Fairness Across DOCSIS Interfaces

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The Fairness Across DOCSIS Interfaces feature introduces an adaptive mechanism to effectively distribute reservable bandwidth for committed information rate (CIR) flows and fair bandwidth for best-effort (BE) service flows across adjacent bonding groups (BGs).

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://tools.cisco.com/ITDIT/CFN/. An account on http://www.cisco.com/ is not required.

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Prerequisites for Fairness Across DOCSIS Interfaces

Table below shows the hardware compatibility prerequisites for this feature.

Note   The hardware components introduced in a given Cisco IOS Release will be supported in all subsequent releases unless otherwise specified.

Table 1: Fairness Across DOCSIS Interfaces for the Cisco CMTS Routers Hardware Compatibility Matrix

CMTS Platform	Processor Engine	Cable Interface Cards	SIP/SPA
Cisco uBR10012 Universal Broadband Router	Cisco IOS Release 12.2(33)SCF and later releases • PRE2 • PRE4 Cisco IOS Release 12.2(33)SCH and later releases • PRE5	Cisco IOS Release 12.2(33)SCF and later releases • Cisco uBR-MC5X20H[1] • Cisco UBR-MC20X20V • Cisco uBR-MC3GX60V[2]	Cisco IOS Release 12.2(33)SCF and later releases • Cisco Wideband SIP and Cisco Wideband SPA • Cisco 10000 Series SIP-600 and Cisco Wideband SPA Cisco IOS Release 12.2(33)SCH and later releases • Cisco Next Generation Wideband SPA

[1]   When Fairness Across DOCSIS Interfaces feature is enabled, the Cisco uBR-5X20H cable interface line card can only act as a Guardian or MAC domain host as bonding is not supported on the card.

[2]   The Cisco uBR-3GX60V cable interface line card is not compatible with PRE2.

Note   The term 'Bonding Group (BG)' is used in this document to refer to all the integrated-cable (IC), modular-cable (MC), and wideband-cable (WC) interfaces in the context of Fairness Across DOCSIS Interfaces feature context. The IC and MC interfaces are considered as a single-channel BG.

Restrictions for Fairness Across DOCSIS Interfaces

- The CIR flows cannot reserve all the RF bandwidth. The CIR flows can only reserve 90 percent[3] of the RF bandwidth that is not statically reserved by the "bandwidth-percent", in addition to the legacy CIR bandwidth.

- It is recommended that the CIR reservation be cleared before disabling Fairness Across DOCSIS Interfaces feature to ensure that the CIR reservation is not more than the static reservable bandwidth specified by

[3]   The reservable bandwidth for CIR flows consists of static and dynamic portions. By default, the static portion of bandwidth is assigned from the legacy configuration. The dynamic portion of bandwidth comes from the headroom left on each RF channel for BE traffic.

the "bandwidth-percent" in legacy configuration. This is to prevent CIR over-subscription after disabling Fairness Across DOCSIS Interfaces feature.

- The effect of Fairness Across DOCSIS Interfaces feature depends on topology and flow distribution. In certain cases, Fairness Across DOCSIS Interfaces feature may not achieve BE fairness or maximum CIR utilization.

- Fairness Across DOCSIS Interfaces feature applies only to dynamic bandwidth sharing (DBS) enabled IC and WB interfaces.

Information About Fairness Across DOCSIS Interfaces

The Fairness Across DOCSIS Interfaces feature is an enhancement over the DOCSIS WFQ scheduler. It enables downstream CIR service flows to be admitted on the interfaces over the thresholds defined in the legacy configuration (that is, "bandwidth-percent" or "max-reserved-bandwidth"). For example, the feature enables large CIR flows (like multicast service flows) to be admitted when the current parameters cannot guarantee enough bandwidth. However, its success rate depends on the allocation and reservation of the bandwidth for cable interfaces within common RF channels.

This feature also ensures fair bandwidth for downstream BE service flows across cable interfaces with common RF channels. The per-flow bandwidth of all active service flows on the adjacent BGs are balanced periodically in proportion to their DOCSIS traffic priority (traffic priority + 1) for downstream BE service flows. This bandwidth, available for BE traffic, can also be used to admit additional CIR flows.

