

Network Configuration Example

Configuring CoS Hierarchical Port Scheduling

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CHAPTER 1

Configuring CoS Hierarchical Port Scheduling

- [About This Network Configuration Example on page 5](#)
- [Benefits of Configuring CoS Hierarchical Port Scheduling on page 5](#)
- [Understanding CoS Hierarchical Port Scheduling \(ETS\) on page 6](#)
- [Understanding CoS Scheduling Behavior and Configuration Considerations on page 12](#)
- [Example: Configuring CoS Hierarchical Port Scheduling \(ETS\) on page 17](#)

About This Network Configuration Example

This network configuration example describes the hierarchical port scheduling feature supported on the Juniper Networks® QFabric™ family of products and provides a step-by-step procedure for configuring hierarchical port scheduling.

Benefits of Configuring CoS Hierarchical Port Scheduling

Hierarchical port scheduling enables you to control the amount of bandwidth allocated to different traffic classes on each port in a way that maximizes flexibility and bandwidth utilization. Hierarchical port scheduling is the Junos® operating system (Junos OS) implementation of enhanced transmission selection (ETS, described in IEEE 802.1Qaz).

ETS is part of the data center bridging (DCB) IEEE standards that provide features to support lossless transport over Ethernet networks for use in data center environments.

ETS provides the flexibility to allocate a guaranteed minimum port bandwidth to any traffic class. In addition, after meeting the minimum bandwidth guarantees, ETS dynamically shares the remaining port bandwidth among the traffic classes in accordance with your configuration. This combination of capabilities results both in bandwidth guarantees for lossless traffic and in better port bandwidth utilization, which saves you money. You can configure different hierarchical port scheduling on different interfaces to customize your bandwidth allocation and utilization.

Bandwidth guarantees ensure that lossless traffic receives the bandwidth required to prevent packet loss. Better port utilization enables you to forward the same amount of traffic on fewer links than switches that do not provide ETS hierarchical scheduling. Thus, you need fewer ports to handle network traffic, which is also cost-effective.

- Related Documentation**
- [Understanding CoS Hierarchical Port Scheduling \(ETS\) on page 6](#)
 - [Understanding CoS Scheduling Behavior and Configuration Considerations on page 12](#)
 - [Example: Configuring CoS Hierarchical Port Scheduling \(ETS\) on page 17](#)

Understanding CoS Hierarchical Port Scheduling (ETS)

Scheduling defines the class-of-service (CoS) properties of output queues. Output queues are mapped to forwarding classes. CoS scheduler properties include the amount of interface bandwidth assigned to the queue, the queue priority, and the drop profiles associated with the queue.

Hierarchical port scheduling is a two-tier process that provides better port bandwidth utilization and greater flexibility to allocate resources to queues (forwarding classes) and to groups of queues (forwarding class sets). Hierarchical scheduling includes the Junos OS implementation of enhanced transmission selection (ETS), as described in IEEE 802.1Qaz.



Video: [What is Enhanced Transmission Selection?](#)

This topic describes:

- [Hierarchical Scheduling Tiers on page 6](#)
- [Hierarchical Scheduling and ETS on page 7](#)
- [ETS Advertisement in DCBX on page 9](#)
- [Hierarchical Scheduling Process on page 9](#)
- [Strict-High Priority Queues and Hierarchical Scheduling on page 10](#)
- [Default Hierarchical Scheduling on page 11](#)

Hierarchical Scheduling Tiers

The two tiers used in hierarchical scheduling are priorities and priority groups, as shown in [Table 1 on page 7](#).

Table 1: Hierarchical Scheduling Tiers

Junos OS Configuration Construct	Equivalent ETS Construct	Description
Forwarding class	Priority	<p>Think about priorities (forwarding classes) as output queues. You map forwarding classes to queues, so each forwarding class represents an output queue.</p> <p>When you use a classifier to map a forwarding class to an IEEE 802.1p code point, the code point identifies that traffic's priority for priority-based flow control (PFC). Thus the forwarding class, the queue mapped to the forwarding class, and the priority (code point) mapped to the forwarding class all identify the same traffic.</p> <p>NOTE: OCX Series switches do not support lossless transport or PFC.</p>
Forwarding class set	Priority group	<p>Priority groups (forwarding class sets) are groups of priorities (forwarding classes). Forwarding class membership in a forwarding class set defines the priority group to which each priority belongs.</p> <p>You can configure up to three unicast priority groups and one multicast priority group.</p>

You apply scheduling properties to each hierarchical scheduling tier as described in the next section.



NOTE: If you explicitly configure one or more priority groups on an interface, any priority (forwarding class) that is not assigned to a priority group (forwarding class set) on that interface is assigned to an automatically generated default priority group and receives *no bandwidth*. This means that if you configure hierarchical scheduling on an interface, every forwarding class that you want to forward traffic on that interface must belong to a forwarding class set.



NOTE: On OCX Series switches, by default, classifiers use DSCP code points to map traffic to forwarding classes. However, hierarchical scheduling works in the same manner as when you use IEEE 802.1p code points to classify traffic. The OCX Series classifies traffic into forwarding classes based on DSCP code points, the forwarding classes are mapped to forwarding class sets, and you apply scheduling properties to each of the two tiers.

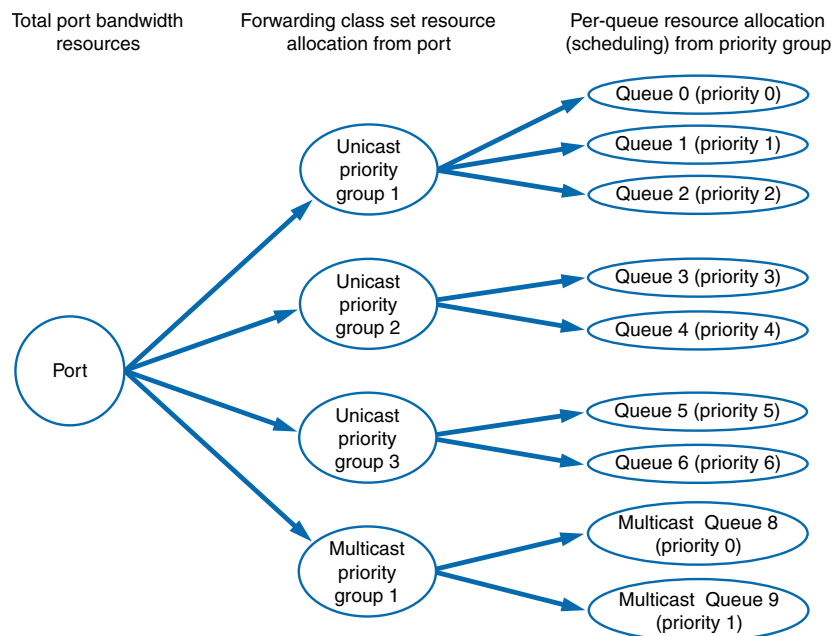
Hierarchical Scheduling and ETS

Two-tier hierarchical scheduling manages bandwidth efficiently by enabling you to define the CoS properties for each priority group and for each priority. The first tier of the hierarchical scheduler allocates port bandwidth to a priority group. The second tier of

the hierarchical scheduler determines the portion of the priority group bandwidth that a priority (queue) can use.

The CoS properties of a priority group define the amount of port bandwidth resources available to the queues in that priority group. The CoS properties you configure for each queue specify the amount of the bandwidth available to the queue from the bandwidth allocated to the priority group. [Figure 1 on page 8](#) shows the relationship of port resource allocation to priority groups, and priority group resource allocation to queues (priorities).

Figure 1: Hierarchical Scheduling Tiers



If a queue (priority) does not use its allocated bandwidth, ETS shares the unused bandwidth among the other queues in the priority group in proportion to the minimum guaranteed rate (transmit rate) scheduled for each queue. If a priority group does not use its allocated bandwidth, ETS shares the unused bandwidth among the priority groups on the port in proportion to the minimum guaranteed rate (guaranteed rate) scheduled for each priority group.

In this way, ETS improves link bandwidth utilization, and it provides each queue and each priority group with the maximum available bandwidth. For example, priorities that consist of bursty traffic can share bandwidth during periods of low traffic transmission, instead of reserving their entire bandwidth allocation when traffic loads are light. All Juniper switches use ETS scheduling, except for QFX5200 and the QFX10000 switches.



NOTE: The available link bandwidth is the bandwidth remaining after servicing strict-high priority flows. Strict-high priority takes precedence over all other traffic (we recommend that you configure a shaping rate to limit the maximum amount of bandwidth that a strict-high priority forwarding class can use to prevent starving other queues).

ETS Advertisement in DCBX

When you configure hierarchical scheduling on a port, Data Center Bridging Capability Exchange protocol (DCBX) advertises:

- Each priority group
- The priorities in each priority group
- The bandwidth properties of each priority group and priority

When you configure hierarchical scheduling on a port, any priority that is not part of an explicitly configured priority group is assigned to the automatically generated default priority group and receives no bandwidth. The default priority group is transparent. It does not appear in the configuration.



NOTE: OCX Series switches do support DCBX, so hierarchical scheduling information is not exchanged with connected peers on OCX Series switches.

Hierarchical Scheduling Process

Hierarchical scheduling consists of multiple configuration steps that create the priorities and the priority groups, schedule their resources, and assign them to interfaces. The steps below correspond to the six blocks in the packet flow diagram shown in [Figure 2 on page 10](#):

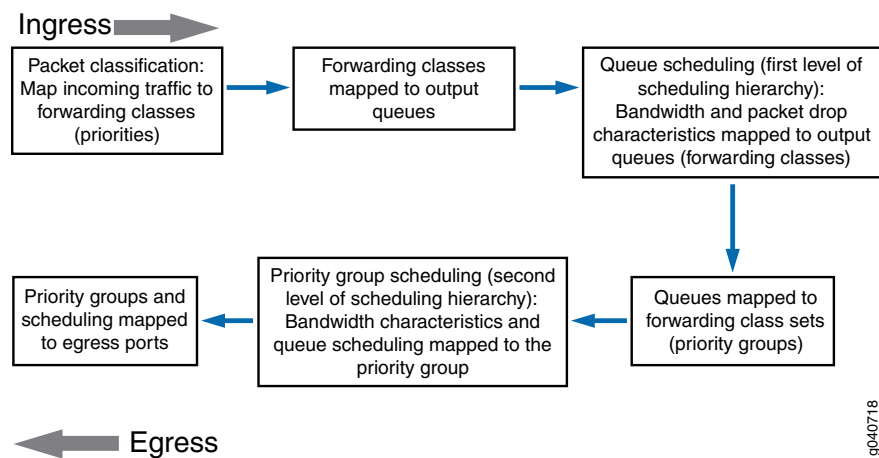
1. Packet classification:
 - Configure classification of incoming traffic into forwarding classes (priorities). This consists of either using the default classifiers or configuring classifiers to map code points and loss priorities to the forwarding classes.
 - Apply the classifiers to ingress interfaces or use the default classifiers. Applying a classifier to an interface groups incoming traffic on the interface into forwarding classes and loss priorities, by applying the classifier code point mapping to the incoming traffic.
2. Configure the output queues for the forwarding classes (priorities). This consists of either using the default forwarding classes and forwarding-class-to-queue mapping, or creating your own forwarding classes and mapping them to output queues.
3. Allocate resources to the forwarding classes:
 - Define resources for the priorities. This consists of configuring schedulers to set minimum guaranteed bandwidth, maximum bandwidth, drop profiles for Weighted Random Early Detection (WRED), and bandwidth priority to apply to a forwarding class. Extra bandwidth is shared among queues in proportion to the minimum guaranteed bandwidth (transmit rate) of each queue.
 - Map resources to priorities. This consists of mapping forwarding classes to schedulers, using a scheduler map.

