parameters all have default settings, so you do not need to perform this procedure unless you want to change these parameters to better match the characteristics of your physical plant.

To configure the parameters, use the following procedure.

Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 5</strong> cable upstream n modulation-profile primary-profile-number secondary-profile-number</td>
<td>Assigns a primary modulation profile, and an optional secondary modulation profile, to the specified upstream port.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-controller)# cable upstream 0 modulation-profile 3 4</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> end</td>
<td>Exits controller interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-controller)# end</td>
<td></td>
</tr>
</tbody>
</table>

Configuring Proactive Channel Management

You can configure two logical channels on a single physical port of the Cisco CMTS router. When you configure logical channels, the upstream related commands are categorized into two groups: physical port level and logical channel level.

**Physical Port Level**

Physical port level commands use the format of **cable upstream n**, where *n* denotes the physical port number.

**Logical Channel Level**

Logical channel level commands use the format of **cable upstream n m**, where *n* denotes the physical port number, and *m* denotes the logical channel index number of 0 or 1.

Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>Command or Action</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
</tr>
<tr>
<td>2</td>
<td>configure terminal</td>
</tr>
<tr>
<td></td>
<td>Example: Router# configure terminal</td>
</tr>
<tr>
<td>3</td>
<td>controller upstream-cable <em>slot/subslot/port</em></td>
</tr>
<tr>
<td></td>
<td>Example: Router(config)# controller upstream-cable 9/0/0</td>
</tr>
<tr>
<td>4</td>
<td>us-channel <em>n hop modulation frequency channel-width</em></td>
</tr>
<tr>
<td></td>
<td>Example: Router(config-controller)# us-channel 0 hop modulation frequency channel-width</td>
</tr>
<tr>
<td></td>
<td>Note: The <em>channel-width</em> option must always appear after the <em>frequency</em> option.</td>
</tr>
<tr>
<td>5</td>
<td>cable upstream <em>n threshold cnr-profiles threshold1-in-db threshold2-in-db</em></td>
</tr>
<tr>
<td></td>
<td>Example: Router(config-controller)# cable upstream 2 threshold cnr-profiles 23 14</td>
</tr>
<tr>
<td></td>
<td>Note: To bypass both the primary and secondary CNR (CNR) thresholds, set the first parameter (<em>threshold1-in-db</em>) to 0. This disallows the second parameter (<em>threshold2-in-db</em>), enabling you to bypass both the CNR (CNR) thresholds.</td>
</tr>
</tbody>
</table>
| 6    | Use one of the following commands:  
|      | • cable upstream *n upstream threshold snr-profiles threshold1-in-db threshold2-in-db*  
|      | • cable upstream *n m upstream threshold snr-profiles threshold1-in-db threshold2-in-db* |
|      | Example: Router(config-controller)# cable upstream 2 threshold snr-profiles 23 14 |
|      | (Optional) Specifies the MER (SNR) threshold and FEC values for the upstream and its two modulation profiles. |
|      | Note: You can bypass the primary MER (SNR) threshold (*threshold1-in-db*) by setting it to 0. However, you must enter the second parameter (*threshold2-in-db*). |
| 7    | cable upstream *n threshold hysteresis hysteresis-in-db* | (Optional) Specifies the hysteresis value to be used in conjunction with the dynamic modulation upgrade thresholds. |
|      | Example: Router(config-controller)# cable upstream 2 threshold hysteresis 3 |
|      | Note: You can bypass the *hysteresis* threshold by setting the value to 0. |
| 8    | Use one of the following commands:  
|      | • cable upstream *n threshold corr-fec corr-fec-threshold* |
|      | (Optional) Specifies the CNR (CNR) threshold and FEC values for the upstream and its two modulation profiles. |
Verifying the Spectrum Management Configuration

Follow the steps given below to verify the spectrum management configuration.

### Step 1
To check the value of the settings you have entered, use the `show running-config` command in privileged EXEC mode:

**Example:**
```
Router# show running-config
```

### Step 2
To display the configuration for each modulation profile, use the `show cable modulation-profile` command in privileged EXEC mode:

**Example:**
```
Router# show cable modulation-profile
```

To display the configuration for a specific modulation profile, add the profile number to the `show cable modulation-profile` command in privileged EXEC mode:

**Example:**
```
Router# show cable modulation-profile 6
```
Step 3  
To display the status and configuration of each upstream, use the `show controllers cable upstream` command in privileged EXEC mode. The following example displays information for upstreams 0 on a cable line card:

**Example:**

```plaintext
Router# show controller cable 8/1/14 upstream 0

Cable8/1/14 Upstream 0 is up
Frequency 19.504 MHz, Channel Width 3.200 MHz, Symbol Rate 2.560 Maps
Modulations (64-QAM) - A-short 64-QAM, A-long 64-QAM, A-ugs 64-QAM
Mapped to shared connector 18 and receiver 56
Spectrum Group 8
MC336x60 CNR measurement : 30 dB
US phy MER(SNR)_estimate for good packets - 32.5530 dB
Nominal Input Power Level 0 dBmV, Tx Timing Offset 1547
Ranging Backoff Start 3, Ranging Backoff End 6
US timing offset adjustment type 0, value 0
Ranging Insertion Interval automatic (60 ms)
US throttling off
Tx Backoff Start 3, Tx Backoff End 5
Modulation Profile Group 221
Concatenation is enabled
Fragmentation is enabled
part_id=0x3142, rev_id=0xC0, rev2_id=0x00
nb_agc_thr=0x0000, nb_agc_nom=0x0000
Minislot Size in number of Timebase Ticks is = 2
Minislot Size in Symbols = 32
Bandwidth Requests = 0xEE3AF
Piggyback Requests = 0x6A24F
Invalid BW Requests= 0x76
Minislots Requested= 0xC13362
Minislots Granted = 0x158609
Minislot Size in Bytes = 24
Map Advance (Dynamic) : 2581 usecs
Map Count Internal = 330309891
No MAP buffer= 0x0 No Remote MAP buffer= 0x0
Map Counts: Controller 8/1/0 = 1321230158
UCD Counts:
Controller 8/1/0:0 = 336057
Controller 8/1/0:1 = 336057
Controller 8/1/0:2 = 336057
Controller 8/1/0:3 = 336057
UCD procedures on lch 0
UCD ucd-succeeds(5) ucd-shut(0) init-state-err(0)
UCD init-tss-err(0) init-timeout(0) init-start-err(0)
UCD ucd-ccc-time(0) ucd-timeout(0) ucd-tss-err(0)
UCD ucd-state-err(0) ucd-process(0) ucd-retries(0)
UCD stale-tss(0)
ATDMA mode enabled
PHY: us errors 0 us recoveries 0 (enp 0)
MAC PHY TSS: tss error start 0 tss error end 0
MAC PHY Status: bcm3140 status 0 lookout status 0
PHY: TSS late 0 discontinuous 0
PHY: TSS mis-match 0 not-aligned 0
PHY: TSS missed snapshots from phy 0
MAP/UCD Replication Instructions:
Controller 8/1/0 index = 477, bitmap = 0x0000F
Dynamic Services Stats:
DSA: 0 REQs 0 RSPs 0 ACKs
DSC: 0 REQs 0 RSPs 0 ACKs
```

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Step 4

To display the hop period and hop threshold values for each upstream, use the `show cable hop` command in privileged EXEC mode:

Example:

Router# show cable hop

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Port Status</th>
<th>Rate Poll</th>
<th>Poll Missed Min</th>
<th>Missed Hop</th>
<th>Hop Corr</th>
<th>Uncorr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ms)</td>
<td>Sample</td>
<td>Pcnt</td>
<td></td>
<td>Errors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Count</td>
<td></td>
<td>Pcnt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Period</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Errors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable3/0/00</td>
<td>20.800 Mhz 105</td>
<td>0</td>
<td>20</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable3/0/01</td>
<td>20.800 Mhz 105</td>
<td>0</td>
<td>48</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable3/0/02</td>
<td>23.120 Mhz 105</td>
<td>0</td>
<td>45</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable3/0/03</td>
<td>22.832 Mhz 105</td>
<td>0</td>
<td>26</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable3/0/04</td>
<td>22.896 Mhz 105</td>
<td>0</td>
<td>43</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable3/0/05</td>
<td>23.040 Mhz 105</td>
<td>0</td>
<td>54</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable4/0/00</td>
<td>22.896 Mhz 117</td>
<td>0</td>
<td>26</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable4/0/01</td>
<td>23.168 Mhz 117</td>
<td>0</td>
<td>87</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable4/0/02</td>
<td>22.896 Mhz 117</td>
<td>0</td>
<td>23</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable4/0/03</td>
<td>20.800 Mhz 117</td>
<td>0</td>
<td>54</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable4/0/04</td>
<td>22.928 Mhz 117</td>
<td>0</td>
<td>22</td>
<td>0%</td>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>Cable4/0/05</td>
<td>22.960 Mhz 117</td>
<td>0</td>
<td>------</td>
<td>25%</td>
<td>45</td>
<td>0</td>
</tr>
</tbody>
</table>

Step 5

To display changes from one state to another, at any time and for any reason, for frequency, modulation, and channel width, use the `history` option of the `show cable hop` command.

Example:

Router# show cable hop c8/1/1 u0 history

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Action</th>
<th>Chg Chg</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>C8/1/1 U0</td>
<td>Feb 20 12:21:29</td>
<td>M</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>SNR&gt;28=-28</td>
<td>CFEC 0&lt;=3</td>
<td>UnCFEC 0&lt;=1</td>
</tr>
<tr>
<td></td>
<td>Feb 20 12:09:08</td>
<td>F</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Configuration changed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 6

To display thresholds for MER (SNR), CNR (CNiR), and FEC, use the `threshold` option of the `show cable hop` command.

Example:

Router# show cable hop c8/1/1 u0 threshold

<table>
<thead>
<tr>
<th>Upstream</th>
<th>SNR(dB)</th>
<th>CNR(dB)</th>
<th>CorrFEC%</th>
<th>UncorrFEC%</th>
<th>MissedSM%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Val Thre1 Thre2</td>
<td>Val Thre1 Thre2</td>
<td>Pcnt Thre</td>
<td>Pcnt Thre</td>
<td>Pcnt Thre</td>
</tr>
<tr>
<td>C8/1/1 u0</td>
<td>33</td>
<td>23</td>
<td>14</td>
<td>60</td>
<td>25</td>
</tr>
</tbody>
</table>

Step 7

To display the assignment of each spectrum group, use the `show cable spectrum-group` command in privileged EXEC mode:

Example:

Router# show cable spectrum-group

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Frequency Band (MHz)</th>
<th>Upstream Port</th>
<th>Weekly Scheduled Availability</th>
<th>Power Level</th>
<th>Shared Spectrum</th>
<th>From Time:</th>
<th>To Time: (dBmV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the above example,

- No—Fiber node is not configured
- 54—ID of the fiber node

Step 8

To display the current CNR (CNiR) value for a particular cable modem, use the `show cable modem cnr` command in privileged EXEC mode:

Example:

```
Router# show cable modem 5.100.1.94 cnr
```

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>IP Address</th>
<th>I/F</th>
<th>MAC State</th>
<th>Prim snr/cnr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0018.689c.17b8</td>
<td>5.100.1.94</td>
<td>C7/0/0/U1</td>
<td>online</td>
<td>428 36.12</td>
</tr>
</tbody>
</table>

Monitoring Spectrum Management

You can either use Cisco CLI commands or SNMP to monitor spectrum management activity on the Cisco CMTS.

See the following sections for more information:

Using CLI Commands

The following commands provide information on the spectrum condition of an upstream:

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Router# show cable hop[cable x/y] [upstream usport]</code></td>
<td>Displays the hop period and hop threshold values, as well as the FEC error counters, for all upstreams in the router, all upstreams on one cable interface line card, or a single upstream.</td>
</tr>
<tr>
<td><code>Router# show cable hop [cable x/y/z] [upstream n] [thresholds]</code></td>
<td>Displays the configured and current value of MER (SNR) in dB, CNR (CNiR) in dB, CorrFEC in percentage, UncorrFEC in percentage, and missed station maintenance in percentage for a specified upstream.</td>
</tr>
</tbody>
</table>
### Command

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| Router# `show cable hop history` | 1. With the `show cable hop history` command for entire CMTS, the most recent change of each action is displayed.  
2. With the `show cable hop history` command for a MAC domain, the most recent three changes of each action are displayed.  
3. With the `show cable hop history` command for a specific upstream, the last ten changes of each action are displayed. Changes are sorted by time with the most recent at the top. |
| Router# `show cable hop [cable x/y[z]] [upstream n] [summary]` | Displays hourly, daily, weekly, 30 days running average, and average since the system was brought up for each specified upstream. |
| Router# `show cable hop [cable x/y[z]] [upstream n] [history]` | Displays changes from one state to another, at any time and for any reason, for frequency, modulation, and channel width. |
| Router# `show cable modem [ip-address | interface | mac-address] [options]` | Displays information, including MER (SNR) values, for the registered and unregistered cable modems. |
| Router# `show cable modulation-profile [num] [initial | long | reqdata | request | short | station]` | Displays the configuration for all modulation profiles, for a particular modulation profile, or for a specific burst type for a particular modulation profile. |
| Router# `show cable spectrum-group [groupnum] [detail]` | Displays information about the spectrum groups that have been configured. |
| Router# `show controllers cable x/y upstream n [ip-address | mac-address] start-freq end-freq res-freq` | Displays the upstream status, including the current frequency, channel width, modulation rate, and spectrum groups. |
| Router# `show controllers cable x/y upstream n spectrum [ip-address | mac-address] start-freq end-freq res-freq` | Displays the noise levels for a particular cable modem or displays the background noise for an entire upstream. |

### Note

The `show cable flap-list` command displays the flap list of the CMTS router, which provides additional information about whether cable modems on an upstream are experiencing problems, and if so, what type of problems are occurring. For more information about the cable modem flapping and how to monitor the cable modem flap list, see the Flap List Troubleshooting for the Cisco CMTS Routers.

### Using SNMP

You can use SNMP to monitor the spectrum management activity. The SNMP manager can be a graphically-based SNMP manager such as CiscoView or the Cable Broadband Troubleshooter (Release 3.0 or later).
The CISCO-CABLE-SPECTRUM-MIB has been enhanced to provide this SNMP support using the following MIB attributes:

**ccsSNRRequestTable**

The table below lists the attributes in the ccsSNRRequestTable table, which contains the CNR (CNiR) measurements that are made for individual cable modems on an upstream.

*Table 45: ccsSNRRequestTable Attributes*

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsSNRRequestIndex</td>
<td>Integer32</td>
<td>Arbitrary index to uniquely identify each table entry.</td>
</tr>
<tr>
<td>ccsSNRRequestMacAddr</td>
<td>MacAddress</td>
<td>MAC address of the remote online cable modem being reported on.</td>
</tr>
<tr>
<td>ccsSNRRequestSNR</td>
<td>Integer32</td>
<td>MER (SNR) value, in dB, that has been measured. This value is 0 when the Operation State is “running.”</td>
</tr>
<tr>
<td>ccsSNRRequestOperation</td>
<td>CCSRequestOperation</td>
<td>Sets the current operation: start, pending, running, or cancel.</td>
</tr>
<tr>
<td>ccsSNRRequestOperState</td>
<td>CCSRequestOperState</td>
<td>Reports on the current operation state: idle, pending, running, noError, canceled, notOnLine, invalidMac, timeOut, fftBusy, fftFailed, others.</td>
</tr>
<tr>
<td>ccsSNRRequestStartTime</td>
<td>TimeStamp</td>
<td>Contains the time when the MER (SNR) measurement operation starts.</td>
</tr>
<tr>
<td>ccsSNRRequestStoppedTime</td>
<td>TimeStamp</td>
<td>Contains the time when the MER (SNR) measurement stops.</td>
</tr>
<tr>
<td>ccsSNRRequestStatus</td>
<td>RowStatus</td>
<td>Controls the modification, creation, and deletion of table entries.</td>
</tr>
</tbody>
</table>

**ccsSpectrumRequestTable**

The table below lists the attributes for each entry in the ccsSpectrumRequestTable table, which is used to obtain the spectrum profile for a particular cable modem or to obtain the background MER (SNR) for an entire upstream.

*Table 46: ccsSpectrumRequestTable Attributes*

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsSpectrumRequestIndex</td>
<td>Integer32</td>
<td>Arbitrary index to uniquely identify each table entry.</td>
</tr>
<tr>
<td>ccsSpectrumRequestIfIndex</td>
<td>InterfaceIndexOrZero</td>
<td>Interface identifying the upstream.</td>
</tr>
<tr>
<td>ccsSpectrumRequestMacAddr</td>
<td>MacAddress</td>
<td>MAC address to specify an MER (SNR) value for a particular cable modem, or 0000.0000.0000 to indicate background noise for the entire spectrum.</td>
</tr>
</tbody>
</table>
**ccsSpectrumDataTable**

The table below lists the attributes in each entry of the ccsSpectrumDataTable table, which contains the results for a spectrum request.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsSpectrumRequestUpperFreq</td>
<td>CCSFrequency</td>
<td>Upper frequency for the frequency range to be monitored (5000 to 42000 KHz, with a default of 42000 KHz).</td>
</tr>
<tr>
<td>ccsSpectrumRequestLowFreq</td>
<td>CCSFrequency</td>
<td>Lower frequency (in KHz) for the frequency range to be monitored (5000 to 42000 KHz, with a default of 5000 KHz).</td>
</tr>
<tr>
<td>ccsSpectrumRequestResolution</td>
<td>Integer32</td>
<td>Requested resolution to determine how the frequency range should be sampled (12 to 37000 KHz, with a default of 60 KHz).</td>
</tr>
<tr>
<td>ccsSpectrumRequestStartTime</td>
<td>TimeStamp</td>
<td>Time when the spectrum measurement began.</td>
</tr>
<tr>
<td>ccsSpectrumRequestStoppedTime</td>
<td>TimeStamp</td>
<td>Time when the spectrum measurement finished.</td>
</tr>
<tr>
<td>ccsSpectrumRequestOperation</td>
<td>CCSRequestOperation</td>
<td>Starts a new spectrum management request or cancels the current one.</td>
</tr>
<tr>
<td>ccsSpectrumRequestOperState</td>
<td>CCSRequestOperState</td>
<td>Provides the operational state of the current spectrum management request.</td>
</tr>
<tr>
<td>ccsSpectrumRequestStatus</td>
<td>RowStatus</td>
<td>Controls the modification, creation, and deletion of table entries.</td>
</tr>
</tbody>
</table>

**ccsUpSpecMgmtTable**

The table below lists the attributes in the ccsUpSpecMgmtTable table, which provides an entry describing each frequency hop.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsSpectrumDataFreq</td>
<td>CCSMeasuredFrequency</td>
<td>Frequency in KHz for which this power measurement was made.</td>
</tr>
<tr>
<td>ccsSpectrumDataPower</td>
<td>INTEGER</td>
<td>Measured received power for the given frequency (~-50 to 50 dBmV).</td>
</tr>
</tbody>
</table>

**Note**

The ccsSpectrumRequestTable and ccsSpectrumDataTable tables provide the same information as that provided by the `show controllers cable upstream spectrum` command.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsUpSpecMgmtHopPriority</td>
<td>INTEGER</td>
<td>Specifies the priority of frequency, modulation profile, and channel width in determining corrective action for excessive noise on the upstream (default is frequency, modulation profile, and channel width).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtSnrThres1</td>
<td>Integer32</td>
<td>Specifies the upper MER (SNR) threshold for modulation profile 1 (5 to 35 dB, default of 25).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtSnrThres2</td>
<td>Integer32</td>
<td>Specifies the upper MER (SNR) threshold for modulation profile 2 (5 to 35 dB, default of 13, and must be lower than that specified for ccsUpSpecMgmtSnrThres1).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFecCorrectThres1</td>
<td>Integer32</td>
<td>Specifies the FEC correctable error threshold for modulation profile 1 (1 to 20 percent)</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFecCorrectThres2</td>
<td>Integer32</td>
<td>Deprecated and no longer used.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtUncorrectThres1</td>
<td>Integer32</td>
<td>Specifies the FEC uncorrectable error threshold for modulation profile 1 (1 to 20 percent).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtUncorrectThres2</td>
<td>Integer32</td>
<td>Deprecated and no longer used.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtSnrPollPeriod</td>
<td>Integer32</td>
<td>Deprecated and no longer used.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtHopCondition</td>
<td>INTEGER</td>
<td>Reports the condition that triggers a frequency hop (MER [SNR] value or percentage of modems going offline).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFromCenterFreq</td>
<td>CCSFrequency</td>
<td>Provides the center frequency (in KHz) before the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtToCenterFreq</td>
<td>CCSFrequency</td>
<td>Provides the current center frequency (in KHz) after the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFromBandWidth</td>
<td>CCSFrequency</td>
<td>Provides the channel width (in KHz) before the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtToBandWidth</td>
<td>CCSFrequency</td>
<td>Provides the current channel width (in KHz) after the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFromModProfile</td>
<td>Integer32</td>
<td>Provides the modulation profile number before the latest frequency hop.</td>
</tr>
</tbody>
</table>
### Attribute Description

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsUpSpecMgmtToModProfile</td>
<td>Integer32</td>
<td>Provides the current modulation profile number after the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtSNR</td>
<td>Integer32</td>
<td>Provides the current MER (SNR) value (in dB) for the upstream.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtCnrThres1</td>
<td>Integer32</td>
<td>Specifies the upper CNR (CNiR) threshold for modulation profile 1 (5 to 35 dB, default of 25).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtCnrThres2</td>
<td>Integer32</td>
<td>Specifies the upper CNR (CNiR) threshold for modulation profile 2 (5 to 35 dB, default of 13, and must be lower than that specified for ccsUpSpecMgmtCnrThres1).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtCNR</td>
<td>Integer32</td>
<td>Provides the current CNR (CNiR) value (in dB) for the upstream.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtMissedMaintMsgThres</td>
<td>Integer32</td>
<td>Provides the frequency hop threshold, as a percentage of station maintenance messages that are lost for a spectrum group.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtHopPeriod</td>
<td>Integer32</td>
<td>Provides the minimum time, in seconds, between frequency hops.</td>
</tr>
</tbody>
</table>

#### ccsHoppingNotification

The table below describes the attributes contained in the notification that is sent after each frequency hop.

