



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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Hardware Compatibility Matrix for Cisco cBR Series Routers



Note The hardware components 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

Cisco CMTS Platform	Processor Engine	Interface Cards
Cisco cBR-8 Converged Broadband Router	<p>Cisco IOS-XE Release 3.15.0S and Later Releases</p> <p>Cisco cBR-8 Supervisor :</p> <ul style="list-style-type: none"> • PID—CBR-CCAP-SUP-160G • PID—CBR-CCAP-SUP-60G¹ • PID—CBR-SUP-8X10G-PIC 	<p>Cisco IOS-XE Release 3.15.0S and Later Releases</p> <p>Cisco cBR-8 CCAP Line Cards:</p> <ul style="list-style-type: none"> • PID—CBR-LC-8D30-16U30 • PID—CBR-LC-8D31-16U30 • PID—CBR-RF-PIC • PID—CBR-RF-PROT-PIC <p>Cisco cBR-8 Downstream PHY Modules:</p> <ul style="list-style-type: none"> • PID—CBR-D30-DS-MOD • PID—CBR-D31-DS-MOD <p>Cisco cBR-8 Upstream PHY Modules:</p> <ul style="list-style-type: none"> • PID—CBR-D30-US-MOD

¹ Effective with Cisco IOS-XE Release 3.17.0S, CBR-CCAP-SUP-60G supports 8 cable line cards. The total traffic rate is limited to 60Gbps, the total number of downstream service flow is limited to 72268, and downstream unicast low-latency flow does not count against the limits.

Prerequisites for Fairness Across DOCSIS Interfaces



Note The term ‘Bonding Group (BG)’ is used in this document to refer to all the integrated-cable (IC) and wideband-cable (WC) interfaces in the context of Fairness Across DOCSIS Interfaces feature context. The IC 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 percent² 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

² 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. The weights (DOCSIS traffic priority (traffic priority + 1)) of all the BGs are equal for downstream BE service flows. The bandwidth, available for BE traffic, can be used to admit additional CIR flows.



Note For information about DOCSIS traffic priority, see [DOCSIS WFQ Scheduler on the Cisco CMTS Routers guide](#).

On-demand CIR Acquisition

When multiple bonding groups sharing the RF-channel bandwidth and the current bonding group's guaranteed bandwidth is insufficient, this feature can "borrow" neighbor bonding group's non-reserved guaranteed bandwidth for current bonding group's CIR.

This feature is only used by multicast service flow.

Fairness Across Bonding Groups

Fairness Across DOCSIS Interfaces feature use the weight value of the aggregated active flow count, that is EIR demand, to periodically re-balance the reservable bandwidth. So that the service flows with the same weight in different bonding groups will have roughly the same throughput.

OFDM Channels

OFDM Channel

DOCSIS 3.1 introduces modes for higher throughput and higher spectral efficiency while still allowing backward compatibility to DOCSIS 3.0. OFDM Channel support includes 1 OFDM channel per port with channel bandwidth from 24 MHz to 192 MHz wide. Effective from Cisco IOS-XE Release 3.18.0SP, a bonding

group can consist of SC-QAMs and OFDM channels. An OFDM channel can have multiple profiles configured, and each profile may have different rate. The OFDM Channel rate can vary constantly depending on the profiles being used. For more information on OFDM channels, see *OFDM Channel Configuration Guide*.

OFDM Channel Rate

An OFDM channel can have multiple profiles configured, and each profile can have different rates. For example, with a 96MHz OFDM channel that is configured with profile A (Control Profile) with modulation 1024-QAM, profile B with modulation 2048-QAM, and profile C with modulation 4096-QAM, the profile rates of profile A, B, and C are 616Mbps, 680Mbps, and 736Mbps respectively.

Effective from Cisco IOS-XE Release 3.18.0SP, if an OFDM channel has both Control Profile (profile A) and Data Profiles (profile B, C, and so on) configured, the lowest Data Profile rate is used for Fairness Across DOCSIS Interface calculation. Otherwise, the Control Profile rate is used.

Interface Bandwidth

Effective from Cisco IOS-XE Release 3.18.0SP, a Wideband-Cable (WB) interface can consist of both SC-QAMs and OFDM channels. If it contains OFDM channels, the highest profile rates are used to calculate the interface bandwidth.

For example, with a 96MHz OFDM channel that is configured with profile A having modulation 1024-QAM, profile B with modulation 2048-QAM, and profile C with modulation 4096-QAM, the profile rates of profile A, B, and C are 616Mbps, 680Mbps, and 736Mbps respectively. Here, 736Mbps is used to calculate the interface bandwidth.

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 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.

Procedure

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Router# <code>configure terminal</code>	Enters global configuration mode.
Step 3	cable acfe enable Example: Router(config)# <code>cable acfe enable</code>	Enables Fairness Across DOCSIS Interfaces feature on the cable interfaces.
Step 4	exit Example: Router(config)# <code>exit</code>	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.

Procedure

	Command or Action	Purpose
Step 1	enable Example: Router> <code>enable</code>	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal Example: Router# <code>configure terminal</code>	Enters global configuration mode.
Step 3	cable acfe max-eir-ratio <i>eir-ratio</i> Example:	Configures the maximum EIR ratio between the BE bandwidth among adjacent BGs.

	Command or Action	Purpose
	<code>Router(config)# cable acfe max-eir-ratio 20</code>	
Step 4	exit Example: <code>Router(config)# exit</code>	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.

Procedure

	Command or Action	Purpose
Step 1	enable Example: <code>Router> enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: <code>Router# configure terminal</code>	Enters global configuration mode.
Step 3	cable acfe constant-eir-demand value Example: <code>Router(config)# cable acfe constant-eir-demand 20</code>	Configures the constant EIR demand as 20 for a BG.
Step 4	exit Example: <code>Router(config)# exit</code>	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.