4. Configure priority groups. This consists of mapping forwarding classes (priorities) to forwarding class sets (priority groups) to define the priorities that belong to each priority group.
5. Define resources for the priority groups. This consists of configuring traffic control profiles to set minimum guaranteed bandwidth (guaranteed rate) and maximum bandwidth (shaping rate) for a priority group. Traffic control profiles also specify a scheduler map, which defines the resources (schedulers) mapped to the priorities in the priority group. Extra port bandwidth is shared among priority groups in proportion to the minimum guaranteed bandwidth of each priority group.

The traffic control profile bandwidth settings determine the port resources available to the priority group. The schedulers specified in the scheduler map determine the amount of priority group resources that each priority receives.

6. Apply hierarchical scheduling to a port. This consists of attaching one or more priority groups (forwarding class sets) to an interface. For each priority group, you also attach a traffic control profile, which contains the scheduling properties of the priority group and the priorities in the priority group. Different priority groups on the same port can use different traffic control profiles, which provides fine tuned control of scheduling for each queue on each interface.

Figure 2: Hierarchical Scheduling Packet Flow



Strict-High Priority Queues and Hierarchical Scheduling

If you configure a strict-high priority queue, you must observe the following rules:

- You must create a separate forwarding class set (priority group) for the strict-high priority queue.
- Only one forwarding class set can contain strict-high priority queues.
- Strict-high priority queues cannot belong to the same forwarding class set as queues that are not strict-high priority.

- A strict-high priority queue cannot belong to a multidestination forwarding class set.
- We recommend that you always apply a shaping rate to strict-high priority queues to prevent them from starving other queues. If you do not apply a shaping rate to limit the amount of bandwidth a strict-high priority queue can use, then the strict-high priority queue can use all of the available port bandwidth and starve other queues on the port.



NOTE: On a QFabric system, if a fabric (fte) interface handles strict-high priority traffic, you must define a separate forwarding class set (priority group) for strict-high priority traffic. Strict-high priority traffic cannot be mixed with traffic of other priorities in a forwarding class set. For example, you might choose to create different forwarding class sets for best effort, lossless, strict-high priority, and multidestination traffic.

Default Hierarchical Scheduling

If you do not explicitly configure hierarchical scheduling, the switch uses the default settings:

- The switch automatically creates a default forwarding class set that contains all of the forwarding classes on the switch. The switch assigns 100 percent of the port output bandwidth to the default forwarding class set. The default forwarding class set is transparent. It does not appear in the configuration and is used for Data Center Bridging Capability Exchange protocol (DCBX) advertisement.



NOTE: OCX Series switches do not support DCBX, so the ETS configuration is not advertised to connected peers.

- Ingress traffic is classified based on the default classifier settings.
- The forwarding classes (queues) in the default forwarding class set receive bandwidth based on the default scheduler settings.

Related Documentation

- *Understanding CoS Packet Flow*
- *Understanding CoS Output Queue Schedulers*
- *Understanding CoS Priority Group Scheduling*
- [Benefits of Configuring CoS Hierarchical Port Scheduling on page 5](#)
- *Understanding CoS Flow Control (Ethernet PAUSE and PFC)*
- *Understanding CoS Classifiers*
- *Understanding CoS Classifiers*
- *Understanding Default CoS Scheduling and Classification*
- *Understanding Default CoS Scheduling and Classification*

- *Understanding CoS Scheduling on QFabric System Node Device Fabric (fte) Ports*
- *Understanding Default CoS Scheduling on QFabric System Interconnect Devices (Junos OS Release 13.1 and Later Releases)*
- [Example: Configuring CoS Hierarchical Port Scheduling \(ETS\) on page 17](#)
- *Example: Configuring Queue Schedulers*
- *Example: Configuring Traffic Control Profiles (Priority Group Scheduling)*
- *Example: Configuring Minimum Guaranteed Output Bandwidth*
- *Example: Configuring Maximum Output Bandwidth*

Understanding CoS Scheduling Behavior and Configuration Considerations

Many factors affect scheduling configuration and bandwidth requirements, including:

- When you configure bandwidth for a forwarding class (each forwarding class is mapped to a queue) or a forwarding class set (priority group), the switch considers only the data as the configured bandwidth. The switch does not account for the bandwidth consumed by the preamble and the interframe gap (IFG). Therefore, when you calculate and configure the bandwidth requirements for a forwarding class or for a forwarding class set, consider the preamble and the IFG as well as the data in the calculations.
- When you configure a forwarding class to carry traffic on the switch (instead of using only default forwarding classes), you must also define a scheduling policy for the user-configured forwarding class. Some switches support enhanced transmission selection (ETS) hierarchical port scheduling, some switches support direct port scheduling, and some switches support both methods of scheduling.

For ETS hierarchical port scheduling, defining a hierarchical scheduling policy using ETS means:

- Mapping a scheduler to the forwarding class in a scheduler map
- Including the forwarding class in a forwarding class set
- Associating the scheduler map with a traffic control profile
- Attaching the traffic control profile to a forwarding class set and an interface

On switches that support port scheduling, defining a scheduling policy means:

- Mapping a scheduler to the forwarding class in a scheduler map.
- Applying the scheduler map to one or more interfaces.
- On each physical interface, either all forwarding classes that are being used on the interface must have rewrite rules configured, or no forwarding classes that are being used on the interface can have rewrite rules configured. On any physical port, do not mix forwarding classes with rewrite rules and forwarding classes without rewrite rules.
- For packets that carry both an inner VLAN tag and an outer VLAN tag, rewrite rules rewrite only the outer VLAN tag.

- For ETS hierarchical port scheduling, configuring the minimum guaranteed bandwidth (**transmit-rate**) for a forwarding class does not work unless you also configure the minimum guaranteed bandwidth (**guaranteed-rate**) for the forwarding class set in the traffic control profile.

Additionally, the sum of the transmit rates of the forwarding classes in a forwarding class set should not exceed the guaranteed rate for the forwarding class set. (You cannot guarantee a minimum bandwidth for the queues that is greater than the minimum bandwidth guaranteed for the entire set of queues.) If you configure transmit rates whose sum exceeds the guaranteed rate of the forwarding class set, the commit check fails and the system rejects the configuration.

- For ETS hierarchical port scheduling, the sum of the forwarding class set guaranteed rates cannot exceed the total port bandwidth. If you configure guaranteed rates whose sum exceeds the port bandwidth, the system sends a syslog message to notify you that the configuration is not valid. However, the system does not perform a commit check. If you commit a configuration in which the sum of the guaranteed rates exceeds the port bandwidth, the hierarchical scheduler behaves unpredictably.
- For ETS hierarchical port scheduling, if you configure the **guaranteed-rate** of a forwarding class set as a percentage, configure all of the transmit rates associated with that forwarding class set as percentages. In this case, if any of the transmit rates are configured as absolute values instead of percentages, the configuration is not valid and the system sends a syslog message.
- There are several factors to consider if you want to configure a strict-high priority queue (forwarding class):
 - You can configure only one strict-high priority queue (forwarding class) on QFX5200, QFX5100, EX4600, QFX3500, and QFX3600 switches, and on QFabric systems.

On QFX10000 switches, there is no limit to the number of strict-high priority queues you can configure.
 - You cannot configure a minimum guaranteed bandwidth (**transmit-rate**) for a strict-high priority queue on QFX5200, QFX5100, EX4600, QFX3500, and QFX3600 switches, and on QFabric systems.

On QFX5200 and QFX10000 switches, you can set the **transmit-rate** on strict-high priority queues to set a limit on the amount of traffic that the queue treats as strict-high priority traffic. Traffic in excess of the **transmit-rate** is treated as best-effort traffic, and receives an excess bandwidth sharing weight of "1", which is the proportion of extra bandwidth the strict-high priority queue can share on the port. Queues that are not strict-high priority queues use the transmit rate (default) or the configured excess rate to determine the proportion (weight) of extra port bandwidth the queue can share. However, you cannot configure an excess rate on a strict-high priority queue, and you cannot change the excess bandwidth sharing weight of "1" on a strict-high priority queue.

For ETS hierarchical port scheduling, you cannot configure a minimum guaranteed bandwidth (**guaranteed-rate**) for a forwarding class set that includes a strict-high priority queue.

- Except on QFX10000 switches, for ETS hierarchical port scheduling only, you must create a separate forwarding class set for a strict-high priority queue. On QFX10000 switches, you can mix strict-high priority and low priority queues in the same forwarding class set.
- Except on QFX10000 switches, for ETS hierarchical port scheduling, only one forwarding class set can contain a strict-high priority queue. On QFX10000 switches, this restriction does not apply.
- Except on QFX10000 switches, for ETS hierarchical port scheduling, a strict-high priority queue cannot belong to the same forwarding class set as queues that are not strict-high priority. (You cannot mix a strict-high priority forwarding class with forwarding classes that are not strict-high priority in one forwarding class set.) On QFX10000 switches, you can mix strict-high priority and low priority queues in the same forwarding class set.
- For ETS hierarchical port scheduling on switches that use different forwarding class sets for unicast and multdestination (multicast, broadcast, and destination lookup fail) traffic, a strict-high priority queue cannot belong to a multdestination forwarding class set.
- On QFX10000 systems, we recommend that you always configure a transmit rate on strict-high priority queues to prevent them from starving other queues. If you do not apply a transmit rate to limit the amount of bandwidth strict-high priority queues can use, then strict-high priority queues can use all of the available port bandwidth and starve other queues on the port.