**Table 49: ccsHoppingNotification Attributes**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccsUpSpecMgmtHopCondition</td>
<td>INTEGER</td>
<td>Reports the condition that triggers a frequency hop (MER [SNR] value or percentage of modems going offline).</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFromCenterFreq</td>
<td>CCSFrequency</td>
<td>Provides the center frequency (in KHz) before the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtToCenterFreq</td>
<td>CCSFrequency</td>
<td>Provides the current center frequency (in KHz) after the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFromBandWidth</td>
<td>CCSFrequency</td>
<td>Provides the channel width (in KHz) before the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtToBandWidth</td>
<td>CCSFrequency</td>
<td>Provides the current channel width (in KHz) after the latest frequency hop.</td>
</tr>
<tr>
<td>ccsUpSpecMgmtFromModProfile</td>
<td>Integer32</td>
<td>Provides the modulation profile number before the latest frequency hop.</td>
</tr>
</tbody>
</table>
Spectrum Management and Advanced Spectrum Management

### Configuration Examples

This section provides the following configuration examples:

#### Spectrum Group and Combiner Group Examples

The following examples help you to determine whether spectrum group and combiner groups are configured and activated.

**Example: Verifying Spectrum Group Creation**

To verify that a spectrum group has been created, enter the `show cable spectrum-group` command:

```bash
Router# show cable spectrum-group
spectrum-group 1
spectrum-group 2
spectrum-group 3
```

**Example: Time-Scheduled Spectrum Group**

If your cable plant has an upstream noise characteristic on a weekly cycle, use time-scheduled spectrum allocation.

```bash
Router(config)# cable spectrum-group 1 time Mon 08:00:00 frequency 21600000
```

Deletion is performed using the `delete` keyword:

```bash
Router(config)# cable spectrum-group 1 time Mon 18:00:00 delete frequency 21600000
```

**Example: Verifying Spectrum Group Configuration**

To verify if spectrum groups have been configured and activated, enter the `show cable spectrum-group` command. This command displays each spectrum group, the frequencies assigned to it, the upstream port to which it has been assigned, whether a schedule exists for it, the currently measured power level, and whether it is a shared spectrum group.

```bash
Router# show cable spectrum-group
22:07:46: %SYS-5-CONFIG_I: Configured from console by console
Group No. Spectrum Frequency Upstream Weekly Scheduled Power Level Shared

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Frequency</th>
<th>Upstream</th>
<th>Weekly</th>
<th>Power</th>
<th>Level</th>
<th>Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.000-15.000</td>
<td>0</td>
<td>Yes</td>
<td>0</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>12.000</td>
<td>0</td>
<td>Yes</td>
<td>0</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>22.000</td>
<td>Cable6/0 U5</td>
<td>7</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>29.000</td>
<td>Cable6/0 U4</td>
<td>6</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>26.000</td>
<td>0</td>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>35.000-41.000</td>
<td>0</td>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>16.000-19.000</td>
<td>Cable6/0 U3</td>
<td>5</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5.000-10.000</td>
<td>Thu 21:50:00 to Thu 21:45:00</td>
<td>0</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
Example: Determining the Upstream Ports Assigned to a Combiner Group

Following is a sample topology for a CMTS with combiner groups designated A through J. Combiner groups C and E have multiple upstream ports that should be configured in a shared spectrum group. The other upstreams should be configured in a nonshared spectrum group.

In this example, ten combiner groups are served with frequency hop tables from three spectrum groups:

Cable3/0
DS +-----+ Upconverter +----- laser group 1
U0 +----- combiner group A
U1 +----- combiner group B
U2 +----- combiner group C
U3 +----- combiner group C
U4 +----- combiner group D
U5 +----- combiner group E

Cable4/0
DS +-----+ Upconverter +----- laser group 2
U0 +----- combiner group E
U1 +----- combiner group F
U2 +----- combiner group G
U3 +----- combiner group H
U4 +----- combiner group I
U5 +----- combiner group J

The laser group term refers to the set of fiber nodes that share the same downstream signal. An optical splitter is often used to create individual feeds per node.

In the downstream direction, two 6-MHz channel slots are assigned. All fiber nodes in combiner groups A through E should have a channel slot containing the downstream signal from Cable3/0. Combiner groups A through E are said to belong to laser group 1.

All fiber nodes in combiner groups E through J should have a channel slot containing the downstream signal from Cable4/0. Combiner groups E through J are said to belong to laser group 2.

Because combiner group E belongs to two laser groups, there should be two different downstream channel slots for Cable3/0 and Cable4/0.

Example: Combiner Group

The following example enables spectrum management for all upstream ports, where all combiner groups use the frequency band from 20 to 26 MHz:

```plaintext
CMTS01(config)# cable spectrum-group 1 band 20000000 26000000
CMTS01(config)# cable spectrum-group 2 shared
CMTS01(config)# cable spectrum-group 2 band 20000000 26000000
CMTS01(config)# cable spectrum-group 3 shared
CMTS01(config)# cable spectrum-group 3 band 20000000 26000000
CMTS01(config)# controller upstream-Cable 9/0/0
CMTS01(config-controller)# cable spectrum-group 1
CMTS01(config-controller)# cable upstream 2 spectrum-group 2
CMTS01(config-controller)# cable upstream 3 spectrum-group 2
CMTS01(config-controller)# cable upstream 5 spectrum-group 3
CMTS01(config-controller)# exit
CMTS01(config)# controller upstream-Cable 9/0/1
CMTS01(config-controller)# cable spectrum-group 1
CMTS01(config-controller)# cable upstream 0 spectrum-group 3
```

A description of the spectrum groups 1 through 3 follows:
• Spectrum group 1—This group is nonshared. Upstream RF domains exist for each member upstream port.

<table>
<thead>
<tr>
<th>Upstream Port</th>
<th>RF Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 U0</td>
<td>combiner group A</td>
</tr>
<tr>
<td>Cable3/0 U1</td>
<td>combiner group B</td>
</tr>
<tr>
<td>Cable3/0 U4</td>
<td>combiner group D</td>
</tr>
<tr>
<td>Cable4/0 U1</td>
<td>combiner group F</td>
</tr>
<tr>
<td>Cable4/0 U2</td>
<td>combiner group G</td>
</tr>
<tr>
<td>Cable4/0 U3</td>
<td>combiner group H</td>
</tr>
<tr>
<td>Cable4/0 U4</td>
<td>combiner group I</td>
</tr>
<tr>
<td>Cable4/0 U5</td>
<td>combiner group J</td>
</tr>
</tbody>
</table>

• Spectrum group 2—This group is shared. A single upstream RF domain exists.

<table>
<thead>
<tr>
<th>Upstream Port</th>
<th>RF Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 U2</td>
<td>combiner group C</td>
</tr>
<tr>
<td>Cable3/0 U3</td>
<td>combiner group C</td>
</tr>
</tbody>
</table>

• Spectrum group 3—This group is shared. A single upstream RF domain exists.

<table>
<thead>
<tr>
<th>Upstream Port</th>
<th>RF Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable3/0 U5</td>
<td>combiner group E</td>
</tr>
<tr>
<td>Cable4/0 U0</td>
<td>combiner group E</td>
</tr>
</tbody>
</table>

For the 20- to 26-MHz band of each RF domain, the spectrum is channelized according to the channel width settings of each member port. For example, if the ports U2 and U3 of Cable3/0 are set to 3.2 MHz and 1.6 MHz channel widths, respectively, then spectrum group 2 uses the following channelization:

<table>
<thead>
<tr>
<th>Channel Width Start Stop Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Mhz) (Mhz) (Mhz) (Mhz)</td>
</tr>
<tr>
<td>1 5.2 20.0 23.2 21.6</td>
</tr>
<tr>
<td>2* 1.6 20.0 21.6 20.8</td>
</tr>
<tr>
<td>3* 1.6 21.6 23.2 22.4</td>
</tr>
<tr>
<td>4 1.6 23.2 24.8 24.0</td>
</tr>
</tbody>
</table>

Channels 2 and 3 are not available when channel 1 is in use.

Because the group is shared, ports U2 and U3 will be assigned channels 1 and 4, respectively, to prevent overlap.

<table>
<thead>
<tr>
<th>Channel Width Start Stop Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Mhz) (Mhz) (Mhz) (Mhz)</td>
</tr>
<tr>
<td>1 3.2 20.0 23.2 21.6</td>
</tr>
<tr>
<td>2 3.2 23.2 26.4 24.8</td>
</tr>
<tr>
<td>3 1.6 20.0 21.6 20.8</td>
</tr>
<tr>
<td>4 1.6 21.6 23.2 22.4</td>
</tr>
<tr>
<td>5 1.6 23.2 24.8 24.0</td>
</tr>
<tr>
<td>6 1.6 24.8 26.4 25.6</td>
</tr>
</tbody>
</table>

There are no alternate frequency assignments for either port, and bandwidth is wasted from 24.8 to 26.0 MHz. To create alternate channels, increase the upper boundary from 26.0 to 28.0 MHz.
> 7 1.6 26.4 28.0 27.4

Try to reduce the spectrum allocation when it is used with small channel widths. Otherwise, there will be a large number of upstream channel slots, and the frequency hopping may require several minutes to find a clean slot.

**Example: Other Spectrum Management Configurations**

To configure differing spectrum groups, refer to the following examples:

- Use the following example to configure spectrum group 3 with an upstream band of 12,000,000 to 18,000,000 Hz and default power level of 0 dBmV:

```
Router(config)# cable spectrum-group 3 band 12000000 18000000
```

- Use the following example to add the upstream band 20,000,000 to 24,000,000 Hz to the list of valid bands with a change in the power level of 13 dBmV for spectrum group 3:

```
Router(config)# cable spectrum-group 3 band 20000000 24000000 13
```

- Use the following example to configure a continuous band between 5,000,004 and 40,000,000 Hz for scheduled spectrum group 4 with a default power level of 0 dBmV. The band is available to the spectrum group starting at 12:00 p.m. local time each Monday:

```
Router(config)# cable spectrum-group 4 time Monday 12:00:00 band 5000004 40000000
```

- Use the following example to add the upstream frequency 9,500,000 Hz to the list of valid frequencies and change the nominal power level to 5 dBmV. The spectrum manager adjusts frequencies and power levels on this group at 2:00 a.m. local time each day:

```
Router(config)# cable spectrum-group 3 time 02:00:00 frequency 9500000 5
```

- Use the following example to configure the minimum period before which a frequency hop can occur in seconds:

```
Router(config)# cable spectrum-group 3 hop period 800
```

- Use the following example to configure the threshold value (expressed as a percentage) of the number of “offline” modems identified before the router initiates an automatic frequency hop:

```
Router(config)# cable spectrum-group 3 hop threshold 40
```

- Use the following example to configure a particular spectrum group as a shared RF spectrum group. Specifying a given spectrum group as “shared” tells the router that you want to be sure that upstream frequencies assigned to upstream ports are not assigned to additional upstream ports:

```
Router(config)# cable spectrum-group 3 shared
```

- Use the following example to remove a specified spectrum group from your configuration:

```
Router(config)# no cable spectrum-group 3
Dynamic Upstream Modulation Examples

The following examples describe how to display modulation profile information with the `show cable modulation-profile` command and to define a modulation profile with the `cable modulation-profile` command.

Verifying Your Settings

**Step 1**
To check the value of the settings you have entered, enter the `show running-config` command in privileged EXEC mode:

Example:
```
Router# show running-config
```

To review changes you make to the configuration, use the `show startup-config` command in privileged EXEC mode to display the information stored in NVRAM.

**Step 2**
To display modulation profile group information, use the `show cable modulation-profile` command in privileged EXEC mode:

Example:
```
Router# show cable modulation-profile [profile] [iuc-code]
```

This command uses the following syntax:

- `profile`—(Optional) Profile number. Valid values are from 1 to 8.
- `iuc-code`—(Optional) Internal usage code.

Valid options are:
- `initial`—Initial ranging burst
- `long`—Long grant burst
- `request`—Request burst
- `short`—Short grant burst
- `station`—Station ranging burst

Example: Modulation Profiles

The Cisco CMTS has one preconfigured modulation profile resident in memory, which defines a typical profile for QPSK modulation. To use the Dynamic Upstream Modulation feature, a second profile must be created that is unique from the first profile, and typically provides a higher, more robust modulation scheme.

The following example is a modulation profile for QAM-16, in which the initial, request, and station maintenance messages are sent as QPSK, and the short and long data packets are sent as QAM-16. The QAM-16 modulation is more bandwidth-efficient than QPSK, but QPSK is more robust than QAM-16.
The upstream request and station maintenance messages use less time on the cable network when configured in QPSK for symbol rates of 640K, 1280K, and 2560K symbols/sec. Thus, these messages are actually more efficient when used in QPSK mode and they ensure a more reliable modem connection. The upstream initial maintenance message takes exactly the same amount of time on the cable network, no matter how it is configured. Modems connect more quickly and experience fewer cycles of power adjustment during initial maintenance if the system is set for QPSK.

Note

Router# configure terminal
Router(config)# cable modulation-profile 2 request 0 16 1 8 qpsk scrambler 152 no-diff 64 fixed uw16
Router(config)# cable modulation-profile 2 initial 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed uw16
Router(config)# cable modulation-profile 2 station 5 34 0 48 qpsk scrambler 152 no-diff 128 fixed uw16
Router(config)# cable modulation-profile 2 short 6 75 6 8 16qam scrambler 152 no-diff 72 fixed uw16
Router(config)# cable modulation-profile 2 long 8 220 0 8 16qam scrambler 152 no-diff 160 fixed uw16

In the following example, all message types are carried with QAM-16 modulation. Although QAM-16 modulation offers a consistent modulation scheme for all five types of messages, the added length of the QAM-16 preamble offsets the increased bandwidth efficiency of the MAC data message for the station maintenance messages and bandwidth request messages.

Router# configure terminal
Router(config)# cable modulation-profile 2 request 0 16 1 8 16qam scrambler 152 no-diff 128 fixed uw16
Router(config)# cable modulation-profile 2 initial 5 34 0 48 16qam scrambler 152 no-diff 256 fixed uw16
Router(config)# cable modulation-profile 2 station 5 34 0 48 16qam scrambler 152 no-diff 256 fixed uw16
Router(config)# cable modulation-profile 2 short 5 75 6 8 16qam scrambler 152 no-diff 144 fixed uw16
Router(config)# cable modulation-profile 2 long 8 220 0 8 16qam scrambler 152 no-diff 160 fixed uw16

Note

When using DOCSIS concatenation with a 16-QAM or mixed symbol rate, configure the CMTS for Unique Word 16 ("uw16") in the preamble for both short and long data burst profiles.

Add the cable upstream port-number modulation-profile primary profile-number secondary profile-number command to the appropriate interfaces. In this example, modulation profile 2 is for QAM-16 modulation and profile 1 is for QPSK modulation.

Router# configure terminal
Router(config)# controller upstream-Cable 6/0/0
Router(config-controller)# cable upstream 0 modulation-profile 2 1
**Example: Input Power Level**

In the following example, the modem transmit power at 24.8 MHz is adjusted upstream by 1 dBmV and the modem transmit power at 28.0 MHz is adjusted upstream by 2 dBmV.

```
CMTS01(config)# cable spectrum-group 1 frequency 21600000
CMTS01(config)# cable spectrum-group 1 frequency 24800000 1
CMTS01(config)# cable spectrum-group 1 frequency 28000000 2
```

**Advanced Spectrum Management Configuration Examples**

This section provides the following typical configurations:

**Example: Advanced Spectrum Management for the Cisco cBR Series Routers**

This section provides an excerpt from a typical configuration example for a Cisco cBR Series router using a cable interface line card. This configuration does the following:

- Configures four spectrum groups with a hop period of 30 seconds.
- Creates a QPSK modulation profile and assigns it to four upstreams on the Cisco cable interface line card in slot 6/1/0.
- Assigns a spectrum group to each of the four upstreams.
- Configures each upstream for the default CNR (CNiR) and FEC thresholds.

```
cable modulation-profile 21 qpsk
interface Cable6/1/0
cable bundle 1
cable downstream annex B
cable downstream modulation 256qam
cable downstream interleave-depth 32
! upstream 0
cable upstream 0 spectrum-group 1
cable upstream 0 modulation-profile 21
cable upstream 0 threshold cnr-profiles 16 0
cable upstream 0 threshold Corr-Fec 3
cable upstream 0 threshold Uncorr-Fec 1
no cable upstream 0 shutdown ! upstream 1
cable upstream 1 spectrum-group 2
cable upstream 1 modulation-profile 21
cable upstream 1 threshold cnr-profiles 16 0
cable upstream 1 threshold Corr-Fec 3
cable upstream 1 threshold Uncorr-Fec 1
no cable upstream 1 shutdown ! upstream 2
cable upstream 2 spectrum-group 3
cable upstream 2 modulation-profile 21
cable upstream 2 threshold cnr-profiles 16 0
cable upstream 2 threshold Corr-Fec 3
cable upstream 2 threshold Uncorr-Fec 1
no cable upstream 2 shutdown ! upstream 3
cable upstream 3 spectrum-group 4
cable upstream 3 modulation-profile 21
cable upstream 3 threshold cnr-profiles 16 0
cable upstream 3 threshold Corr-Fec 3
cable upstream 3 threshold Uncorr-Fec 1
no cable upstream 3 shutdown
```
Additional References

The following sections provide references related to Spectrum Management and Advanced Spectrum Management for the Cisco CMTS routers.

Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMTS Command Reference</td>
<td>Cisco Broadband Cable Command Reference Guide</td>
</tr>
</tbody>
</table>

Standards and RFCs

<table>
<thead>
<tr>
<th>Standards</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP-RFIv1.1-I09-020830</td>
<td>Data-over-Cable Service Interface Specifications Radio Frequency Interface Specification, version 1.1</td>
</tr>
<tr>
<td>SP-RFIv2.0-I03-021218</td>
<td>Data-over-Cable Service Interface Specifications Radio Frequency Interface Specification, version 2.0</td>
</tr>
<tr>
<td>SP-OSSIv2.0-I03-021218</td>
<td>Data-over-Cable Service Interface Specifications Operations Support System Interface Specification, version 2.0</td>
</tr>
<tr>
<td>SP-BPI+-I09-020830</td>
<td>Data-over-Cable Service Interface Specifications Baseline Privacy Plus Interface Specification, version 2.0</td>
</tr>
</tbody>
</table>

MIBs

<table>
<thead>
<tr>
<th>MIBs</th>
<th>MIBs Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISCO-CABLE-SPECTRUM-MIB</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="https://www.cisco.com/go/mibs">https://www.cisco.com/go/mibs</a></td>
</tr>
</tbody>
</table>

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.</td>
<td><a href="https://www.cisco.com/cisco/web/support/index.html">https://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>
Feature Information for Spectrum Management and Advanced Spectrum Management

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note
The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum Management and Advanced Spectrum Management</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 14

Upstream Scheduler Mode

This document describes how to configure optional upstream (US) scheduler modes.

With this feature, you can select Unsolicited Grant Services (UGS), Real Time Polling Service (rtPS) or Non-Real Time Polling Service (nrtPS) scheduling types, as well as packet-based or Time Division Multiplex (TDM) based scheduling. Low latency queuing (LLQ) emulates a packet-mode-like operation over the TDM infrastructure of DOCSIS. As such, the feature provides the typical trade-off between packets and TDM. With LLQ, you have more flexibility in defining service parameters for UGS, rtPS or nrtPS, but with no guarantee (other than statistical distribution) regarding parameters such as delay and jitter.

