



# DOCSIS WFQ Scheduler on the Cisco CMTS Routers

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The DOCSIS WFQ Scheduler is an output packet scheduler that provides output scheduling services on both WAN uplink interfaces and DOCSIS downstream interfaces.

## 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.

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## Hardware Compatibility Matrix for the Cisco cBR Series Routers



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**Note** The hardware components that are introduced in a given Cisco IOS-XE Release are supported in all subsequent releases unless otherwise specified.

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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><b>Cisco IOS-XE Release 16.5.1 and Later Releases</b></p> <p>Cisco cBR-8 Supervisor:</p> <ul style="list-style-type: none"> <li>• PID—CBR-SUP-250G</li> <li>• PID—CBR-CCAP-SUP-160G</li> <li>• PID—CBR-CCAP-SUP-60G</li> <li>• PID—CBR-SUP-8X10G-PIC</li> </ul>	<p><b>Cisco IOS-XE Release 16.5.1 and Later Releases</b></p> <p>Cisco cBR-8 CCAP Line Cards:</p> <ul style="list-style-type: none"> <li>• PID—CBR-LC-8D30-16U30</li> <li>• PID—CBR-LC-8D31-16U30</li> <li>• PID—CBR-RF-PIC</li> <li>• PID—CBR-RF-PROT-PIC</li> <li>• PID—CBR-CCAP-LC-40G</li> <li>• PID—CBR-CCAP-LC-40G-R</li> </ul> <p>Cisco cBR-8 Downstream PHY Modules:</p> <ul style="list-style-type: none"> <li>• PID—CBR-D30-DS-MOD</li> <li>• PID—CBR-D31-DS-MOD</li> </ul> <p>Cisco cBR-8 Upstream PHY Modules:</p> <ul style="list-style-type: none"> <li>• PID—CBR-D30-US-MOD</li> <li>• PID—CBR-D31-US-MOD</li> </ul>

## Prerequisites for DOCSIS WFQ Scheduler

No special equipment or software is needed to use the DOCSIS WFQ Scheduler feature.

## Restrictions for DOCSIS WFQ Scheduler

- The DBS feature is only applicable to DOCSIS 3.0 downstream channel bonding.

## Information About DOCSIS WFQ Scheduler

The DOCSIS WFQ scheduling engine is used to provide output packet scheduling services, including absolute priority queueing, weighted fair queueing, minimum rate guarantee, traffic shaping, and DOCSIS bonding group dynamic bandwidth sharing on the Cisco cBR-8 converged broadband router.

The DOCSIS WFQ Scheduler provides services on both WAN uplink interfaces and DOCSIS downstream interfaces. The scheduling parameters on WAN uplink interfaces are configured through the Modular QoS

CLI (MQC). On cable downstream interfaces, queues are created for DOCSIS service flows with parameters configured by DOCSIS downstream QoS type, length, values (TLVs).

The default queue size for the DOCSIS service flows (with bandwidth greater than 150 Mbps) is based on the bandwidth on the cable downstream interfaces (see Table below). Additionally, the queue limit for all service flows can also be adjusted using the **cable queue-limit** command, buffer size in service class or downstream buffer control TLVs.



**Note** The default queue size change, and the **cable queue-limit** command do not affect the DOCSIS high priority queues.

Table below is an example of the queue size based on Annex B 256 QAM channels.

**Table 2: Bandwidth, Queue Sizes, and Queue Limits**

Channel	Bandwidth (Mbps)	Default Queue Size	Queue Size				
			1 ms	20 ms	30 ms	40 ms	200 ms
1	37.5	63	63	63	92	123	617
2	75	255	63	123	185	247	1235
3	112.5	255	63	185	277	370	1852
4	150	255	63	247	370	494	2470
5	187.5	319	63	308	463	617	3087
6	225	383	63	370	555	741	3705
7	262.5	447	63	432	648	864	4323
8	300	511	63	494	741	988	4940
12	450	767	63	741	1111	1482	7411
14	525	895	63	864	1296	1729	8646
16	600	1023	63	988	1482	1976	9881

The DOCSIS WFQ Scheduler also allows significant enhancement to the queue scaling limits.

