DOCSIS WFQ Scheduler on the Cisco CMTS Routers

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Cisco IOS Release 12.2(33)SCB introduces the Data-over-Cable Service Interface Specifications (DOCSIS) Weighted Fair Queuing (WFQ) Scheduler on the Cisco uBR10012 Universal Broadband Router. 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 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 for DOCSIS WFQ Scheduler" section on page 96.

Use Cisco Feature Navigator to find information about platform support and Cisco IOS, Catalyst OS, and Cisco IOS XE software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

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Prerequisites for DOCSIS WFQ Scheduler

Table 1 shows the Cisco Cable Modem Termination System (CMTS) hardware compatibility prerequisites for this feature.

Table 1 DOCSIS 3.0 WFQ Scheduler QoS Support Hardware Compatibility Matrix

CMTS Platform	Processor Engine	Cable Interface Cards	SIP/SPA
Cisco uBR10012 Universal Broadband Router	**Cisco IOS Release 12.2(33)SCB and later releases** • PRE2 • PRE4	**Cisco IOS Release 12.2(33)SCB and later releases** • Cisco uBR10-MC5X20S/U/H **Cisco IOS Release 12.2(33)SCC and later** • Cisco UBR-MC20X20V[1] **Cisco IOS Release 12.2(33)SCE and later** • Cisco uBR-MC3GX60V[2]	**Cisco IOS Release 12.2(33)SCB and later releases** • Cisco Wideband SIP and Cisco Wideband SPA • Cisco 10000 Series SIP-600 and Cisco Wideband SPA or Cisco 5-Port Gigabit Ethernet SPA or Cisco 1-Port 10-Gigabit Ethernet SPA
Cisco uBR7246VXR Universal Broadband Router	**Cisco IOS Release 12.2(33)SCD and later releases** • NPE-G2	**Cisco IOS Release 12.2(33)SCD and later releases** • Cisco uBR-MC88V[3]	–
Cisco uBR7225VXR Universal Broadband Router	**Cisco IOS Release 12.2(33)SCD and later releases** • NPE-G2	**Cisco IOS Release 12.2(33)SCD and later releases** • Cisco uBR-MC88V[3]	–

1. The Cisco UBR-MC20X20V cable interface line card has three variants: Cisco UBR-MC20X20V-0D, Cisco UBR-MC20X20V-5D, and Cisco UBR-MC20X20V-20D. The Cisco UBR-MC20X20V-0D line card supports 20 upstreams and 0 (no) downstreams. The Cisco UBR-MC20X20V-5D line card supports 20 upstreams and 5 downstreams, and the Cisco UBR-MC20X20V-20D line card supports 20 upstreams and 20 downstreams.
2. Cisco uBR3GX60V cable interface line card is not compatible with PRE2. You must use PRE4 with the Cisco uBR3GX60V cable interface line card.
3. The Cisco uBR-MC88V cable interface line card is not compatible with NPE-G1. You must use NPE-G2 with the Cisco uBR-MC88V cable interface line card.

Note SPA interface processors (SIPs) and shared port adapters (SPAs) are required to only use DOCSIS 3.0 downstream channel bonding. Similarly, the Dynamic Bandwidth Sharing (DBS) feature is only applicable with DOCSIS 3.0 downstream channel bonding and is not a prerequisite for using the WFQ scheduler.

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 uBR10012 universal broadband router. It replaces the existing Versatile Traffic Management System (VTMS) scheduler.

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).

Starting with Cisco IOS Release 12.2(33)SCG, the default queue size for the DOCSIS service flows (with bandwidth greater than 150 Mbps) is increased from 255 to higher values based on the bandwidth on the cable downstream interfaces (see Table 2). Additionally, the queue limit for all service flows can also be adjusted using the **cable queue-limit** command. For more information, see the *Cisco IOS CMTS Cable Command Reference*.

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

Table 2 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

For DOCSIS downstream interfaces, the DOCSIS WFQ Scheduler implements traffic shaping and physical link scheduling at two separate layers, which allows it to account for traffic overhead differently. This allows the scheduler to schedule accurately at the physical layer while conforming to DOCSIS specifications.

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

Table 3 shows the queue scaling number comparisons.