- Finding Feature Information, on page 283
- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 283
- Restrictions for Upstream Scheduler Mode, on page 284
- Information About Upstream Scheduler Mode for the Cisco CMTS Routers, on page 285
- How to Configure Upstream Scheduler Modes, on page 285
- Additional References, on page 286
- Feature Information for Upstream Scheduler Mode, on page 287

Finding Feature Information

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Table 50: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
<td></td>
</tr>
</tbody>
</table>

Restrictions for Upstream Scheduler Mode

- To ensure proper operation, Interface-based Admission Control must be enabled. When the LLQ option is enabled, it is possible for the upstream path to be filled with so many calls that it becomes unusable, making voice quality unacceptable. Interface-based admission control must be used to limit the number of calls to ensure acceptable voice quality, as well as to ensure traffic other than voice traffic.

- Even if Interface-based admission control is not enabled, the default (DOCSIS) scheduling mode blocks traffic after a certain number of calls.

- UGS with Activity Detection (UGS-AD) is not supported by the LLQ scheduler mode but remains supported by the default DOCSIS scheduler mode.
Information About Upstream Scheduler Mode for the Cisco CMTS Routers

With UGS, a service flow is created that enables a cable modem to transmit fixed-size bursts of data at a guaranteed rate and with a guaranteed level of jitter by providing periodic transmission opportunities to the cable modem for fixed-sized frames. This kind of service flow is particularly suitable for VoIP applications.

With rtPS, a service flow is created that provides a periodic opportunity for a cable modem to request permission to transmit data by polling a single cable modem for a bandwidth request, rather than all the cable modems. This satisfies applications that have a requirement for real-time data transmission, and enables the cable modem to transmit data bursts of varying length. This kind of service flow is particularly suitable for MPEG VoIP.

The rtPS requests, by default, are internally treated as priority 7—the highest priority for all Best Effort traffic. This high priority reduces the latency of rtPS traffic under congestion.

With nrtPS, a service flow is created that provides a periodic opportunity for a cable modem to request permission to transmit data by polling a single cable modem for a bandwidth request, rather than all the cable modems. The data bursts may be of varying length. This kind of service flow is particularly suitable for non-interactive services such as file transfers.

How to Configure Upstream Scheduler Modes

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Use one the following commands:</td>
<td>Enters interface configuration mode for the specified cable interface.</td>
</tr>
<tr>
<td></td>
<td>• interface cable slot/subslot/port</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• interface cable slot/port</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# interface cable 7/0/1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>cable upstream $n$ scheduling type ugs mode [llq</td>
<td>Enables LLQ-type (packet-based) scheduling for UGS services.</td>
</tr>
<tr>
<td></td>
<td>docsis]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Router(config-if)# cable upstream 4 scheduling type ugs mode llq</code></td>
<td><strong>Purpose</strong>&lt;br&gt;Any combination of ugs, rtps, nrtps, llq, and docsis is allowed. The only default value is docsis.</td>
</tr>
<tr>
<td><strong>Step 5</strong>&lt;br&gt;`cable upstream n scheduling type rtps mode [llq</td>
<td>docsis]`</td>
</tr>
<tr>
<td><strong>Step 6</strong>&lt;br&gt;<code>end</code></td>
<td>Exits interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
</tbody>
</table>

### What to do next

To confirm whether the scheduler is operating in DOCSIS mode, use the `show interface cable mac-scheduler` command.

```
Router# show interface cable 7/0/1 mac-scheduler 0
DOCSIS 1.1 MAC scheduler for Cable7/0/1/U0 : rate 30720000
  wfg:None
  ua_balance:OFF
  fairness:OFF
  Queue[Rng Polls] flows 0
  Queue[CIR Grants] flows 0
  Queue[BE(07) Grants] flows 0
  Queue[BE(06) Grants] flows 0
  Queue[BE(05) Grants] flows 0
  Queue[BE(04) Grants] flows 0
  Queue[BE(03) Grants] flows 0
  Queue[BE(02) Grants] flows 0
  Queue[BE(01) Grants] flows 0
  Queue[BE(00) Grants] flows 0
  Req Slots 2601578997, Req/Data Slots 4484512
  Init Mtn Slots 38265829, Stn Mtn Slots 78753
  Short Grant Slots 0, Long Grant Slots 0
  Adv Phy Short Grant Slots 412, Adv Phy Long Grant Slots 5519087
  Adv Phy UGS Grant Slots 0
  Avg upstream channel utilization : 1%
  Avg percent contention slots : 98%
  Avg percent initial ranging slots : 1%
  Avg percent minislots lost on late MAPs : 0%
  MAP TSS: lch_state 9, init_retries 0
  late_initial_maps 0, late_ucd_maps 0
  mac-phy tss errors 0, missed ccc 0
```

### Additional References

The following sections provide references related to the Cisco CMTS routers.
Feature Information for Upstream Scheduler Mode

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 51: Feature Information for Upstream Scheduler Mode

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream Scheduler Mode</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 15

Generic Routing Encapsulation

This document describes the Generic Routing Encapsulation (GRE) feature. This feature is a tunneling protocol that enables the encapsulation of a wide variety of protocol packet types inside IP tunnels, creating a virtual point-to-point link to Cisco routers at remote points over an IP internetwork.

- Finding Feature Information, on page 289
- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 290
- Restrictions for Implementing Tunnels, on page 290
- Restrictions for GRE IPv6 Tunnels, on page 291
- Information About Implementing Tunnels, on page 292
- Information About IPv6 over IPv4 GRE Tunnels, on page 293
- Information About GRE IPv6 Tunnels, on page 296
- How to Implement Tunnels, on page 296
- Configuration Examples for Implementing Tunnels, on page 303
- How to Configure IPv6 over IPv4 GRE Tunnels, on page 306
- Configuration Examples for IPv6 over IPv4 GRE Tunnels, on page 307
- How to Configure GRE IPv6 Tunnels, on page 308
- Configuration Examples for GRE IPv6 Tunnels, on page 310
- Additional References, on page 310
- Feature Information for Generic Routing Encapsulation, on page 311

Finding Feature Information

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.
Hardware Compatibility Matrix for the Cisco cBR Series Routers

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.

Table 52: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Restrictions for Implementing Tunnels

• It is important to allow the tunnel protocol to pass through a firewall and access control list (ACL) check.

• Multiple point-to-point tunnels can saturate the physical link with routing information if the bandwidth is not configured correctly on a tunnel interface.

• A tunnel looks like a single hop link, and routing protocols may prefer a tunnel over a multihop physical path. The tunnel, despite looking like a single hop link, may traverse a slower path than a multihop link. A tunnel is as robust and fast, or as unreliable and slow, as the links that it actually traverses. Routing
protocols that make their decisions based only on hop counts will often prefer a tunnel over a set of physical links. A tunnel might appear to be a one-hop, point-to-point link and have the lowest-cost path, but the tunnel may actually cost more in terms of latency when compared to an alternative physical topology. For example, in the topology shown in the figure below, packets from Host 1 will appear to travel across networks w, t, and z to get to Host 2 instead of taking the path w, x, y, and z because the tunnel hop count appears shorter. In fact, the packets going through the tunnel will still be traveling across Router A, B, and C, but they must also travel to Router D before coming back to Router C.

**Figure 2: Tunnel Precautions: Hop Counts**

![Diagram of network topology](image)

- A tunnel may have a recursive routing problem if routing is not configured accurately. The best path to a tunnel destination is via the tunnel itself; therefore recursive routing causes the tunnel interface to flap. To avoid recursive routing problems, keep the control-plane routing separate from the tunnel routing by using the following methods:
  - Use a different autonomous system number or tag.
  - Use a different routing protocol.
  - Ensure that static routes are used to override the first hop (watch for routing loops).

The following error is displayed when there is recursive routing to a tunnel destination:

```
%TUN-RECURDOWN Interface Tunnel 0
temporarily disabled due to recursive routing
```

**Restrictions for GRE IPv6 Tunnels**

- GRE tunnel keepalive packets are not supported.
- Multipoint GRE (mGRE) IPv6 tunneling is not supported.
- There is limited support for tunnel transport in virtual routing and forwarding (VRF). The limited support in VRF is applicable to IPv6 point-to-point GRE without tunnel protection.
Information About Implementing Tunnels

Tunneling Versus Encapsulation

To understand how tunnels work, you must be able to distinguish between concepts of encapsulation and tunneling. Encapsulation is the process of adding headers to data at each layer of a particular protocol stack. The Open Systems Interconnection (OSI) reference model describes the functions of a network. To send a data packet from one host (for example, a PC) to another on a network, encapsulation is used to add a header in front of the data packet at each layer of the protocol stack in descending order. The header must contain a data field that indicates the type of data encapsulated at the layer immediately above the current layer. As the packet ascends the protocol stack on the receiving side of the network, each encapsulation header is removed in reverse order.

Tunneling encapsulates data packets from one protocol within a different protocol and transports the packets on a foreign network. Unlike encapsulation, tunneling allows a lower-layer protocol and a same-layer protocol to be carried through the tunnel. A tunnel interface is a virtual (or logical) interface. Tunneling consists of three main components:

- **Passenger protocol** — The protocol that you are encapsulating. For example, IPv4 and IPv6 protocols.
- **Carrier protocol** — The protocol that encapsulates. For example, generic routing encapsulation (GRE) and Multiprotocol Label Switching (MPLS).
- **Transport protocol** — The protocol that carries the encapsulated protocol. The main transport protocol is IP.

**Tunnel ToS**

Tunnel type of service (ToS) allows you to tunnel network traffic and group all packets in the same ToS byte value. The ToS byte values and Time-to-Live (TTL) hop-count value can be set in the encapsulating IP header of tunnel packets for an IP tunnel interface on a router. Tunnel ToS feature is supported for Cisco Express Forwarding (formerly known as CEF), fast switching, and process switching.

The ToS and TTL byte values are defined in RFC 791, RFC 2474, and RFC 2780 obsolete the use of the ToS byte as defined in RFC 791. RFC 791 specifies that bits 6 and 7 of the ToS byte (the first two least significant bits) are reserved for future use and should be set to 0.

**Path MTU Discovery**

Path MTU Discovery (PMTUD) can be enabled on a GRE or IP-in-IP tunnel interface. When PMTUD (RFC 1191) is enabled on a tunnel interface, the router performs PMTUD processing for the GRE (or IP-in-IP) tunnel IP packets. The router always performs PMTUD processing on the original data IP packets that enter the tunnel. When PMTUD is enabled, packet fragmentation is not permitted for packets that traverse the tunnel because the Don’t Fragment (DF) bit is set on all the packets. If a packet that enters the tunnel encounters a link with a smaller MTU, the packet is dropped and an Internet Control Message Protocol (ICMP) message is sent back to the sender of the packet. This message indicates that fragmentation was required (but not permitted) and provides the MTU of the link that caused the packet to be dropped.
PMTUD on a tunnel interface requires that the tunnel endpoint be able to receive ICMP messages generated by routers in the path of the tunnel. Ensure that ICMP messages can be received before using PMTUD over firewall connections.

Use the `tunnel path-mtu-discovery` command to enable PMTUD for the tunnel packets and use the `show interfaces tunnel` command to verify the tunnel PMTUD parameters. PMTUD works only on GRE and IP-in-IP tunnel interfaces.

**QoS Options for Tunnels**

A tunnel interface supports various quality of service (QoS) features as a physical interface. QoS provides a way to ensure that mission-critical traffic has an acceptable level of performance. QoS options for tunnels include support for applying generic traffic shaping (GTS) directly on the tunnel interface and support for class-based shaping using the modular QoS CLI (MQC). Tunnel interfaces also support class-based policing, but they do not support committed access rate (CAR).

GRE tunnels allow the router to copy the IP precedence bit values of the ToS byte to the tunnel or the GRE IP header that encapsulates the inner packet. Intermediate routers between the tunnel endpoints can use the IP precedence values to classify packets for QoS features such as policy routing, weighted fair queueing (WFQ), and weighted random early detection (WRED).

When packets are encapsulated by tunnel or encryption headers, QoS features are unable to examine the original packet headers and correctly classify the packets. Packets that travel across the same tunnel have the same tunnel headers, so the packets are treated identically if the physical interface is congested. Tunnel packets can, however, be classified before tunneling and encryption can occur when a user applies the QoS preclassify feature on the tunnel interface or on the crypto map.

Class-based WFQ (CBWFQ) inside class-based shaping is not supported on a multipoint interface.

For examples of how to implement some QoS features on a tunnel interface, see the section “Configuring QoS Options on Tunnel Interfaces Examples, on page 304” on page 32.

**Information About IPv6 over IPv4 GRE Tunnels**

**Overlay Tunnels for IPv6**

Overlay tunneling encapsulates IPv6 packets in IPv4 packets for delivery across an IPv4 infrastructure (a core network or the figure below). By using overlay tunnels, you can communicate with isolated IPv6 networks without upgrading the IPv4 infrastructure between them. Overlay tunnels can be configured between border devices or between a border device and a host; however, both tunnel endpoints must support both the IPv4 and IPv6 protocol stacks. IPv6 supports the following types of overlay tunneling mechanisms:

- Manual
- Generic routing encapsulation (GRE)
Overlay Tunnels for IPv6

- IPv4-compatible
- 6to4
- Intrasite Automatic Tunnel Addressing Protocol (ISATAP)

Figure 3: Overlay Tunnels

Overlay tunnels reduce the maximum transmission unit (MTU) of an interface by 20 octets (assuming that the basic IPv4 packet header does not contain optional fields). A network that uses overlay tunnels is difficult to troubleshoot. Therefore, overlay tunnels that connect isolated IPv6 networks should not be considered a final IPv6 network architecture. The use of overlay tunnels should be considered as a transition technique toward a network that supports both the IPv4 and IPv6 protocol stacks or just the IPv6 protocol stack.

Use the table below to help you determine which type of tunnel that you want to configure to carry IPv6 packets over an IPv4 network.

Table 53: Suggested Usage of Tunnel Types to Carry IPv6 Packets over an IPv4 Network

<table>
<thead>
<tr>
<th>Tunneling Type</th>
<th>Suggested Usage</th>
<th>Usage Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>Simple point-to-point tunnels that can be used within a site or between sites.</td>
<td>Can carry IPv6 packets only.</td>
</tr>
<tr>
<td>GRE- and IPv4-compatible</td>
<td>Simple point-to-point tunnels that can be used within a site or between sites.</td>
<td>Can carry IPv6, Connectionless Network Service (CLNS), and many other types of packets.</td>
</tr>
<tr>
<td>IPv4-compatible</td>
<td>Point-to-multipoint tunnels.</td>
<td>Uses the ::/96 prefix. We do not recommend using this tunnel type.</td>
</tr>
<tr>
<td>6to4</td>
<td>Point-to-multipoint tunnels that can be used to connect isolated IPv6 sites.</td>
<td>Sites use addresses from the 2002::/16 prefix.</td>
</tr>
<tr>
<td>6RD</td>
<td>IPv6 service is provided to customers over an IPv4 network by using encapsulation of IPv6 in IPv4.</td>
<td>Prefixes can be from the SP’s own address block.</td>
</tr>
<tr>
<td>Tunneling Type</td>
<td>Suggested Usage</td>
<td>Usage Notes</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ISATAP</td>
<td>Point-to-multipoint tunnels that can be used to connect systems within a site.</td>
<td>Sites can use any IPv6 unicast addresses.</td>
</tr>
</tbody>
</table>

Individual tunnel types are discussed in detail in this document. We recommend that you review and understand the information about the specific tunnel type that you want to implement. When you are familiar with the type of tunnel you need, see the table below for a summary of the tunnel configuration parameters that you may find useful.

**Table 54: Tunnel Configuration Parameters by Tunneling Type**

<table>
<thead>
<tr>
<th>Tunneling Type</th>
<th>Tunneling Type</th>
<th>Tunnel Configuration Parameter</th>
<th>Tunnel Mode</th>
<th>Tunnel Source</th>
<th>Tunnel Destination</th>
<th>Interface Prefix or Address</th>
<th>An IPv6 address.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISATAP</td>
<td>IPv4-compatible</td>
<td>IPv4-compatible</td>
<td>Manual</td>
<td>ipv6ip auto-tunnel</td>
<td>Not required. These are all point-to-multipoint tunneling types. The IPv4 destination address is calculated, on a per-packet basis, from the IPv6 destination.</td>
<td>IPv6-compatible</td>
<td>An IPv6 address.</td>
</tr>
<tr>
<td>ISATAP</td>
<td>6to4</td>
<td>6to4</td>
<td>Manual</td>
<td>ipv6ip 6to4</td>
<td>An IPv6 address.</td>
<td>IPv6-compatible</td>
<td>An IPv6 address.</td>
</tr>
<tr>
<td>ISATAP</td>
<td>6RD</td>
<td>6RD</td>
<td>Manual</td>
<td>ipv6ip 6rd</td>
<td>An IPv6 address.</td>
<td>IPv6-compatible</td>
<td>An IPv6 address.</td>
</tr>
<tr>
<td>ISATAP</td>
<td>ISATAP</td>
<td>ISATAP</td>
<td>Manual</td>
<td>ipv6ip isatap</td>
<td>An IPv6 address.</td>
<td>IPv6-compatible</td>
<td>An IPv6 address.</td>
</tr>
</tbody>
</table>

**GRE IPv4 Tunnel Support for IPv6 Traffic**

IPv6 traffic can be carried over IPv4 GRE tunnels using the standard GRE tunneling technique that is designed to provide the services to implement any standard point-to-point encapsulation scheme. As in IPv6 manually configured tunnels, GRE tunnels are links between two points, with a separate tunnel for each link. The tunnels are not tied to a specific passenger or transport protocol but, in this case, carry IPv6 as the passenger protocol with the GRE as the carrier protocol and IPv4 or IPv6 as the transport protocol.

The primary use of GRE tunnels is for stable connections that require regular secure communication between two edge devices or between an edge device and an end system. The edge devices and the end systems must be dual-stack implementations.
Information About GRE IPv6 Tunnels

Overview of GRE IPv6 Tunnels

The GRE IPv6 Tunnels feature enables the delivery of packets from other protocols through an IPv6 network and allows the routing of IPv6 packets between private networks across public networks with globally routed IPv6 addresses.

For point-to-point GRE tunnels, each tunnel interface requires a tunnel source IPv6 address and a tunnel destination IPv6 address when being configured. All packets are encapsulated with an outer IPv6 header and a GRE header.

How to Implement Tunnels

Determining the Tunnel Type

Before configuring a tunnel, you must determine the type of tunnel you want to create.

**SUMMARY STEPS**

1. Determine the passenger protocol. A passenger protocol is the protocol that you are encapsulating.
2. Determine the **tunnel mode** command keyword, if appropriate.

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Determine the passenger protocol. A passenger protocol is the protocol that you are encapsulating.</td>
</tr>
<tr>
<td>Step 2</td>
<td>Determine the <strong>tunnel mode</strong> command keyword, if appropriate.</td>
</tr>
</tbody>
</table>

The table below shows how to determine the appropriate keyword to be used with the **tunnel mode** command.

**Table 55: Determining the tunnel mode Command Keyword**

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>dvmrp</td>
<td>Use the <strong>dvmrp</strong> keyword to specify that the Distance Vector Multicast Routing Protocol encapsulation will be used.</td>
</tr>
<tr>
<td>gre ip</td>
<td>Use the <strong>gre</strong> and <strong>ip</strong> keywords to specify that GRE encapsulation over IP will be used.</td>
</tr>
<tr>
<td>gre ipv6</td>
<td>Use the <strong>gre</strong> and <strong>ipv6</strong> keywords to specify that GRE encapsulation over IPv6 will be used.</td>
</tr>
<tr>
<td>ipip [ decapsulate-any ]</td>
<td>Use the <strong>ipip</strong> keyword to specify that IP-in-IP encapsulation will be used. The optional <strong>decapsulate-any</strong> keyword terminates any number of IP-in-IP tunnels at one tunnel interface. Note that this tunnel will not carry any outbound traffic; however, any number of remote tunnel endpoints can use a tunnel configured as their destination.</td>
</tr>
<tr>
<td>ipv6</td>
<td>Use the <strong>ipv6</strong> keyword to specify that generic packet tunneling in IPv6 will be used.</td>
</tr>
</tbody>
</table>
### Configuring an IPv4 GRE Tunnel

Perform this task to configure a GRE tunnel. A tunnel interface is used to pass protocol traffic across a network that does not normally support the protocol. To build a tunnel, you must define a tunnel interface on each of the two routers, and the tunnel interfaces must reference each other. At each router, the tunnel interface must be configured with a Layer 3 address. The tunnel endpoints, tunnel source, and tunnel destination must be defined, and the type of tunnel must be selected. Optional steps can be performed to customize the tunnel.

Remember to configure the router at each end of the tunnel. If only one side of a tunnel is configured, the tunnel interface may still come up and stay up (unless keepalive is configured), but packets going into the tunnel will be dropped.

