



Junos[®] OS

CoS on Enhanced IQ PICs

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Juniper Networks, Inc.
1194 North Mathilda Avenue
Sunnyvale, California 94089
USA
408-745-2000
www.juniper.net

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Junos® OS CoS on Enhanced IQ PICs

13.1

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Table of Contents

	About the Documentation	vii
	Documentation and Release Notes	vii
	Supported Platforms	vii
	Using the Examples in This Manual	vii
	Merging a Full Example	viii
	Merging a Snippet	viii
	Documentation Conventions	ix
	Documentation Feedback	xi
	Requesting Technical Support	xi
	Self-Help Online Tools and Resources	xi
	Opening a Case with JTAC	xii
Part 1	Overview	
Chapter 1	CoS on Enhanced IQ PICs	3
	CoS on Enhanced IQ PICs Overview	3
	Calculation of Expected Traffic on IQE PIC Queues	3
	Excess Bandwidth Calculations Terminology	4
	Excess Bandwidth Basics	4
	Logical Interface Modes on IQE PICs	6
	Default Rates for Queues on IQE PICs	10
	Sample Calculations of Excess Bandwidth Sharing on IQE PICs	12
Part 2	Configuration	
Chapter 2	Configuration Tasks	29
	Configuring ToS Translation Tables	29
	Configuring Excess Bandwidth Sharing on IQE PICs	33
	IQE PIC Excess Bandwidth Sharing Overview	33
	IQE PIC Excess Bandwidth Sharing Configuration	34
	Configuring Layer 2 Policing on IQE PICs	36
	Layer 2 Policer Limitations	37
	Configuring Layer 2 Policers on IQE PICs	37
	Configuring Low-Latency Static Policers on IQE PICs	38
	Assigning Default Frame Relay Rewrite Rule to IQE PICs	40
	Defining Custom Frame Relay Rewrite Rule on IQE PICs	40
Chapter 3	Configuration Statements	43
	excess-priority	43
	excess-rate	44
	forwarding-classes (Class-of-Service)	45
	frame-relay-de (Defining Loss Priority Rewrites)	46

guaranteed-rate	47
loss-priority-rewrites	48
loss-priority-rewrites (Assigning to an Interface)	49
schedulers (Class of Service)	50
shaping-rate (Limiting Excess Bandwidth Usage)	51
translation-table	52

Part 3

Index

Index	55
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List of Tables

	About the Documentation	vii
	Table 1: Notice Icons	ix
	Table 2: Text and Syntax Conventions	ix
Part 1	Overview	
Chapter 1	CoS on Enhanced IQ PICs	3
	Table 3: Basic Example of Excess Bandwidth	4
	Table 4: Hardware Use of Basic Example Parameters	5
	Table 5: Default Mode Example for IQE PICs	6
	Table 6: Undersubscribed PIR Mode Example for IQE PICs	7
	Table 7: Oversubscribed PIR Mode Example for IQE PICs	8
	Table 8: CIR Mode Example for IQE PICs	9
	Table 9: Excess Rate Mode Example for IQE PICs	10
	Table 10: Default Queue Rates on the IQE PIC	10
	Table 11: PIR Mode, with No Excess Configuration	12
	Table 12: PIR Mode, with No Excess Hardware Behavior	12
	Table 13: PIR Mode with Transmit Rate Configuration	13
	Table 14: PIR Mode with Transmit Rate Hardware Behavior	13
	Table 15: Second PIR Mode with Transmit Rate Configuration Example	13
	Table 16: Second PIR Mode with Transmit Rate Hardware Behavior Example	14
	Table 17: PIR Mode with Transmit Rate and Excess Rate Configuration	14
	Table 18: PIR Mode with Transmit Rate and Excess Rate Hardware Behavior	15
	Table 19: Excess Rate Configuration	15
	Table 20: Excess Rate Hardware Behavior	15
	Table 21: PIR Mode Generating Error Condition	16
	Table 22: PIR Mode Generating Error Condition Behavior	16
	Table 23: CIR Mode with No Excess Rate Configuration	17
	Table 24: CIR Mode with No Excess Rate Hardware Behavior	17
	Table 25: CIR Mode with Some Shaping Rates and No Excess Rate Configuration	18
	Table 26: CIR Mode with Some Shaping Rates and No Excess Rate Hardware Behavior	18
	Table 27: CIR Mode with Shaping Rates and Transmit Rates and No Excess Rate Configuration	19
	Table 28: CIR Mode with Shaping Rates and Transmit Rates and No Excess Rate Hardware Behavior	19
	Table 29: CIR Mode with Shaping Rates Greater Than Logical Interface Shaping Rate Configuration	20
	Table 30: CIR Mode with Shaping Rates Greater Than Logical Interface Shaping Rate Hardware Behavior	20