Table 3 Queue Scaling Limits

Queue Criteria	PRE4	PRE2	PRE2, Cisco IOS Release 12.2(33)SCA or earlier	NPE-G2/ MC88V
Total Number of Queues Per System[1]	384,000	384,000	65,534	64,000
Total Number of CIR Queues	120,000	120,000	65,534	64,000
Number of Queues Per GE Link	16[2]	16[2]	32[3]	N/A
Maximum Number of Packets in PXF	Small 1,703,936 Large 245,760	Small 52,428 Large 32,768	Small 52,428 Large 32,768	Small 150,000 Large 50,000
Queue Size on WAN Uplink	16,00-32,00	16,00-32,00	32,000-16,000	N/A
Queue Size on DOCSIS Downstream[4]	255	255	64	128

1. Includes network-control and default queues.
2. 14 user-configurable queues, 1 class-default queue, and 1 system queue.
3. 30 user-configurable queues, 1 class-default queue, and 1 system queue.
4. Starting Cisco IOS Release 12.2(33)SCG, the Queue Size on the PRE4 and PRE2 modules varies from 255 to 1023 with bandwidth 150 Mbps to 600 Mbps. See Table 2.

The following sections explain the DOCSIS WFQ Scheduler features:

- Queue Types, page 78
- DOCSIS QoS Support, page 79
- High Priority Traffic, page 81
- Enhanced Rate Bandwidth Allocation, page 81
- DOCSIS 3.0 Downstream Bonding Support with Bonding Group Dynamic Bandwidth Sharing, page 83

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.

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.

The following conditions apply to CIR queues:

- CIR queues are supported only on DOCSIS downstream interfaces. They are not supported on WAN uplink interfaces.
- Each DOCSIS flow with a non-zero minimum reserved rate uses its own CIR queue.

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 quantum value.

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

Note The maximum traffic burst size and the peak traffic rate are supported as described in the "Enhanced Rate Bandwidth Allocation" section on page 81.

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 4 shows the default mappings of DOCSIS priority to excess ratio.

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

Table 4 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

Cisco IOS Release 12.2(33)SCC introduces the option to configure custom priority to excess ratio mappings for downstream service flows that override the default mappings listed in Table 4.

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.

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.

Note Modular cable interfaces are not supported on Cisco uBR7200 series routers.

The **cable downstream qos wfq weights** command is used to configure the mappings. For more details on this command, refer to *Cisco IOS CMTS Cable Command Reference Guide*.

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.

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 uBR10012 Universal Broadband Router, the **cable ds-max-burst** command is used to control this behavior explicitly.

For more details on this behavior and the CLI, refer to *Cisco IOS CMTS Cable Command Reference Guide*.

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

Table 5 summarizes the ERBA support for the Cisco uBR10012 router.

Table 5 Enhanced Rate Bandwidth Allocation Support for the Cisco uBR10012 Router

	Policer Rate	Policer Exceed Action	Policer Token Bucket Size	Queue Shape Rate
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

In Cisco uBR7246VXR and Cisco uBR7225VXR routers, the dual token bucket-based shaper is used to support ERBA on the Cisco uBR-MC88V line card (the ERBA feature is always enabled on the Cisco uBR-MC88V line card). The dual token bucket shaper has two independent token buckets for each service flow. The maximum rate of one bucket is configured to MSR and the maximum tokens are set to maximum traffic burst. The other bucket is configured with the refilling rate of the *peak-rate* and the maximum tokens are set to the default level, of 4 milliseconds. Packets are shaped if any of the two buckets are exhausted.

Table 6 summarizes the ERBA dual token bucket configuration for the Cisco uBR7246VXR and Cisco uBR7225VXR routers.

Table 6 ERBA Dual Token Bucket Configuration

	Token Bucket Rate (One)	Token Bucket Size (One)	Token Bucket Rate (Two)	Token Bucket Size (Two)
Traditional Service Flow	Maximum Sustained Traffic Rate	4ms * MSR	N/A	N/A
ERBA-enabled Service Flow	Maximum Sustained Traffic Rate	Maximum Traffic Burst or 4ms * MSR	Peak Rate	4ms * Peak 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: http://www.cisco.com/en/US/docs/ios/cable/configuration/guide/cmts_docsis11.html#wp1274325

Peak Traffic Rate

Note The **cable ds-max-burst** command is not supported on the Cisco uBR7246VXR and Cisco uBR7225VXR routers.

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, then the value specified by the **cable ds-max-burst** command is used.

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.

For more details on the **cable service class** and **cable service attribute withhold-TLVs** commands, see *Cisco IOS CMTS Cable Command Reference Guide*.

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.

On the Cisco uBR10012 universal broadband router, the DOCSIS 3.0 downstream channel bonding is supported on the SPA RF channels. To efficiently utilize the underlying RF channel bandwidth and to provide QoS to the downstream service flows, dynamic bandwidth sharing (DBS) is supported on the interfaces using SPA RF channels.

