MQC Hierarchical Queueing with Three-Level Scheduler

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The MQC Hierarchical Queueing with Three-Level Scheduler feature provides a flexible packet scheduling and queueing system in which you can specify how excess bandwidth is to be allocated among the subscriber (logical) queues.

Finding Feature Information

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 MQC Hierarchical Queueing with the Three-Level Scheduler” section on page 9.

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Prerequisites for the Three-Level Scheduler

Traffic classes must be configured on the router using the `class-map` command.

Restrictions for the Three-Level Scheduler

- The three-level scheduler does not support bandwidth propagation. Therefore, you cannot configure a bandwidth guarantee for any queue other than a priority queue.
- To allow oversubscription provisioning, the admission control check is not performed.
- The three-level scheduler does not allocate an implicit bandwidth guarantee for the parent class-default class. Instead, the scheduler uses the ratio of the classes to allocate bandwidth.
- When hierarchical policies are enabled on multiple VLANs and each VLAN hierarchical policy has priority services configured in a child policy, the three-level scheduler first services the priority traffic from all VLANs and then proportionally shares the remaining bandwidth of the interface among all of the VLANs.

Information About MQC Hierarchical Queueing with the Three-Level Scheduler

Before configuring the MQC Hierarchical Queueing with the Three-Level Scheduler feature, you should be familiar with the following concepts:

- Hierarchical Queueing with Three-Level Scheduler Functionality, page 2
- Modular QoS Command-Line Interface and the Three-Level Scheduler, page 3
- Scheduling Hierarchy, page 3
- Priority Service and Latency, page 4

Hierarchical Queueing with Three-Level Scheduler Functionality

The Hierarchical Queueing with three-level Scheduler feature provides a flexible packet scheduling and queueing system in which you can specify how excess bandwidth is to be allocated among the subscriber queues and logical interfaces. Rather than allocating an implicit minimum bandwidth guarantee to each queue, the three-level scheduler uses the bandwidth-remaining ratio parameter to allocate unused bandwidth to each logical queue. The three-level scheduler services queues based on the following user-configurable parameters:

- Maximum rate—The specified shape rate of the parent queue.
- Bandwidth-remaining ratio—The value used to determine the portion of unused, non-guaranteed bandwidth allocated to a logical queue relative to other queues competing for the unused bandwidth.

The three-level scheduler supports priority propagation by propagating the priority guarantees you configure for subscriber services down to the logical interface level. Therefore, the priority traffic is serviced first at the logical and class level. After servicing the priority traffic bandwidth, the three-level scheduler allocates unused bandwidth to the logical queues based on the configured bandwidth-remaining ratio. In this default case, the three-level scheduler allocates an equal share of the unused bandwidth to each logical queue.
The `bandwidth` command must be configured as a percentage of the available bandwidth or as an absolute bandwidth. You cannot concurrently configure the `bandwidth` and `bandwidth remaining` commands on the same class queue or on the same policy map.

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**Note**

The three-level scheduler supports queueing on the egress interface only.

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**Modular QoS Command-Line Interface and the Three-Level Scheduler**

The Modular Quality of Service Command-Line Interface (MQC) is designed to simplify the configuration of Quality of Service (QoS) such as three-level scheduling on Cisco routers and switches by defining a common command syntax and resulting set of QoS behaviors across platforms. This model replaces the previous model of defining unique syntaxes for each QoS feature and for each platform.

The MQC contains the following three steps:

- Define a traffic class using the `class-map` command.
- Create a traffic policy by associating the traffic class with one or more QoS features using the `policy-map` command.
- Attach the traffic policy to the interface, subinterface, or virtual circuit (VC) using the `service-policy` command.

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**Scheduling Hierarchy**

As shown in Figure 1 on page 3, the three-level scheduler uses the following scheduling hierarchy to allocate bandwidth for subscriber traffic:

- Class layer
- Logical layer (VLAN or ATM VC)
- Physical layer (interface or ATM virtual path)

![Figure 1: Scheduling Hierarchy](image)
Table 1 provides an example of how the scheduling hierarchy can apply to Ethernet and ATM topologies.

### Table 1 Applying the Scheduling Hierarchy to Ethernet and ATM

<table>
<thead>
<tr>
<th>Scheduling Hierarchy</th>
<th>Ethernet</th>
<th>ATM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class layer (virtual time)</td>
<td>MQC-defined queues</td>
<td>MQC-defined queues</td>
</tr>
<tr>
<td>Logical layer (virtual time)</td>
<td>VLAN (inner tag)</td>
<td>Virtual channel (VC)</td>
</tr>
<tr>
<td>Physical (real time)</td>
<td>VLAN (inner tag), if session is the logical layer identifier</td>
<td>Virtual path (VP)</td>
</tr>
</tbody>
</table>

### Priority Service and Latency

The three-level scheduler supports multiple levels of priority service that you can use for such purposes as control traffic, handle delay-sensitive traffic (for example, voice), apply minimum guarantees, and determine excess bandwidth allocation.

The three-level scheduler uses priority level 1 for voice, priority level 2 for video, and the excess bandwidth for data.