Table 31: CIR Mode with Excess Rate Configuration	20
Table 32: CIR Mode with Excess Rate Hardware Behavior	21
Table 33: Oversubscribed PIR Mode with Transmit Rate Configuration	22
Table 34: Oversubscribed PIR Mode with Transmit Rate Hardware Behavior	22
Table 35: Oversubscribed PIR Mode with Transmit Rate and Excess Rate Configuration	23
Table 36: Oversubscribed PIR Mode with Transmit Rate and Excess Rate Hardware Behavior	23
Table 37: CIR Mode with Transmit Rate and Excess Rate Configuration	24
Table 38: CIR Mode with Transmit Rate and Excess Rate Hardware Behavior	24
Table 39: Excess Priority Configuration	25
 Part 2	 Configuration
 Chapter 2	 Configuration Tasks
	29
	Table 40: Default Handling of Excess Traffic
	34

About the Documentation

- Documentation and Release Notes on page vii
- Supported Platforms on page vii
- Using the Examples in This Manual on page vii
- Documentation Conventions on page ix
- Documentation Feedback on page xi
- Requesting Technical Support on page xi

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If the information in the latest release notes differs from the information in the documentation, follow the product Release Notes.

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Supported Platforms

For the features described in this document, the following platforms are supported:

- T Series
- M Series

Using the Examples in This Manual

If you want to use the examples in this manual, you can use the **load merge** or the **load merge relative** command. These commands cause the software to merge the incoming configuration into the current candidate configuration. The example does not become active until you commit the candidate configuration.

If the example configuration contains the top level of the hierarchy (or multiple hierarchies), the example is a *full example*. In this case, use the **load merge** command.

If the example configuration does not start at the top level of the hierarchy, the example is a *snippet*. In this case, use the **load merge relative** command. These procedures are described in the following sections.

Merging a Full Example

To merge a full example, follow these steps:

1. From the HTML or PDF version of the manual, copy a configuration example into a text file, save the file with a name, and copy the file to a directory on your routing platform.

For example, copy the following configuration to a file and name the file **ex-script.conf**. Copy the **ex-script.conf** file to the **/var/tmp** directory on your routing platform.

```
system {
  scripts {
    commit {
      file ex-script.xml;
    }
  }
}
interfaces {
  fxp0 {
    disable;
    unit 0 {
      family inet {
        address 10.0.0.1/24;
      }
    }
  }
}
```

2. Merge the contents of the file into your routing platform configuration by issuing the **load merge** configuration mode command:

```
[edit]
user@host# load merge /var/tmp/ex-script.conf
load complete
```

Merging a Snippet

To merge a snippet, follow these steps:

1. From the HTML or PDF version of the manual, copy a configuration snippet into a text file, save the file with a name, and copy the file to a directory on your routing platform.

For example, copy the following snippet to a file and name the file **ex-script-snippet.conf**. Copy the **ex-script-snippet.conf** file to the **/var/tmp** directory on your routing platform.

```
commit {
  file ex-script-snippet.xml; }
```

2. Move to the hierarchy level that is relevant for this snippet by issuing the following configuration mode command:


```
[edit]
user@host# edit system scripts
[edit system scripts]
```

3. Merge the contents of the file into your routing platform configuration by issuing the **load merge relative** configuration mode command:

```
[edit system scripts]
user@host# load merge relative /var/tmp/ex-script-snippet.conf
load complete
```

For more information about the **load** command, see the CLI User Guide.

Documentation Conventions

Table 1 on page ix defines notice icons used in this guide.

Table 1: Notice Icons

Icon	Meaning	Description
	Informational note	Indicates important features or instructions.
	Caution	Indicates a situation that might result in loss of data or hardware damage.
	Warning	Alerts you to the risk of personal injury or death.
	Laser warning	Alerts you to the risk of personal injury from a laser.

Table 2 on page ix defines the text and syntax conventions used in this guide.