On QFX5200, QFX5100, EX4600, QFX3500, and QFX3600 switches, and on QFabric systems, we recommend that you always apply a shaping rate to the strict-high priority queue to prevent it from starving other queues. If you do not apply a shaping rate to limit the amount of bandwidth a strict-high priority queue can use, then the strict-high priority queue can use all of the available port bandwidth and starve other queues on the port.

- On QFabric systems, if any queue that contains outgoing packets does not transmit packets for 12 consecutive seconds, the port automatically resets. Failure of a queue to transmit packets for 12 consecutive seconds might be due to:
 - A strict-high priority queue consuming all of the port bandwidth
 - Several queues consuming all of the port bandwidth
 - Any queue or port receiving continuous priority-based flow control (PFC) or 802.3x Ethernet PAUSE messages (received PFC and PAUSE messages prevent a queue or a port, respectively, from transmitting packets because of network congestion)
 - Other conditions that prevent a queue from obtaining port bandwidth for 12 consecutive seconds

If the cause is a strict-high priority queue consuming all of the port bandwidth, use rate shaping to configure a maximum rate for the strict-high priority queue and prevent it from using all of the port bandwidth. To configure rate shaping, include the **shaping-rate (rate | percent percentage)** statement at the **[edit class-of-service schedulers scheduler-name]** hierarchy level and apply the shaping rate to the strict-high priority

scheduler. We recommend that you always apply a shaping rate to strict-high priority traffic to prevent the strict-high priority queue from starving other queues.

If several queues consume all of the port bandwidth, you can use a scheduler to rate shape those queues and prevent them from using all of the port bandwidth.

- For transmit rates below 1 Gbps, we recommend that you configure the transmit rate as a percentage instead of as a fixed rate. This is because the system converts fixed rates into percentages and might round small fixed rates to a lower percentage. For example, a fixed rate of 350 Mbps is rounded down to 3 percent instead of 3.5 percent.
- When you set the maximum bandwidth for a queue or for a priority group (**shaping-rate**) at 100 Kbps or lower, the traffic shaping behavior is accurate only within +/- 20 percent of the configured **shaping-rate**.
- On QFX10000 switches, configuring rate shaping (`[set class-of-service schedulers scheduler-name transmit-rate (rate | percentage) exact]`) on a LAG interface using the `[edit class-of-service interfaces lag-interface-name scheduler-map scheduler-map-name]` statement can result in scheduled traffic streams receiving more LAG link bandwidth than expected.

You configure rate shaping in a scheduler to set the maximum bandwidth for traffic assigned to a forwarding class on a particular output queue on a port. For example, you can use a scheduler to configure rate shaping on traffic assigned to the best-effort forwarding class mapped to queue 0, and then apply the scheduler to an interface using a scheduler map, to set the maximum bandwidth for best-effort traffic mapped to queue 0 on that port. Traffic in the best-effort forwarding can use no more than the amount of port bandwidth specified by the transmit rate when you use the **exact** option.

LAG interfaces are composed of two or more Ethernet links bundled together to function as a single interface. The switch can hash traffic entering a LAG interface onto any member link in the LAG interface. When you configure rate shaping and apply it to a LAG interface, the way that the switch applies the rate shaping to traffic depends on how the switch hashes the traffic onto the LAG links.

To illustrate how link hashing affects the way the switch applies a shaping rate to LAG traffic, let's look at a LAG interface (**ae0**) that has two member links (**xe-0/0/20** and **xe-0/0/21**). On LAG **ae0**, we configure rate shaping of **2g** for traffic assigned to the **best-effort** forwarding class, which is mapped to output queue 0. When traffic in the **best-effort** forwarding class reaches the LAG interface, the switch hashes the traffic onto one of the two member links.

If the switch hashes all of the **best-effort** traffic onto the same LAG link, the traffic receives a maximum of 2g bandwidth on that link. In this case, the intended cumulative limit of 2g for best-effort traffic on the LAG is enforced.

However, if the switch hashes the **best-effort** traffic onto both of the LAG links, the traffic receives a maximum of 2g bandwidth on *each* LAG link, not 2g as a cumulative total for the entire LAG, so the best-effort traffic receives a maximum of 4g on the LAG, not the 2g set by the rate shaping configuration. When hashing spreads the traffic assigned to an output queue (which is mapped to a forwarding class) across multiple LAG links, the effective rate shaping (cumulative maximum bandwidth) on the LAG is:

(number of LAG member interfaces) x (rate shaping for the output queue) = cumulative LAG rate shaping

- On switches that do not use virtual output queues (VOQs), ingress port congestion can occur during periods of egress port congestion if an ingress port forwards traffic to more than one egress port, and at least one of those egress ports experiences congestion. If this occurs, the congested egress port can cause the ingress port to exceed its fair allocation of ingress buffer resources. When the ingress port exceeds its buffer resource allocation, frames are dropped at the ingress. Ingress port frame drop affects not only the congested egress ports, but also all of the egress ports to which the congested ingress port forwards traffic.

If a congested ingress port drops traffic that is destined for one or more uncongested egress ports, configure a weighted random early detection (WRED) drop profile and apply it to the egress queue that is causing the congestion. The drop profile prevents the congested egress queue from affecting egress queues on other ports by dropping frames at the egress instead of causing congestion at the ingress port.



NOTE: On systems that support lossless transport, do not configure drop profiles for lossless forwarding classes such as the default **fcoe** and **no-loss** forwarding classes. FCoE and other lossless traffic queues require lossless behavior. Use priority-based flow control (PFC) to prevent frame drop on lossless priorities.

- On systems that use different classifiers for unicast and multdestination traffic and that support lossless transport, on an ingress port, do not configure classifiers that map the same IEEE 802.1p code point to both a multdestination traffic flow and a lossless unicast traffic flow (such as the default lossless **fcoe** or **no-loss** forwarding classes). Any code point used for multdestination traffic on a port should not be used to classify unicast traffic into a lossless forwarding class on the same port.

If a multdestination traffic flow and a lossless unicast traffic flow use the same code point on a port, the multdestination traffic is treated the same way as the lossless traffic. For example, if priority-based flow control (PFC) is applied to the lossless traffic, the multdestination traffic of the same code point is also paused. During periods of congestion, treating multdestination traffic the same as lossless unicast traffic can create ingress port congestion for the multdestination traffic and affect the multdestination traffic on all of the egress ports the multdestination traffic uses.

For example, the following configuration can cause ingress port congestion for the multdestination flow:

1. For unicast traffic, IEEE 802.1p code point 011 is classified into the **fcoe** forwarding class:

```
user@switch# set class-of-service classifiers ieee-802.1 ucast_cl forwarding-class fcoe loss-priority low code-points 011
```
2. For multdestination traffic, IEEE 802.1p code point 011 is classified into the **mcast** forwarding class:


```
user@switch# set class-of-service classifiers ieee-802.1 mcast-cl forwarding-class mcast
loss-priority low code-points 011
```

3. The unicast classifier that maps traffic with code point **011** to the **fcoe** forwarding class is mapped to interface **xe-0/0/1**:

```
user@switch# set class-of-service interfaces xe-0/0/1 unit 0 classifiers ieee-802.1 ucast-cl
```

4. The multdestination classifier that maps traffic with code point **011** to the **mcast** forwarding class is mapped to all interfaces (multidestination traffic maps to all interfaces and cannot be mapped to individual interfaces):

```
user@switch# set class-of-service multi-destination classifiers ieee-802.1 mcast-cl
```

Because the same code point (**011**) maps unicast traffic to a lossless traffic flow and also maps multidestination traffic to a multidestination traffic flow, the multidestination traffic flow might experience ingress port congestion during periods of congestion.

To avoid ingress port congestion, do not map the code point used by the multidestination traffic to lossless unicast traffic. For example:

1. Instead of classifying code point **011** into the **fcoe** forwarding class, classify code point **011** into the **best-effort** forwarding class:

```
user@switch# set class-of-service classifiers ieee-802.1 ucast-cl forwarding-class
best-effort loss-priority low code-points 011
```

2. user@switch# set class-of-service classifiers ieee-802.1 mcast-cl forwarding-class mcast loss-priority low code-points 011
 3. user@switch# set class-of-service interfaces xe-0/0/1 unit 0 classifiers ieee-802.1 ucast-cl
 4. user@switch# set class-of-service multi-destination classifiers ieee-802.1 mcast-cl
- Because the code point **011** does not map unicast traffic to a lossless traffic flow, the multidestination traffic flow does not experience ingress port congestion during periods of congestion.

The best practice is to classify unicast traffic with IEEE 802.1p code points that are also used for multidestination traffic into best-effort forwarding classes.

Example: Configuring CoS Hierarchical Port Scheduling (ETS)

Hierarchical port scheduling defines the class-of-service (CoS) properties of output queues, which are mapped to forwarding classes. Traffic is classified into forwarding classes based on code point (priority), so mapping queues to forwarding classes also maps queues to priorities). Hierarchical port scheduling enables you to group priorities that require similar CoS treatment into priority groups. You define the port bandwidth resources for a priority group, and you define the amount of the priority group's resources that each priority in the group can use.

Hierarchical port scheduling is the Junos OS implementation of enhanced transmission selection (ETS), as described in IEEE 802.1Qaz. One major benefit of hierarchical port scheduling is greater port bandwidth utilization. If a priority group on a port does not use all of its allocated bandwidth, other priority groups on that port can use that bandwidth. Also, if a priority within a priority group does not use its allocated bandwidth, other priorities within that priority group can use that bandwidth.

Configuring hierarchical scheduling is a multistep procedure that includes:

- Mapping forwarding classes to queues
- Defining forwarding class sets (priority groups)
- Defining behavior aggregate classifiers
- Configuring priority-based flow control (PFC) for lossless priorities (queues)
- Applying classifiers and PFC configuration to ingress interfaces
- Defining drop profiles
- Defining schedulers
- Mapping forwarding classes to schedulers
- Defining traffic control profiles
- Assigning priority groups and traffic control profiles to egress ports



NOTE: OCX Series switches do not support lossless transport and do not support PFC. Although this example includes configuring lossless transport with PFC, the portions of the example that do not pertain to lossless transport still apply to OCX Series switches. (You can configure hierarchical scheduling on OCX Series switches, but you cannot configure lossless transport or lossless forwarding classes.)