Note For information about DOCSIS traffic priority, see DOCSIS WFQ Scheduler on the Cisco CMTS Routers guide.

How to Configure Fairness Across DOCSIS Interfaces

This section describes the following tasks that are required to implement Fairness Across DOCSIS Interfaces feature:

Configuring Fairness Across DOCSIS Interfaces

This section describes how to enable Fairness Across DOCSIS Interfaces feature on the cable interfaces. The configuration is applied to all WB, MC or IC interfaces on the router.

Restriction We recommend that you clear the CIR reservation before disabling the Fairness Across DOCSIS Interfaces feature to ensure that CIR reservation is not more than the static reservable bandwidth specified by the "bandwidth-percent" in the legacy configuration.

DETAILED STEPS

	Command or Action	Purpose
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 acfe enable** **Example:** Router(config)# **cable acfe enable**	Enables Fairness Across DOCSIS Interfaces feature on the cable interfaces.
Step 4	**exit** **Example:** Router(config)# **exit**	Exits global configuration mode and returns to privileged EXEC mode.

Configuring Maximum Excess Information Rate Ratio

This section describes how to configure the maximum Excess Information Rate (EIR) ratio between the BE bandwidth among adjacent BGs.

The EIR ratio is used to maintain the maximum EIR bandwidth difference between BGs. It helps to prevent BGs (which has only a few active BE service flows) from getting very low or zero EIR bandwidth. Otherwise, these BGs will not be able to admit CIR flows as they get only very low EIR bandwidth.

For example, there are two BGs sharing the same RF channel, with BG1 having 1000 active BE service flows and BG2 having none. If "max-eir-ratio" is not used, BG1 gets all the bandwidth leaving no bandwidth for BG2. When a voice CIR tries for bandwidth at BG2, it will get rejected. If "max-eir-ratio" is set at 10, BG2 gets about 10 percent of the QAM that is sufficient to admit the voice CIR. The 'max-eir-ratio' is a trade-off between perfect fairness and CIR utilization. It means, compromising 'flow fairness' to prevent some BGs from getting all the bandwidth leaving the other BGs with none.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Router> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**cable acfe max-eir-ratio** *eir-ratio* **Example:** `Router(config)# `**`cable acfe max-eir-ratio 20`**	Configures the maximum EIR ratio between the BE bandwidth among adjacent BGs.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns to privileged EXEC mode.

Configuring Constant Excess Information Rate Demand

This section describes how to configure the constant excess information rate (EIR) demand for a bonding group (BG). EIR demand is a unitless value that is used to determine relative bandwidth ratio between BGs.

An active EIR flow with DOCSIS priority-0 is given 1000 units of demand in ACFE module. Therefore a BG with constant-eir-demand set to 1 will get no more than 1/1000 of the bandwidth of a single service flow.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cable acfe constant-eir-demand** *value*
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** Router# configure terminal	Enters global configuration mode.
Step 3	**cable acfe constant-eir-demand** *value* **Example:** Router(config)# **cable acfe constant-eir-demand 20**	Configures the constant EIR demand as 20 for a BG.
Step 4	**exit** **Example:** Router(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

Configuring Maximum Bonus Bandwidth

This section describes how to configure the maximum usable bonus bandwidth for a BG.

Bonus bandwidth is the additional bandwidth provided by the Fairness Across DOCSIS Interfaces feature to each BG for CIR reservation. In the default maximum bonus bandwidth configuration, a single BG can reserve all the underlying RF bandwidth. When the maximum bonus is set, the AC module will not admit CIR flows above that setting even if the scheduler has guaranteed more bandwidth. This will effectively prevent BGs from being starved for CIR flows.

Note The **cable acfe max-bonus-bandwidth** command configuration is applicable only for the new incoming CIR flows. It will not terminate the existing CIR flows that exceeds the **max-bonus-bandwidth** .