DBS is the dynamic allocation of bandwidth for wideband (WB), integrated cable (IC), and modular-cable (MC) 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, IC, or MC.

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

In the DBS mode, the bandwidth of the shared RF channels is dynamically allocated among the WB, IC, and MC 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, IC, or MC interface level. By default, bandwidth for a WB, IC, or MC channel is statically allocated (non-DBS).

DBS does not prevent static bandwidth configuration. If a static portion of the bandwidth is configured on any RF channel that one or more DBS-enabled channel utilizes, that portion is subtracted from the RF channel bandwidth. This portion of bandwidth is dedicated to the non-DBS interface and becomes unavailable to the DBS WB, IC, or MC interfaces.

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 into the Parallel Express Forwarding (PXF) engine. 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, page 84 (required)
- Verifying the Service Flows and Queues, page 86 (required)
- Verifying the DOCSIS Priority to Excess Ratio Mapping, page 88 (required)
- Verifying the HQF Queue Detail Information, page 90 (required)

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.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface cable** {*slot/port* | *slot/subslot/port*}
4. **cable downstream qos wfq weights** {*weight1...weight 8*}
5. **end**

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	**interface cable** {*slot/port*|*slot/subslot/port*} **Example:** `Router(config)# interface cable 3/0/0`	Enters interface configuration mode for the indicated cable downstream interface. • On the Cisco uBR7246VXR router, the valid values are: – *slot*—3 to 6 – *port*—0 or 1 (depending on the cable interface) • On the Cisco uBR7225VXR router, the valid values are: – *slot*—1 and 2 – *port*—0 or 1 (depending on the cable interface) • On the Cisco uBR10012 router, the valid values are: – *slot*—5 to 8 – *subslot*—0 or 1 – *port*—0 to 4 (depending on the cable interface)
Step 4	**cable downstream qos wfq weigthts** {*weight1...weight8*} **Example:** `Router(config-if)# cable downstream qos wfq weights 10 20 30 40 50 60 70 80`	Configures the custom excess ratios for 8 priorities: • *weight1...weight8*—Custom weight. Valid values range from 1 to 100. **Note** The custom values are used only for new service flows and not existing ones.
Step 5	**end** **Example:** `Router(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying the Service Flows and Queues

Cisco uBR10012 Router

To verify the downstream (DS) service flows and parameters for a modem, use the **show cable modem** [*mac-address* | *ip-address*] **qos** command on the Cisco uBR10012 router as shown in the following example:

```
Router# show cable modem 0018.f826.3453 qos

Sfid  Dir Curr  Sid   Sched  Prio MaxSusRate  MaxBrst   MinRsvRate  Throughput
          State       Type

7     US  act   1     BE     7    0           3044      0           0
8     DS  act   N/A   BE     7    0           2000000   100000      7429769
29    DS  act   N/A   BE     0    0           3044      0           0
```

To verify the detailed service flow configuration, use the **show interfaces** *cable-interface* **service-flow** *sfid* **qos** command on the Cisco uBR10012 router as shown in the following example:

```
Router# show interfaces c7/0/0 service-flow 8 qos

Sfid  Dir Curr  Sid   Sched  Prio MaxSusRate  MaxBrst   MinRsvRate  Throughput
          State       Type
8     DS  act   N/A   BE     7    0           2000000   100000      7430397
```

To verify the detailed service flow statistics, use the **show interfaces** *cable-interface* **service-flow** *sfid* **counters** command on the Cisco uBR10012 router as shown in the following example:

```
Router# show interfaces c7/0/0 service-flow 8 counters

Sfid  Packets              Bytes                PacketDrop Bits/Sec   Packet/Sec
8     100913               121095600            374337     7431599    773
```

To verify the service flow ID to queue ID (queue index) association, use the **show cr10k-rp** *cable-interface sfid* **queue** command on the Cisco uBR10012 router as shown in the following example:

```
Router# show cr10k-rp mod 1/2/0:0 queue

Docsis queues on the interface: 0
Total DOCSIS Queues Allocated: 45
Available/Maximal reservable rate(kbps): 3750/3750

HQF BLT Info (LBLT Group 36):
LBLT 36: wt/qntm 1/10000; PBLT 1236: BW 3750Kbps, flowbit prd/ofst 512/0, rsrc/flrsrc 3/3

BE Queues:

CIR Queues:

LL Queues:
```