This example describes how to configure hierarchical scheduling:

- [Requirements on page 18](#)
- [Overview on page 19](#)
- [Configuration on page 23](#)
- [Verification on page 33](#)

Requirements

This example uses the following hardware and software components:

- One switch (this example was tested on a Juniper Networks QFX3500 Switch)
- Junos OS Release 11.1 or later for the QFX Series or Junos OS Release 14.1X53-D20 or later for the OCX Series

Overview

Keep the following considerations in mind when you plan the port bandwidth allocation for priority groups and for individual priorities:

- How much traffic and what types of traffic you expect to traverse the system.
- How you want to divide different types of traffic into priorities (forwarding classes) to apply different CoS treatment to different types of traffic. Dividing traffic into priorities includes:
 - Mapping the code points of ingress traffic to forwarding classes using behavior aggregate (BA) classifiers. This classifies incoming traffic into the appropriate forwarding class based on code point.
 - Mapping forwarding classes to output queues. This defines the output queue for each type of traffic.
 - Attaching the BA classifier to the desired ingress interfaces so that incoming traffic maps to the desired forwarding classes and queues.
- How you want to organize priorities into priority groups (forwarding class sets).

Traffic that requires similar treatment usually belongs in the same priority group. To do this, place forwarding classes that require similar bandwidth, loss, and other characteristics in the same forwarding class set. For example, you can map all types of best-effort traffic forwarding classes into one forwarding class set.

- How much of the port bandwidth you want to allocate to each priority group and to each of the priorities in each priority group. The following considerations apply to bandwidth allocation:
 - Estimate how much traffic you expect in each forwarding class, and how much traffic you expect in each forwarding class set (the amount of traffic you expect in a forwarding class set is the aggregate amount of traffic in the forwarding classes that belong to the forwarding class set).
 - The combined minimum guaranteed bandwidth of the priorities (forwarding classes) in a priority group should not exceed the minimum guaranteed bandwidth of the priority group (forwarding class set). The transmit rate scheduler parameter defines the minimum guaranteed bandwidth for forwarding classes. Scheduler maps associate schedulers with forwarding classes.
 - The combined minimum guaranteed bandwidth of the priority groups (forwarding class sets) on a port should not exceed the port's total bandwidth. The guaranteed rate parameter in the traffic control profile defines the minimum bandwidth for a forwarding class set. Associating a scheduler map with a traffic control profile sets the scheduling for the individual forwarding classes in the forwarding class set.

This example creates hierarchical port scheduling by defining priority groups for best effort, guaranteed delivery, and high-performance computing (HPC) traffic. Each priority group includes priorities that need to receive similar CoS treatment. Each priority group and each priority within each priority group receive the CoS resources needed to service

their flows. Lossless priorities use PFC to prevent packet loss when the network experiences congestion.

Topology

Table 2 on page 20 shows the configuration components for this example.



NOTE: OCX Series switches do not support lossless transport and do not support PFC. If you eliminate the configuration elements for the default lossless **fcoe** and **no-loss** forwarding classes (including classifier, forwarding class set, scheduler, and traffic control profile configuration for those forwarding classes) and for PFC, this example works for OCX Series switches. However, because the default **fcoe** and **no-loss** forwarding classes do not carry traffic on OCX Series switches, you can apply the bandwidth allocated to those forwarding classes to other forwarding classes. By default, the active forwarding classes (**best-effort**, **network-control**, and **mcast**) share the unused bandwidth assigned to the **fcoe** and **no-loss** forwarding classes.

Table 2: Components of the Hierarchical Port Scheduling (ETS) Configuration Topology

Property	Settings
Hardware	QFX3500 switch
Mapping of forwarding classes (priorities) to queues	<p>best-effort to queue 0</p> <p>be2 to queue 1</p> <p>fcoe (Fibre Channel over Ethernet) to queue 3</p> <p>no-loss to queue 4</p> <p>hpc (high-performance computing) to queue 5</p> <p>network-control to queue 7</p> <p>NOTE: On switches that do not support the ELS CLI, if you are using Junos OS Release 12.2 or later, use the default forwarding-class-to-queue mapping for the lossless fcoe and no-loss forwarding classes. If you explicitly configure the default lossless forwarding classes, the traffic mapped to those forwarding classes is treated as lossy (best-effort) traffic and does <i>not</i> receive lossless treatment.</p> <p>On switches that do not support the ELS CLI, in Junos OS Release 12.3 and later, you can include the <i>no-loss</i> packet drop attribute in the explicit forwarding class configuration to configure a lossless forwarding class.</p>
Forwarding class sets (priority groups)	<p>best-effort-pg: contains forwarding classes best-effort, be2, and network control</p> <p>guar-delivery-pg: contains forwarding classes fcoe and no-loss</p> <p>hpc-pg: contains forwarding class hpc</p>

Table 2: Components of the Hierarchical Port Scheduling (ETS) Configuration Topology (*continued*)

Property	Settings
Behavior aggregate classifier (maps forwarding classes and loss priorities to incoming packets by IEEE 802.1 code point)	Name— hsclassifier1 Code point mapping: <ul style="list-style-type: none"> • 000 to forwarding class best-effort and loss priority low • 001 to forwarding class be2 and loss priority high • 011 to forwarding class fcoe and loss priority low • 100 to forwarding class no-loss and loss priority low • 101 to forwarding class hpc and loss priority low • 110 to forwarding class network-control and loss priority low
PFC	Congestion notification profile name— gd-cnp PFC enabled on code points: 011 (fcoe priority), 010 (no-loss priority)
Drop profiles NOTE: The fcoe and no-loss priorities (queues) do not use drop profiles because they are lossless traffic classes.	dp-be-low: drop start point 25 , drop end point 50 , maximum drop rate 80 dp-be-high: drop start point 10 , drop end point 40 , maximum drop rate 100 dp-hpc: drop start point 75 , drop end point 90 , maximum drop rate 75 dp-nc: drop start point 80 , drop end point 100 , maximum drop rate 100
Queue schedulers	be-sched: minimum bandwidth 3g , maximum bandwidth 100% , priority low , drop profiles dp-be-low and dp-be-high fcoe-sched: minimum bandwidth 2.5g , maximum bandwidth 100% , priority low hpc-sched: minimum bandwidth 2g , maximum bandwidth 100% , priority low , drop profile dp-hpc nc-sched: minimum bandwidth 500m , maximum bandwidth 100% , priority low , drop profile dp-nc nl-sched: minimum bandwidth 2g , maximum bandwidth 100% , priority low
Forwarding class-to-scheduler mapping	Scheduler map be-map : Forwarding class best-effort , scheduler be-sched Forwarding class be2 , scheduler be-sched Forwarding class network-control , scheduler nc-sched Scheduler map gd-map : Forwarding class fcoe , scheduler fcoe-sched Forwarding class no-loss , scheduler nl-sched Scheduler map hpc-map : Forwarding class hpc , scheduler hpc-sched
Traffic control profiles	be-tcp: scheduler map be-map , minimum bandwidth 3.5g , maximum bandwidth 100% gd-tcp: scheduler map gd-map , minimum bandwidth 4.5g , maximum bandwidth 100% hpc-tcp: scheduler map hpc-map , minimum bandwidth 2g , maximum bandwidth 100%

Table 2: Components of the Hierarchical Port Scheduling (ETS) Configuration Topology (*continued*)

Property	Settings
Interfaces	<p>This example configures hierarchical port scheduling on interfaces xe-0/0/20 and xe-0/0/21. Because traffic is bidirectional, you apply the ingress and egress configuration components to both interfaces:</p> <ul style="list-style-type: none"> • Classifier Name—hsclassifier1 • Forwarding class sets—best-effort-pg, guar-deliver-pg, hpc-pg • Congestion notification profile—gd-cnp

Figure 3 on page 22 shows a block diagram of the configuration components and the configuration flow of the CLI statements used in the example. You can perform the configuration steps in a different sequence if you want.

Figure 3: Hierarchical Port Scheduling Components Block Diagram

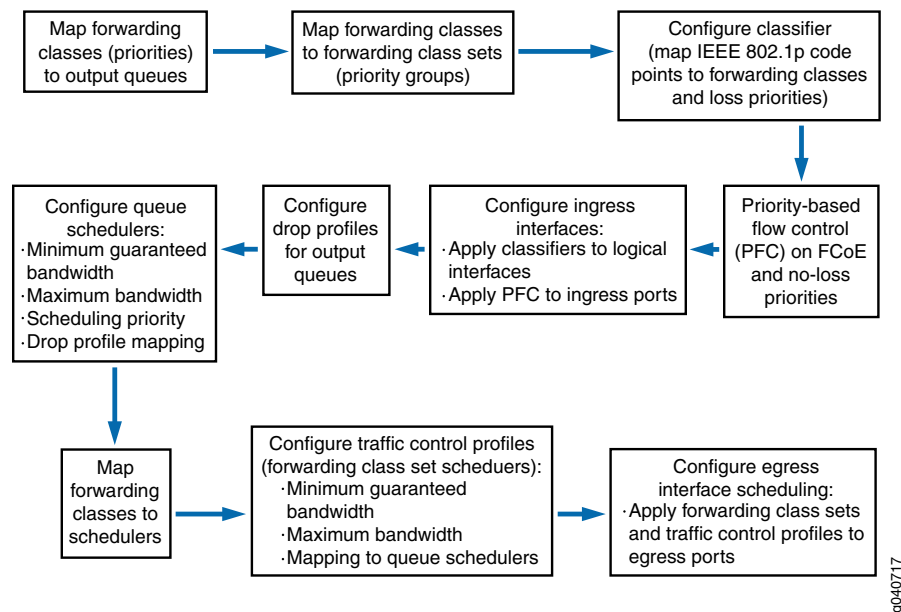
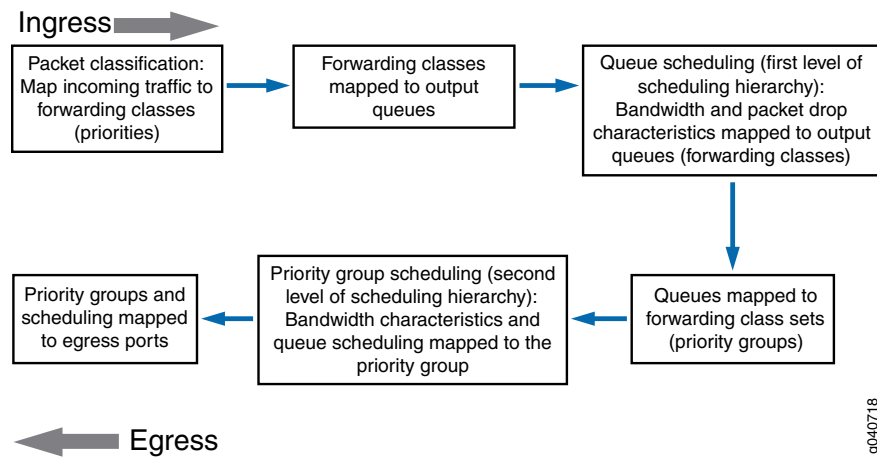


Figure 4 on page 23 shows a block diagram of the hierarchical scheduling packet flow from ingress to egress.