### GRE Tunnel Keepalive

Keepalive packets can be configured to be sent over IP-encapsulated GRE tunnels. You can specify the rate at which keepalives are sent and the number of times that a device will continue to send keepalive packets without a response before the interface becomes inactive. GRE keepalive packets may be sent from both sides of a tunnel or from just one side.

### Before you begin

Ensure that the physical interface to be used as the tunnel source in this task is up and configured with the appropriate IP address. For hardware technical descriptions and information about installing interfaces, see the hardware installation and configuration publication for your product.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td>* Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><strong>interface type number</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config)# interface tunnel 0</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td><strong>bandwidth</strong> <em>kb/s</em>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-if)# bandwidth 1000</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>keepalive</strong> <em>[period [retries]]</em>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-if)# keepalive 3 7</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>tunnel source</strong> `{ip-address</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>tunnel destination</strong> `{hostname</td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 8</strong></td>
<td>tunnel key <em>key-number</em></td>
<td>(Optional) Enables an ID key for a tunnel interface. <strong>Note</strong> This command is supported only on GRE tunnel interfaces. We do not recommend relying on this key for security purposes.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-if)# tunnel key 1000</td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td>tunnel mode gre { ip</td>
<td>multipoint}</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Device(config-if)# tunnel mode gre ip</td>
<td></td>
</tr>
</tbody>
</table>
| **Step 10** | ip mtu *bytes* | (Optional) Sets the MTU size of IP packets sent on an interface.  
- If an IP packet exceeds the MTU set for the interface, the Cisco software will fragment it unless the DF bit is set.  
- All devices on a physical medium must have the same protocol MTU in order to operate.  
- For IPv6 packets, use the *ipv6 mtu* command. **Note** If the *tunnel path-mtu-discovery* command is enabled do not configure this command. |
| **Example:** | Device(config-if)# ip mtu 1400 |
| **Step 11** | ip tcp mss *mss-value* | (Optional) Specifies the maximum segment size (MSS) for TCP connections that originate or terminate on a router. |
| **Example:** | Device(config-if)# ip tcp mss 250 |
| **Step 12** | tunnel path-mtu-discovery [age-timer {aging-mins | infinite}] | (Optional) Enables PMTUD on a GRE or IP-in-IP tunnel interface.  
- When PMTUD is enabled on a tunnel interface, PMTUD will operate for GRE IP tunnel packets to minimize fragmentation in the path between the tunnel endpoints. |
| **Example:** | Device(config-if)# tunnel path-mtu-discovery |
| **Step 13** | end | Exits interface configuration mode and returns to privileged EXEC mode. |
| **Example:** | Device(config-if)# end |

### What to Do Next

Proceed to the “Verifying Tunnel Configuration and Operation” section.
# Configuring 6to4 Tunnels

## Before you begin

With 6to4 tunnels, the tunnel destination is determined by the border-router IPv4 address, which is concatenated to the prefix 2002::/16 in the format 2002:border-router-IPv4-address::/48. The border router at each end of a 6to4 tunnel must support both the IPv4 and IPv6 protocol stacks.

### Note

The configuration of only one IPv4-compatible tunnel and one 6to4 IPv6 tunnel is supported on a router. If you choose to configure both of these tunnel types on the same router, Cisco recommends that they not share the same tunnel source.

A 6to4 tunnel and an IPv4-compatible tunnel cannot share the same interface because both of them are NBMA “point-to-multipoint” access links, and only the tunnel source can be used to reorder the packets from a multiplexed packet stream into a single packet stream for an incoming interface. When a packet with an IPv4 protocol type of 41 arrives on an interface, the packet is mapped to an IPv6 tunnel interface on the basis of the IPv4 address. However, if both the 6to4 tunnel and the IPv4-compatible tunnel share the same source interface, the router cannot determine the IPv6 tunnel interface to which it should assign the incoming packet.

Manually configured IPv6 tunnels can share the same interface because a manual tunnel is a “point-to-point” link, and both IPv4 source and the IPv4 destination of the tunnel are defined.

## Procedure

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<thead>
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</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong> interface tunnel <strong>tunnel-number</strong></td>
<td>Specifies a tunnel interface and number and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config)# interface tunnel 0</td>
</tr>
<tr>
<td><strong>Step 4</strong> ipv6 address <strong>ipv6-prefix/prefix-length</strong> [eui-64]</td>
<td>Specifies the IPv6 address assigned to the interface and enables IPv6 processing on the interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• The 32 bits following the initial 2002::/16 prefix correspond to an IPv4 address assigned to the tunnel source.</td>
</tr>
<tr>
<td>Router(config-if)# ipv6 address 2002:c0a8:6301:1::1/64</td>
<td><strong>Note</strong> See the &quot;Configuring Basic Connectivity for IPv6&quot; module for more information on configuring IPv6 addresses.</td>
</tr>
</tbody>
</table>
### Purpose

**Command or Action**

**Step 5**

`tunnel source {ip-address | interface-type interface-number}`

**Example:**

```
Router(config-if)# tunnel source TenGigabitEthernet 4/1/0
```

**Purpose**

Specifies the source IPv4 address or the source interface type and number for the tunnel interface.

**Note**

The interface type and number specified in the `tunnel source` command must be configured with an IPv4 address.

**Step 6**

`tunnel mode ipv6ip 6to4`

**Example:**

```
Router(config-if)# tunnel mode ipv6ip 6to4
```

**Purpose**

Specifies an IPv6 overlay tunnel using a 6to4 address.

**Step 7**

`exit`

**Example:**

```
Router(config-if)# exit
```

**Purpose**

Exits interface configuration mode and returns to global configuration mode.

**Step 8**

`ipv6 route ipv6-prefix / prefix-length tunnel tunnel-number`

**Example:**

```
Router(config)# ipv6 route 2002::/16 tunnel 0
```

**Purpose**

Configures a static route to the specified tunnel interface.

**Note**

- When configuring a 6to4 overlay tunnel, you must configure a static route for the IPv6 6to4 prefix 2002::/16 to the 6to4 tunnel interface.
- The tunnel number specified in the `ipv6 route` command must be the same tunnel number specified in the `interface tunnel` command.

**Step 9**

`end`

**Example:**

```
Router(config)# end
```

**Purpose**

Exits global configuration mode and returns to privileged EXEC mode.

### What to Do Next

Proceed to the “Verifying Tunnel Configuration and Operation” section.

### Verifying Tunnel Configuration and Operation

The `show` and `ping` commands in the steps below can be used in any sequence. The following commands can be used for GRE tunnels, IPv6 manually configured tunnels, and IPv6 over IPv4 GRE tunnels.

**Step 1**

`enable`

Enables privileged EXEC mode. Enter your password if prompted.

**Example:**

```
Device> enable
```

**Step 2**

`show interfaces tunnel number [accounting]`
Two routers are configured to be endpoints of a tunnel. Device A has TenGigabit Ethernet interface 4/1/0 configured as the source for tunnel interface 0 with an IPv4 address of 10.0.0.1 and an IPv6 prefix of 2001:0DB8:1111:2222::1/64. Device B has TenGigabit Ethernet interface 4/1/0 configured as the source for tunnel interface 1 with an IPv4 address of 10.0.0.2 and an IPv6 prefix of 2001:0DB8:1111:2222::2/64.

To verify that the tunnel source and destination addresses are configured, use the `show interfaces tunnel` command on Device A.

**Example:**

```
Device A# show interfaces tunnel 0
```

```
Tunnel0 is up, line protocol is up
Hardware is Tunnel
MTU 1514 bytes, BW 9 Kbit, DLY 500000 usec,
   reliability 255/255, txload 1/255, rxload 1/255
Encapsulation TUNNEL, loopback not set
Keepalive not set
Tunnel source 10.0.0.1 (TenGigabitEthernet4/1/0), destination 10.0.0.2, fastswitch TTL 255
Tunnel protocol/transport GRE/IP, key disabled, sequencing disabled
Tunnel TTL 255
Checksumming of packets disabled, fast tunneling enabled
Last input 00:00:14, output 00:00:04, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue :0/0 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  4 packets input, 352 bytes, 0 no buffer
  Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
  8 packets output, 704 bytes, 0 underruns
  0 output errors, 0 collisions, 0 interface resets
  0 output buffer failures, 0 output buffers swapped out
```

**Step 3**  
`ping [protocol] destination`

To check that the local endpoint is configured and working, use the `ping` command on Device A.

**Example:**

```
DeviceA# ping 2001:0DB8:1111:2222::2
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:0DB8:1111:2222::2, timeout is 2 seconds:
!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/20 ms
```

**Step 4**  
`show ip route [address [mask]]`

To check that a route exists to the remote endpoint address, use the `show ip route` command.

**Example:**

```
DeviceA# show ip route 10.0.0.2
```

```
Routing entry for 10.0.0.0/24
   Known via "connected", distance 0, metric 0 (connected, via interface)
Routing Descriptor Blocks:
   * directly connected, via TenGigabitEthernet4/1/0
     Route metric is 0, traffic share count is 1
```
Step 5  ping [protocol] destination

To check that the remote endpoint address is reachable, use the ping command on Device A.

Note  The remote endpoint address may not be reachable using the ping command because of filtering, but the tunnel traffic may still reach its destination.

Example:

DeviceA# ping 10.0.0.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/21/28 ms

To check that the remote IPv6 tunnel endpoint is reachable, use the ping command again on Device A. The note regarding filtering earlier in step also applies to this example.

Example:

DeviceA# ping 2001:0DB8:1111:2222::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/20 ms

These steps may be repeated at the other endpoint of the tunnel.

---

Configuration Examples for Implementing Tunnels

Example: Configuring a GRE IPv4 Tunnel

The following example shows a simple configuration of GRE tunneling. Note that TenGigabit Ethernet interface 4/1/0 is the tunnel source for Router A and the tunnel destination for Router B. TenGigabit Ethernet interface 4/1/1 is the tunnel source for Router B and the tunnel destination for Router A.

**Router A**

```
interface Tunnel 0
ip address 10.1.1.2 255.255.255.0
  tunnel source TenGigabitEthernet 4/1/0
  tunnel destination 192.168.3.2
  tunnel mode gre ip
!
interface TenGigabitEthernet 4/1/0
  ip address 192.168.4.2 255.255.255.0
```

**Router B**

```
interface Tunnel 0
```
Configuring QoS Options on Tunnel Interfaces Examples

The following sample configuration applies GTS directly on the tunnel interface. In this example, the configuration shapes the tunnel interface to an overall output rate of 500 kb/s.

```
interface Tunnel 0
ip address 10.1.2.1 255.255.255.0
```
The following sample configuration shows how to apply the same shaping policy to the tunnel interface with the MQC commands:

```
policy-map tunnel
  class class-default
  shape average 500000 125000 125000
!
interface Tunnel 0
  ip address 10.1.2.1 255.255.255.0
  service-policy output tunnel
  tunnel source 10.1.35.1
  tunnel destination 10.1.35.2
```

**Policing Example**

When an interface becomes congested and packets start to queue, you can apply a queueing method to packets that are waiting to be transmitted. Logical interfaces—tunnel interfaces in this example—do not inherently support a state of congestion and do not support the direct application of a service policy that applies a queueing method. Instead, you must apply a hierarchical policy. Create a "child" or lower-level policy that configures a queueing mechanism, such as low-latency queueing, with the `priority` command and CBWFQ with the `bandwidth` command.

```
policy-map child
  class voice
  priority 512

Create a "parent" or top-level policy that applies class-based shaping. Apply the child policy as a command under the parent policy because admission control for the child class is done according to the shaping rate for the parent class.

```
policy-map tunnel
  class class-default
  shape average 2000000
  service-policy child

Apply the parent policy to the tunnel interface.

```
interface Tunnel 0
  service-policy tunnel
```

In the following example, a tunnel interface is configured with a service policy that applies queueing without shaping. A log message is displayed noting that this configuration is not supported.

```
Router(config)# interface tunnel1
Router(config-if)# service-policy output child
Class Based Weighted Fair Queueing not supported on this interface
```
# How to Configure IPv6 over IPv4 GRE Tunnels

## Configuring GRE on IPv6 Tunnels

GRE tunnels can be configured to run over an IPv6 network layer and to transport IPv4 and IPv6 packets in IPv6 tunnels.

### Before you begin

When GRE IPv6 tunnels are configured, IPv6 addresses are assigned to the tunnel source and the tunnel destination. The tunnel interface can have either IPv4 addresses or IPv6 addresses assigned (this is not shown in the task). The host or device at each end of a configured tunnel must support both the IPv4 and IPv6 protocol stacks.

### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| Step 1 | enable | Enables privileged EXEC mode.  
--- | --- | --- |
| Example: | Device> enable | • Enter your password if prompted. |
| Step 2 | configure terminal | Enters global configuration mode. |
| Example: | Device# configure terminal | |
| Step 3 | interface tunnel tunnel-number | Specifies a tunnel interface and number, and enters interface configuration mode. |
| Example: | Device(config)# interface tunnel 0 | |
| Step 4 | **Enter one of the following commands:**  
  - ipv6 address {ipv6-address|prefix-length|prefix-name/sub-bit|prefix-length}  
  - ipv6 address ipv6-prefix|prefix-length [eui-64] | Specifies the IPv6 network assigned to the interface and enables IPv6 processing on the interface.  
--- | --- | --- |
| Example: | Device(config-if)# ipv6 address 3ffe:b00:c18:1::3/127 | • If you specify the **eui-64** keyword, the software configures an IPv6 address for an interface and enables IPv6 processing on the interface using an EUI-64 interface ID in the low-order 64 bits of the address. |
| Step 5 | tunnel source {ip-address | ipv6-address | interface-type interface-number} | Specifies the source IPv4 address, IPv6 address, or the source interface type and number for the tunnel interface.  
--- | --- | --- |
| Example: | Device(config-if)# tunnel source Tengigabitethernet 4/1/0 | • If an interface is specified, the interface must be configured with an IPv4 address. |
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 6</strong></td>
<td>`tunnel destination {hostname</td>
<td>ip-address</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><code>Device(config-if)# tunnel destination 2001:DB8:1111:2222::1/64</code></td>
<td></td>
</tr>
</tbody>
</table>

| **Step 7** | `tunnel mode {aurp | cayman | dvmrp | eon | gre | gre multipoint | gre ipv6 | ipip [decapsulate-any] | iptalk | ipv6 | mpls | nos}` | Specifies a GRE IPv6 tunnel. Note: The `tunnel mode gre ipv6` command specifies GRE as the encapsulation protocol for the tunnel. |
| **Example:** | `Device(config-if)# tunnel mode gre ipv6` | |

| **Step 8** | `end` | Returns to privileged EXEC mode. |
| **Example:** | `Device(config-if)# end` | |

---

### Configuration Examples for IPv6 over IPv4 GRE Tunnels

#### Example: GRE Tunnel Running IS-IS and IPv6 Traffic

The following example configures a GRE tunnel running both IS-IS and IPv6 traffic between Router A and Router B:

**Router A Configuration**

```plaintext
ipv6 unicast-routing
clns routing
!
interface tunnel 0
  no ip address
  ipv6 address 3ffe:b00:c18:1::3/127
  ipv6 router isis
  tunnel source TenGigabitEthernet 4/1/0
  tunnel destination 2001:DB8:1111:2222::1/64
  tunnel mode gre ipv6
!
interface TenGigabitEthernet4/1/0
  ip address 10.0.0.1 255.255.255.0
!
router isis
  net 49.0000.0000.000a.00
```

**Router B Configuration**

```plaintext
ipv6 unicast-routing
clns routing
```
Example: Tunnel Destination Address for IPv6 Tunnel

Router(config)#interface Tunnel0
Router(config-if)#ipv6 address 2001:1:1::1/48
Router(config-if)#tunnel source TenGigabitEthernet 4/1/0
Router(config-if)#tunnel destination 10.0.0.2
Router(config-if)#tunnel mode gre ipv6
Router(config-if)#exit

Router(config)#interface TenGigabitEthernet4/1/0
Router(config-if)#ip address 10.0.0.1 255.255.255.0
Router(config-if)#exit

Router(config)#ipv6 unicast-routing
Router(config)#router isis
Router(config)#net 49.0000.0000.000a.00

How to Configure GRE IPv6 Tunnels

Configuring GRE IPv6 Tunnels

Perform this task to configure a GRE tunnel on an IPv6 network. GRE tunnels can be configured to run over an IPv6 network layer and transport IPv6 and IPv4 packets through IPv6 tunnels.

Note

You must enable IPv6 or configure IPv6 MTU size more than 1500 on a tunnel's exit interface to avoid receiving warning messages.

Before you begin

When GRE IPv6 tunnels are configured, IPv6 addresses are assigned to the tunnel source and the tunnel destination. The tunnel interface can have either IPv4 or IPv6 addresses (this is not shown in the task below). The host or device at each end of the configured tunnel must support both IPv4 and IPv6 protocol stacks.
### SUMMARY STEPS
1. `enable`
2. `configure terminal`
3. `interface tunnel tunnel-number`
4. `tunnel source {ipv6-address | interface-type interface-number}`
5. `tunnel destination ipv6-address`
6. `tunnel mode gre ipv6`
7. `end`

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><code>enable</code></td>
<td>Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Device&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

| **Step 2**        | Enters global configuration mode. |
| `configure terminal` | |
| **Example:**      | |
| Device# configure terminal | |

| **Step 3**        | Specifies a tunnel interface and number and enters interface configuration mode. |
| `interface tunnel tunnel-number` | |
| **Example:**      | |
| Device(config)# interface tunnel 0 | |

| **Step 4**        | Specifies the source IPv6 address or the source interface type and number for the tunnel interface. |
| `tunnel source {ipv6-address | interface-type interface-number}` | |
| **Example:**      | Only the syntax used in this context is displayed. For more details, see the IPv6 Command Reference. |
| Device(config-if)# tunnel source ethernet 0 | |

| **Step 5**        | Specifies the destination IPv6 address for the tunnel interface. |
| `tunnel destination ipv6-address` | |
| **Example:**      | Only the syntax used in this context is displayed. For more details, see the IPv6 Command Reference. |
| Device(config-if)# tunnel destination 2001:0DB8:0C18:2::300 | |

| **Step 6**        | Specifies a GRE IPv6 tunnel. |
| `tunnel mode gre ipv6` | |
| **Example:**      | The `tunnel mode gre ipv6` command specifies GRE as the encapsulation protocol for the tunnel interface. Only the syntax used in this context is displayed. For more details, see the IPv6 Command Reference. |
| Device(config-if)# tunnel mode gre ipv6 | |
### Configuration Examples for GRE IPv6 Tunnels

#### Example: Configuring GRE IPv6 Tunnels

The following example shows how to configure a GRE tunnel over an IPv6 transport. In this example, Ethernet0/0 has an IPv6 address, and this is the source address used by the tunnel interface. The destination IPv6 address of the tunnel is specified directly. In this example, the tunnel carries both IPv4 and IS-IS traffic.

```plaintext
interface Tunnel0
  ip address 10.1.1.1 255.255.255.0
  ip router isis
  tunnel source Ethernet0/0
  tunnel destination 2001:DB8:1111:2222::1
  tunnel mode gre ipv6

interface Ethernet0/0
  no ip address
  ipv6 address 2001:DB8:1111:1111::1/64

router isis
  net 49.0001.0000.0000.000a.00
```

### Additional References

The following sections provide references related to the GRE feature.

#### Related Documents

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<td>Cisco CMTS Cable Command Reference, at the following URL:</td>
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<tr>
<td>Configuring GRE Tunnel over Cable</td>
<td>Configuring GRE Tunnel over Cable, at the following URL:</td>
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<table>
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<tr>
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<th>MIBs Link</th>
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<tbody>
<tr>
<td>No new or modified MIBs are supported by this feature.</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://tools.cisco.com/ITDIT/MIBS/servlet/index">http://tools.cisco.com/ITDIT/MIBS/servlet/index</a></td>
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<td>RFC 2003</td>
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<td>RFC 2784</td>
<td>Generic Routing Ecapsulation (GRE)</td>
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<td>Key and Sequence Number Extensions to GRE</td>
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Technical Assistance

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<tr>
<td>The Cisco Technical Support &amp; Documentation website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

Feature Information for Generic Routing Encapsulation

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.
The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic Routing Encapsulation</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 16

Transparent LAN Service over Cable

This document describes the Transparent LAN Service (TLS) over Cable feature, which enhances existing Wide Area Network (WAN) support to provide more flexible Managed Access for multiple Internet service provider (ISP) support over a hybrid fiber-coaxial (HFC) cable network. This feature allows service providers to create a Layer 2 tunnel by mapping an upstream service identifier (SID) to an IEEE 802.1Q Virtual Local Area Network (VLAN).