The following sections explain the DOCSIS WFQ Scheduler features:

## Queue Types

The DOCSIS WFQ Scheduler feature supports the following types of queues:

- Priority queues
- CIR queues
- Best Effort queues

## Priority Queues

Priority queues are serviced with absolute priority over all the other queues. On DOCSIS downstream interfaces, the priority queues are configured by DOCSIS applications that request a priority service flow, for example, a packet cable voice service flow. On WAN uplink interfaces, the priority queues are configured by the MQC policy maps.

The following restrictions apply to priority queues:

- Only one priority queue is allowed per WAN uplink interface.
- Only one priority queue is allowed for low latency service flows created for each DOCSIS downstream interface.
- All low latency flows on a DOCSIS downstream are aggregated to the single priority queue.

## CIR Queues

A CIR queue is guaranteed to be serviced with at least the Committed Information Rate (CIR). CIR queues are used to service DOCSIS service flows with non-zero minimum reserved rates. If the offered load to a CIR queue exceeds its CIR value, the excess traffic is serviced as best effort traffic.

## Best Effort Queues

The Best Effort (BE) queues share the interface bandwidth not used by the priority queue and the CIR queues. The sharing is in proportion to each queue's excess ratio.

The following conditions apply to BE queues:

- On DOCSIS downstream interfaces, BE queues are created by DOCSIS service flows that do not request a minimum reserved rate.
- Each DOCSIS flow without a minimum reserved rate uses its own BE queue.

## DOCSIS QoS Support

DOCSIS defines a set of quality of service (QoS) parameters, including traffic priority, maximum sustained traffic rate, minimum reserved traffic rate, maximum traffic burst, maximum downstream latency, and peak traffic rate.

The downstream service flows use the QoS parameters to specify the desired QoS. The downstream policer and scheduler provides services such as traffic shaping, bandwidth provisioning, traffic prioritization, and bandwidth guarantee.

The DOCSIS service flow parameters are mapped to the packet queue parameters and provided with appropriate QoS support for the packet queues to support the DOCSIS parameters

The following DOCSIS QoS parameters are supported:

- Traffic priority
- Maximum sustained traffic rate
- Minimum reserved traffic rate




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**Note** The maximum traffic burst size and the peak traffic rate are supported as described in the [http://www.cisco.com/c/en/us/td/docs/cable/cbr/configuration/guide/b\\_cmts\\_quality\\_of\\_services/docsis\\_wfq\\_scheduler.html#con\\_1085732](http://www.cisco.com/c/en/us/td/docs/cable/cbr/configuration/guide/b_cmts_quality_of_services/docsis_wfq_scheduler.html#con_1085732).

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## Traffic Priority

The downstream channel bandwidth available to the best effort traffic, namely the channel bandwidth minus the amount consumed by the priority traffic and the CIR traffic, is allocated to the best effort service flows in proportion to their DOCSIS traffic priorities. For example, if there are three service flows sending packets at a particular moment over the same downstream channel, and their DOCSIS traffic priorities are 0, 1 and 3, respectively, their share of the channel bandwidth will be 1:2:4. To achieve this bandwidth allocation, each service flow is assigned a value known as its excess ratio which is derived from its DOCSIS priority. Table below shows the default mappings of DOCSIS priority to excess ratio.




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**Note** When traffic priority for a flow is not explicitly specified, a default priority value of 0 is used as per the DOCSIS specification.

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**Table 3: DOCSIS Priority to Excess Ratio Mapping**

DOCSIS Traffic Priority	Excess Ratio
0	4
1	8
2	12
3	16
4	20
5	24
6	28
7	32

### Custom DOCSIS Priority to Excess Ratio Mappings

This option is introduced to configure custom priority to excess ratio mappings for downstream service flows that override the default mappings listed in the above Table.




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**Note** The configured values are used only for new service flows that are created after the configuration has been applied. All the existing service flows maintain their previous excess ratio values.

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The option to configure priority to excess ratio mappings is available on a per downstream forwarding interface basis and is applicable to legacy cable, wideband and modular cable, and integrated cable interfaces.

The cable downstream qos wfq weights command is used to configure the mappings.

## Maximum Sustained Traffic Rate

The maximum sustained traffic rate (MSR) specifies the peak information rate of a service flow. The MSR of a service flow is mapped to the shape rate of the packet queue. When the maximum sustained traffic rate is not specified or set to zero, its traffic rate becomes limited only by the physical channel capacity set by DOCSIS specifications.