Figure 4: Hierarchical Port Scheduling Packet Flow Block Diagram



Configuration

CLI Quick Configuration

To quickly configure hierarchical port scheduling on systems that support lossless transport, copy the following commands, paste them in a text file, remove line breaks, change variables and details to match your network configuration, and then copy and paste the commands into the CLI at the [edit class-of-service] hierarchy level:

```

[edit class-of-service]
set forwarding-classes class best-effort queue-num 0
set forwarding-classes class be2 queue-num 1
set forwarding-classes class hpc queue-num 5
set forwarding-classes class network-control queue-num 7
set forwarding-class-sets best-effort-pg class best-effort
set forwarding-class-sets best-effort-pg class be2
set forwarding-class-sets best-effort-pg class network-control
set forwarding-class-sets guar-delivery-pg class fcoe
set forwarding-class-sets guar-delivery-pg class no-loss
set forwarding-class-sets hpc-pg class hpc
set classifiers ieee-802.1 hsclassifier1 forwarding-class best-effort loss-priority low code-points 000
set classifiers ieee-802.1 hsclassifier1 forwarding-class be2 loss-priority high code-points 001
set classifiers ieee-802.1 hsclassifier1 forwarding-class fcoe loss-priority low code-points 011
set classifiers ieee-802.1 hsclassifier1 forwarding-class no-loss loss-priority low code-points 100
set classifiers ieee-802.1 hsclassifier1 forwarding-class hpc loss-priority low code-points 101
set classifiers ieee-802.1 hsclassifier1 forwarding-class network-control loss-priority low code-points 110
set congestion-notification-profile gd-cnp input ieee-802.1 code-point 011 pfc
set congestion-notification-profile gd-cnp input ieee-802.1 code-point 100 pfc
set interfaces xe-0/0/20 unit 0 classifiers ieee-802.1 hsclassifier1
set interfaces xe-0/0/21 unit 0 classifiers ieee-802.1 hsclassifier1
set interfaces xe-0/0/20 congestion-notification-profile gd-cnp
set interfaces xe-0/0/21 congestion-notification-profile gd-cnp
set drop-profiles dp-be-low interpolate fill-level 25 fill-level 50 drop-probability 0 drop-probability 80
set drop-profiles dp-be-high interpolate fill-level 10 fill-level 40 drop-probability 0 drop-probability 100
set drop-profiles dp-nc interpolate fill-level 80 fill-level 100 drop-probability 0 drop-probability 100
set drop-profiles dp-hpc interpolate fill-level 75 fill-level 90 drop-probability 0 drop-probability 75
  
```

```

set schedulers be-sched priority low transmit-rate 3g
set schedulers be-sched shaping-rate percent 100
set schedulers be-sched drop-profile-map loss-priority low protocol any drop-profile dp-be-low
set schedulers be-sched drop-profile-map loss-priority high protocol any drop-profile dp-be-high
set schedulers fcoe-sched priority low transmit-rate 2500m
set schedulers fcoe-sched shaping-rate percent 100
set schedulers hpc-sched priority low transmit-rate 2g
set schedulers hpc-sched shaping-rate percent 100
set schedulers hpc-sched drop-profile-map loss-priority low protocol any drop-profile dp-hpc
set schedulers nc-sched priority low transmit-rate 500m
set schedulers nc-sched shaping-rate percent 100
set schedulers nc-sched drop-profile-map loss-priority low protocol any drop-profile dp-nc
set schedulers nl-sched priority low transmit-rate 2g
set schedulers nl-sched shaping-rate percent 100
set scheduler-maps be-map forwarding-class best-effort scheduler be-sched
set scheduler-maps be-map forwarding-class be2 scheduler be-sched
set scheduler-maps be-map forwarding-class network-control scheduler nc-sched
set scheduler-maps gd-map forwarding-class fcoe scheduler fcoe-sched
set scheduler-maps gd-map forwarding-class no-loss scheduler nl-sched
set scheduler-maps hpc-map forwarding-class hpc scheduler hpc-sched
set traffic-control-profiles be-tcp scheduler-map be-map guaranteed-rate 3500m
set traffic-control-profiles be-tcp shaping-rate percent 100
set traffic-control-profiles gd-tcp scheduler-map gd-map guaranteed-rate 4500m
set traffic-control-profiles gd-tcp shaping-rate percent 100
set traffic-control-profiles hpc-tcp scheduler-map hpc-map guaranteed-rate 2g
set traffic-control-profiles hpc-tcp shaping-rate percent 100
set interfaces xe-0/0/20 forwarding-class-set best-effort-pg output-traffic-control-profile be-tcp
set interfaces xe-0/0/20 forwarding-class-set guar-delivery-pg output-traffic-control-profile
gd-tcp
set interfaces xe-0/0/20 forwarding-class-set hpc-pg output-traffic-control-profile hpc-tcp
set interfaces xe-0/0/21 forwarding-class-set best-effort-pg output-traffic-control-profile be-tcp
set interfaces xe-0/0/21 forwarding-class-set guar-delivery-pg output-traffic-control-profile
gd-tcp
set interfaces xe-0/0/21 forwarding-class-set hpc-pg output-traffic-control-profile hpc-tcp

```

OCX Series Switches

Because OCX Series switches do not support lossless transport, the following subset of the configuration eliminates the lossless configuration elements and provides hierarchical port scheduling for the best-effort, be2, hpc, and network-control forwarding classes. In addition, on OCX Series switches, you would probably use DSCP classifiers and code points instead of IEEE classifiers and code points. To quickly configure hierarchical port scheduling on an OCX Series switch, copy the following commands, paste them in a text file, remove line breaks, change variables and details to match your network configuration, and then copy and paste the commands into the CLI at the [edit class-of-service] hierarchy level:

```

[edit class-of-service]
set forwarding-classes class best-effort queue-num 0
set forwarding-classes class be2 queue-num 1
set forwarding-classes class hpc queue-num 5
set forwarding-classes class network-control queue-num 7
set forwarding-class-sets best-effort-pg class best-effort
set forwarding-class-sets best-effort-pg class be2
set forwarding-class-sets best-effort-pg class network-control
set forwarding-class-sets hpc-pg class hpc
set classifiers ieee-802.1 hsclassifier1 forwarding-class best-effort loss-priority low code-points
000
set classifiers ieee-802.1 hsclassifier1 forwarding-class be2 loss-priority high code-points 001

```



```

set classifiers ieee-802.1 hsclassifier1 forwarding-class hpc loss-priority low code-points 101
set classifiers ieee-802.1 hsclassifier1 forwarding-class network-control loss-priority low
code-points 110
set interfaces xe-0/0/20 unit 0 classifiers ieee-802.1 hsclassifier1
set interfaces xe-0/0/21 unit 0 classifiers ieee-802.1 hsclassifier1
set drop-profiles dp-be-low interpolate fill-level 25 fill-level 50 drop-probability 0 drop-probability
80
set drop-profiles dp-be-high interpolate fill-level 10 fill-level 40 drop-probability 0 drop-probability
100
set drop-profiles dp-nc interpolate fill-level 80 fill-level 100 drop-probability 0 drop-probability
100
set drop-profiles dp-hpc interpolate fill-level 75 fill-level 90 drop-probability 0 drop-probability
75
set schedulers be-sched priority low transmit-rate 3g
set schedulers be-sched shaping-rate percent 100
set schedulers be-sched drop-profile-map loss-priority low protocol any drop-profile dp-be-low
set schedulers be-sched drop-profile-map loss-priority high protocol any drop-profile dp-be-high
set schedulers hpc-sched priority low transmit-rate 2g
set schedulers hpc-sched shaping-rate percent 100
set schedulers hpc-sched drop-profile-map loss-priority low protocol any drop-profile dp-hpc
set schedulers nc-sched priority low transmit-rate 500m
set schedulers nc-sched shaping-rate percent 100
set schedulers nc-sched drop-profile-map loss-priority low protocol any drop-profile dp-nc
set scheduler-maps be-map forwarding-class best-effort scheduler be-sched
set scheduler-maps be-map forwarding-class be2 scheduler be-sched
set scheduler-maps be-map forwarding-class network-control scheduler nc-sched
set scheduler-maps hpc-map forwarding-class hpc scheduler hpc-sched
set traffic-control-profiles be-tcp scheduler-map be-map guaranteed-rate 3500m
set traffic-control-profiles be-tcp shaping-rate percent 100
set traffic-control-profiles hpc-tcp scheduler-map hpc-map guaranteed-rate 2g
set traffic-control-profiles hpc-tcp shaping-rate percent 100
set interfaces xe-0/0/20 forwarding-class-set best-effort-pg output-traffic-control-profile be-tcp
set interfaces xe-0/0/20 forwarding-class-set hpc-pg output-traffic-control-profile hpc-tcp
set interfaces xe-0/0/21 forwarding-class-set best-effort-pg output-traffic-control-profile be-tcp
set interfaces xe-0/0/21 forwarding-class-set hpc-pg output-traffic-control-profile hpc-tcp

```

Step-by-Step Procedure

To perform a step-by-step configuration of the forwarding classes (priorities), forwarding class sets (priority groups), classifiers, queue schedulers, PFC, traffic control profiles, and interfaces to set up hierarchical port scheduling (ETS):

1. Configure the forwarding classes (priorities) and map them to unicast output queues (do not explicitly map the **fcpe** and **no-loss** forwarding classes to output queues; use the default configuration):

```

[edit class-of-service]
user@switch# set forwarding-classes class best-effort queue-num 0
user@switch# set forwarding-classes class be2 queue-num 1
user@switch# set forwarding-classes class hpc queue-num 5
user@switch# set forwarding-classes class network-control queue-num 7

```

2. Configure forwarding class sets (priority groups) to group forwarding classes (priorities) that require similar CoS treatment:

```

[edit class-of-service]
user@switch# set forwarding-class-sets best-effort-pg class best-effort
user@switch# set forwarding-class-sets best-effort-pg class be2
user@switch# set forwarding-class-sets best-effort-pg class network-control
user@switch# set forwarding-class-sets guar-delivery-pg class fcpe
user@switch# set forwarding-class-sets guar-delivery-pg class no-loss
user@switch# set forwarding-class-sets hpc-pg class hpc

```



NOTE: On OCX Series switches, you would not configure the `guar-delivery-pg` forwarding class set for lossless traffic.