To verify the service flow queue information, use the **show pxf cpu queue** *interface-name* command on the Cisco uBR10012 router as shown in the following example:

```
Router# show pxf cpu queue modular-cable 1/2/0:0

Cable Interface Queues:

QID     Len/Max  Dequeues   TailDrops   MinRt  Wt/Quantum  ShapeRt FlowId
                                        (Kbps)             (Kbps)
131147    0/255  190        0           0         1/240     0       58
131148    0/255  33820      0           0         1/10000   0       32824
```

```
Cable Service Flow Queues:

* Best Effort Queues

QID     Len/Max  Dequeues   TailDrops   MinRt  Wt/Quantum  ShapeRt FlowId
                                        (Kbps)             (Kbps)
131241    0/255  0          0           0         1/240    0       32881

* CIR Queues

QID     Len/Max  Dequeues   TailDrops   MinRt  Wt/Quantum  ShapeRt FlowId
                                        (Kbps)             (Kbps)
2049    254/255  131018     485751      99        1/1920   0       32880

* Low Latency Queues

QID     Len/Max  Dequeues   TailDrops
```

Cisco uBR7246VXR and Cisco uBR7225VXR Routers

To verify the downstream hierarchical queueing framework (HQF) queue information for a modem, use the **show cable modem** [*mac-address* | *ip-address*] **queue** command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show cable modem 41.3.190.2 queue

* idx/gqid Len/Limit Deqs      Drops     CIR       MIR/PR     ForwInt  SFID
            pkts    pkts      pkts      kbps       kbps
BE Queues:
    3/43     0/128   103       0         0           0/0      In5/1:1 Ca5/1:22

CIR Queues:

Low Latency Queues:
```

To verify the downstream HQF queue information for the interface, use the **show interfaces** *cable-interface* **service-flow** *sfid* **queue** command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces c3/0 service-flow 8 queue

*   idx/gqid   Len/Limit Deqs      Drops    CIR         MIR/PR
                 pkts    pkts      pkts     kbps         kbps
      0/53       0/128   0         0        100       15000/0

 I: Cable Interface Queue
 $: Low Latency Queue
 ~: Low Latency Policing Queue
```

To verify the detailed downstream HQF information for all queues under this interface, use the **show interfaces** *cable-interface* **service-flow** *sfid* **queue verbose** command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces c3/0 service-flow 8 queue verbose

   blt (0x19FA93C0, index 6, qid 53, fast_if_number 20) layer CLASS_HIER0
   scheduling policy: FIFO (110)
   classification policy: NONE (120)
   drop policy: TAIL (141)
   packet size fixup policy: NONE (0)   no of global policers: 0
   D/Traffic Shaping enabled
   blt flags: 0x22A208C    scheduler: 0x1A015D80
```

```
   total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 9500 total
active 1
   D/Traffic Shaping enabled
   txcount 0 txqbytes 0 drops 0 qdrops 0 nobuffers 0 flowdrops 0
   qsize 0 aggregate limit/bytes 128/375000 availbuffers 128
   holdqueue_out 0 perc 0.00 remaining_ratio/perc 20
   visible_bw 100 max_rate 15000 allocated_bw 100 vc_encap 0 ecn_threshold NONE
   weight A 1 quantum A 1500 credit A 1500
   weight B 1 quantum B 1500 credit B 1500
   min-rate tokens: 1500, credit: 0, depth: 1500

   backpressure_policy 0 scheduler_flags C03F
   last_sortq[A/B] 0/0, remaining pak/particles 0/0
   leaf_blt[P1] 0x1A015D80 burst packets/bytes[P1] 0/0
   leaf_blt[P2] 0x1A015D80 burst packets/bytes[P2] 0/0
   leaf_blt[NOTP] 0x1A015D80 burst packets/bytes[NOTP] 0/0

   OUTPUT Shaping
     Bc internal 0 Be internal 0 Time interval 4
     increment 15000 increment_lower 0 increment_limit 15000
     last visit 0 credit 0 outstanding_tokens 0 maxtokens 32000000
     system timer delayed 0 restart timer 0
     timer set 0 hqf_shape_running 562
     nextexpire_system_time 0 nextexpire_time_qindex -1
```

Verifying the DOCSIS Priority to Excess Ratio Mapping

Cisco uBR10012 Router

To verify the DOCSIS priority to excess ratio mapping configuration on the Cisco uBR10012 router, use the **show running-config interface** command as shown in the following example:

```
Router# show running-config interface cable 8/0/0 | i qos

cable downstream qos wfq weights 10 20 30 40 50 60 70 80
```

To verify the excess ratio for each queue on an interface, use the **show cr10k-rp interface queue be** command on the Cisco uBR10012 router as shown in the following example:

```
Router# show cr10k cable8/1/0 queue be

Forwarding Interface: Cable8/1/0

Docsis queues on the interface: 8
Total DOCSIS Queues Allocated: 25
Available/Maximal reservable rate(kbps): 25232/26000

HQF BLT Info (LBLT Group 86):
LBLT 110: wt/qntm 1/10000; PBLT 1286: BW 26000Kbps, flowbit prd/ofst 32/3, rsrc/flrsrc
17/17

BE Queues:
Queue Index: 131268, GlobalQID 83, CBLT ID 131268
        MinRate(Kbps) 0, ExcessRatio 4, ShapeRate(bps) 10000000, QLimit 255 Service
Flow(s): rp_sf_index 32880, lc_sfid 3, min_rate(bps) 0, max_rate(bps) 10000000
peak_rate(bps) 0

Queue Index: 131376, GlobalQID 81, CBLT ID 131376
        MinRate(Kbps) 0, ExcessRatio 32, ShapeRate(bps) 0, QLimit 255 Service Flow(s):
rp_sf_index 33115, lc_sfid 39, min_rate(bps) 0, max_rate(bps) 0 peak_rate(bps) 0
```

```
Queue Index: 131377, GlobalQID 82, CBLT ID 131377
        MinRate(Kbps) 0, ExcessRatio 24, ShapeRate(bps) 5000000, QLimit 255 Service
Flow(s): rp_sf_index 33116, lc_sfid 40, min_rate(bps) 0, max_rate(bps) 5000000
peak_rate(bps) 0

Queue Index: 131378, GlobalQID 85, CBLT ID 131378
        MinRate(Kbps) 0, ExcessRatio 32, ShapeRate(bps) 0, QLimit 255 Service Flow(s):
rp_sf_index 33120, lc_sfid 35, min_rate(bps) 0, max_rate(bps) 0 peak_rate(bps) 0

Queue Index: 131379, GlobalQID 88, CBLT ID 131379
        MinRate(Kbps) 0, ExcessRatio 24, ShapeRate(bps) 5000000, QLimit 255 Service
Flow(s): rp_sf_index 33121, lc_sfid 43, min_rate(bps) 0, max_rate(bps) 5000000
peak_rate(bps) 0

Queue Index: 131398, GlobalQID 109, CBLT ID 131398
        MinRate(Kbps) 0, ExcessRatio 32, ShapeRate(bps) 0, QLimit 255 Service Flow(s):
rp_sf_index 33170, lc_sfid 37, min_rate(bps) 0, max_rate(bps) 0 peak_rate(bps) 0

Queue Index: 131399, GlobalQID 110, CBLT ID 131399
        MinRate(Kbps) 0, ExcessRatio 24, ShapeRate(bps) 5000000, QLimit 255 Service
Flow(s): rp_sf_index 33171, lc_sfid 51, min_rate(bps) 0, max_rate(bps) 5000000
peak_rate(bps) 0
```

Cisco uBR7246VXR and Cisco uBR7225VXR Routers

To verify the DOCSIS priority to excess ratio mapping configuration on the Cisco uBR7246VXR and Cisco uBR7225VXR routers, use the **show interfaces** *cable-interface* **service-flow** *sfid* **queue verbose** command as shown in the following example:

```
Router# show interfaces c3/0 service-flow 8 queue verbose

   blt (0x19FA93C0, index 6, qid 53, fast_if_number 20) layer CLASS_HIER0
   scheduling policy: FIFO (110)
   classification policy: NONE (120)
   drop policy: TAIL (141)
   packet size fixup policy: NONE (0)   no of global policers: 0
   D/Traffic Shaping enabled
   blt flags: 0x22A208C    scheduler: 0x1A015D80
   total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 9500 total
active 1
   D/Traffic Shaping enabled
   txcount 0 txqbytes 0 drops 0 qdrops 0 nobuffers 0 flowdrops 0
   qsize 0 aggregate limit/bytes 128/375000 availbuffers 128
   holdqueue_out 0 perc 0.00 remaining_ratio/perc 20
   visible_bw 100 max_rate 15000 allocated_bw 100 vc_encap 0 ecn_threshold NONE
   weight A 1 quantum A 1500 credit A 1500
   weight B 1 quantum B 1500 credit B 1500
   min-rate tokens: 1500, credit: 0, depth: 1500

   backpressure_policy 0 scheduler_flags C03F
   last_sortq[A/B] 0/0, remaining pak/particles 0/0
   leaf_blt[P1] 0x1A015D80 burst packets/bytes[P1] 0/0
   leaf_blt[P2] 0x1A015D80 burst packets/bytes[P2] 0/0
   leaf_blt[NOTP] 0x1A015D80 burst packets/bytes[NOTP] 0/0