Restriction If the maximum bonus bandwidth is less than the current CIR reservation on an interface, no new CIR flows are admitted until the CIR reservation drops below the maximum bonus bandwidth configuration.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Router> enable	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**wideband-cable** | **modular-cable** | **interface-cable** }*slot*/*subslot* /*port* :*interface-num* **Example:** `Router(config)# interface wideband-cable 1/0/0:0`	Specifies the interface to be configured. **Note** The valid values for the arguments depend on CMTS router and cable interface line card. See the hardware documentation for your router chassis and cable interface line card for supported values.
Step 4	**cable acfe max-bonus-bandwidth** *bonus-bandwidth* **Example:** `Router(config-if)# cable acfe max-bonus-bandwidth 1000000`	Configures the maximum usable bonus bandwidth for a BG.
Step 5	**end** **Example:** `Router(config)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying the Fairness Across DOCSIS Interfaces

To monitor the Fairness Across DOCSIS Interfaces feature, use the following procedures:

Verifying Reservable Bandwidth

To display the reserved and reservable bandwidth for a particular interface, use the **show interface {wideband-cable | modular-cable | integrated-cable}** command as shown in the example:

```
Router# show interfaces wideband-cable 1/0/0:1 downstream
Total downstream bandwidth 3235 Kbps
Total downstream reserved/reservable bandwidth 0/200 Kbps
Total downstream guaranteed/non-guaranteed bonus bandwidth 66618/9972 Kbps
!
```

The "reservable bandwidth" is a part of the guaranteed bandwidth from the legacy configuration. When the Fairness Across DOCSIS Interfaces feature is disabled, values of both the "guaranteed bonus bandwidth" and "non-guaranteed bonus bandwidth" are zero. When the feature is enabled, the "reservable bandwidth" and "guaranteed bonus bandwidth" represents the maximum CIR that can be reserved on the interface. Unicast CIR flows exceeding this limit are rejected. The additional "non-guaranteed bonus bandwidth" allows the multicast CIR flows to pass the AC module. However, the service flow may not be created successful because the bandwidth comes from the shared pool.

Note The "guaranteed bonus bandwidth" and "non-guaranteed bonus bandwidth" are part of the bandwidth provided by the maximum bonus bandwidth configuration. The "non-guaranteed bonus bandwidth" is expected to be used only by multicast service flows in Cisco IOS Release 12.2(33)SCF.

To display the reserved and reservable bandwidth for a particular interface, use the **show cable admission-control interface** command as shown in the example:

```
Router# show cable admission-control interface wideband-cable 1/0/0:1 verbose
Interface Wideband-Cable1/0/0:1
Configured AC Max Reservable Bandwidth = 6000000 bps
 Resource - Downstream Bandwidth
 -------------------------------
Bkt     Name   Minor # of  Major # of  Excls # of  Non-Ex Curr. Curr. Conf  # of
No             Level Times Level Times Level Times Level  Resv  Ovrsb Level Rej
1              0     0     0     0     0     0     0   *   0.0   0.0   G     0
2              0     0     0     0     0     0     0   *   0.0   0.0   G     0
3              0     0     0     0     0     0     0   *   0.0   0.0   G     0
4              0     0     0     0     0     0     0   *   0.0   0.0   G     0
5              0     0     0     0     0     0     0   *   0.0   0.0   G     0
6              0     0     0     0     0     0     0   *   0.0   0.0   G     0
7              0     0     0     0     0     0     0   *   0.0   0.0   G     0
8              0     0     0     0     0     0     100*  50.0  0.0   G     0
 Note: * indicates that the thresholds are implicit
WB-NB CIR for Wideband-Cable1/0/0:1
CIR Values for Cable8/1/4
Bkt SFAC BW    Rsvd CIR   Reject #
0   0          0          0
1   0          0          0
2   0          0          0
3   0          0          0
4   0          0          0
5   0          0          0
6   0          0          0
7   4500000    3000000    0
Available Guaranteed Bonus BW (bps): 30375000
Available Non-guaranteed Bonus BW (bps): 0
WB Multicast CIR Utilization
Bkt SFAC BW    Rsvd CIR   Reject #
0   0          0          0
1   0          0          0
2   0          0          0
3   0          0          0
4   0          0          0
5   0          0          0
6   0          0          0
7   1500000    0          0
Available Guaranteed Bonus BW (bps): 30375000
Available Non-guaranteed Bonus BW (bps): 0
```