3. Configure a classifier to set the loss priority and IEEE 802.1 code points assigned to each forwarding class at the ingress:

```
[edit class-of-service]
user@switch# set classifiers ieee-802.1 hsclassifier1 forwarding-class best-effort
loss-priority low code-points 000
user@switch# set classifiers ieee-802.1 hsclassifier1 forwarding-class be2 loss-priority
high code-points 001
user@switch# set classifiers ieee-802.1 hsclassifier1 forwarding-class fcoe loss-priority
low code-points 011
user@switch# set classifiers ieee-802.1 hsclassifier1 forwarding-class no-loss loss-priority
low code-points 100
user@switch# set classifiers ieee-802.1 hsclassifier1 forwarding-class hpc loss-priority low
code-points 101
user@switch# set classifiers ieee-802.1 hsclassifier1 forwarding-class network-control
loss-priority low code-points 110
```



NOTE: On OCX Series switches, you would not configure the `fcoe` and `no-loss` portions of the classifier.

4. Configure a congestion notification profile to enable PFC on the FCoE and no-loss queue IEEE 802.1 code points:

```
[edit class-of-service]
user@switch# set congestion-notification-profile gd-cnp input ieee-802.1 code-point 011
pfc
user@switch# set congestion-notification-profile gd-cnp input ieee-802.1 code-point 100
pfc
```



NOTE: This step does not apply to OCX Series switches, which do not support PFC.

5. Assign the classifier to the interfaces:

```
[edit class-of-service]
user@switch# set interfaces xe-0/0/20 unit 0 classifiers ieee-802.1 hsclassifier1
user@switch# set interfaces xe-0/0/21 unit 0 classifiers ieee-802.1 hsclassifier1
```

6. Apply the PFC configuration to the interfaces:

```
[edit class-of-service]
user@switch# set interfaces xe-0/0/20 congestion-notification-profile gd-cnp
user@switch# set interfaces xe-0/0/21 congestion-notification-profile gd-cnp
```



NOTE: This step does not apply to OCX Series switches, which do not support PFC.

7. Configure the drop profile for the best-effort low loss-priority queue:

```
[edit class-of-service]
user@switch# set drop-profiles dp-be-low interpolate fill-level 25 fill-level 50
drop-probability 0 drop-probability 80
```
8. Configure the drop profile for the best-effort high loss-priority queue:

```
[edit class-of-service]
user@switch# set drop-profiles dp-be-high interpolate fill-level 10 fill-level 40
drop-probability 0 drop-probability 100
```
9. Configure the drop profile for the network-control queue:

```
[edit class-of-service]
user@switch# set drop-profiles dp-nc interpolate fill-level 80 fill-level 100 drop-probability
0 drop-probability 100
```
10. Configure the drop profile for the high-performance computing queue:

```
[edit class-of-service]
user@switch# set drop-profiles dp-hpc interpolate fill-level 75 fill-level 90 drop-probability
0 drop-probability 75
```
11. Define the minimum guaranteed bandwidth, priority, maximum bandwidth, and drop profiles for the best-effort queue:

```
[edit class-of-service]
user@switch# set schedulers be-sched priority low transmit-rate 3g
user@switch# set schedulers be-sched shaping-rate percent 100
user@switch# set schedulers be-sched drop-profile-map loss-priority low protocol any
drop-profile dp-be-low
user@switch# set schedulers be-sched drop-profile-map loss-priority high protocol any
drop-profile dp-be-high
```
12. Define the minimum guaranteed bandwidth, priority, and maximum bandwidth for the FCoE queue:

```
[edit class-of-service]
user@switch# set schedulers fcoe-sched priority low transmit-rate 2500m
user@switch# set schedulers fcoe-sched shaping-rate percent 100
```



NOTE: This step does not apply to OCX Series switches, which do not support lossless transport.

13. Define the minimum guaranteed bandwidth, priority, maximum bandwidth, and drop profile for the high-performance computing queue:

```
[edit class-of-service]
user@switch# set schedulers hpc-sched priority low transmit-rate 2g
user@switch# set schedulers hpc-sched shaping-rate percent 100
user@switch# set schedulers hpc-sched drop-profile-map loss-priority low protocol any
drop-profile dp-hpc
```
14. Define the minimum guaranteed bandwidth, priority, maximum bandwidth, and drop profile for the network-control queue:

```
[edit class-of-service]
user@switch# set schedulers nc-sched priority low transmit-rate 500m
user@switch# set schedulers nc-sched shaping-rate percent 100
```

```
user@switch# set schedulers nc-sched drop-profile-map loss-priority low protocol any
drop-profile dp-nc
```

15. Define the minimum guaranteed bandwidth, priority, and maximum bandwidth for the no-loss queue:

```
[edit class-of-service]
user@switch# set schedulers nl-sched priority low transmit-rate 2g
user@switch# set schedulers nl-sched shaping-rate percent 100
```



NOTE: This step does not apply to OCX Series switches, which do not support lossless transport.

16. Map the schedulers to the appropriate forwarding classes (queues):

```
[edit class-of-service]
user@switch# set scheduler-maps be-map forwarding-class best-effort scheduler be-sched
user@switch# set scheduler-maps be-map forwarding-class be2 scheduler be-sched
user@switch# set scheduler-maps be-map forwarding-class network-control scheduler
nc-sched
user@switch# set scheduler-maps gd-map forwarding-class fcoe scheduler fcoe-sched
user@switch# set scheduler-maps gd-map forwarding-class no-loss scheduler nl-sched
user@switch# set scheduler-maps hpc-map forwarding-class hpc scheduler hpc-sched
```



NOTE: On OCX Series switches, because lossless transport is not supported, you would not configure the gd-map scheduler map.

17. Define the traffic control profile for the best-effort priority group (queue scheduler to mapping, minimum guaranteed bandwidth, and maximum bandwidth):

```
[edit class-of-service]
user@switch# set traffic-control-profiles be-tcp scheduler-map be-map guaranteed-rate
3500m
user@switch# set traffic-control-profiles be-tcp shaping-rate percent 100
```

18. Define the traffic control profile for the guaranteed delivery priority group (queue to scheduler mapping, minimum guaranteed bandwidth, and maximum bandwidth):

```
[edit class-of-service]
user@switch# set traffic-control-profiles gd-tcp scheduler-map gd-map guaranteed-rate
4500m
user@switch# set traffic-control-profiles gd-tcp shaping-rate percent 100
```



NOTE: This step does not apply to OCX Series switches, which do not support lossless transport.

19. Define the traffic control profile for the high-performance computing priority group (queue to scheduler mapping, minimum guaranteed bandwidth, and maximum bandwidth):

```
[edit class-of-service]
```

```

user@switch# set traffic-control-profiles hpc-tcp scheduler-map hpc-map guaranteed-rate
2g
user@switch# set traffic-control-profiles hpc-tcp shaping-rate percent 100

```

20. Apply the three priority groups (forwarding class sets) and the appropriate traffic control profiles to the egress ports:

```

[edit class-of-service]
user@switch# set interfaces xe-0/0/20 forwarding-class-set best-effort-pg
output-traffic-control-profile be-tcp
user@switch# set interfaces xe-0/0/20 forwarding-class-set guar-delivery-pg
output-traffic-control-profile gd-tcp
user@switch# set interfaces xe-0/0/20 forwarding-class-set hpc-pg
output-traffic-control-profile hpc-tcp
user@switch# set interfaces xe-0/0/21 forwarding-class-set best-effort-pg
output-traffic-control-profile be-tcp
user@switch# set interfaces xe-0/0/21 forwarding-class-set guar-delivery-pg
output-traffic-control-profile gd-tcp
user@switch# set interfaces xe-0/0/21 forwarding-class-set hpc-pg
output-traffic-control-profile hpc-tcp

```



NOTE: Because OCX Series switches do not support lossless transport, on OCX Series switches, you would not apply the `guar-deliver-pg` forwarding class set and the `gd-tcp` traffic control profile to interfaces.

Results

Display the results of the configuration (the system shows only the explicitly configured parameters; it does not show default parameters such as the `fcoe` and `no-loss` lossless forwarding classes). On OCX Series switches, you would not see the lossless configuration components in the output:

```

user@switch> show configuration class-of-service
classifiers {
  ieee-802.1 hsclassifier1 {
    forwarding-class best-effort {
      loss-priority low code-points 000;
    }
    forwarding-class be2 {
      loss-priority high code-points 001;
    }
    forwarding-class fcoe {
      loss-priority low code-points 011;
    }
    forwarding-class no-loss {
      loss-priority low code-points 100;
    }
    forwarding-class hpc {
      loss-priority low code-points 101;
    }
    forwarding-class network-control {
      loss-priority low code-points 110;
    }
  }
}

```

```
}
drop-profiles {
  dp-be-low {
    interpolate {
      fill-level [ 25 50 ];
      drop-probability [ 0 80 ];
    }
  }
  dp-be-high {
    interpolate {
      fill-level [ 10 40 ];
      drop-probability [ 0 100 ];
    }
  }
  dp-hpc {
    interpolate {
      fill-level [ 75 90 ];
      drop-probability [ 0 75 ];
    }
  }
  dp-nc {
    interpolate {
      fill-level [ 80 100 ];
      drop-probability [ 0 100 ];
    }
  }
}
forwarding-classes {
  class best-effort queue-num 0;
  class be2 queue-num 1;
  class hpc queue-num 5;
  class network-control queue-num 7;
}
traffic-control-profiles {
  be-tcp {
    scheduler-map be-map;
    shaping-rate percent 100;
    guaranteed-rate 3500000000;
  }
  gd-tcp {
    scheduler-map gd-map;
    shaping-rate percent 100;
    guaranteed-rate 4500000000;
  }
  hpc-tcp {
    scheduler-map hpc-map;
    shaping-rate percent 100;
    guaranteed-rate 2g;
  }
}
forwarding-class-sets {
  guar-delivery-pg {
    class fcoe;
    class no-loss;
  }
  best-effort-pg {
```

```

        class best-effort;
        class be2;
        class network-control;
    }
    hpc-pg {
        class hpc;
    }
}
congestion-notification-profile {
    gd-cnp {
        input {
            ieee-802.1 {
                code-point 011 {
                    pfc;
                }
                code-point 100 {
                    pfc;
                }
            }
        }
    }
}
}
interfaces {
    xe-0/0/20 {
        forwarding-class-set {
            best-effort-pg {
                output-traffic-control-profile be-tcp;
            }
            guar-delivery-pg {
                output-traffic-control-profile gd-tcp;
            }
            hpc-pg {
                output-traffic-control-profile hpc-tcp;
            }
        }
        congestion-notification-profile gd-cnp;
        unit 0 {
            classifiers {
                ieee-802.1 hsclassifier1;
            }
        }
    }
    xe-0/0/21 {
        forwarding-class-set {
            best-effort-pg {
                output-traffic-control-profile be-tcp;
            }
            guar-delivery-pg {
                output-traffic-control-profile gd-tcp;
            }
            hpc-pg {
                output-traffic-control-profile hpc-tcp;
            }
        }
        congestion-notification-profile gd-cnp;
        unit 0 {