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

• Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 313
• Prerequisites for Transparent LAN Service over Cable, on page 314
• Restrictions for Transparent LAN Service over Cable, on page 314
• Information About Transparent LAN Service over Cable, on page 315
• How to Configure the Transparent LAN Service over Cable, on page 317
• Configuration Examples for Transparent LAN Service over Cable, on page 320
• Verifying the Transparent LAN Service over Cable Configuration, on page 321
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• Feature Information for Transparent LAN Service over Cable, on page 323

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
Table 57: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco cBR-8 Converged Broadband Router</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
<td>Cisco IOS-XE Release 16.5.1 and Later Releases</td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Supervisor:</td>
<td>Cisco cBR-8 CCAP Line Cards:</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-250G</td>
<td>• PID—CBR-LC-8D30-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-160G</td>
<td>• PID—CBR-LC-8D31-16U30</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-CCAP-SUP-60G</td>
<td>• PID—CBR-RF-PIC</td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-SUP-8X10G-PIC</td>
<td>• PID—CBR-RF-PROT-PIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PID—CBR-CCAP-LC-40G-R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Downstream PHY Modules:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-DS-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco cBR-8 Upstream PHY Modules:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D30-US-MOD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PID—CBR-D31-US-MOD</td>
<td></td>
</tr>
</tbody>
</table>

Prerequisites for Transparent LAN Service over Cable

- You must know the hardware (MAC) addresses of the cable modems that are to be mapped to IEEE 802.1Q VLANs.
- You must create a bridge group for each separate customer on the Layer 2 bridge aggregator, so that traffic from all of the Customer Premises Equipment (CPE) devices for the customer is grouped together into the same 802.1Q tunnel.

Restrictions for Transparent LAN Service over Cable

- Configuring 802.1Q for a particular cable modem removes any previous cable modem configuration on the router.
- We strongly recommend that TLS over Cable only be used when Baseline Privacy Interface (BPI) is enabled in the environment. If BPI is not enabled when using the TLS feature, traffic can flow between multiple virtual private networks (VPNs), and become vulnerable to denial-of-service attacks or snooping.
We also recommend that remote networks be isolated with a gateway or firewall router when BPI is not enabled.

When the TLS feature is used with Layer 2 VPNs, the participating cable modems must have the Baseline Privacy Interface security feature (BPI) enabled. Otherwise, the Cisco CMTS drops such Layer 2 traffic in the upstream or downstream.

- Packets are mapped to their Layer 2 tunnel only on the basis of Layer 2 information (the cable modem’s MAC address and primary SID). Layer 3 services, such as access lists, IP address source-verify, and IP QoS, are not supported as packets are sent through the tunnel.
- All traffic from a cable modem is mapped to the same Layer 2 tunnel. It is not possible to differentiate traffic from different customer premises equipment (CPE) devices behind the cable modem.
- CPE learning is not available when using the Transparent LAN Service over Cable feature. When a cable modem is mapped to a Layer 2 tunnel, the `show interface cable modem` command shows that the IP addresses for its CPE devices are “unavailable.”
- DOCSIS QoS is supported across the Layer 2 tunnel only on the primary SID. Traffic using secondary services uses the same Layer 2 tunnel as the primary SID.
- The Spanning Tree Protocol (STP) cannot be used with devices (cable modems, their CPE devices, and the endpoint CPE devices) that are using this feature. In particular, Spanning Tree Protocol cannot be used between the VLAN bridge aggregator and the endpoint customer devices.
- The following restrictions apply to Layer 2 tunnels over an Ethernet IEEE 802.1Q VLAN interface:
  - IEEE 802.1Q tunnels are supported only on Ten Gigabit Ethernet interfaces.
  - The Cisco CMTS router supports a maximum of 4095 VLAN IDs, but the switches acting as the bridge aggregator might support a lower number of VLAN IDs. If this is the case, the Cisco CMTS should be configured only for the maximum number of VLANs that are supported by the bridge aggregator switches.

## Information About Transparent LAN Service over Cable

This section contains the following:

### Feature Overview

The Transparent LAN Service over Cable feature enables service providers to provide Layer 2 tunnels for traffic to and from cable modems. This allows customers to create their own virtual local area network (VLAN) using any number of cable modems in multiple sites.

On the Cisco CMTS, you map each cable modem (on the basis of its MAC address) to the appropriate VLAN. The CMTS then creates an internal database of this one-to-one mapping of cable modems to VLANs, and uses it to encapsulate packets for the appropriate VLAN.

The CMTS encapsulates the CPE traffic from mapped cable modems using the following method:

- IEEE 802.1Q Mapping—The cable modem’s MAC address is mapped to an IEEE 802.1Q VLAN on a specific Ten Gigabit Ethernet interface, so that all traffic from the cable modem is tagged with the specified VLAN ID.

Traffic to and from this group of cable modems is bridged into a single logical network (the VLAN) by the bridge aggregator, creating a secure Virtual Private Network (VPN) for that particular group of cable modems. Traffic in one VLAN cannot be sent into another VLAN, unless specifically done so by an external router.
The switch acting as the Layer 2 Bridge Aggregator uses the VLAN tagging to forward the traffic to the appropriate destination. This frees up service providers from needing to know the addressing, routing, and topological details of the customer’s network.

**Transparent LAN Service and Layer 2 Virtual Private Networks**

In addition, service providers can provide a Layer 2 VPN with only minimal configuration changes on the provider’s routers. The service subscriber does not need to make any changes to their private network or cable modems, nor does the service provider have to provide any special DOCSIS configuration files to enable this feature.

For the TLS feature with Layer 2 VPNs:

- When the TLS feature is used with Layer 2 VPNs, the participating cable modems must have the Baseline Privacy Interface security feature (BPI) enabled. Otherwise, the Cisco CMTS drops such Layer 2 traffic in the upstream or downstream.
- Information about Customer Premises Equipment (CPE) does not display in the output of the `show cable modem` command.

**IEEE 802.1Q Mapping**

This section describes the mapping of cable modems to an IEEE 802.1Q VLAN, as it is available in the Transparent LAN Service over Cable feature:

**Overview**

The Transparent LAN Service over Cable feature enables service providers to provide Layer 2 tunnels over an Ethernet network, using IEEE 802.1Q standard tags. This allows customers to create their own virtual network using any number of cable modems in different sites.

On the Cisco CMTS, you map each cable modem (on the basis of its MAC address) to the appropriate VLAN. The CMTS then creates an internal database of this one-to-one mapping of cable modems to VLANs, and uses it to encapsulate packets for the appropriate VLAN.

The CMTS encapsulates the CPE traffic from mapped cable modems using VLAN tags, as defined in IEEE 802.1Q-1993, IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks. The switch acting as the Layer 2 Bridge Aggregator uses the VLAN tagging to forward the packets to the appropriate destination.

Traffic to and from this group of cable modems is bridged into a single logical network by the bridge aggregator, creating a secure Virtual Private Network (VPN) for that particular group of cable modems. Traffic in one VLAN cannot be sent into another VLAN, unless specifically done so by an external router.

**Details of IEEE 802.1Q Mapping**

To implement the Transparent LAN Service over Cable feature using IEEE 802.1Q VLANs, a service provider must perform the following configuration steps:

1. Identify the cable modems and their MAC addresses that should be mapped to the IEEE 802.1Q VLANs.
2. Create the required VLANs on the router that is acting as the bridge aggregator.
3. Enable Layer 2 mapping on the Cisco CMTS, and then map each cable modem on that Cisco CMTS to the appropriate VLAN.
After the Transparent LAN Service over Cable feature has been enabled and configured to use IEEE 802.1Q mappings, the Cisco CMTS immediately begins mapping traffic between the associated cable modems and VLANs. For efficient mapping, the Cisco CMTS maintains an internal database that links each cable modem’s primary service flow ID (SFID) and service ID (SID) to the appropriate VLAN and Ethernet interface. This ensures that all service flows from the cable modem are routed properly.

When the Cisco CMTS receives a packet on an upstream, it looks up its SID to see if it is mapped to a VLAN. If so, and if the packet’s source MAC address is not the cable modem’s MAC address, the Cisco CMTS inserts the appropriate IEEE 802.1Q VLAN tag into the packet’s header and forwards the packet to the appropriate Ethernet interface. If the packet is not being mapped, or if the packet originated from the cable modem, the Cisco CMTS routes the packet using the normal Layer 3 processes.

When the Cisco CMTS receives a packet from a WAN interface that is encapsulated with an IEEE 802.1Q VLAN tag, it looks up the packet’s SID to see if it belongs to a cable modem being mapped. If so, the Cisco CMTS strips off the VLAN tag, adds the proper DOCSIS header, and transmits the packet on the appropriate downstream interface. If the packet is not being mapped, the Cisco CMTS continues with the normal Layer 3 processing.

**Benefits**

The Transparent LAN Service over Cable feature provides the following benefits to cable service providers and their partners and customers:

- Provides Layer 2 level mapping, which is transparent to Layer 3 protocols and services. This means that service providers do not need to know the details of their customers’ network topologies, routing protocols, or IP addressing.
- Allows service providers to maximize the use of their existing Ethernet WAN networks. Multiple customers can be combined on the same outgoing interface, while still ensuring that each customer’s network is kept private while it is transmitted over the tunnel.
- Provides a highly flexible and scalable solution for multiple customers. The service provider needs to create only one bridge group for each VPN, and then only one VLAN mapping for each cable modem should participate in that VPN tunnel.
- Customers retain full control over their private networks, while service providers retain full control over cable modems and the rest of the cable and WAN networks. Only the CPE traffic from the cable modems is mapped into the L2VPN tunnel, while traffic originating at the cable modem continues to be processed as normal by the service provider's network.
- Allows service providers to mix tunneled and non-tunneled cable modems on the same DOCSIS cable network.
- Allows customers to create a single, secure virtual network with Ethernet Layer 2 connectivity for multiple sites.
- Allows multiple tunnels from different customers and endpoints to be aggregated into a single bridge, so as to maximize the use of bandwidth and other network resources.
- Supports the tunneling of multiple Layer 3, non-IP protocols, and not just IP Layer 3 services, as is the case with Layer 3 solutions, such as Multiprotocol Label Switching (MPLS) VPNs.
- All DOCSIS services, including BPI+ encryption and authentication, continue to be supported for all cable modems.

**How to Configure the Transparent LAN Service over Cable**

This section contains the following:
Configuring IEEE 802.1Q VLAN Mapping

This section describes how to enable Layer 2 mapping on the Cisco CMTS, and then to map particular cable modems to an IEEE 802.1Q VLAN.

Enabling and Configuring Layer 2 Tunneling for IEEE 802.1Q Mapping

This section describes how to enable Layer 2 mapping on the Cisco CMTS, and then to map particular cable modems to IEEE 802.1Q VLANs on a Ten Gigabit Ethernet interface.

Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>cable l2-vpn-service xconnect nsi dot1q</td>
<td>Enables Layer 2 tunneling for IEEE 802.1Q VLAN mapping.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable l2-vpn-service xconnect nsi dot1q</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>cable dot1q-vc-map mac-address ethernet-interface vlan-id [cust-name]</td>
<td>Maps the specified MAC address of a cable modem to the indicated VLAN and Ten Gigabit Ethernet interface.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# cable dot1q-vc-map 0000.0C04.0506 TenGigabitEthernet4/1/0 10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>end</td>
<td>Exits global configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# end</td>
<td></td>
</tr>
</tbody>
</table>

Creating the IEEE 802.1Q VLAN Bridge Group

This section describes the minimum configuration needed to configure a Cisco router, which is acting as an IEEE 802.1Q VLAN bridge aggregator, so that it can terminate the VLANs being used with the Transparent LAN Service over Cable feature.
### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface TenGigabitEthernet slot/subslot/port</td>
<td>Enters interface configuration mode for the Ten Gigabit Ethernet interface.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface TenGigabitEthernet4/1/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> ip address ip-address mask</td>
<td>Configures the interface with the specified IP address and subnet mask.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# ip address 10.10.10.85 255.255.255.0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> exit</td>
<td>Exits interface configuration and returns to global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> interface TenGigabitEthernet slot/subslot/port.y</td>
<td>Creates a subinterface on the Ten Gigabit Ethernet interface.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface TenGigabitEthernet4/1/0.10</td>
<td></td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>To simplify network management, set the subinterface number to the same value as the VLAN ID that will use this subinterface (which in this case is 10).</td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>The steps to create a subinterface is not essential for dot1q tagging of frames, but it is recommended.</td>
</tr>
<tr>
<td><strong>Step 7</strong> bridge group number</td>
<td>Configures this subinterface to belong to the specified bridge group.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# bridge group 20</td>
<td></td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>Repeat steps Step 5 through Step 7 for each subinterface to be created and bridged.</td>
</tr>
<tr>
<td><strong>Step 8</strong> end</td>
<td>Exits interface configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# end</td>
<td></td>
</tr>
</tbody>
</table>
Configuration Examples for Transparent LAN Service over Cable

This section lists sample configurations for the Transparent LAN Service over Cable feature on a CMTS router and on a Cisco router acting as a bridge aggregator:

Example: Configuring IEEE 802.1Q VLAN Mapping

The following partial configuration shows a typical configuration that shows a number of cable modems being mapped to two different IEEE 802.1Q VLANs.

```
cable l2-vpn-service xconnect nsi dot1q
! Customer 1
cable dot1q-vc-map 000C.0e03.69f9 TenGigabitEthernet 4/1/0 10 Customer1
cable dot1q-vc-map 0010.7bea.9c95 TenGigabitEthernet 4/1/0 11 Customer1
cable dot1q-vc-map 0010.7bed.81c2 TenGigabitEthernet 4/1/0 12 Customer1
cable dot1q-vc-map 0010.7bed.9b1a TenGigabitEthernet 4/1/0 13 Customer1
! Customer 2
cable dot1q-vc-map 0002.fdfa.137d TenGigabitEthernet 4/1/0 20 Customer2
cable dot1q-vc-map 0006.28f9.9d19 TenGigabitEthernet 4/1/0 21 Customer2
cable dot1q-vc-map 000C.7b6b.58c1 TenGigabitEthernet 4/1/0 22 Customer2
cable dot1q-vc-map 000C.7bed.9dab TenGigabitEthernet 4/1/0 23 Customer2
cable dot1q-vc-map 000C.7b4a.aa7f TenGigabitEthernet 4/1/0 24 Customer2
cable dot1q-vc-map 0050.7302.3d83 TenGigabitEthernet 4/1/0 25 Customer2
...```

Example: Configuring IEEE 802.1Q Bridge Aggregator

The following example shows a router being used as a bridge aggregator to transmit VLANs across the same Ten Gigabit Ethernet interface, using IEEE 802.1Q tagging.

```
! interface TenGigabitEthernet4/1/10
  description Customer1-site10
  encapsulation dot1q 10
  bridge-group 200
! interface TenGigabitEthernet4/1/11
  description Customer1-site11
  encapsulation dot1q 11
  bridge-group 200
! interface TenGigabitEthernet4/1/12
  description Customer1-site12
  encapsulation dot1q 12
  bridge-group 200
! interface TenGigabitEthernet4/1/13
  description Customer1-site13
  encapsulation dot1q 13
  bridge-group 200
! interface TenGigabitEthernet4/1/20
  description Customer2-site20
  encapsulation dot1q 20
```
bridge-group 201
interface TenGigabitEthernet4/1/0.21
description Customer2-site21
encapsulation dot1Q 21
bridge-group 201
interface TenGigabitEthernet4/1/0.22
description Customer2-site22
encapsulation dot1Q 22
bridge-group 201
interface TenGigabitEthernet4/1/0.23
description Customer2-site23
encapsulation dot1Q 23
bridge-group 201
interface TenGigabitEthernet4/1/0.24
description Customer2-site24
encapsulation dot1Q 24
bridge-group 201
interface TenGigabitEthernet4/1/0.25
description Customer2-site25
encapsulation dot1Q 25
bridge-group 201
!
bridge 200 protocol ieee
bridge 201 protocol ieee

Verifying the Transparent LAN Service over Cable Configuration

- `show cable l2-vpn xconnect dot1q-vc-map` — Displays the mapping information of the cable modems to IEEE 802.1Q VLANs.

Following is a sample output of the command:

```
Router# show cable l2-vpn xconnect dot1q-vc-map

MAC Address   Ethernet Interface   VLAN ID  Cable Intf   SID  Customer Name/VPNID
38c8.5cac.4a62 TenGigabitEthernet4/1/2  56  Cable3/0/0  4  Customer2
38c8.5cfe.f6fa TenGigabitEthernet4/1/2  34  Cable3/0/0  3  Customer1
602a.d083.2e1c TenGigabitEthernet4/1/4  43  Cable3/0/0  5  Customer3
```

- `show cable l2-vpn xconnect dot1q-vc-map customer name` — Displays the mapping information of the cable modems to IEEE 802.1Q VLANs for the specified customer name.

Following is a sample output of the command:

```
Router# show cable l2-vpn xconnect dot1q-vc-map customer Customer1

MAC Address   Ethernet Interface   VLAN ID  Cable Intf   SID  Customer Name/VPNID
38c8.5cfe.f6fa TenGigabitEthernet4/1/2  34  Cable3/0/0  3  Customer1
```

- `show cable l2-vpn xconnect dot1q-vc-map mac-address` — Displays the mapping information of the cable modems to IEEE 802.1Q VLANs for the specified MAC address.

Following is a sample output of the command:

```
Router# show cable l2-vpn xconnect dot1q-vc-map 38c8.5cac.4a62

MAC Address   Ethernet Interface   VLAN ID  Cable Intf   SID  Customer Name/VPNID
```
show cable l2-vpn xconnect dot1q-vc-map mac-address verbose—Displays additional information about the Layer 2 mapping, including the number of packets and bytes received on the upstream and downstream.

Following is a sample output of the command:

Router# show cable l2-vpn xconnect dot1q-vc-map 38c8.5cac.4a62 verbose

MAC Address : 38c8.5cac.4a62
Customer Name : Customer2
Prim Sid : 4
Cable Interface : Cable3/0/0
Ethernet Interface : TenGigabitEthernet4/1/2
DOT1Q VLAN ID : 56
Total US pkts : 1
Total US bytes : 342
Total DS pkts : 4
Total DS bytes : 512

Additional References

Standards

<table>
<thead>
<tr>
<th>Standards</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP-RFIv1.1-I08-020301</td>
<td>Data-over-Cable Service Interface Specifications Radio Frequency Interface Specification</td>
</tr>
<tr>
<td>IEEE 802.1Q, 1998 Edition</td>
<td>IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks</td>
</tr>
</tbody>
</table>

RFCs

<table>
<thead>
<tr>
<th>RFCs 2</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 1163</td>
<td>A Border Gateway Protocol</td>
</tr>
<tr>
<td>RFC 1164</td>
<td>Application of the Border Gateway Protocol in the Internet</td>
</tr>
<tr>
<td>RFC 2233</td>
<td>DOCSIS OSSI Objects Support</td>
</tr>
<tr>
<td>RFC 2283</td>
<td>Multiprotocol Extensions for BGP-4</td>
</tr>
<tr>
<td>RFC 2665</td>
<td>DOCSIS Ethernet MIB Objects Support</td>
</tr>
<tr>
<td>RFC 2669</td>
<td>Cable Device MIB</td>
</tr>
</tbody>
</table>

2 Not all supported RFCs are listed.
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

Feature Information for Transparent LAN Service over Cable

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 58: Feature Information for Upstream Channel Bonding

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent LAN Service over Cable</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Router.</td>
</tr>
</tbody>
</table>
Downgrading Channel Bonding in Battery Backup Mode

Cisco CMTS supports downgrading the channel bonding for cable modems and media terminal adapters (MTAs) in battery backup mode.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Contents

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 325
- Prerequisites for Downgrading Channel Bonding in Battery Backup Mode, on page 326
- Restrictions for Downgrading Channel Bonding in Battery Backup Mode, on page 327
- Information About Downgrading Channel Bonding in Battery Backup Mode, on page 327
- How to Configure Downgrading Channel Bonding in Battery Backup Mode, on page 328
- Verifying the Configuration for Channel Bonding Downgrade in Battery Backup Mode, on page 330
- Additional References, on page 333
- Feature Information for Downgrading Channel Bonding in Battery Backup Mode, on page 334

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
### Table 59: Hardware Compatibility Matrix for the Cisco cBR Series Routers

<table>
<thead>
<tr>
<th>Cisco CMTS Platform</th>
<th>Processor Engine</th>
<th>Interface Cards</th>
</tr>
</thead>
</table>

### Prerequisites for Downgrading Channel Bonding in Battery Backup Mode

- The cable modem must be DOCSIS3.0-compliant with battery backup capability.
- At least one free Downstream Resilient Bonding Group (RBG) must be available.

**Note**<br>For information about how to reserve RBG and verify reserved RBG, refer to [Downstream Resiliency Bonding Group](#), on page 161
Restrictions for Downgrading Channel Bonding in Battery Backup Mode

- If the cable modem does not support the CM-STATUS events 9 and 10, channel bonding is not downgraded for the cable modem in battery backup mode.

Note

We recommend that you configure separate dynamic bonding groups for each primary channel in a MAC domain.

- If the cable modem has an active voice call, channel bonding is not downgraded for the cable modem in battery backup mode.

- If the cable modem is working on the protect line card, channel bonding is not downgraded if its primary channel is not included in the dynamic bonding group.

- If the line card switches over when the cable modem is entering or exiting the battery backup mode, the cable modem may go offline.

Information About Downgrading Channel Bonding in Battery Backup Mode

When this feature is enabled and the cable modem enters the battery backup mode, channel bonding is downgraded to one downstream and one upstream channels (battery backup 1x1 mode). This feature reduces the power usage when the cable modem is running on battery backup. When the cable modem returns to the AC power mode, the channel bonding is returned to its original configuration. You can configure this feature globally and for each MAC domain.

Note

We recommend that you enable this feature globally and for each MAC domain.

The cable modem uses the following CM-STATUS events to indicate its power status to the Cisco CMTS:

- 9—Indicates that the cable modem is operating in battery backup mode.
- 10—Indicates that the cable modem has returned to AC power mode.

When this feature is disabled, cable modem cannot downgrade the channel bonding even if it is running on battery backup.
Downgrading Channel Bonding in Battery Backup Mode

This section contains the following:

**Configuring Channel Bonding Downgrade in Battery Backup Mode Globally**

**Procedure**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> cable reduction-mode mta-battery enable</td>
<td>Enables the channel bonding downgrade for cable modems in battery backup mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# cable reduction-mode mta-battery enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> cable reduction-mode mta-battery dampen-time seconds</td>
<td>(Optional) Configures the dampen time, in seconds, to defer the cable modems from entering or exiting the channel bonding downgrade 1x1 mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# cable reduction-mode mta-battery dampen-time 40</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> cable reduction-mode mta-battery ranging-init-technique us-ranging-init-technique</td>
<td>(Optional) Configures the init-ranging technique.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# cable reduction-mode mta-battery ranging-init-technique 3</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> cable reduction-mode mta-battery dynamic-channel-percent percent</td>
<td>(Optional) Configures the maximum and first try percentage of dynamic channel bandwidth in battery backup mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# cable reduction-mode mta-battery dynamic-channel-percent 10</td>
<td><strong>Note</strong> Ensure to leave enough bandwidth for primary channel so that it can allocate dynamic channel bandwidth when it joins a newly created dynamic bonding group.</td>
</tr>
<tr>
<td><strong>Step 7</strong> exit</td>
<td>Returns to the privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# exit</td>
<td></td>
</tr>
</tbody>
</table>
# Configuring Channel Bonding Downgrade in Battery Backup Mode for MAC Domain

## Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Step 2 configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Step 3 interface wideband-cable</td>
<td>Configures a wideband cable interface.</td>
</tr>
<tr>
<td>slot/subslot/port:wideband-channel</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface wideband-cable 1/0/0:7</td>
<td></td>
</tr>
<tr>
<td>Step 4 cable ds-resiliency</td>
<td>Reserves a resiliency bonding group or WB interface for usage on a line card, on a per controller basis.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# cable ds-resiliency</td>
<td></td>
</tr>
<tr>
<td>Step 5 exit</td>
<td>Returns to the global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td>Step 6 interface cable slot/subslot/port</td>
<td>Specifies the cable interface on the router and enters the interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface cable 9/0/0</td>
<td></td>
</tr>
<tr>
<td>Step 7 cable reduction-mode mta-battery enable</td>
<td>Enables the channel bonding downgrade for cable modems in battery backup mode for each MAC domain.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# cable reduction-mode mta-battery enable</td>
<td></td>
</tr>
<tr>
<td>Step 8 cable cm-status enable 9</td>
<td>Enables the CM-STATUS event 9 for the MAC domain. The value 9 indicates that the cable modem is operating in battery backup mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# cable cm-status enable 9</td>
<td></td>
</tr>
<tr>
<td>Step 9 cable cm-status enable 10</td>
<td>Enables the CM-STATUS event 10 for the MAC domain. The value 10 indicates that the cable modem has returned to AC power mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# cable cm-status enable 10</td>
<td></td>
</tr>
</tbody>
</table>
Verifying the Configuration for Channel Bonding Downgrade in Battery Backup Mode

- **show cable modem**—Displays information if the cable modem is running in battery backup mode.

  Following is a sample output of the command:

  ```
  Router# show cable modem
  D MAC Address IP Address I/F MAC Prim RxPwr Timing Num
  I State Sid (dBmv) Offset CPE
  P f45f.d4a1.b75a --- C6/1/0/UB p-online(pt) 846 -3.50 1475 0
  N c427.9551.3489 30.154.1.12 C6/1/0/UB w-online(pt) 930 -0.50 1579 2
  Y f45f.d4a1.b762 30.55.223.253 C6/1/0/UB w-online 1770 0.00 1503 0
  Y 0016.925e.661a 30.55.230.136 C6/1/0/UB w-online 825 -0.50 1477 1
  Y 4458.2945.458a 30.0.7.72 C6/1/0/UB w-online(pt) 847 -0.50 1473 1
  N 4458.2945.401e --- C6/1/0/UB w-online(pt)(bm) 895 0.00 1481 0
  ```

- **show cable modem reduction-mode mta-battery**—Displays the channel bonding downgrade information for cable modems in battery backup mode.

  Following is a sample output of the command:

  ```
  Router# show cable modem reduction-mode mta-battery
  I/F MAC Address ID I/F RFs ID I/F Upstream
  ------ -------------- -------------- ----------------- ----------------- ------------
  C7/0/0 0025.2eaf.843e 897 Wi7/0/0:0 4 252 Wi7/0/0:1 US0
  C7/0/0 0025.2eaf.8356 897 Wi7/0/0:0 4 252 Wi7/0/0:1 US0
  C7/0/0 0015.d176.5199 897 Wi7/0/0:0 4 252 Wi7/0/0:1 US0
  ```

  Following is a sample output of the command for a cable modem when the MAC address is specified:

  ```
  Router# show cable modem 0025.2eaf.843e reduction-mode mta-battery
  I/F MAC Address ID I/F RFs ID I/F Upstream
  ------ -------------- -------------- -------------- ------------
  ```
Following is a sample output of the command for a cable modem when the IP address is specified:

```
Router# show cable modem 90.18.0.9 reduction-mode mta-battery
```

<table>
<thead>
<tr>
<th>I/F</th>
<th>MAC Address</th>
<th>ID</th>
<th>I/F</th>
<th>RFs</th>
<th>ID</th>
<th>I/F</th>
<th>Upstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7/0/0</td>
<td>0025.2eaf.843e 897 Wi7/0/0:0</td>
<td>4</td>
<td>252</td>
<td>W17/0/0:1</td>
<td>US0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Following is a sample output of the command for a cable modem when the IPv6 address is specified:

```
Router# show cable modem 2001:18::9 reduction-mode mta-battery
```

<table>
<thead>
<tr>
<th>I/F</th>
<th>MAC Address</th>
<th>ID</th>
<th>I/F</th>
<th>RFs</th>
<th>ID</th>
<th>I/F</th>
<th>Upstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7/0/0</td>
<td>0025.2eaf.843e 897 Wi7/0/0:0</td>
<td>4</td>
<td>252</td>
<td>W17/0/0:1</td>
<td>US0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **show cable modem verbose**—Displays the detailed information for the cable modem.

Following is a sample output of the command:

```
Router# show cable modem 54d4.6ffb.30fd verbose
```

| MAC Address | IP Address | IPv6 Address | Dual IP | Prim Sid | Host Interface | MD-US-SG | MD-DS-SG / MD-US-SG | MD-CM-SG | Primary Wideband Channel ID | Primary Downstream | Wideband Capable | RCP Index | RCP ID | Downstream Channel DCID RF Channel | Downstream Channel DCID RF Channel | Downstream Channel DCID RF Channel | Downstream Channel DCID RF Channel | Multi-Transmit Channel Mode | Extended Upstream Transmit Power | Upstream Channel | Ranging Status | Upstream SNR (dB) | Upstream Data SNR (dB) | Received Power (dBmV) | Reported Transmit Power (dBmV) | Peak Transmit Power (dBmV) | Phy Max Power (dBmV) | Minimum Transmit Power (dBmV) | Timing Offset (97.6 ns) | Initial Timing Offset | Rng Timing Adj Moving Avg (0.381 ns) | Rng Timing Adj Lt Moving Avg | Rng Timing Adj Minimum | Rng Timing Adj Maximum | Pre-EQ Good | Pre-EQ Scaled | Pre-EQ Impulse |
|------------|------------|-------------|---------|----------|----------------|----------|----------------------|---------|--------------------------|----------------|-----------------|-----------|---------|----------------|--------------------------|--------------------------|--------------------------|----------------|----------------|------------------|----------------|----------------|------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
Downgrading Channel Bonding in Battery Backup Mode

Verifying the Configuration for Channel Bonding Downgrade in Battery Backup Mode

Pre-EQ Direct Loads : 0 0
Good Codewords rx : 515 472
Corrected Codewords rx : 0 0
Uncorrectable Codewords rx : 0 0
Phy Operating Mode : atdma* atdma*
sysDescr :
Downstream Power : 0.00 dBmV (SNR = ----- dB)
MAC Version : DOC3.0
QoS Provisioned Mode : DOC1.1
Enable DOCSIS2.0 Mode : Y
Modem Status : (Modem= w-online, Security=disabled)
Capabilities : (Frag=N, Concat=N, PHS=Y)
Security Capabilities : (Priv=, EAE=Y, Key_len=)
L2VPN Capabilities : (L2VPN=N, eSAFE=N)
Sid/Said Limit : (Max US Sids=16, Max DS Sids=15)
Optional Filtering Support : (Taps/Symbol= 1, Num of Taps= 24)
Number of CPE IPs : 0(Max CPE IPs = 16)
CFG Max-CPE : 200
Flaps : 0()
Errors : 0 CRCs, 0 HCSes
Stn Mtn Failures : 0 aborts, 0 exhausted
Total US Flows : 1(1 active)
Total DS Flows : 1(1 active)
Total US Data : 7 packets, 2006 bytes
Total US Throughput : 0 bits/sec, 0 packets/sec
Total DS Data : 5 packets, 1202 bytes
Total DS Throughput : 0 bits/sec, 0 packets/sec
LB group ID assigned (index) : 2151416065 (48131)
LB group ID in config file (index) : N/A (N/A)
LB policy ID : 0
LB policy ID in config file : 0
LB priority : 0
Tag :
Required DS Attribute Mask : 0x0
Forbidden DS Attribute Mask : 0x0
Required US Attribute Mask : 0x0
Forbidden US Attribute Mask : 0x0
Service Type ID :
Service Type ID in config file :
Active Classifiers : 2 (Max = NO LIMIT)
CM Upstream Filter Group : 0
CM Downstream Filter Group : 0
CPE Upstream Filter Group : 0
CPE Downstream Filter Group : 0
DSA/DSX messages : permit all
Voice Enabled : NO
CM Energy Management Capable : Y
CM Enable Energy Management : Y
CM Enter Energy Management : No
Battery Mode : Yes
Battery Mode Status : BATTERY_MODE / AC_POWER_MODE
DS Change Times : 0
Boolean Services : 2
Number of Multicast DSIDs Support : 16
MDF Capability Mode : 2
IGMP/MLD Version : MLDv2
FCType10 Forwarding Support : Y
Features Bitmask : 0x0
Total Time Online : 2h12m (2h12m since last counter reset)
CM Initialization Reason : NO_PRIM_SF_USCHAN
CFG Max IPv6 CPE Prefix : 16 (~1 used)
Battery Mode indicates if the cable modem is in battery backup mode or AC power mode.

Battery Mode Status indicates the status of the cable modem:

- When the cable modem is in AC_POWER_MODE/BATTERY_MODE status, it is in stable state.
- When the cable modem is in AC_POWER_PENDING/BATTERY_PENDING status, it is in transfer state.
- When the cable modem is in AC_POWER_HOLD/BATTERY_HOLD status, it is updating status of the last event received until the dampen time expires.

• `show cable modem cm-status`—Displays the cable modem CM-STATUS event information.

Following is a sample output of the command:

```plaintext
Router# show cable modem e448.c70c.9d80 cm-status

I/F  MAC Address  Event           TID  Count  Error  Dups  Time
C6/0/3/UB e448.c70c.9d80 Battery backup 14  1   0   0  Apr 2 22:17:29
  e448.c70c.9d80 A/C power    1  1   0   0  Apr 2 22:43:52
```

**Additional References**

**Related Documents**

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMTS commands</td>
<td>Cisco CMTS Cable Command Reference</td>
</tr>
</tbody>
</table>

**Standards and RFCs**

<table>
<thead>
<tr>
<th>Standard/RFC</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM-SP-MULPIv3.1-101-131029</td>
<td>Data-Over-Cable Service Interface Specifications, DOCSIS 3.1, MAC and Upper Layer Protocols Interface Specification</td>
</tr>
</tbody>
</table>
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
<tr>
<td>documentation and tools for troubleshooting and resolving technical issues</td>
<td></td>
</tr>
<tr>
<td>with Cisco products and technologies.</td>
<td></td>
</tr>
<tr>
<td>To receive security and technical information about your products, you can</td>
<td></td>
</tr>
<tr>
<td>subscribe to various services, such as the Product Alert Tool (accessed from</td>
<td></td>
</tr>
<tr>
<td>Field Notices), the Cisco Technical Services Newsletter, and Really Simple</td>
<td></td>
</tr>
<tr>
<td>Syndication (RSS) Feeds.</td>
<td></td>
</tr>
<tr>
<td>Access to most tools on the Cisco Support website requires a Cisco.com user</td>
<td></td>
</tr>
<tr>
<td>ID and password.</td>
<td></td>
</tr>
</tbody>
</table>

Feature Information for Downgrading Channel Bonding in Battery Backup Mode

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Backup 1x1 Mode</td>
<td>Cisco IOS XE Everest 16.6.1</td>
<td>This feature was introduced in the Cisco IOS XE Everest 16.6.1 on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 18

Upstream Bonding Support for D-PON

The DOCSIS Passive Optical Network (D-PON) architecture, also known as RF over Glass (RFoG), helps the cable operators enter fiber-to-home market space and utilize the DOCSIS infrastructure effectively.

- Hardware Compatibility Matrix for the Cisco cBR Series Routers, on page 335
- Prerequisites for Upstream Bonding Support for D-PON, on page 336
- Restrictions for Upstream Bonding Support for D-PON, on page 336
- Information About Upstream Bonding Support for D-PON, on page 337
- How to Configure Upstream Bonding Support for D-PON, on page 338
- Verifying the Upstream Bonding Support for D-PON, on page 340
- Additional References, on page 341
- Feature Information for Upstream Bonding Support for D-PON, on page 341

Hardware Compatibility Matrix for the Cisco cBR Series Routers

Note

The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.
### Prerequisites for Upstream Bonding Support for D-PON

- DOCSIS 3.0 cable modems (CMs)
- DOCSIS 2.0 capable set-top boxes (STBs)
- You should configure the `cable upstream ranging-init-technique 2` command to prevent the use of additional broadcast initial ranging opportunities for the non D-PON reference upstream channels.

### Restrictions for Upstream Bonding Support for D-PON

- Multiple CMs cannot work at the same time. Each CM must get a separate time slot for upstream data transmission. Configuring D-PON ensures that the upstream scheduler allows only a single CM to transmit at a particular time.
- cBR8 does not support Upstream Bonding for D-PON on Remote-PHY.
- It is possible to enable or disable D-PON for individual Mac domain.
• When D-PON is enabled in a MAC domain, you must manually shut down and enable the MAC domain using `shutdown` and `no shutdown` command.

• All frequencies in a MAC domain must have the same configuration for:
  • minislot size
  • channel-width
  • modulation profile

• Supports only ATDMA DOCSIS mode.

• The following features are not supported in MAC domains configured for D-PON:
  • Load balancing
  • Spectrum management
  • Upstream configuration (to change upstream configuration, you should shut down the MAC domain)
  • S-CDMA logical channels
  • Lower modulations profiles (D-PON uses only 16 QAM and 64 QAM modulation profiles)
  • Channel-width other than 3.2 MHz and 6.4 MHz
  • In-service Software Upgrade (ISSU)
  • Mixing of D-PON and HFC on the same MAC domain
  • Software licensing

---

Information About Upstream Bonding Support for D-PON

D-PON is a type of networking that allows the CMTS to transmit RF signals over the optical network. This technology enables the cable operators to use the RF technologies in a Hybrid Fiber-Coaxial (HFC) network.

The downstream data from the CMTS is combined with other RF signals at the hub and is sent to the transmitter. The signal from the transmitter is intended for multiple PONs. Each PON serves 32 homes from a single fiber.

The upstream data from the Optical Network Terminal (ONT) is combined at the splitter and sent to the hub, which is then routed to the optical receiver (RX). Upstream data from multiple optical receivers are combined and sent to the CMTS.

The upstream data to the CMTS contains signals from multiple PONs. Each upstream optical receiver is dedicated to a PON that can have multiple DOCSIS upstream sources (multiple modems and DSG terminals).

A PON can be configured in different ways, depending on the coaxial network. These configurations broadly fall under the following categories:

• Internal Control Configuration—In this configuration, the internal CM of the ONT controls the laser. Upstream signals go to the Ethernet interface of the CM allowing the ONT to control upstream timing. The device that uses this type of configuration is the Digital Audio Visual Council (DAVIC) set top terminal (STT).
• External Control Configuration—In this configuration, the presence of the RF at the ONT upstream input activates the laser. The device that uses this type of configuration is the DOCSIS Set-top Gateway (DSG) device.

• Dual Control Configuration—In this configuration, the home that contains an ONT with and internal CM and other DOCSIS upstream sources, like DSG devices. The RF presence detector or the internal CM control line detects the upstream signal and activates the upstream laser.

### D-PON on Upstream Scheduling

In D-PON implementation, the native upstream scheduling software of the CMTS controls the timing of the upstream data transmission. Only one PON Receiver Domain (PRD) is allowed to transmit upstream data at any given point of time, irrespective of the upstream frequency allocation. The reason for this is that two lasers from the ONT of a PRD cannot work simultaneously as it leads to an Optical Beat Interference (OBI). Moreover, the use of a frequency modulation (FM) for and upstream signal transmission results in PHY errors when multiple ONTs within a PON transmits simultaneously.

Initial maintenance regions are scheduled on all upstream channels to prevent the DOCSIS 3.0 CMs in a D-PON environment from failing initial ranging on any upstream channel. When a ranging request is received within a MAC domain configured for D-PON, the CM receives an upstream channel override to the D-PON reference channel (US0).

In this implementation of D-PON, a DOCSIS device within a PRD is given a timeslot to transmit the upstream data, irrespective of the upstream frequency. Therefore, there is no benefit in having more than one upstream in a MAC domain without using the upstream channel bonding feature.

The D-PON feature supports the following service types:
  • Best effort (BE) 3.0 using up to four frequencies concurrently
  • BE 2.0 using only a single frequency
  • Unsolicited grant service (UGS) using only a single frequency
  • Real-time polling service (RTPS) using only a single frequency
  • Non-real-time polling service (nRTPS) using only a single frequency

### How to Configure Upstream Bonding Support for D-PON

This section describes how to enable D-PON for a MAC domain on the Cisco cBR router. The bonding group must include a reference channel which is default to the upstream channel 0.
The USCB can support a maximum of 4 US channels in a RFOG MAC domain in the following combination:

- US0
- US0, US1
- US0, US1, US2
- US0, US1, US2, US3

All US channels must be configured to have the same number of minislots, channel width (only 3.2 and 6.4 MHz supported), DOCSIS mode (only ATDMA supported) and modulation profile.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode. Enter your password if prompted.</td>
</tr>
<tr>
<td>Example: Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface cable slot/subslot/cable-interface-index</td>
<td>Enters interface configuration mode for the specified cable interface.</td>
</tr>
<tr>
<td>Example: Router(config)# interface cable 8/0/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> cable upstream dpon</td>
<td>Enables D-PON for a MAC domain.</td>
</tr>
<tr>
<td>Example: Router(config-if)# cable upstream dpon</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> shutdown</td>
<td>Shuts down the interface.</td>
</tr>
<tr>
<td>Example: Router(config-if)# shutdown</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> no shutdown</td>
<td>Enables the interface.</td>
</tr>
<tr>
<td>Example: Router(config-if)# no shutdown</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> end</td>
<td>Exits interface configuration mode and returns to the privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Router(config-if)# end</td>
<td></td>
</tr>
</tbody>
</table>
DOCSIS 3.0 Cable Modems Upstream Bonding Enters Partial Bonding

Sometimes, upstream bonding enters partial bonding while reverting to the original CLC after switchover.

In the following example, the switchover is performed between CLC in slot 1 and 0. After reverting to CLC in slot 1, C1/0/3/UB turns to C1/0/3/p. The following output highlights the change:

```
Router# show cable modem
Load for five secs: 1%/0%; one minute: 2%; five minutes: 2% Time source is NTP, 13:00:25.570 UTC Thu Feb 18 2016
MAC Address IP Address I/F MAC Prim RxPwr Timing Num I D
4844.8789.e0fc 10.78.100.6 C1/0/0/UB w-online 6 -0.50 1787 0 N
c8fb.2639.33d0 10.78.100.7 C1/0/1/UB w-online 1 -1.00 1793 0 N
4844.8789.e10e 10.78.100.10 C1/0/2/UB w-online 1 -0.50 1784 0 N
602a.d0a2.9b3e 10.78.100.11 C1/0/3/p w-online 4 1.50 1789 0 N
0025.2ecf.f922 10.78.100.8 C1/0/4/UB w-online 1 -1.00 1788 0 N
```

This partial bonding can be recovered using the `shutdown` and `no shutdown` commands on the related upstream port under the controller. The following is a sample configuration:

```
Router(config)# controller Upstream-Cable 1/0/3
Router(config-controller)# us-channel 0 shutdown
Router(config-controller)# no us-channel 0 shutdown
```

Verifying the Upstream Bonding Support for D-PON

To verify the upstream scheduler output for a MAC domain configured with D-PON, use the `show interface cable mac-scheduler` command.