Verifying Global Fairness Across DOCSIS Interfaces Status and Statistics

To display the global status and statistics of the Fairness Across DOCSIS Interfaces feature, use the **show cable acfe summary** command as shown in the example:

```
Router# show cable acfe summary
ACFE state: Enabled
EIR Rebalance period (secs): 5
EIR Rebalance invocations:   254
CIR Acquire rate/limit:      100/100
CIR Acquire invocations:     0
CIR Acquire throttled:       0
CIR Oversubscriptions:       0
```

```
Maximal EIR ratio:        10
Constant EIR demand:      2
```

Verifying Per-Controller Fairness Across DOCSIS Interfaces Status and Statistics

To display the status and statistics for each controller interface, use the **show cable acfe controller** command as shown in the following example:

```
Router# show cable acfe controller modular-cable 1/0/0
EIR Rebalance invoked: 301832
Adaptive CIR granted:  0
Adaptive CIR rejected: 0
Total clusters: 2
!
```

The BG clusters span across multiple channels and are used as a means to share the underlying RF channel bandwidth dynamically.

```
RF      FlexBW
0       30375
1       30375
RF      FlexBW
2       30375
3       30375
```

Verifying Per-Interface Fairness Across DOCSIS Interfaces Status and Statistics

To display the status and statistics for each interface, use the **show cable acfe interface** command as shown in the following example:

```
Router# show cable acfe interface wideband-cable 1/0/0:1
EIR Demand (raw/scale):   0/1
Per-Flow EIR BW (kbps):   19125
Guar Bonus BW (kbps):     19125
Non-guar Bonus BW (kbps): 38250
Reserved Bonus BW (kbps): 0
!
```

The EIR demand is the number of active BE service flows for each BG within a specific time period weighted by DOCSIS priority. The EIR portion is adjusted periodically in proportion to the EIR demand for each BG within the same BG cluster.

```
AC Max Reserved Bandwidth: 200 kbps
Bucket Reservations (kbps):
!
```

For information on Bucket Reservations, see the Service Flow Admission Control for the Cisco CMTS Routers guide.

Troubleshooting

The following **debug** commands help you troubleshoot an improper configuration:

- **debug cable acfe** —Enables debug operation for the Fairness Across DOCSIS Interfaces feature. You should run the debug cable acfe command first to enable other debug options listed below.

- **debug cable acfe algorithm** —Provides debugging information on internal operations of algorithms.

- **debug cable acfe all** —Provides debugging information of all cable events.

- **debug cable acfe filter** —Provides debugging information after applying the filter to limit the debug output.

- **debug cable acfe filter controller** —Provides debugging information on specific controllers.

- **debug cable acfe cluster** —Provides debugging information on specific clusters.

- **debug cable acfe hccp** —Provides debugging information on high availability and Hot Standby Connection-to-Connection Protocol (HCCP) activities.

- **debug cable acfe process** —Provides debugging information on process activities.

- **debug cable acfe read**—Provides debugging information from the system.

- **debug cable acfe topology** —Provides debugging information on cluster topology.

- **debug cable acfe verbose** —Provides debugging information on all internal data.

- **debug cable acfe write** —Provides debugging output to the router.

For detailed information on these and other debug commands, see the Cisco IOS CMTS Cable Command Reference guide.

Configuration Examples for Fairness Across DOCSIS Interfaces

This section lists the following sample configurations for the Fairness Across DOCSIS Interfaces feature on a Cisco CMTS router:

Example: Fairness Across DOCSIS Interfaces

The following sample configuration shows Fairness Across DOCSIS Interfaces feature enabled on the router:

```
Current configuration : 39682 bytes
!
! Last configuration change at 04:30:02 UTC Wed Jan 19 2
! NVRAM config last updated at 04:23:17 UTC Wed Jan 19 2
!
version 12.2
!
cable clock dti
cable acfe enable
!
.
.
.
```

Example: Maximum EIR Demand Ratio

The following sample configuration shows maximum EIR demand ratio configured on the router:

```
Building configuration...
Current configuration : 54253 bytes
!
version 12.2
!
```

```
cable clock dti
cable acfe enable
cable acfe max-eir-ratio 20
!
```