```

```
        classifiers {
            ieee-802.1 hsclassifier1;
        }
    }
}
scheduler-maps {
    be-map {
        forwarding-class best-effort scheduler be-sched;
        forwarding-class network-control scheduler nc-sched;
        forwarding-class be2 scheduler be-sched;
    }
    gd-map {
        forwarding-class fcoe scheduler fcoe-sched;
        forwarding-class no-loss scheduler nl-sched;
    }
    hpc-map {
        forwarding-class hpc scheduler hpc-sched;
    }
}
schedulers {
    be-sched {
        transmit-rate 3g;
        shaping-rate percent 100;
        priority low;
        drop-profile-map loss-priority low protocol any drop-profile dp-be-low;
        drop-profile-map loss-priority high protocol any drop-profile dp-be-high;
    }
    fcoe-sched {
        transmit-rate 25000000000;
        shaping-rate percent 100;
        priority low;
    }
    hpc-sched {
        transmit-rate 2g;
        shaping-rate percent 100;
        priority low;
        drop-profile-map loss-priority low protocol any drop-profile dp-hpc;
    }
    nc-sched {
        transmit-rate 500m;
        shaping-rate percent 100;
        priority low;
        drop-profile-map loss-priority low protocol any drop-profile dp-nc;
    }
    nl-sched {
        transmit-rate 2g;
        shaping-rate percent 100;
        priority low;
    }
}
```




TIP: To quickly configure the interfaces, issue the **load merge terminal** command, and then copy the hierarchy and paste it into the switch terminal window.

Verification



NOTE: The verification output is based on the full example configuration. On OCX Series switches, you do not see lossless configuration components in the output. Comments about lossless configuration components do not apply to OCX Series switches.

To verify that you created the hierarchical port scheduling components and they are operating properly, perform these tasks:

- [Verifying the Forwarding Classes \(Priorities\) on page 33](#)
- [Verifying the Forwarding Class Sets \(Priority Groups\) on page 34](#)
- [Verifying the Classifier on page 35](#)
- [Verifying Priority-Based Flow Control on page 35](#)
- [Verifying the Output Queue Schedulers on page 36](#)
- [Verifying the Drop Profiles on page 38](#)
- [Verifying the Priority Group Output Schedulers \(Traffic Control Profiles\) on page 39](#)
- [Verifying the Interface Configuration on page 40](#)

Verifying the Forwarding Classes (Priorities)

Purpose Verify that you created the forwarding classes and mapped them to the correct queues. (The system shows only the explicitly configured forwarding classes. It does not show default forwarding classes such as **fcoe** and **no-loss**.)

Action List the forwarding classes using the operational mode command **show class-of-service forwarding-class**:

```
user@switch> show class-of-service forwarding-class
```

Forwarding class	ID	Queue	Policing priority	No-Loss
best-effort	0	0	normal	Disabled
be2	1	3	normal	Disabled
hpc	2	4	normal	Disabled
network-control	3	7	normal	Disabled
mcast	8	8	normal	Disabled

Meaning The **show class-of-service forwarding-class** command lists all of the configured forwarding classes, the internal identification number of each forwarding class, the queues that are mapped to the forwarding classes, the policing priority, and whether the forwarding class is lossless (no-loss packet drop attribute enabled) or lossy forwarding class (no-loss packet drop attribute disabled). The command output shows that:

- Forwarding class **best-effort** maps to queue **0** and is lossy
- Forwarding class **be2** maps to queue **1** and is lossy
- Forwarding class **hpc** maps to queue **5** and is lossy
- Forwarding class **network-control** maps to queue **7** and is lossy

In addition, the command lists the default multicast (multidestination) forwarding class and the default queue to which it is mapped.

Verifying the Forwarding Class Sets (Priority Groups)

Purpose Verify that you created the priority groups and that the correct priorities (forwarding classes) belong to the appropriate priority group.

Action List the forwarding class sets using the operational mode command **show class-of-service forwarding-class-set**:

```
user@switch> show class-of-service forwarding-class-set
```

```
Forwarding class set: best-effort-pg, Type: normal-type, Forwarding class set index: 19907
```

Forwarding class	Index
best-effort	0
be2	1
network-control	5

```
Forwarding class set: guar-delivery-pg, Type: normal-type, Forwarding class set index: 43700
```

Forwarding class	Index
fcoe	2
no-loss	3

```
Forwarding class set: hpc-pg, Type: normal-type, Forwarding class set index: 60758
```

Forwarding class	Index
hpc	4

Meaning The **show class-of-service forwarding-class-set** command lists all of the configured forwarding class sets (priority groups), the forwarding classes (priorities) that belong to each priority group, and the internal index number of each priority group. The command output shows that:

- The forwarding class set **best-effort-pg** includes the forwarding classes **best-effort**, **be2**, and **network-control**.
- The forwarding class set **guar-delivery-pg** includes the forwarding classes **fcoe** and **no-loss**.
- The forwarding class set **hpc-pg** includes the forwarding class **hpc**.

Verifying the Classifier

Purpose Verify that the classifier maps forwarding classes to the correct IEEE 802.1p code points and packet loss priorities.

Action List the classifier configured for hierarchical port scheduling using the operational mode command **show class-of-service classifier name hsclassifier1**:

```
user@switch> show class-of-service classifier name hsclassifier1
Classifier: hsclassifier1, Code point type: ieee-802.1, Index: 43607
  Code point      Forwarding class      Loss priority
  000             best-effort             low
  001             be2                 high
  011             fcoe                 low
  100             no-loss             low
  101             hpc                 low
  110             network-control    low
```

Meaning The **show class-of-service classifier name hsclassifier1** command lists all of the IEEE 802.1p code points and the loss priorities mapped to all of the forwarding classes in the classifier. The command output shows that the forwarding classes **best-effort**, **be2**, **no-loss**, **fcoe**, **hpc**, and **network-control** have been created and mapped to IEEE 802.1p code points and loss priorities.

Verifying Priority-Based Flow Control

Purpose Verify that PFC is enabled on the correct priorities for lossless transport.

Action List the congestion notification profiles using the operational mode command **show class-of-service congestion-notification**:

```
user@switch> show class-of-service congestion-notification
Type: Input, Name: gd-cnp, Index: 51687
Cable Length: 100 m
  Priority      PFC          MRU
  000          Disabled
  001          Disabled
  010          Disabled
  011          Enabled      2500
  100          Enabled      2500
  101          Disabled
  110          Disabled
  111          Disabled
Type: Output
  Priority      Flow-Control-Queues
  000          0
  001          1
  010          2
  011          3
  100          4
  101          4
```

	5
110	
	6
111	
	7

Meaning The **show class-of-service congestion-notification** command lists all of the congestion notification profiles and the IEEE 802.1p code points with PFC enabled. The command output shows that PFC is enabled for code points **011** (**fcoe** priority and queue) and **100** (**no-loss** priority and queue) for the **gd-cnp** congestion notification profile.

The command also shows the default cable length (100 meters), the default maximum receive unit (2500 bytes), and the default mapping of priorities to output queues because this example does not include configuring these options.

Verifying the Output Queue Schedulers

Purpose Verify that you created the output queue schedulers with the correct bandwidth parameters and priorities, mapped to the correct queues, and mapped to the correct drop profiles.

Action List the scheduler maps using the operational mode command **show class-of-service scheduler-map**:

```
user@switch> show class-of-service scheduler-map
Scheduler map: be-map, Index: 64023
```

```
Scheduler: be-sched, Forwarding class: best-effort, Index: 13005
  Transmit rate: 3000000000 bps, Rate Limit: none, Buffer size: remainder,
  Buffer Limit: none, Priority: low
  Excess Priority: unspecified
  Shaping rate: 100 percent,
  drop-profile-map-set-type: mark
  Drop profiles:
    Loss priority  Protocol  Index  Name
    Low           any      55387  dp-be-low
    Medium high   any      1      <default-drop-profile>
    High          any      4369   dp-be-high
```

```
Scheduler: be-sched, Forwarding class: be2, Index: 13005
  Transmit rate: 3000000000 bps, Rate Limit: none, Buffer size: remainder,
  Buffer Limit: none, Priority: low
  Excess Priority: unspecified
  Shaping rate: 100 percent,
  drop-profile-map-set-type: mark
  Drop profiles:
    Loss priority  Protocol  Index  Name
    Low           any      55387  dp-be-low
    Medium high   any      1      <default-drop-profile>
    High          any      4369   dp-be-high
```

```
Scheduler: nc-sched, Forwarding class: network-control, Index: 45740
  Transmit rate: 5000000000 bps, Rate Limit: none, Buffer size: remainder,
  Buffer Limit: none, Priority: low
  Excess Priority: unspecified
  Shaping rate: 100 percent,
  drop-profile-map-set-type: mark
```

Drop profiles:

Loss priority	Protocol	Index	Name
Low	any	44207	dp-nc
Medium high	any	1	<default-drop-profile>
High	any	1	<default-drop-profile>

Scheduler map: gd-map, Index: 61447

Scheduler: fcoe-sched, Forwarding class: fcoe, Index: 37289

Transmit rate: 2500000000 bps, Rate Limit: none, Buffer size: remainder,
Buffer Limit: none, Priority: low

Excess Priority: unspecified

Shaping rate: 100 percent,

drop-profile-map-set-type: mark

Drop profiles:

Loss priority	Protocol	Index	Name
Low	any	44207	<default-drop-profile>
Medium high	any	1	<default-drop-profile>
High	any	1	<default-drop-profile>