Table 2: Text and Syntax Conventions

Convention	Description	Examples
Bold text like this	Represents text that you type.	To enter configuration mode, type the configure command: user@host> configure
Fixed-width text like this	Represents output that appears on the terminal screen.	user@host> show chassis alarms No alarms currently active

Table 2: Text and Syntax Conventions (*continued*)

Convention	Description	Examples
<i>Italic text like this</i>	<ul style="list-style-type: none"> Introduces or emphasizes important new terms. Identifies book names. Identifies RFC and Internet draft titles. 	<ul style="list-style-type: none"> A policy <i>term</i> is a named structure that defines match conditions and actions. <i>Junos OS System Basics Configuration Guide</i> RFC 1997, <i>BGP Communities Attribute</i>
<i>Italic text like this</i>	Represents variables (options for which you substitute a value) in commands or configuration statements.	Configure the machine's domain name: [edit] root@# set system domain-name <i>domain-name</i>
Text like this	Represents names of configuration statements, commands, files, and directories; configuration hierarchy levels; or labels on routing platform components.	<ul style="list-style-type: none"> To configure a stub area, include the stub statement at the [edit protocols ospf area area-id] hierarchy level. The console port is labeled CONSOLE.
< > (angle brackets)	Enclose optional keywords or variables.	stub <default-metric <i>metric</i> >;
(pipe symbol)	Indicates a choice between the mutually exclusive keywords or variables on either side of the symbol. The set of choices is often enclosed in parentheses for clarity.	broadcast multicast (<i>string1</i> <i>string2</i> <i>string3</i>)
# (pound sign)	Indicates a comment specified on the same line as the configuration statement to which it applies.	rsvp { # Required for dynamic MPLS only
[] (square brackets)	Enclose a variable for which you can substitute one or more values.	community name members [<i>community-ids</i>]
Indentation and braces ({ })	Identify a level in the configuration hierarchy.	[edit] routing-options { static { route default { nexthop <i>address</i> ; retain; } } }
;(semicolon)	Identifies a leaf statement at a configuration hierarchy level.	
J-Web GUI Conventions		
Bold text like this	Represents J-Web graphical user interface (GUI) items you click or select.	<ul style="list-style-type: none"> In the Logical Interfaces box, select All Interfaces. To cancel the configuration, click Cancel.
> (bold right angle bracket)	Separates levels in a hierarchy of J-Web selections.	In the configuration editor hierarchy, select Protocols>Ospf .

Documentation Feedback

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- Document or topic name
- URL or page number
- Software release version (if applicable)

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- Find product documentation: <http://www.juniper.net/techpubs/>
- Find solutions and answer questions using our Knowledge Base: <http://kb.juniper.net/>
- Download the latest versions of software and review release notes: <http://www.juniper.net/customers/csc/software/>
- Search technical bulletins for relevant hardware and software notifications: <https://www.juniper.net/alerts/>

- Join and participate in the Juniper Networks Community Forum:
<http://www.juniper.net/company/communities/>
- Open a case online in the CSC Case Management tool: <http://www.juniper.net/cm/>

To verify service entitlement by product serial number, use our Serial Number Entitlement (SNE) Tool: <https://tools.juniper.net/SerialNumberEntitlementSearch/>

Opening a Case with JTAC

You can open a case with JTAC on the Web or by telephone.

- Use the Case Management tool in the CSC at <http://www.juniper.net/cm/>.
- Call 1-888-314-JTAC (1-888-314-5822 toll-free in the USA, Canada, and Mexico).

For international or direct-dial options in countries without toll-free numbers, see <http://www.juniper.net/support/requesting-support.html>.

PART 1

Overview

- [CoS on Enhanced IQ PICs on page 3](#)

CHAPTER 1

CoS on Enhanced IQ PICs

- [CoS on Enhanced IQ PICs Overview on page 3](#)
- [Calculation of Expected Traffic on IQE PIC Queues on page 3](#)

CoS on Enhanced IQ PICs Overview

The Enhanced IQ (IQE) PIC family supports a series of non-channelized and channelized interfaces that run at a large variety of speeds. Sophisticated Class-of-Service (CoS) techniques are available for the IQE PICs at the channel level. These techniques include policing based on type-of-service (ToS) bits, five priority levels, two shaping rates (the guaranteed rate and shaping rate), a shared scheduling option, DiffServ code point (DSCP) rewrite on egress, and configurable delay buffers for queuing. All of these features, with numerous examples, are discussed in this chapter. For a comparison of the capabilities of IQE PICs with other types of PICs, see *Hardware Capabilities and Limitations*.

For information about CoS components that apply generally to all interfaces, see *CoS Overview*. For general information about configuring interfaces, see the *Junos® OS Network Interfaces*.

IQE PICs can be used in Juniper Networks M40e, M120, M320 Multiservice Edge Routers and T Series Core Routers to supply enhanced CoS capabilities for edge aggregation. The same interface configuration syntax is used for basic configuration, and other CoS statements are applied at channel levels. Some configuration statements are available only in Junos OS Release 9.3 and later, as noted in this chapter.