Procedure

	Command or Action	Purpose
Step 1	enable Example: <pre>Router> enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: <pre>Router# configure terminal</pre>	Enters global configuration mode.
Step 3	interface {wideband-cable interface-cable }slot/subslot /port :interface-num Example: <pre>Router(config)# interface wideband-cable 1/0/0:0</pre>	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: <pre>Router(config-if)# cable acfe max-bonus-bandwidth 1000000</pre>	Configures the maximum usable bonus bandwidth for a BG.
Step 5	end Example: <pre>Router(config)# end</pre>	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 1875 Kbps
Total downstream reserved/reservable bandwidth 20000/1500 Kbps
Total downstream guaranteed/non-guaranteed bonus bandwidth 20760/9741 Kbps
Router#
```

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” is 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.

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 1/0/0:0

Interface Wi1/0/0:0
BGID: 28673

Resource - Downstream Bandwidth
-----
App-type   Name           Reservation/bps  Exclusive
1          0              0               Not configured
2          0              0               Not configured
3          0              0               Not configured
4          0              0               Not configured
5          0              0               Not configured
6          0              0               Not configured
7          0              0               Not configured
8          20000000      0               Not configured
Max Reserved BW = 1500000 bps
Total Current Reservation = 20000000 bps
Guaranteed Bonus BW = 20760000 bps
Non-guaranteed Bonus BW = 9741000 bps
Subset BGs: In1/0/0:8 In1/0/0:9 In1/0/0:10 In1/0/0:11 In1/0/0:12
Superset BGs: N/A
Overlapping BGs: Wi1/0/0:8 Wi1/0/0:9 Wi1/0/0:10
Router#
```

Effective with Cisco IOS-XE Release 3.18.0SP, Capacity BW is also displayed. It is a summation of the channel capacity of the RF channels in this interface, and the capacity of OFDM channels is calculated considering the lowest profile rate.


```

Router#show cable admission-control interface wideband-Cable 2/0/0:1

Interface Wi2/0/0:1
BGID: 8194

Resource - Downstream Bandwidth
-----
App-type   Name           Reservation/bps   Maximum         Rejected
1          1              4000             90%            0
2          2              0                N/A            0
3          3              0                90%            0
4          4              0                N/A            0
5          5              0                N/A            0
6          6              0                90%            0
7          7              0                N/A            0
8          8              0                87%            0
Max Reserved BW = 11424000 bps
Total Current Reservation = 4000 bps
Guaranteed Bonus BW = 884352000 bps
Non-guaranteed Bonus BW = 225904000 bps
Capacity BW = 1428000000 bps
Subset BGs: In2/0/0:0 In2/0/0:1 In2/0/0:2 In2/0/0:3 In2/0/0:4 In2/0/0:5 In2/0/0:6 In2/0/0:7
             In2/0/0:158 Wi2/0/0:0
Superset BGs: N/A

```

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 integrated-Cable 1/0/0
EIR Rebalance invoked: 450963
Adaptive CIR granted: 20
Adaptive CIR rejected: 1
Total clusters: 9
RF FlexBW
8 36376
9 36376
10 32625
.....

```

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

Use the **show controllers integrated-Cable acfe cluster** command to show Per-controller statistics and clusters and checking the bandwidth information as follows:

```
Router# show controllers integrated-Cable 1/0/0 acfe cluster 0
Integrated-Cable 1/0/0 status:
Topology changed: No

=====Cluster 0=====
Number of RF: 2
RF FlexBW  WB  ExcessBW  Quanta
0  35625  -   35438   35438
      0   187   187
1  35250  0   35250   35250

Number of BG: 2
Intf Demand CIR Max  CstrMin Alloc NBonus Ratio
WB0  1000  0  70875  35250  35437  35438  14855190400
IC0  1000  0  35625  0      35438  187    14855609600
```

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
!
```

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.

```

!
interface integrated-Cable1/0/0:0
cable bundle 1
  cable rf-bandwidth-percent 10
!
interface Wideband-Cable9/0/0:0
cable bundle 1
  cable rf-channels channel-list 0
  bandwidth-percent 1
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 IC interface has only 1 BE flow, then IC 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 IC interface, as it would exceed the bonus bandwidth. If the 'max-eir-ratio' is set to 10, then the IC 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

```

Example: Maximum Bonus Bandwidth

```

cable acfe constant-eir-demand 2
!

!
interface integrated-Cable1/0/0:0
cable bundle 1
  cable rf-bandwidth-percent 10
  cable acfe constant-eir-demand 2
!
interface Wideband-Cable9/0/0:0
cable bundle 1
  cable rf-channels channel-list 0
  bandwidth-percent 1
  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

Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>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.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	http://www.cisco.com/support

Feature Information for Fairness Across DOCSIS Interfaces

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 Downstream Interface Configuration

Feature Name	Releases	Feature Information
Fairness Across DOCSIS Interfaces	Cisco IOS-XE 3.15.0S	This feature was introduced on the Cisco cBR Series Converged Broadband Router .
Fairness Across DOCSIS Interfaces	Cisco IOS-XE 3.17.0S	<p>On-demand CIR acquisition and Fairness across bonding groups were supported.</p> <p>The following commands were modified:</p> <ul style="list-style-type: none"> • show cable acfe summary • show cable acfe interface

Feature Name	Releases	Feature Information
Hierarchical QoS	Cisco IOS-XE 3.18.0SP	This feature was introduced on the Cisco cBR Series Converged Broadband Router.