Scheduler: nl-sched, Forwarding class: no-loss, Index: 29359

Transmit rate: 2000000000 bps, Rate Limit: none, Buffer size: remainder,
Buffer Limit: none, Priority: low

Excess Priority: unspecified

Shaping rate: 100 percent,

drop-profile-map-set-type: mark

Drop profiles:

Loss priority	Protocol	Index	Name
Low	any	44207	<default-drop-profile>
Medium high	any	1	<default-drop-profile>
High	any	1	<default-drop-profile>

Scheduler map: hpc-map, Index: 56941

Scheduler: hpc-sched, Forwarding class: hpc, Index: 55900

Transmit rate: 2000000000 bps, Rate Limit: none, Buffer size: remainder,
Buffer Limit: none, Priority: low

Excess Priority: unspecified

Shaping rate: 100 percent,

drop-profile-map-set-type: mark

Drop profiles:

Loss priority	Protocol	Index	Name
Low	any	57716	dp-hpc
Medium high	any	1	<default-drop-profile>
High	any	1	<default-drop-profile>

Meaning The **show class-of-service scheduler-map** command lists all of the configured scheduler maps. For each scheduler map, the command output includes:

- The name of the scheduler map (**scheduler-map** field)
- The name of the scheduler (**scheduler** field)
- The forwarding classes mapped to the scheduler (**forwarding-class** field)
- The minimum guaranteed queue bandwidth (**transmit-rate** field)
- The scheduling priority (**priority** field)

- The maximum bandwidth in the priority group the queue can consume (**shaping-rate** field)
- The drop profile loss priority (**loss priority** field) for each drop profile name (**name** field)

The command output shows that:

- The scheduler map **be-map** was created and has these properties:
 - There are two schedulers, **be-sched** and **nc-sched**.
 - The scheduler **be-sched** has two forwarding classes, **best-effort** and **be2**.
 - Scheduler **be-sched** forwarding classes **best-effort** and **be2** share a minimum guaranteed bandwidth of **3,000,000,000 bps**, can consume a maximum of **100 percent** of the priority group bandwidth, and use the drop profile **dp-be-low** for low loss-priority traffic, the default drop profile for medium-high loss-priority traffic, and the drop profile **dp-be-high** for high loss-priority traffic.
 - The scheduler **nc-sched** has one forwarding class, **network-control**.
 - The **network-control** forwarding class has a minimum guaranteed bandwidth of **500,000,000 bps**, can consume a maximum of **100 percent** of the priority group bandwidth, and uses the drop profile **dp-nc** for low loss-priority traffic and the default drop profile for medium-high and high loss priority traffic.
- The scheduler map **gd-map** was created and has these properties:
 - There are two schedulers, **fcoe-sched** and **nl-sched**.
 - The scheduler **fcoe-sched** has one forwarding class, **fcoe**.
 - The **fcoe** forwarding class has a minimum guaranteed bandwidth of **2,500,000,000 bps**, and can consume a maximum of **100 percent** of the priority group bandwidth.
 - The scheduler **nl-sched** has one forwarding class, **no-loss**.
 - The **no-loss** forwarding class has a minimum guaranteed bandwidth of **2,000,000,000 bps**, and can consume a maximum of **100 percent** of the priority group bandwidth.
- The scheduler map **hpc-map** was created and has these properties:
 - There is one scheduler, **hpc-sched**.
 - The scheduler **hpc-sched** has one forwarding class, **hpc**.
 - The **hpc** forwarding class has a minimum guaranteed bandwidth of **2,000,000,000 bps**, can consume a maximum of **100 percent** of the priority group bandwidth, and uses the drop profile **dp-hpc** for low loss-priority traffic and the default drop profile for medium-high and high loss-priority traffic.

Verifying the Drop Profiles

Purpose Verify that you created the drop profiles **dp-be-high**, **dp-be-low**, **dp-hpc**, and **dp-nc** with the correct fill levels and drop probabilities.

Action List the drop profiles using the operational mode command **show configuration class-of-service drop-profiles**:

```
user@switch> show configuration class-of-service drop-profiles
dp-be-low {
    interpolate {
        fill-level [ 25 50 ];
        drop-probability [ 0 80 ];
    }
}
dp-be-high {
    interpolate {
        fill-level [ 10 40 ];
        drop-probability [ 0 100 ];
    }
}
dp-hpc {
    interpolate {
        fill-level [ 75 90 ];
        drop-probability [ 0 75 ];
    }
}
dp-nc {
    interpolate {
        fill-level [ 80 100 ];
        drop-probability [ 0 100 ];
    }
}
```

Meaning The **show configuration class-of-service drop-profiles** command lists the drop profiles and their properties. The command output shows that there are four drop profiles configured, **dp-be-high**, **dp-be-low**, **dp-hpc**, and **dp-nc**. The output also shows that:

- For **dp-be-low**, the drop start point (the first fill level) is when the queue is 25 percent filled, the drop end point (the second fill level) occurs when the queue is 50 percent filled, and the drop probability at the drop end point is 80 percent.
- For **dp-be-high**, the drop start point (the first fill level) is when the queue is 10 percent filled, the drop end point (the second fill level) occurs when the queue is 40 percent filled, and the drop probability at the drop end point is 100 percent.
- For **dp-hpc**, the drop start point (the first fill level) is when the queue is 75 percent filled, the drop end point (the second fill level) occurs when the queue is 90 percent filled, and the drop probability at the drop end point is 75 percent.
- For **dp-nc**, the drop start point (the first fill level) is when the queue is 80 percent filled, the drop end point (the second fill level) occurs when the queue is 100 percent filled, and the drop probability at the drop end point is 100 percent.

Verifying the Priority Group Output Schedulers (Traffic Control Profiles)

Purpose Verify that you created the traffic control profiles **be-tcp**, **gd-tcp**, and **hpc-tcp** with the correct bandwidth parameters and scheduler mapping.

Action List the traffic control profiles using the operational mode command **show class-of-service traffic-control-profile**:

```
user@switch> show class-of-service traffic-control-profile
Traffic control profile: be-tcp, Index: 40535
  Shaping rate: 100 percent
  Scheduler map: be-map
  Guaranteed rate: 3500000000

Traffic control profile: gd-tcp, Index: 37959
  Shaping rate: 100 percent
  Scheduler map: gd-map
  Guaranteed rate: 4500000000

Traffic control profile: hpc-tcp, Index: 47661
  Shaping rate: 100 percent
  Scheduler map: hpc-map
  Guaranteed rate: 2000000000
```

Meaning The **show class-of-service traffic-control-profile** command lists all of the configured traffic control profiles. For each traffic control profile, the command output includes:

- The name of the traffic control profile (**traffic-control-profile**)
- The maximum port bandwidth the priority group can consume (**shaping-rate**)
- The scheduler map associated with the traffic control profile (**scheduler-map**)
- The minimum guaranteed priority group port bandwidth (**guaranteed-rate**)

The command output shows that:

- The traffic control profile **be-tcp** can consume a maximum of **100 percent** of the port bandwidth, is associated with the scheduler map **be-map**, and has a minimum guaranteed bandwidth of **3,500,000,000 bps**.
- The traffic control profile **gd-tcp** can consume a maximum of **100 percent** of the port bandwidth, is associated with the scheduler map **gd-map**, and has a minimum guaranteed bandwidth of **4,500,000,000 bps**.
- The traffic control profile **hpc-tcp** can consume a maximum of **100 percent** of the port bandwidth, is associated with the scheduler map **hpc-map**, and has a minimum guaranteed bandwidth of **2,000,000,000 bps**.

Verifying the Interface Configuration

Purpose Verify that the classifier, the congestion notification profile, and the forwarding class sets are configured on interfaces **xe-0/0/20** and **xe-0/0/21**.

Action List the interfaces using the operational mode commands **show configuration class-of-service interfaces xe-0/0/20** and **show configuration class-of-service interfaces xe-0/0/21**:

```
user@switch> show configuration class-of-service interfaces xe-0/0/20
forwarding-class-set {
  best-effort-gp {
    output-traffic-control-profile be-tcp;
```



```

    }
    guar-delivery-pg {
        output-traffic-control-profile gd-tcp;
    }
    hpc-pg {
        output-traffic-control-profile hpc-tcp;
    }
}
congestion-notification-profile gd_cnp;
unit 0 {
    classifiers {
        ieee-802.1 hsclassifier1;
    }
}

user@switch> show configuration class-of-service interfaces xe-0/0/21
forwarding-class-set {
    best-effort-gp {
        output-traffic-control-profile be-tcp;
    }
    guar-delivery-pg {
        output-traffic-control-profile gd-tcp;
    }
    hpc-pg {
        output-traffic-control-profile hpc-tcp;
    }
}
congestion-notification-profile gd_cnp;
unit 0 {
    classifiers {
        ieee-802.1 hsclassifier1;
    }
}

```

Meaning The `show configuration class-of-service interfaces interface-name` command shows that each interface includes the forwarding class sets **best-effort-gp**, **guar-delivery-pg**, and **hpc-pg**, congestion notification profile **gd_cnp**, and the IEEE 802.1p classifier **hsclassifier1**.

- Related Documentation**
- *Defining CoS Unicast BA Classifiers (DSCP, DSCP IPv6, IEEE 802.1p)*
 - [Benefits of Configuring CoS Hierarchical Port Scheduling on page 5](#)
 - *Assigning CoS Components to Interfaces*
 - *Example: Configuring WRED Drop Profiles*
 - *Example: Configuring Drop Profile Maps*
 - *Example: Configuring Forwarding Classes*
 - *Example: Configuring Forwarding Class Sets*
 - *Example: Configuring Queue Schedulers*
 - *Example: Configuring Queue Scheduling Priority*
 - *Example: Configuring Traffic Control Profiles (Priority Group Scheduling)*
 - *Example: Configuring Minimum Guaranteed Output Bandwidth*

- *Example: Configuring Maximum Output Bandwidth*
- *Configuring CoS PFC (Congestion Notification Profiles)*
- *Overview of CoS Changes Introduced in Junos OS Release 12.2*
- [Understanding CoS Hierarchical Port Scheduling \(ETS\) on page 6](#)
- [Understanding CoS Scheduling Behavior and Configuration Considerations on page 12](#)
- *Understanding CoS Scheduling on QFabric System Node Device Fabric (fte) Ports*
- *Understanding Default CoS Scheduling on QFabric System Interconnect Devices (Junos OS Release 13.1 and Later Releases)*