Calculation of Expected Traffic on IQE PIC Queues

This topic discusses the following topics related to calculating the expected traffic flow on IQE PIC queues:

- [Excess Bandwidth Calculations Terminology on page 4](#)
- [Excess Bandwidth Basics on page 4](#)
- [Logical Interface Modes on IQE PICs on page 6](#)
- [Default Rates for Queues on IQE PICs on page 10](#)
- [Sample Calculations of Excess Bandwidth Sharing on IQE PICs on page 12](#)

Excess Bandwidth Calculations Terminology

The following terms are used in this discussion of IQE PIC queue calculations:

- CIR mode—A physical interface is in CIR mode when one of more of its “children” (logical interfaces in this case) have a guaranteed rate configured, but some logical interfaces have a shaping rate configured.
- Default mode—A physical interface is in default mode if none of its “children” (logical interfaces in this case) have a guaranteed rate or shaping rate configured.
- Excess mode—A physical interface is in excess mode when one of more of its “children” (logical interfaces in this case) have an excess rate configured.
- PIR mode—A physical interface is in PIR mode if none of its “children” (logical interfaces in this case) have a guaranteed rate configured, but some logical interfaces have a shaping rate configured.

Excess Bandwidth Basics

This basic example illustrates the interaction of the guaranteed rate, the shaping rate, and the excess rate applied to four queues. The same concepts extend to logical interfaces (units) and cases in which the user does not configure an explicit value for these parameters (in that case, the system uses implicit parameters).

In this section, the term “not applicable” (NA) means that the feature is not explicitly configured. All traffic rates are in megabits per second (Mbps).

The hardware parameters derived from the configured rates are relatively straightforward except for the excess weight. The excess rate is translated into an absolute value called the excess weight. The scheduler for an interface picks a logical unit first, and then a queue within the logical unit for transmission. Logical interfaces and queues that are within their guaranteed rates are picked first, followed by those in the excess region. If the transmission rate for a logical interface or queue is more than the shaping rate, the scheduler skips the logical interface or queue. Scheduling in the guaranteed region uses straight round-robin, whereas scheduling in the excess region uses weighed round-robin (WRR) based on the excess weights. The excess weights are in the range from 1 to 127, but they are transparent to the user and subject to change with implementation. The weights used in this example are for illustration only.

This example uses a logical interface with a transmit rate (CIR) of 10 Mbps and a shaping rate (PIR) of 10 Mbps. The user has also configured percentage values of transmit rate (CIR), shaping rate (PIR), and excess rate as shown in [Table 3 on page 4](#).

Table 3: Basic Example of Excess Bandwidth

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	5%	5%	10%	10 Mbps
Q1	30%	80%	50%	10 Mbps

Table 3: Basic Example of Excess Bandwidth (*continued*)

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q2	10%	15%	30%	10 Mbps
Q3	15%	35%	30%	10 Mbps

The values used by the hardware based on these parameters are shown in [Table 4 on page 5](#).

Table 4: Hardware Use of Basic Example Parameters

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Weight	Expected Traffic Rate
Q0	0.5 Mbps	0.5 Mbps	10	0.5 Mbps
Q1	3 Mbps	8 Mbps	50	5.19 Mbps
Q2	1 Mbps	1.5 Mbps	30	1.5 Mbps
Q3	1.5 Mbps	3.5 Mbps	30	2.81 Mbps
Totals:	6 Mbps	13.5 Mbps	120	10 Mbps (maximum output)

There are a number of important points regarding excess bandwidth calculations:

- The guaranteed rates should add up to less than the logical interface guaranteed rate (10 Mbps).
- Shaping rates (PIRs) can be oversubscribed.
- Excess rates can be oversubscribed. This rate is only a ratio at which the sharing occurs.
- Each queue receives the minimum of the guaranteed bandwidth because each queue is transmitting at its full burst if it can.
- The excess (remaining) bandwidth is shared among the queues in the ratio of their excess rates. In this case, the excess bandwidth is the logical interface bandwidth minus the sum of the queue transmit rates, or 10 Mbps – 6 Mbps = 4 Mbps.
- However, transmission rates are capped at the shaping rate (PIR) of the queue. For example, Queue 0 gets 0.5 Mbps.
- Queue 0 also gets a guaranteed transmit rate (CIR) of 0.5 Mbps and is eligible for excess bandwidth calculated as 4 Mbps (10 Mbps – 6 Mbps) multiplied by 10/127. However, because the shaping rate (PIR) for Queue 0 is 0.5 Mbps, the expected traffic rate is capped at 0.5 Mbps.
- Queue 1 gets its guaranteed transmit rate (CIR) of 3 Mbps. Because Queue 0 has already been dealt with, Queue 1 is eligible for sharing the excess bandwidth along with Queue 2 and Queue 3. So Queue 1 is entitled to an excess bandwidth of 4 Mbps multiplied by $50 / (30 + 30 + 50)$, or 1.81 Mbps.