```
Router# show interface cable 8/0/0 mac-scheduler 1
DOCSIS 1.1 MAC scheduler for Cable8/0/0/U1 : rate 30720000
wfg=None
us_balance:OFF
dpon_mode:ON
fairness:OFF
Queue[Rng Polls] flows 0
Queue[CIR Grants] flows 0
Queue[BE(07) Grants] flows 0
Queue[BE(06) Grants] flows 0
Queue[BE(05) Grants] flows 0
Queue[BE(04) Grants] flows 0
Queue[BE(03) Grants] flows 0
Queue[BE(02) Grants] flows 0
Queue[BE(01) Grants] flows 0
Queue[BE(00) Grants] flows 0
Req Slots 1824595508, Req/Data Slots 10640906
Init Mtn Slots 89924653, Stn Mtn Slots 989543
Short Grant Slots 0, Long Grant Slots 0
Adv Phy Short Grant Slots 538, Adv Phy Long Grant Slots 219831
Adv Phy UGS Grant Slots 0
```
Additional References

The following sections provide references related to the Upstream Bonding Support for D-PON feature.

Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prisma D-PON</td>
<td>Cisco Prisma D-PON</td>
</tr>
</tbody>
</table>

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</td>
<td><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></td>
</tr>
<tr>
<td>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</td>
<td></td>
</tr>
<tr>
<td>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td></td>
</tr>
</tbody>
</table>

Feature Information for Upstream Bonding Support for D-PON

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream Bonding Support for D-PON</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
CHAPTER 19

Energy Management Mode

Data-over-Cable Service Interface Specifications (DOCSIS) cable modems (CM) and CMTS support a low power energy mode referred to as the Energy Management 1x1 (EM) mode. During idle times, when the data rate demand of a user is met by the available capacity on a single upstream and downstream channel pair to which it is assigned, the CM switches to the Energy Management 1x1 mode. When the CM requires a higher data rate than that can be reliably provided on the single channel pair, the CMTS instructs the CM to return to the larger transmit and receive channel set.

Contents

• Information About Energy Management Mode, on page 343
• Prerequisites for Energy Management Mode, on page 347
• Restrictions for the Energy Management Mode, on page 347
• How to Configure the Energy Management Mode, on page 350
• Verifying the Energy Management Mode, on page 351
• Feature Information for Energy Management Mode, on page 354

Information About Energy Management Mode

The following sections provide more information about the Energy Management mode.

Note

DOCSIS 3.1 CM’s do not support the Energy Management mode in cBR-8 routers.

Dynamic Downstream Bonding Group

To support the Energy Management 1x1 (EM) mode feature, CMTS selects an upstream and a downstream channel pair for CM. The downstream and upstream channel assigned to the CMs should be available. If CMTS selects a channel that is not available, the downstream bonding channel might fail.

To simplify the process, CMTS chooses the 1x1 bonding group for the CM according to the following rules:

• For upstream, it chooses the highest actual amiable bandwidth channel from the upstream channels currently used by the CM.

• For downstream, CMTS chooses the current primary downstream channel used by the CM.
• If the CM is online with channel bonding 1xN or Nx1, and requests to enter into the EM mode, CMTS does not change the upstream and the downstream channel if the original channel bonding is 1 and the Quality of Service (QoS) parameter is not updated.

• CMTS checks the existing dynamic bonding groups (DBG), for an exact match in the target channel.
  • If found, CMTS uses this bonding group to instruct the CM to enter into EM mode.
  • If there is no available DBG and there is an unused DBG, CMTS adds the primary channel into the unused DBG and instructs the CM to enter the EM mode.
  • If there is no available DBG and no unused DBG, CMTS logs a warning to notify you that a new DGB should be configured.

Flow Chart of the CM Power State

The following figure shows the flow chart of the CM power state:
Interaction with the Battery Mode

Energy management mode is similar to battery mode as they both enter the 1x1 mode to save power. But, both have a different purpose to enter the 1x1 mode, so there are some differences in their behavior. The purpose of EM mode is to save power when the traffic is low, and it has minimum impact on the normal service. The purpose of the battery mode is to try to guarantee the voice service, especially the 911 call service, for which it may drop other services, if necessary.

The table below describes the behavior difference between energy management mode and battery mode.
**Interaction with the Battery Mode**

<table>
<thead>
<tr>
<th></th>
<th>Energy Management (EM) Mode</th>
<th>Battery Mode (BM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QoS</td>
<td>Minimum reserved rate service up to 200k.</td>
<td>No minimum reserved rate.</td>
</tr>
</tbody>
</table>
| Multicast                 | • IGMP request is guaranteed.  
                            • If the CM has joined the Internet Group Management Protocol (IGMP) groups, CMTS rejects the EM request to enter the EM mode and keeps the CM in the IGMP groups.  
                            • If the CM is in the EM mode and IGMP join request is received, CMTS instructs the CM to leave the EM mode.  
                            • If the CM has joined IGMP groups and CMTS receives a CM-STATUS event with code 9, CMTS lets the CM leave the IGMP group.  
                            • If the CM is in the BM, CMTS rejects the IGMP join request from the CM. |  

BM has higher priority than the EM mode. If a CM is already in EM mode and a power off occurs, CM enters into the BM. After the power is restored, the CM returns to the normal mode, and if the traffic is lower than the threshold, it re-enters the EM mode. The CM does not directly transfer from the BM to the EM mode.

The interaction between the battery mode and the energy management mode is illustrated in the figure below:

*Figure 5: Interaction Between the BM and the EM Modes*

1. When the CM is in normal mode and CMTS receives a request to enter the EM mode, CMTS instructs the CM to enter the EM mode with downstream bonding channel (DBC).
2. When the CM is in EM mode and CMTS receives a request to leave the EM mode, CMTS instructs the CM to leave the EM mode to normal mode with DBC.
3. When the CM is in normal mode and CMTS receives a message: CM operating on battery backup, CMTS instructs the CM to enter the BM mode with DBC.
4. When the CM is in BM mode and CMTS receives a message: CM operating on AC power, CMTS instructs the CM to leave the BM mode to normal mode with DBC.
5. When the CM is in EM mode and CMTS receives a message: CM operating on battery backup, CMTS
instructs the CM to enter the BM mode with service flow re-admin.
6. When the CM is in BM mode and CMTS receives a request to enter EM mode, CMTS waits until it
receives the message: CM operating on AC power. It then instructs the CM to return to normal mode.

Handling Energy Management Request Load

When many CMs send EM requests at the same time, such as at the beginning or end of work hours, the traffic
soars or slumps in a very short period and causes heavy load for CMTS. A throttle mechanism is adopted to
avoid such load surge for CMTS.

The line card EM process defines a variable that indicates the current transactions handled by the process.
When an energy management request is received and the maximum number of transactions is not met, CMTS
handles this request and updates the counter of current transactions. When the maximum number of transactions
is met, CMTS sends a temporary reject response. After a transaction is over or a CM goes offline, the counter
of current transactions is updated.

Supervisor High Availability and Line Card Switchover

Energy Management feature supports supervisor high availability and line card switchover with limitations.
The active supervisor or line card syncs the EM mode data of a CM to the standby SUP or protected line card
when the CM enters a stable EM status. When a CM enters or leaves the EM mode with an ongoing DBC
process, the supervisor high availability or line card switchover causes the CM to enter into an offline or
online status.

Prerequisites for Energy Management Mode

To enable the energy management mode, you must configure resiliency bonding group (RBG) and dynamic
bonding group.

Restrictions for the Energy Management Mode

Restrictions for CMTS High Availability

• If there is no DBG available, CMTS cannot create a new DBG on the protected line card and CMs cannot
  enter the EM mode.

• Line card switchover is not supported when the CM enters the EM mode from the normal mode or exits
  the EM mode to the normal mode.

• To reduce the operation of the EM mode, the information about the EM status is not synced with the
  protected line card. Hence, the EM status is cleared after the line card high availability.
Restrictions for Dynamic Bonding Group

To support the EM feature, CMTS configures separate DBG for each primary channel in each MAC domain. For example, if a MAC domain has eight primary channels, it will create eight DBGs for the MAC domain. This ensures that the EM does not fail due to lack of DBGs.

Restrictions for Interaction of CMTS with Other Features

The following sections describe the restrictions for CMTS interaction with other features.

Voice

If a voice call is in progress, CMTS does not instruct the CM to enter into the EM mode.

When the CM is in the EM mode, and it receives a voice call, it adds a dynamic Unsolicited Grant Service (UGS) or Unsolicited Grant Service with activity detection (UGS-AD) service flow. During the voice call, the CM does not exit from the EM mode irrespective of the flow of traffic. Voice service is given the highest priority.

Dynamic Bonding Change and Dynamic Channel Change and Related Applications

In D2.0 and D3.0 load-balance (static and dynamic), CM is not moved by load-balance when it is in EM mode.

For RF-adapt, CM is not relocated to an alternate logical channel by the RF-adapt when it is in EM mode.

Multicast

- When the CM is in a multicast group, CMTS would reject the EM request for both bonded and non-bonded multicast cases.
- When the CM is in EM state and a multicast join request is received, CMTS discards this join request and forces the CM to exit the EM mode.
- When the CM is in EM state and a voice call is in progress, and a new multicast join request is received, CMTS discards this join request and does not force the CM to exit the EM mode since the voice call is in progress.
- There is a threshold for currently handled transactions. When there is multicast join request and the maximum transaction threshold has been reached, CMTS cannot instruct the CM to exit the EM mode. The multicast join is also be denied until the CM can exit the EM mode.
- When the CM is in EM mode and needs to join PacketCable Multimedia (PCMM) multicast, you should send a GateSet request twice, so that the gate can be set up successfully. The first GateSet request only forces the modem to exit the EM mode, but does not set up the gate.

Committed Information Rate

If the QoS is defined by the Minimum Reserved Rate service flow QoS parameter in excess of 200 kbps, when the CM enters into the EM mode, CMTS only provides 200 kbps as the minimum reserved rate. If the minimum reserved rates is less than 200 kbps, CMTS schedules the minimum reserved rate according to the service flow configuration when the CM enters into the EM mode.

CMTS records the Minimum Reserved Rate service flow QoS parameter when the CM enters into the EM mode. When the CM exits the EM mode, CMTS uses the original parameter.
When the CM enters the EM mode, it selects one of the CM upstream channels. If the service flow is completely on that upstream channel, the service flow parameter is not changed. This behavior is because the service flow is not moved into the DBC operation, and the change of the service flow parameter has no benefit.

**Admission Control**

When a request is received to exit the EM mode and recovery to the original wideband interface is restricted due to an admission control failure, CMTS forces the CM to go offline and re-register to prevent it from getting stuck in the EM mode. In such a case, CMTS logs a warning message.

**Battery Mode**

When CMTS receives the status of the CM as operating on battery power, CMTS instructs the CM to enter into the BM. If the CM rejects the instruction received, CMTS keeps the modem in normal status.

When the CM is in BM and CMTS receives the status of the CM as operating on A/C power, CMTS instructs the CM to exit the BM. If the CM rejects the instruction received, CMTS forces the CM to go offline to prevent it from getting stuck in the battery mode. In such a case, CMTS logs a warning message.

**Attribute Mask**

When selecting an upstream or a downstream channel pair for energy management mode, CMTS selects channels that meet the requirements of the attribute masks for the existing service flows for the corresponding CM.

In some cases, adherence to the service flow attribute-based assignment may not be possible when selecting an upstream and downstream channel pair for energy management mode of operation. To resolve this conflict, CMTS supports one or both of the following approaches:

1. CMTS may require strict adherence to the required and forbidden attribute masks and thus deny entry into the EM mode if these masks cannot be met by the available individual channels in the MD-CM-SG.

2. CMTS may allow the CM to enter the EM mode while not meeting all the criteria for the attribute masks. In this case, CMTS logs a warning event notifying that the attribute masks are not maintained.

For the following case, CMTS supports approach two:

When the CM is instructed to enter into the EM mode and the selected target upstream and downstream channels do not adhere to the service flow attribute mask. For this conflict CMTS instructs the modem to enter into the EM mode. CMTS also logs a warning message to notify this conflict.

**Dynamic Service Addition**

When the CM is in EM mode, DSA request can still be set up even if the requested attributes cannot be met with a single channel. In order to not effect voice services, the CM is not forced to exit the EM mode.

**Restrictions for Configuration Change and Interface Shutdown**

1. **Shutdown of the upstream channel**—Shutdown of the upstream channel recalculates the MD-US-SG-ID and assigns a new MD-US-SG-ID. In this case, the CM is not offline and internal data structure of the CM instance is not updated. DBC operation checks the MD-US-SG-ID, so when the CM enters into the EM mode there is a mismatch between the MD-US-SD-ID on the CM and the new MD-US-SG-ID. Hence, DBC fails and the CM cannot get into the EM mode.
2. Change in Upstream Service Group makes the CM in EM mode go offline—The US-SG configuration change blocks the DBC behavior and the CM gets stuck in the EM mode. To avoid this scenario, when there is a change in the Upstream Service Group (US-SG), such as shutdown or no shutdown of the upstream channels, CMTS makes the CM go offline. The CM should re-register as a normal CM with the wideband channel bonding including multiple channels.

3. Modify the original wideband interface—When the CM is in EM mode, change in the original wideband interface channels on the CM makes the CM go offline and re-register as a normal CM.

4. Disable or enable feature—When you disable this feature, CMTS does not force CMs to exit from the EM mode unless CMs sends a request. CMTS does not accept EM requests after the EM feature is disabled from the CLI.

How to Configure the Energy Management Mode

This section describes how to configure the energy management feature on the Cisco cBR-8.

Contents

Enabling Energy Management Mode

To enable the energy management mode, complete the following procedure:

```plaintext
configure terminal
cable reduction-mode energy-management enable
```

Verifying the Energy Management Mode

- To verify if the CM is in EM mode, use the `show cable modem` command. If the cable modem is working in energy management mode, the MAC state is displayed with an "em" flag.

```plaintext
show cable modem
```

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>IP Address</th>
<th>I/F</th>
<th>MAC Prim RxPwr</th>
</tr>
</thead>
<tbody>
<tr>
<td>7cb2.1b0f.ea72 40.4.58.4</td>
<td>C7/0/0/UB</td>
<td>w-online(em)</td>
<td>2 0.00</td>
</tr>
<tr>
<td>54d4.6ff8.2f6b 40.4.58.24</td>
<td>C7/0/0/UB</td>
<td>w-online</td>
<td>3 -0.50</td>
</tr>
<tr>
<td>0025.2ed9.9a22 40.4.58.3</td>
<td>C7/0/0/UB</td>
<td>w-online</td>
<td>4 0.50</td>
</tr>
</tbody>
</table>

- To verify which CM is in EM mode and to get the original wideband and upstream channel information, use the `show cable modem reduction-mode energy-management-mode` command.

```plaintext
show cable modem reduction-mode energy-management-mode
```

<table>
<thead>
<tr>
<th>I/F</th>
<th>MAC Address</th>
<th>Orig BG</th>
<th>Orig US</th>
<th>Curr BG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C7/0/0</td>
<td>0025.2ed9.9a22 897</td>
<td>Wi7/0/0:0</td>
<td>0x3B 4 252</td>
<td>Wi7/0/0:1 US0</td>
</tr>
</tbody>
</table>
Enabling Energy Management Mode per MAC Domain

CMTS supports the EM feature when enabled both globally and per MAC domain. Use the following procedure to enable energy management feature per MAC domain.

To enable the EM mode per MAC domain, complete the following procedure:

```markdown
configure terminal
interface cable slot/subslot/cable-interface-index
cable reduction-mode energy-management enable
```

Configuring Initialization Ranging Technique in Dynamic Bonding Channel

The default value for the technique in init-ranging is set to 1 and the valid range is 1-4.

To configure the technique in init-ranging, complete the following procedure:

```markdown
configure terminal
cable reduction-mode energy-management ranging-init-technique value
```

Configuring the Percentage for the Dynamic Channel Bandwidth

Make sure that you leave enough bandwidth for the primary channel so that it can allocate dynamic channel bandwidth when it joins to a newly created DBG. The default percentage value is set to 5 and the valid range is 1-96.

To configure the percentage of dynamic channel bandwidth, complete the following procedure:

```markdown
configure terminal
cable reduction-mode energy-management dynamic-channel-percent value
```

Configuring the Queue Size for Energy Management

The default value for the queue size is set to 150 and the valid range is 50-10000.

To set the queue size of the energy management requests, complete the following procedure:

```markdown
configure terminal
cable reduction-mode energy-management process-queue-size value
```

Verifying the Energy Management Mode

This section describes how to verify the EM mode.
Viewing the Basic Statistics for Energy Management Receive Request

To view the basic statistics for all energy management receive request events for a specific CM, use the `show cable modem <cable if | mac_addr | ip_addr> reduction-mode energy-management-status` command.

```
show cable modem c8/0/0 reduction-mode energy-management-status
```

<table>
<thead>
<tr>
<th>I/F</th>
<th>MAC Address</th>
<th>Event</th>
<th>TID</th>
<th>Count</th>
<th>Error</th>
<th>Dups</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>C8/0/0</td>
<td>54d4.6ffb.2e21</td>
<td>Enter EM mode</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Jul 16 21:38:18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exit EM mode</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>Jul 16 21:38:39</td>
</tr>
<tr>
<td>C8/0/0</td>
<td>602a.d07c.4ec6</td>
<td>Enter EM mode</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Jul 16 21:40:57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exit EM mode</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Jul 16 21:41:17</td>
</tr>
</tbody>
</table>

To clear the basic receive statistics for all EM_REQ events for a specified CM, use the `clear cable modem <cable if | mac_addr | ip_addr> em-status` command.

Verifying the Configuration Parameters

To verify the configuration parameters used in the CM configuration file, use the `show cable modem <mac address> reduction-mode energy-management-param` command.

```
show cable modem 54d4.6ffb.2e21 reduction-mode energy-management-param
```

```
Energy Management feature enable : Y
DS entry bitrate threshold(bps) : 100000
DS entry time threshold(s) : 120
DS exit bitrate threshold(bps) : 200000
DS exit time threshold(s) : 2
US entry bitrate threshold(bps) : 100000
US entry time threshold(s) : 120
US exit bitrate threshold(bps) : 200000
US exit time threshold(s) : 2
cycle period(s) : 300
```

Viewing Information Regarding a Cable Modem

To view all the information regarding a CM, use the `show cable modem mac address verbose` command.