The effect of the **cable acfe max-eir-ratio** command is demonstrated using a simple BG cluster, a 37.5 Mbps RF bandwidth shared by an MC and WB interface. The interfaces are configured as given in the following configuration example:

```
!
interface Modular-Cable1/0/0:0
cable bundle 1
 cable rf-bandwidth-percent 10
!
interface Wideband-Cable1/0/0:0
cable bundle 1
 cable rf-channel 0 bandwidth-percent 10
end
!
```

On this RF channel, 20 percent of the bandwidth is reserved by the 'bandwidth-percent' allowing Fairness Across DOCSIS Interfaces feature to use 27 Mbps, that is: (100 - 20) * 90 * 37.5). If the 'max-eir-ratio' is above 100 and the WB interface has 99 active BE flows and the MC interface has only 1 BE flow, then MC interface gets only 270 kbps, that is 1/(1+99)*27 of the bonus bandwidth. The BE traffic enjoys perfect fairness here. However, it is not possible to admit a unicast CIR flow beyond 270 kbps on the MC interface, as it would exceed the bonus bandwidth. If the 'max-eir-ratio' is set to 10, then the MC interface is treated to have 99/10 flows on it, resulting in a higher bonus bandwidth allocation. The 'max-eir-ratio' is a trade-off between perfect fairness and CIR utilization.

Example: Constant EIR Demand

The following sample configuration shows constant EIR demand on the router:

```
Building configuration...
Current configuration : 54253 bytes
!
version 12.2
!
cable clock dti
cable acfe enable
cable acfe max-eir-ratio 20
cable acfe constant-eir-demand 2
!

!
interface Modular-Cable1/0/0:0
cable bundle 1
 cable rf-bandwidth-percent 10
 cable acfe constant-eir-demand 2

!
interface Wideband-Cable1/0/0:0
cable bundle 1
 cable rf-channel 0 bandwidth-percent 10
 cable acfe constant-eir-demand 2

end
!
```

Example: Maximum Bonus Bandwidth

The following sample configuration shows the maximum bonus bandwidth enabled on the router:

```
Building configuration...
Current configuration : 274 bytes
!
interface Wideband-Cable1/0/0:0
cable bundle 1
cable rf-channel 0 bandwidth-percent 10
cable acfe max-bonus-bandwidth 10000
end
!
```
In this per-interface configuration, even if the Fairness Across DOCSIS Interfaces feature guarantees more than 10 Mbps for a WB interface, the AC module will not pass more than 10 Mbps bandwidth above the legacy reservable bandwidth.

```
!
.
.
.
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
Cisco IOS CMTS Cable Command Reference	Cisco IOS CMTS Command Reference
Dynamic Bandwidth Sharing	Dynamic Bandwidth Sharing on the Cisco CMTS Router
DOCSIS WFQ Scheduler	DOCSIS WFQ Scheduler on the Cisco CMTS Routers
Service Flow Admission Control for the Cisco CMTS Routers	Service Flow Admission Control for the Cisco CMTS Routers

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
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.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Fairness Across DOCSIS Interfaces

Table below lists the release history for this feature.

Use Cisco Feature Navigator to find information about 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 http://tools.cisco.com/ITDIT/CFN/. An account on http://www.cisco.com/ is not required.

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

Table 2: Feature Information for Fairness Across DOCSIS Interfaces

Feature Name	Releases	Feature Information
Fairness Across DOCSIS Interfaces	12.2(33)SCF	The Fairness Across DOCSIS Interfaces feature introduces an adaptive mechanism to effectively distribute reservable bandwidth for CIR flows and fair bandwidth for BE service flows across adjacent BGs. The following commands were introduced or modified: • **cable acfe enable** • **cable acfe max-eir-ratio** • **cable acfe max-bonus-bandwidth** • **debug cable acfe** • **debug cable acfe filter** • **show cable acfe controller** • **show cable acfe interface** • **show cable acfe summary** • **show cable admission-control** • **show cr10k-rp controller** • **show interface integrated-cable** • **show interface modular-cable** • **show interface wideband-cable**