For a priority class with policing configured, traffic is policed according to the rate specified in the `police` command (1000 kbps as shown in the following example configuration), regardless of whether or not the underlying interface is congested.

```
Router(config-pmap-c)# priority
Router(config-pmap-c)# police 1000
```

### Latency Requirements

Delay-sensitive traffic incurs a maximum of 10 milliseconds (ms) of latency on edge router interfaces and a maximum of 1 ms of latency on core router interfaces. For interface speeds at T1/E1 and below, the three-level scheduler services 2 maximum transmission units (MTUs) of nonpriority traffic before servicing a priority packet. Requirements for high-speed interfaces are not as strict as 2 MTUs, but are always bound by 10 ms on edge interfaces and 1 ms on core interfaces.

The three-level scheduler also supports the minimal latency requirement (2 MTUs of nonpriority traffic in front of priority traffic) at the physical link rate. However, in some cases, it is impossible for the three-level scheduler to service all competing packets with a latency of 2 MTUs. For example, if many priority packets compete at the same time for bandwidth, the last one serviced may incur latency that is greater than 2 MTUs.

### Priority Propagation with Imposed Burstiness

A single physical interface can have large numbers of logical interfaces and each of these logical interfaces can have both priority and nonpriority traffic competing for the physical link. To minimize latency, the priority traffic of one logical interface has priority over the nonpriority traffic of other logical interfaces, thereby imposing burstiness on the minimum rate traffic of other logical interfaces. The latency that the priority traffic incurs results from the rate constraining the delivered rate of the priority traffic. In many cases, this constraining rate is not the rate of the priority class’s parent policy.
For example, suppose a 10 Gigabit Ethernet (GE) interface has 100 VLANs that are shaped to various rates. Each VLAN has a priority class and additional classes configured. Through priority propagation, the scheduler delivers latency to the priority traffic based on the 10 GE rate and not the VLAN rate.

The priority traffic of one logical interface cannot only impose burstiness on other traffic, but also starve other traffic. The only way to prevent the starvation of other traffic is by configuring a policer on the priority queue by limiting the percent of priority traffic to less than 90 percent of the parent bandwidth and the port bandwidth.

How to Configure Bandwidth-Remaining Ratios

To configure bandwidth-remaining ratios on subinterface-level and class-level queues, see the “Distribution of Remaining Bandwidth Using Ratio” module.

Configuration Examples for the Three-Level Scheduler

This section provides the following configuration example:

- Tuning the Bandwidth-Remaining Ratio: Example, page 5

Tuning the Bandwidth-Remaining Ratio: Example

The following example configuration shows how to tune the bandwidth-remaining ratio using the `bandwidth remaining ratio` command. In the example, the class-default class of Parent1 has a bandwidth-remaining ratio of 9 and the class-default class of Parent2 has a bandwidth-remaining ratio of 7.

```
policy-map Child
  class prec0
    priority level 1
    police 100
  !
  class prec2
    priority level 2
    police 300
  !
policy-map Parent1
  class class-default
    shape average 10000
    bandwidth remaining ratio 9
  !
policy-map Parent2
  class class-default
    shape average 1000
    bandwidth remaining ratio 7
```

Figure 2 shows an example of the queueing presentation based on the above configuration and assuming that the Parent1 policy is enabled on subinterface 1 and that the Parent2 policy is enabled on subinterface 2, and that the interface speed is 2100 kbps.
Based on the preceding configuration, the three-level scheduler distributes bandwidth in the following way (assuming that the voice traffic is active on subinterface 1 only and the video traffic is active on subinterface 2 only):

- A total of 400 kbps of bandwidth is used from the interface: 100 kbps-bandwidth guarantee for voice traffic on subinterface 1 and 300-kbps bandwidth guarantee for video traffic on subinterface 2.
- The remaining 1700-kbps bandwidth is distributed across the subinterface-level queues based on their bandwidth-remaining ratios:
  - Subinterface 1 with bandwidth-remaining ratio 9 receives 956 kbps.
  - Subinterface 2 with bandwidth-remaining ratio 7 receives 743 kbps.
Additional References

The following sections provide references related to the MQC Hierarchical Queueing with three-level Scheduler feature.

Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
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<tbody>
<tr>
<td>QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples</td>
<td>Cisco IOS Quality of Service Solutions Command Reference</td>
</tr>
<tr>
<td>Bandwidth-remaining ratio</td>
<td>“Distribution of Remaining Bandwidth Using Ratio” module</td>
</tr>
<tr>
<td>Shaping traffic</td>
<td>“Regulating Packet Flow—Using Class-Based Traffic Shaping” module</td>
</tr>
<tr>
<td>Traffic policing and shaping</td>
<td>“Policing and Shaping Overview” module</td>
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Standards

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<th>Title</th>
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MIBs

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<th>MIBs Link</th>
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<td>No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
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RFCs

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## Technical Assistance

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

Table 2 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 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 2 lists only the Cisco IOS XE Software release that introduced support for a given feature in a given Cisco IOS XE Software release train. Unless noted otherwise, subsequent releases of that Cisco IOS XE Software release train also support that feature.

<table>
<thead>
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<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
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<td>MQC Hierarchical Queueing with Three-Level Scheduler</td>
<td>Cisco IOS XE Release 2.1</td>
<td>This feature was introduced on Cisco ASR 1000 Series Routers. The following commands were introduced or modified: bandwidth remaining ratio, show policy-map, show policy-map interface.</td>
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