```
show cable modem 54d4.6ffb.30fd verbose
```

```
MAC Address : 54d4.6ffb.30fd
IP Address  : 40.4.58.14
Dual IP     : Y
Prim SId    : 9
Host Interface : C7/0/0/UB
MD-DS-SG / MD-US-SG : 1 / 1
MD-CM-SG    : 0x3C0101
Primary Wideband Channel ID : 897 (W17/0/0:0)
Primary Downstream : In7/0/0:2 (RfId : 722)
Wideband Capable : Y
RCP Index    : 3
RCP ID       : 00 10 00 00 08
Downstream Channel DCID RF Channel : 99 7/0/0:2
Downstream Channel DCID RF Channel : 97 7/0/0:0
```
Downstream Channel DCID RF Channel : 98 7/0/0:1
Downstream Channel DCID RF Channel : 100 7/0/0:3
Multi-Transmit Channel Mode : Y
Extended Upstream Transmit Power : 0dB
Upstream Channel : US0 US1
Ranging Status : sta sta
Upstream SNR (dB) : 36.12 32.55
Upstream Data SNR (dB) : -- --
Received Power (dBmV) : 0.00 0.00
Reported Transmit Power (dBmV) : 25.25 26.00
Peak Transmit Power (dBmV) : 54.00 54.00
 Phy Max Power (dBmV) : 54.00 54.00
Minimum Transmit Power (dBmV) : 24.00 24.00
Timing Offset (97.6 ns): 1226 1226
Initial Timing Offset : 1229 973
Rng Timing Adj Moving Avg(0.381 ns): -1 0
Rng Timing Adj Lt Moving Avg : -7 0
Rng Timing Adj Minimum : -768 0
Rng Timing Adj Maximum : 0 64768
Pre-EQ Good : 0 0
Pre-EQ Scaled : 0 0
Pre-EQ Impulse : 0 0
Pre-EQ Direct Loads : 0 0
Good Codewords rx : 515 472
Corrected Codewords rx : 0 0
Uncorrectable Codewords rx : 0 0
Phy Operating Mode : atdma* atdma*
sysDescr : Downstream Power : 0.00 dBmV (SNR = ----- dB)
MAC Version : DOC3.0
QoS Provisioned Mode : DOC1.1
Enable DOCSIS2.0 Mode : Y
Modem Status : {Modem= w-online(em), Security-disabled}
Capabilities : {Frag=N, Concat=N, PHS=Y}
Security Capabilities : {Priv=, EAR=Y, Key_len=}
L2VPN Capabilities : {L2VPN=N, eSAFE=N}
Sid/Said Limit : {Max US Sids=16, Max DS Saids=15}
Optional Filtering Support : {802.1P=N, 802.1Q=N, DUT=N}
Transmit Equalizer Support : {Taps/Symbol= 1, Num of Taps= 24}
Number of CPE IPs : 0(Max CPE IPs = 16)
CFG Max-CPE : 200
Flaps : 0()
Errors : 0 CRCs, 0 HCSes
Stn Mtn Failures : 0 aborts, 0 exhausted
Total US Flows : 1(1 active)
Total DS Flows : 1(1 active)
Total US Data : 7 packets, 2006 bytes
Total US Throughput : 0 bits/sec, 0 packets/sec
Total DS Data : 5 packets, 1202 bytes
Total DS Throughput : 0 bits/sec, 0 packets/sec
LB group ID assigned (index) : 2151416065 (48131)
LB group ID in config file (index) : N/A (N/A)
LB policy ID : 0
LB policy ID in config file : 0
LB priority : 0
Tag :
Required DS Attribute Mask : 0x0
Forbidden DS Attribute Mask : 0x0
Required US Attribute Mask : 0x0
Forbidden US Attribute Mask : 0x0
Service Type ID :
Service Type ID in config file :
Active Classifiers : 2 (Max = NO LIMIT)
CM Upstream Filter Group : 0
Feature Information for Energy Management Mode

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 63: Feature Information for Downgrading Channel Bonding in Battery Backup Mode

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Management Mode</td>
<td>Cisco IOS XE Fuji 16.7.1</td>
<td>This feature was integrated on the Cisco cBR Series Converged Broadband Routers.</td>
</tr>
</tbody>
</table>
Cable Modem Steering

The cable modem steering feature helps to redirect or steer cable modems to multiple CMTS routers. A configurable string is used to bond the cable modem to the proper CMTS. Once the bonding is done, the CMTS can move the cable modem within itself for load balancing.

- Cable Modem Steering on the Cisco cBR Series Converged Broadband Routers, on page 355
- Prerequisites for Cable Modem Steering, on page 356
- Restrictions for Cable Modem Steering, on page 356
- Information About Cable Modem Steering, on page 356
- How to Configure Cable Modem Steering on the CMTS Router, on page 358
- Verifying and Troubleshooting Cable Modem Steering, on page 360
- Additional References, on page 362
- Feature Information for Cable Modem Steering, on page 363

Cable Modem Steering on the Cisco cBR Series Converged Broadband Routers

First Published: July 13, 2016

The cable modem steering feature helps to redirect or steer cable modems to multiple CMTS routers. A configurable string is used to bond the cable modem to the proper CMTS. Once the bonding is done, the CMTS can move the cable modem within itself for load balancing.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.
Prerequisites for Cable Modem Steering

DOCSIS 3.0-defined type, length, values (TLVs) are required to aid channel selection. All TLVs encoded as general extension information in cable modem configuration files are backward compatible with DOCSIS 1.1 and DOCSIS 2.0 cable modems.

Note

The hardware components introduced in a given Cisco IOS Release are supported in all subsequent releases unless otherwise specified.

Restrictions for Cable Modem Steering

The Cable Modem Steering feature has the following general restrictions:

- To restrict the cable modem on the exact downstream on the target CMTS, the redirection must be configured on the target CMTS.
- You must manually execute the `clear cable modem service-type` command to clear the cable modem service type identifier stored at the CMTS during registration.
- You must manually execute the `clear cable modem attribute-masks` command to clear the cable modem attribute masks stored at the CMTS during registration. These attribute masks are used to restrict usage of upstream channels during ranging time.
- Cable modem steering supports only upstream masks.
- Channel steering does not take place when the cable modem fails in initial ranging.
- The cable modem will take more time to come online when channel steering is deployed. The time taken is proportional to the number of modems, and the downstreams and upstreams that the cable modem can reach.
- A modem cannot be load balanced to any upstream channel with attributes that conflict with attribute masks of the modem.
- Do not configure to use UCC in DOCSIS LBG.

Information About Cable Modem Steering

Cable modem steering allows you to redirect or steer the cable modems to one or more CMTS routers using downstream frequency overrides. Once a cable modem registers on a downstream on the proper CMTS router, the CMTS router can move the cable modem to any location for load balancing.

The DOCSIS 3.0-compliant Service Type Identifier used as the configurable string in the cable modem configuration file is backward-compatible with DOCSIS 1.1 and DOCSIS 2.0 cable modems.

The CMTS router can also impose restrictions on the number of channels a cable modem can use. DOCSIS 3.0 defines several TLVs to aid the channel selection.

The following TLVs are used in cable modem steering:
• TLV 43.9 (Cable Modem Attribute Masks) limits the set of channels the CMTS router can assign to the cable modem by allowing or forbidding certain binary attributes. The cable modem attribute masks have four sub-TLVs and cable modem steering makes use of two sub-TLVs, which are listed below:
  • TLV 43.9.3—Cable Modem Upstream Required Attribute Mask (C.1.1.18.1.8.3 of CM-SP-MULPlv3.0-I07-080215). It is a 32-bit mask representing the set of binary upstream channel attributes required for the cable modem.
  • TLV 43.9.4—Cable Modem Upstream Forbidden Attribute Mask (C.1.1.18.1.8.4 of CM-SP-MULPlv3.0-I07-080215). It is a 32-bit mask representing the set of binary upstream channel attributes forbidden for the cable modem.

• TLV 43.11 is used for a redirection action based on the service type identifier field. The cable modem sends the TLV 43.11 in the REG-REQ MAC message. The DOCSIS 1.1 and DOCSIS 2.0 modems will also send this file ID when doing the registration.

• TLV43.1, defined as Policy ID in DOCSIS 2.0 and DOCSIS 3.0, is parsed and stored in the cable modem during registration. Before moving the cable modem during load balancing (LB), the CMTS router checks whether the cable modem has a preconfigured policy with the same Policy ID. If the policy does exist, the CMTS router disables LB for this cable modem and moves to the next cable modem. If the policy does not exist on the CMTS router, or the Policy ID is missing from the cable modem configuration file, LB prohibition is not performed.

The following TLVs are supported in cable modem steering:
  • TLV 43.11 (Service type identifier) from section C.1.1.18.1.10 in CM-SP-MULPlv3.0-I07-080215.
  • Cable modem attribute masks (TLV 43.9) from C.1.1.18.1.8.3 and C.1.1.18.1.8.4 of CM-SP-MULPlv3.0-I07-080215.
  • TLV portion (43.1, Policy ID) of REQ-REQ
  • TLV 18---Ranging Hold-off Priority Field
  • TLV 19---Channel Class ID

### Upstream Channel Descriptor TLV for Ranging Hold-off

The Upstream Channel Descriptor (UCD) TLV for Ranging Hold-off feature, enables the Cisco cBR Series Converged Broadband router to hold off a cable modem from initial ranging based on TLV 18 and 19 specified in the upstream channel descriptor (UCD) messages. The router can hold off a cable modem from initial ranging only for 5 minutes. This default value cannot be changed. This feature is supported with DOCSIS 2.0 and later releases cable modems using upstream logical channels.

### Ranging Class ID

The CMTS enables UCD TLV for ranging hold-off after detecting the TLVs from the cable modem registration request (REG-REQ) or multipart registration request (REG-REQ-MP), and saves these TLVs as a cable modem ranging class ID.

By default, DOCSIS load balance is supported for all cable modems with all types of ranging class IDs. In the event of DOCSIS load balance, a cable modem moves to the target upstream channel only if the ranging class ID matches with the upstream channel class ID.

### Cable Modem Exclusion for DOCSIS Load Balance

You can exclude a cable modem or a group of cable modems from DOCSIS load balance based on their device type, MAC address, and Organizational Unique Identifier (OUI) using the `cable load-balance exclude` command in global configuration mode.
How to Configure Cable Modem Steering on the CMTS Router

This section describes the following required and optional procedures:

Configuring an Upstream Channel Class ID

This configuration is optional. A channel class ID must be configured for an upstream logical channel if you want to configure UCD TLV ranging hold-off on the CMTS router.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><code>Router&gt; enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><code>controller upstream-cable slot/subslot/controller-port-number</code></td>
<td>Specifies the cable interface and enters cable interface configuration mode. Arguments for this command may vary depending on the CMTS router, line card, and Cisco IOS software release. For details, see the Cisco IOS CMTS Cable Command Reference .</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><code>Router(config)# controller Upstream-Cable 3/0/0</code></td>
<td>• Slot—Slot where the interface card resides. The valid range is from 0 to 3 and 6 to 9 on the Cisco cBR-8 router.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Subslot—Subslot where the interface card resides. The valid value is 0 on the Cisco cBR-8 router.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• controller-port-number—Controller port number. The valid values are from 0 to 7 on the Cisco cBR-8 router.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td><code>us-channel us-channel-id chan-class-id id</code></td>
<td>Configures the channel class ID for an upstream logical channel.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><code>Router(config-controller)# us-channel 3 chan-class-id ff</code></td>
<td>• us-channel-id—Specifies the upstream channel id.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• id—Channel class ID for the logical upstream channel in the hexadecimal format. The valid range is from 0 to ffffffff. The default value is 0.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><code>end</code></td>
<td>Returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><code>Router(config-controller)# end</code></td>
<td></td>
</tr>
</tbody>
</table>
## Configuring an Upstream Ranging Hold-off Priority Value

This configuration is optional.

Maximum time that a cable modem can inhibit transmissions on an upstream channel in response to its ranging class ID matching a bit value in the Ranging Hold-off Priority field in the cable modem configuration file is 300 seconds (five minutes) per *DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification*. This default timer value cannot be changed.

### Procedure

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Step 3</strong> controller upstream-cable</td>
</tr>
<tr>
<td>Example:</td>
<td>• <em>Slot</em>—Slot where the interface card resides. The valid range is from 0 to 3 and 6 to 9 on the Cisco cBR-8 router.</td>
</tr>
<tr>
<td>Router(config)# controller upstream-cable 3/0/0</td>
<td>• <em>Subslot</em>—Subslot where the interface card resides. The valid value is 0 on the Cisco cBR-8 router.</td>
</tr>
<tr>
<td></td>
<td>• <em>controller-port-number</em>—Controller port number. The valid values are from 0 to 7 on the Cisco cBR-8 router.</td>
</tr>
<tr>
<td><strong>Step 4</strong> us-channel <em>us-channel-id</em> rng-holdoff priority</td>
<td>Configures the ranging hold-off priority value for an upstream logical channel.</td>
</tr>
<tr>
<td>Example:</td>
<td>• <em>us-channel-id</em>—Specifies the upstream channel id.</td>
</tr>
<tr>
<td>Router(config-controller)# us-channel 3 rng-holdoff 1</td>
<td>• <em>rng-holdoff</em> <em>priority</em>—Specifies the ranging hold-off priority value in the hexadecimal format. The valid range is from 0 to ffffffff. The default value is 0.</td>
</tr>
<tr>
<td></td>
<td><strong>Step 5</strong> end</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-controller)# end</td>
<td></td>
</tr>
</tbody>
</table>
# Verifying and Troubleshooting Cable Modem Steering

This section provides the verification and troubleshooting information:

## Verifying an Upstream Ranging Class ID Configuration

To verify an upstream ranging class ID of a cable modem, use the `show cable modem` command with the `verbose` keyword.

Following is a sample output of the `show cable modem verbose` command:

```
Router# show cable modem 68b6.fcfe.22e5 verbose

MAC Address : 68b6.fcfe.22e5
IP Address : 192.168.0.8
Dual IP : Y
Prim SId : 8
Host Interface : C8/0/0/UB
MD-DS-SG / MD-US-SG : 1 / 2
MD-CM-SG : 0x5A0102
Primary Wideband Channel ID : 3073 (W18/0/0:0)
Primary Downstream : Mo8/0/0:0 (RfId : 2304)
Wideband Capable : Y
RCP Index : 3
RCP ID : 00 10 00 00 18
Downstream Channel DCID RF Channel : 45 8/0/0:0
Downstream Channel DCID RF Channel : 46 8/0/0:1
Downstream Channel DCID RF Channel : 47 8/0/0:2
Downstream Channel DCID RF Channel : 48 8/0/0:3
Downstream Channel DCID RF Channel : 49 8/0/0:4
Downstream Channel DCID RF Channel : 50 8/0/0:5
Downstream Channel DCID RF Channel : 51 8/0/0:6
Downstream Channel DCID RF Channel : 52 8/0/0:7
Downstream Channel DCID RF Channel : 53 8/0/0:8
Downstream Channel DCID RF Channel : 54 8/0/0:9
Downstream Channel DCID RF Channel : 55 8/0/0:10
Downstream Channel DCID RF Channel : 56 8/0/0:11
Downstream Channel DCID RF Channel : 57 8/0/0:12
Downstream Channel DCID RF Channel : 58 8/0/0:13
Downstream Channel DCID RF Channel : 59 8/0/0:14
Downstream Channel DCID RF Channel : 60 8/0/0:15
Downstream Channel DCID RF Channel : 61 8/0/0:16
Downstream Channel DCID RF Channel : 62 8/0/0:17
Downstream Channel DCID RF Channel : 63 8/0/0:18
Downstream Channel DCID RF Channel : 64 8/0/0:19
Downstream Channel DCID RF Channel : 65 8/0/0:20
Downstream Channel DCID RF Channel : 66 8/0/0:21
Downstream Channel DCID RF Channel : 67 8/0/0:22
Downstream Channel DCID RF Channel : 68 8/0/0:23
UDC Enabled : N
Extended Upstream Transmit Power : 61dB
Multi-Transmit Channel Mode : Y
Number of US in UBG : 8
Upstream Channel : US0 US1 US2 US3
Ranging Status : sta sta sta sta
Upstream SNR (dB) : 30.62 32.32 18.25 24.26
Upstream Data SNR (dB) : -- -- -- --
Received Power (dBmV) : 0.50 0.00 -0.50 -0.50
Reported Transmit Power (dBmV) : 30.75 30.75 29.25 29.25
```
<table>
<thead>
<tr>
<th>Peak Transmit Power (dBmV)</th>
<th>61.00</th>
<th>61.00</th>
<th>61.00</th>
<th>61.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phy Max Power (dBmV)</td>
<td>48.00</td>
<td>48.00</td>
<td>48.00</td>
<td>48.00</td>
</tr>
<tr>
<td>Minimum Transmit Power (dBmV)</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Timing Offset</td>
<td>(97.6 ns)</td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
</tr>
<tr>
<td>Pre-EQ Good</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pre-EQ Scaled</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pre-EQ Impulse</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pre-EQ Direct Loads</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Good Codewords rx</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Corrected Codewords rx</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Phy Operating Mode</td>
<td>atdma* atdma* atdma* atdma*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream Channel</td>
<td>US4 US5 US6 US7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranging Status</td>
<td>sta sta sta sta</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream SNR (dB)</td>
<td>15.53</td>
<td>31.62</td>
<td>31.1</td>
<td>31.87</td>
</tr>
<tr>
<td>Upstream Data SNR (dB)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Received Power (dBmV)</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Reported Transmit Power (dBmV)</td>
<td>29.25</td>
<td>30.75</td>
<td>30.75</td>
<td>30.75</td>
</tr>
<tr>
<td>Peak Transmit Power (dBmV)</td>
<td>61.00</td>
<td>61.00</td>
<td>61.00</td>
<td>61.00</td>
</tr>
<tr>
<td>Phy Max Power (dBmV)</td>
<td>48.00</td>
<td>48.00</td>
<td>48.00</td>
<td>48.00</td>
</tr>
<tr>
<td>Minimum Transmit Power (dBmV)</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Phy Operating Mode</td>
<td>atdma* atdma* atdma* atdma*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sysDescr</td>
<td>DOCSIS 3.0 Cable Modem Router</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream Power</td>
<td>7.40 dBmV (SNR = 43.30 dB)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAC Version</td>
<td>DOC3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QoS Provisioned Mode</td>
<td>DOC1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enable DOCSIS2.0 Mode</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modem Status</td>
<td>(Modem= w-online, Security=disabled)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capabilities</td>
<td>(Frag=N, Concat=N, PHS=Y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security Capabilities</td>
<td>(Priv-, EAR=Y, Key_len–)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2VPN Capabilities</td>
<td>(L2VPN=Y, eSAFE=Y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sid/Said Limit</td>
<td>(Max US Sids=8, Max DS Saids=64)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optional Filtering Support</td>
<td>(802.1P=N, 802.1Q=N, DUT=Y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmit Equalizer Support</td>
<td>(Taps/Symbol=1, Num of Taps= 24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of CPE</td>
<td>0(Max CPE = 16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of CPE IPS</td>
<td>0(Max CPE IPS = 16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of CPE IPv6</td>
<td>0(Max CPE IPv6 = 16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFG Max-CPE</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flaps</td>
<td>19(Oct 11 04:00:25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errors</td>
<td>CRCs, HCSes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stn Mtn Failures</td>
<td>0 aborts, 12 exhausted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total US Flows</td>
<td>1(1 active)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total DS Flows</td>
<td>1(1 active)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total US Data</td>
<td>3294 packets, 577031 bytes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total US Throughput</td>
<td>0 bits/sec, 0 packets/sec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total DS Data</td>
<td>2263 packets, 200777 bytes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Additional References

The following sections provide references related to the Cable Modem Steering feature.

Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMTS cable commands</td>
<td>Cisco IOS CMTS Cable Command Reference</td>
</tr>
</tbody>
</table>

Standards and RFCs

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>CM-SP-MULPIv3.0-I07-080215</td>
<td>DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification</td>
</tr>
<tr>
<td>CM-SP-MULPIv3.0-I18-120329</td>
<td>DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification</td>
</tr>
<tr>
<td>CM-SP-RFI2.0-I13-080215</td>
<td>DOCSIS 2.0 Radio Frequency Interface Specification</td>
</tr>
</tbody>
</table>

Total DS Throughput : 0 bits/sec, 0 packets/sec
LB group ID assigned (index) : 2153382146 (55810)
LB group ID in config file (index) : N/A (N/A)
LB policy ID : 0
LB policy ID in config file : 0
LB priority : 0
Tag :
Required DS Attribute Mask : 0x0
Forbidden DS Attribute Mask : 0x0
Required US Attribute Mask : 0x0
Forbidden US Attribute Mask : 0x0
Service Type ID :
Service Type ID in config file :
Ranging Class ID : 0x2
Active Classifiers : 0 (Max - NO LIMIT)
CM Upstream Filter Group : 0
CM Downstream Filter Group : 0
CPE Upstream Filter Group : 0
CPE Downstream Filter Group : 0
DSA/DSX messages : permit all
Voice Enabled : NO
DS Change Times : 0
Boolean Services : 2
Number of Multicast DSIDs Support : 63
MDF Capability Mode : 2
IGMP/MLD Version : MLDv2
FTCtype10 Forwarding Support : Y
Features Bitmask : 0x0
Total Time Online : 9h27m (9h27m since last counter reset)
CM Initialization Reason : BAD_DHCP_ACK
CFG Max IPv6 CPE Prefix : 16 (-1 used)
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

Feature Information for Cable Modem Steering

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn) link. An account on the Cisco.com page is not required.

Note

The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 64: Feature Information for Cable Modem Steering on the Cisco CMTS Routers

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
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<tbody>
<tr>
<td>Cable Modem Steering</td>
<td>Cisco IOS XE Everest 16.6.1</td>
<td>This feature was integrated into Cisco IOS XE Everest 16.6.1 on the Cisco cBR Series Converged Broadband Routers.</td>
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</table>