   OUTPUT Shaping
     Bc internal 0 Be internal 0 Time interval 4
     increment 15000 increment_lower 0 increment_limit 15000
     last visit 0 credit 0 outstanding_tokens 0 maxtokens 32000000
     system timer delayed 0 restart timer 0
     timer set 0 hqf_shape_running 562
     nextexpire_system_time 0 nextexpire_time_qindex -1
```

Verifying the HQF Queue Detail Information

Cisco uBR7246VXR and Cisco uBR7225VXR Routers

To verify the downstream HQF queue information for all the queues under an interface, use the **show interfaces** {**integrated-cable | wideband-cable**} *slot/port*: *sub-interface* **queue** command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces integrated-cable 3/0:0 queue

* idx/gqid Len/Limit Deqs      Drops     CIR       MIR/PR     SFID
             pkts    pkts      pkts      kbps       kbps
BE Queues:
I   0/1      0/128   0         0         0          0/0          -
    1/42     0/128   16        0         0          0/0       Ca4/0:116
    2/44     0/128   4         0         0        1000/0      Ca4/0:3890

CIR Queues:

Low Latency Queues:

 I: Cable Interface Queue
 $: Low Latency Queue
```

To verify the detailed downstream HQF queue information for all the queues under an interface, use the **show interfaces** {**integrated-cable | wideband-cable**} *slot/port*: *sub-interface* **queue** [**verbose**] command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces integrated-cable 4/0:0 queue verbose

   blt (0x20265E60, index 0, qid 0, fast_if_number 20) layer PHYSICAL
   scheduling policy: WFQ (111)
   classification policy: CLASS_BASED (122)
   drop policy: TAIL (141)
   packet size fixup policy: NONE (0)   no of global policers: 0
   D/Traffic Shaping enabled
   blt flags: 0x222000    scheduler: 0x202D2D80
   total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 0
total active 0
   D/Traffic Shaping enabled
   txcount 13 txqbytes 746 drops 0 qdrops 0 nobuffers 0 flowdrops 0
   qsize 0 aggregate limit/bytes 8000/0 availbuffers 8000
   holdqueue_out 1000 perc 0.00 remaining_ratio/perc 0
   visible_bw 2600 max_rate 2600 allocated_bw 2080 vc_encap 0 ecn_threshold NONE
   weight A 1 quantum A 1500 credit A 0
   weight B 1 quantum B 1500 credit B 0
   min-rate tokens: 13000, credit: 0, depth: 13000

   backpressure_policy 1 scheduler_flags C03F
   last_sortq[A/B] 0/0, remaining pak/particles 0/0
   leaf_blt[P1] 0x202D2D80 burst packets/bytes[P1] 0/0
   leaf_blt[P2] 0x202D2D80 burst packets/bytes[P2] 0/0
   leaf_blt[NOTP] 0x202D2D80 burst packets/bytes[NOTP] 0/0

   OUTPUT Shaping
     Bc internal 0 Be internal 0 Time interval 4
     increment 2600 increment_lower 0 increment_limit 2600
     last visit 145532 credit 0 outstanding_tokens 20192 maxtokens 20800
     system timer delayed 0 restart timer 0
     timer set 0 hqf_shape_running 21
     nextexpire_system_time 0 nextexpire_time_qindex -1
   next layer HQFLAYER_CLASS (max entries 2000)
```

```
BE Queues:
    blt (0x20265DA0, index 0, qid 1, fast_if_number 20) layer CLASS_HIER0
    scheduling policy: FIFO (110)
    classification policy: NONE (120)
    drop policy: TAIL (141)
    packet size fixup policy: NONE (0)   no of global policers: 0
    blt flags: 0x220000    scheduler: 0x202D2CC0
    total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 0
 total active 1

    txcount 13 txqbytes 746 drops 0 qdrops 0 nobuffers 0 flowdrops 0
    qsize 0 aggregate limit/bytes 128/0 availbuffers 128
    holdqueue_out 0 perc 0.00 remaining_ratio/perc 0
    visible_bw 0 max_rate 26000 allocated_bw 26000 vc_encap 0 ecn_threshold NONE
    weight A 1 quantum A 1600 credit A 0
    weight B 1 quantum B 1600 credit B 46
    min-rate tokens: 13000, credit: 0, depth: 13000

    backpressure_policy 0 scheduler_flags C03F
    last_sortq[A/B] 0/0, remaining pak/particles 0/0
    leaf_blt[P1] 0x202D2CC0 burst packets/bytes[P1] 0/0
    leaf_blt[P2] 0x202D2CC0 burst packets/bytes[P2] 0/0
    leaf_blt[NOTP] 0x202D2CC0 burst packets/bytes[NOTP] 1/46