**Note** The Cisco cBR Cisco Packet Processor (CPP) forwarding processor supports a maximum ratio of 1,000:1 between the highest MaxSusRate or MinRsvRate and the lowest MaxSusRate or MinRsvRate. The scheduler is impacted when the ratio exceeds the value. This limitation is per downstream forwarding interface (Wideband-Cable, Integrated-Cable, and Downstream-Cable).

However, flows implemented by Low Latency Queuing (LLQ) are not be affected by this limitation.

## Minimum Reserved Traffic Rate

The minimum reserved traffic rate (MRR) specifies the minimum rate reserved for a service flow. The MRR of a service flow is mapped to the CIR of the packet queue, which ensures the minimum amount of bandwidth a queue gets under congestion. When the MRR is not specified, the CIR is set to zero as per DOCSIS specifications.

## High Priority Traffic

High priority traffic flows are mapped to a Low Latency Queue (LLQ) on the data forwarding interface. The packets in LLQ are serviced with absolute priority over other queues on the same interface.

The following service flows require high priority service:

- Service flows with DOCSIS downstream latency TLV set to a value above zero. For example, PacketCable Multimedia Specification (PCMM) voice calls.
- PacketCable downstream service flows.
- Service flows with Unsolicited Grant Service (UGS) type—non-PacketCable voice calls—upstream flows.

## Enhanced Rate Bandwidth Allocation

The DOCSIS WFQ Scheduler supports the Enhanced Rate Bandwidth Allocation (ERBA) feature for service flows. The ERBA feature allows cable modems (CMs) to burst their temporary transmission rates up to the full line rate for short durations of time. This capability provides higher bandwidth for instantaneous bandwidth requests without having to make changes to existing service levels in the QoS profile.

The DOCSIS WFQ Scheduler allows each service flow to have one dedicated queue. When ERBA is enabled for the service flow, the peak rate is implemented as the queue shape rate within the scheduler, while the maximum sustained rate is set as the token bucket refill rate. When ERBA is turned off, the burst size and the peak rate value are not used.

The maximum traffic burst parameter is used to control a service flow burst duration, to burst up to the channel line rate or a configured peak rate, when it is within its maximum burst size allowance. On the Cisco cBR-8 Converged Broadband Router, the **cable ds-max-burst** command is used to control this behavior explicitly.



**Note** The ERBA feature is not applicable for high priority service flows and multicast service flows.

Table below summarizes the ERBA support for the Cisco cBR-8 router.

**Table 4: Enhanced Rate Bandwidth Allocation Support for the Cisco cBR-8 Router**

	<b>Policer Rate</b>	<b>Policer Exceed Action</b>	<b>Policer Token Bucket Size</b>	<b>Queue Shape Rate</b>
Traditional Service Flow	Maximum Sustained Traffic Rate (unused)	Transmit	A value computed internally by CMTS (unused)	Maximum Sustained Traffic Rate
ERBA-Enabled Service Flow	Maximum Sustained Traffic Rate	Drop	Maximum Traffic Burst TLV	Peak Traffic Rate

For information about ERBA support on the Cisco CMTS routers, refer to Using Enhanced Bandwidth Rate Allocation (ERBA) Support for DOCSIS 1.0 Cable Modems at the following location: [DOCSIS 1.1 for the Cisco CMTS Routers](#)

## Peak Traffic Rate

The *peak-rate* option of the **cable ds-max-burst** command allows you to specify the peak rate an ERBA-enabled service flow can use. The *peak-rate* value is a global value and is applied to all service flows created after the configuration of the **cable ds-max-burst** command. The default value of the *peak-rate* is zero.

If the DOCSIS 3.0 TLV 25.27 is specified for a service flow, the *peak-rate* value is set as the TLV value. However, if ERBA is not turned on for a service flow, the *peak-rate* value is ignored.

The *peak-rate* value can also be configured through cable service class command which forms part of the service class template. During modem registration or Dynamic Service Addition (DSA) operation, the service class name TLV 25.4 is sent to create the static or dynamic downstream service flow that matches the service class template. These downstream service flows are created with a specific *peak-rate*. If the *peak-rate* is not specified in the cable modem's configuration file, then the peak rate specified by the **cable ds-max-burst burst-threshold threshold peak-rate peak rate** command is used.