CIR Queues:

Low Latency Queues:
```

To verify the normal downstream HQF queue information for all the class layer bandwidth limited traffic (CBLT) queues under an interface, use the **show interfaces** {**integrated-cable | wideband-cable**} *slot/port*: *sub-interface* **queue cblt** [*index* | **priority**] command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces integrated-cable 3/0:0 queue cblt 1

    blt (0x65CE3EA0, index 1, qid 45, fast_if_number 19) layer CLASS_HIER0
    scheduling policy: FIFO (110)
    classification policy: NONE (120)
    drop policy: TAIL (141)
    packet size fixup policy: NONE (0)   no of global policers: 0
    D/Traffic Shaping enabled
    blt flags: 0x22A208C    scheduler: 0x65D504C0
    total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 1000 total
active 1
    D/Traffic Shaping enabled
    txcount 890 txqbytes 63900 drops 0 qdrops 0 nobuffers 0 flowdrops 0
    qsize 0 aggregate limit/bytes 128/100000 availbuffers 128
    holdqueue_out 0 perc 0.00 remaining_ratio/perc 11
    visible_bw 0 max_rate 4000 allocated_bw 0 vc_encap 0 ecn_threshold NONE
    weight A 1 quantum A 1500 credit A 1500
    weight B 1 quantum B 1500 credit B 1500
    min-rate tokens: 1500, credit: 0, depth: 1500

    backpressure_policy 0 scheduler_flags C03F
    last_sortq[A/B] 0/0, remaining pak/particles 0/0
    leaf_blt[P1] 0x65D504C0 burst packets/bytes[P1] 0/0
    leaf_blt[P2] 0x65D504C0 burst packets/bytes[P2] 0/0
    leaf_blt[NOTP] 0x65D504C0 burst packets/bytes[NOTP] 0/0

    OUTPUT Shaping
```

```
      Bc internal 0 Be internal 0 Time interval 4
      increment 4000 increment_lower 0 increment_limit 4000
      last visit 87456736 credit 0 outstanding_tokens 23760 maxtokens 24352
      peak_rate_credit 0 peak_rate_tokens 0 peak_rate_increment 0
      system timer delayed 0 restart timer 0
      timer set 0 hqf_shape_running 17254
      nextexpire_system_time 0 nextexpire_time_qindex -1
```

To verify the normal and priority downstream HQF queue information for all the CBLT queues under an interface, use the **show interfaces** {**integrated-cable | wideband-cable**} *slot/port*: *sub-interface* **queue cblt** [*index* | **priority**] command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces integrated-cable 3/0:0 queue cblt priority

    blt (0x19FA9300, index 0, qid 52, fast_if_number 20) layer CLASS_HIER0
    scheduling policy: FIFO (110)
    classification policy: NONE (120)
    drop policy: TAIL (141)
    packet size fixup policy: NONE (0)   no of global policers: 0
    blt flags: 0x200800    scheduler: 0x1A015CC0
    total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 9500 total
active 1

    txcount 114 txqbytes 12864 drops 0 qdrops 0 nobuffers 0 flowdrops 0
    qsize 0 aggregate limit/bytes 128/0 availbuffers 128
    holdqueue_out 0 perc 0.00 remaining_ratio/perc 0
    visible_bw 0 max_rate 37500 allocated_bw 0 vc_encap 0 ecn_threshold NONE
    weight A 1 quantum A 1500 credit A 1500
    weight B 1 quantum B 1500 credit B 1500
    min-rate tokens: 1500, credit: 0, depth: 1500

    backpressure_policy 0 scheduler_flags C83F
    last_sortq[A/B] 0/0, remaining pak/particles 0/0
    leaf_blt[P1] 0x1A015CC0 burst packets/bytes[P1] 0/0
    leaf_blt[P2] 0x1A015CC0 burst packets/bytes[P2] 0/0
    leaf_blt[NOTP] 0x1A015CC0 burst packets/bytes[NOTP] 0/0

PRIORITY LEVEL 1: total bandwidth 500 kbps, total percent 0%
```

To verify the downstream HQF queue information for all the physical layer bandwidth limited traffic (PBLT) queues under an interface, use the **show interfaces** {**integrated-cable | wideband-cable**} *slot/port*: *sub-interface* **queue pblt** command on the Cisco uBR7246VXR and Cisco uBR7225VXR routers as shown in the following example:

```
Router# show interfaces integrated-cable 3/0:0 queue pblt

   blt (0x19FB4700, index 0, qid 0, fast_if_number 20) layer PHYSICAL
   scheduling policy: WFQ (111)
   classification policy: CLASS_BASED (122)
   drop policy: TAIL (141)
   packet size fixup policy: NONE (0)   no of global policers: 0
   blt flags: 0x220000    scheduler: 0x1A0210C0
   total guarantee percent 0 total remaining perc 0 total bandwidth guarantee 0 total
active 0

   txcount 67743 txqbytes 6281007 drops 2 qdrops 0 nobuffers 0 flowdrops 0
   qsize 0 aggregate limit/bytes 8000/0 availbuffers 8000
   holdqueue_out 1000 perc 0.00 remaining_ratio/perc 0
   visible_bw 37500 max_rate 37500 allocated_bw 18000 vc_encap 0 ecn_threshold NONE
   weight A 1 quantum A 1500 credit A 1500
   weight B 1 quantum B 1500 credit B 1500
   min-rate tokens: 13000, credit: 0, depth: 13000
```

```
backpressure_policy 1 scheduler_flags C03F
last_sortq[A/B] 0/0, remaining pak/particles 0/0
leaf_blt[P1] 0x1A0210C0 burst packets/bytes[P1] 0/0
leaf_blt[P2] 0x1A0210C0 burst packets/bytes[P2] 0/0
leaf_blt[NOTP] 0x1A0210C0 burst packets/bytes[NOTP] 0/0
```

Additional References

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

Related Documents

Related Topic	Document Title
CMTS cable commands	*Cisco IOS CMTS Cable Command Reference*
Modular Quality of Service	*MQC QoS on the Cisco CMTS Routers*
Enhanced Bandwidth Rate Allocation	*DOCSIS 1.1 for the Cisco CMTS Routers*
Dynamic Bandwidth Sharing	*Dynamic Bandwidth Sharing on the Cisco CMTS Router*

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 IOS 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 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.	http://www.cisco.com/support

Feature Information for DOCSIS WFQ Scheduler

Table 7 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(33)SCB or a later release appear in the table.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

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

Note Table 7 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release. Unless noted otherwise, subsequent releases of that Cisco IOS software release also support that feature.

Table 7 Feature Information for DOCSIS WFQ Scheduler

Feature Name	Releases	Feature Information
DOCSIS WFQ Scheduler	12.2(33)SCB	The DOCSIS WFQ Scheduler provides output scheduling services on DOCSIS downstream interfaces. Cisco IOS Release 12.2(33)SCB introduces this feature on the Cisco uBR10012 Universal Broadband Router.
DOCSIS WFQ Scheduler	12.2(33)SCC	Cisco IOS Release 12.2(33)SCC introduces the option to configure user-defined priorities to map DOCSIS priority value to an excess ratio value. Using this feature, you can configure priorities in the downstream direction rather than using the default rates. The following command was introduced: **cable downstream qos wfq weights**
Enhanced Rate Bandwidth Allocation	12.2(33)SCD	Support was added for the Cisco uBR7246VXR and Cisco uBR7225VXR routers. Dual token bucket based shaper is used to support ERBA on the uBR-MC88V line card for the Cisco uBR7246VXR and Cisco uBR7225VXR routers. The following section provides information about this feature: • Enhanced Rate Bandwidth Allocation, page 81

Table 7 Feature Information for DOCSIS WFQ Scheduler (continued)

Feature Name	Releases	Feature Information
DOCSIS 3.0 Downstream Bonding Support with Bonding Group Dynamic Bandwidth Sharing	12.2(33)SCD	Support was added for the Cisco uBR7246VXR and Cisco uBR7225VXR routers. The following commands were introduced or modified: • **show cable modem** • **show interface cable service-flow** • **show interface integrated-cable** • **show interface wideband-cable queue**
Suppressing Downstream and Upstream Peak Rate TLVs for pre DOCSIS 3.0 Cable Modems	12.2(33)SCB10	Support was added to restrict sending of the DOCSIS 3.0 TLVs to DOCSIS 1.X and DOCSIS 2.0 cable modems. A new command **cable service attribute withhold-TLVs** was introduced.
Optimization of queue size	12.2(33)SCG	Default queue size for the DOCSIS service flows (with bandwidth greater than 150 Mbps) is increased. A new command **cable queue-limit** was introduced