**Note** The option to specify peak rate in the **cable ds-max-burst** command is not available on the Cisco cBR Series Converged Broadband routers.

If a service flow has both service class and TLV 25.27 defined *peak-rate*, then the *peak-rate* value specified in the TLV is used.

Some of the DOCSIS 1.x and DOCSIS 2.0 cable modems, which are not fully DOCSIS 1.x or DOCSIS 2.0 compliant, may fail to come online when they receive TLV 25.27 from the Cisco CMTS during registration. In order to overcome this you can configure the **cable service attribute withhold-TLVs command with the peak-rate** keyword to restrict sending of this TLV to non-DOCSIS 3.0 cable modems.

## DOCSIS 3.0 Downstream Bonding Support with Bonding Group Dynamic Bandwidth Sharing

DOCSIS 3.0 introduces the concept of downstream channel bonding. Each Bonding Group (BG) is made up of a collection of downstream channels, which can be used by one or more bonding groups. Each downstream channel can also serve as a primary channel in a MAC domain and carry non-bonded traffic, while being part of a BG.

Prior to DOCSIS 3.0 standards, the downstream service flows were associated with a single downstream interface, which in turn corresponded to a physical downstream on an RF channel. In DOCSIS 3.0, the downstream service flows are associated with the downstream bonding groups. These bonding groups can use multiple downstream RF channels.

DBS is the dynamic allocation of bandwidth for wideband (WB) and integrated cable (IC) interfaces sharing the same downstream channel. Due to the channel sharing nature of the bonding groups, the bandwidth available to bonding groups or non-bonded channels is not fixed. The bandwidth depends on the configuration and the traffic load on the WB or IC.




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**Note** Bonding groups are implemented as WB interfaces and non-bonded channels as IC interfaces.

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In the DBS mode, the bandwidth of the shared RF channels is dynamically allocated among the WB and IC interfaces. The DBS enables efficient use of the underlying RF channel bandwidth even in the presence of high burst traffic. The DBS is configured at the WB or IC interface level. By default, bandwidth for a WB or IC channel is statically allocated (non-DBS).

For information about DBS support on the Cisco CMTS routers, refer to the [Dynamic Bandwidth Sharing on the Cisco CMTS Router](#) feature.

## How to Configure DOCSIS WFQ Scheduler

You cannot configure the DOCSIS WFQ Scheduler feature as it is automatically loaded. The parameters that the schedule uses include the interface bandwidth and queue parameters.

This section describes the following required and optional procedures:

### Mapping DOCSIS Priority to Excess Ratio

This section describes how to map DOCSIS priorities to custom excess ratios for downstream service flows. These custom mappings will override the default mappings.

#### Procedure

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



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface wideband-cable slot/subslot/port</b> <b>:wideband-channel</b> or <b>interface</b> <b>integrated-cable slot/subslot/port :rf-channel</b> <b>Example:</b> <pre>Router(config)# interface wideband-cable 2/0/0:0 or Router(config)# interface integrated-cable 1/0/0:0</pre>	Enters interface configuration mode for the indicated cable downstream interface.
<b>Step 4</b>	<b>cable downstream qos wfq weights</b> <b>{weight1...weight8}</b> <b>Example:</b> <pre>Router(config-if)# cable downstream qos wfq weights 10 20 30 40 50 60 70 80</pre>	Configures the custom excess ratios for 8 priorities: <b>Note</b> The custom values are used only for new service flows and not existing ones.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Router(config-if)# end</pre>	Exits interface configuration mode and returns to privileged EXEC mode.

## Verifying the Downstream Queues Information

To verify the downstream queue information for a modem, use the **show cable modem** [*mac-address* |*ip-address*] **service-flow** command.

To check queue stats of all queues on an Integrated-Cable or Wideband-Cable interface, use the **show cable dp queue** *interface* command.

## Additional References

The following sections provide references related to the DOCSIS WFQ Scheduler feature.

**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>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for DOCSIS WFQ Scheduler

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 5: Feature Information for DOCSIS WFQ Scheduler**

Feature Name	Releases	Feature Information
DOCSIS WFQ scheduler	Cisco IOS XE Everest 16.6.1	This feature was integrated into Cisco IOS XE Everest 16.6.1 on the Cisco cBR Series Converged Broadband Routers.