- In the same way, Queue 2 is eligible for its guaranteed transmit rate (CIR) of 1 Mbps and an excess bandwidth of 4 Mbps multiplied by $30 / (30 + 30 + 50)$, or 1.09 Mbps. However, because Queue 2 has a shaping rate (PIR) of 1.5 Mbps, the bandwidth of Queue 2 is capped at 1.5 Mbps. The additional 0.59 Mbps can be shared by Queue 1 and Queue 3.
- Queue 3 is eligible for an excess of 4 Mbps multiplied by $30 / (30 + 30 + 50)$, or 1.09 Mbps. This total of 2.59 Mbps is still below the shaping rate (PIR) for Queue 3 (3.5 Mbps).
- The remaining bandwidth of 0.59 Mbps (which Queue 2 could not use) is shared between Queue 1 and Queue 3 in the ratio 50/30. So Queue 3 can get 0.59 multiplied by $30 / (50 + 30)$, or 0.22 Mbps. This gives a total of 2.81 Mbps.
- Therefore, Queue 1 gets 3 Mbps + 1.82 Mbps + $(0.59 \text{ Mbps} * 50 / (50 + 30))$, or approximately 5.19 Mbps.

Logical Interface Modes on IQE PICs

On IQE PICs, scheduling occurs level-by-level. That is, based on the parameters configured on the logical interface, the scheduler first picks a logical interface to transmit from. Then, based on the configuration of the underlying queues, the IQE PIC selects one of the queues to transmit from. Therefore, it is important to understand how different logical interface parameters are configured or derived (not explicitly configured), and also how the same values are established at the queue level.

In the following examples, assume that the bandwidth available at the physical interface level is 400 Mbps and there are four logical interfaces (units) configured. A per-unit scheduler is configured, so the logical interfaces operate in different modes depending on the parameters configured.

If no class-of-service parameters are configured on any of the logical interfaces, the interface is in default mode. In default mode, the guaranteed rate (CIR) available at the physical interface (400 Mbps) is divided equally among the four logical interfaces. Each of the four gets a guaranteed rate (CIR) of 100 Mbps. Because none of the four logical interfaces have a shaping rate (PIR) configured, each logical interface can transmit up to the maximum of the entire 400 Mbps. Because there is no excess rate configured on any of the logical interfaces, each of the four gets an equal, minimum excess weight of 1. The configured and hardware-derived bandwidths for this default mode example are shown in [Table 5 on page 6](#).

Table 5: Default Mode Example for IQE PICs

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 0	NA	NA	NA	100 Mbps	400 Mbps	1
Unit 1	NA	NA	NA	100 Mbps	400 Mbps	1

Table 5: Default Mode Example for IQE PICs (*continued*)

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 2	NA	NA	NA	100 Mbps	400 Mbps	1
Unit 3	NA	NA	NA	100 Mbps	400 Mbps	1

If a subset of the logical interfaces (units) have a shaping rate (PIR) configured, but none of them have a guaranteed rate (CIR) or excess rate, then the physical interface is in PIR mode. Furthermore, if the sum of the shaping rates on the logical interfaces is less than or equal to the physical interface bandwidth, the physical interface is in undersubscribed PIR mode. If the sum of the shaping rates on the logical interfaces is more than the physical interface bandwidth, the physical interface is in oversubscribed PIR mode. These modes are the same as on other PICs, where only a shaping rate and guaranteed rate can be configured.

In undersubscribed PIR mode, the logical interfaces with a configured shaping rate receive preferential treatment over those without a configured shaping rate. For logical interfaces with a shaping rate configured, the guaranteed rate is set to the shaping rate. For the logical interfaces without a shaping rate, the remaining logical interface bandwidth is distributed equally among them. Excess weights for the logical interfaces with a shaping rate are set to an implementation-dependent value proportional to the shaping rate. Excess weights for the logical interfaces without a shaping rate are set to the minimum weight (1). However, although the excess weights for the configured logical interfaces are never used because the logical interfaces cannot transmit above their guaranteed rates, the excess weights are still determined for consistency with oversubscribed mode. Also, logical interfaces without a configured shaping rate can transmit up to a maximum of the physical bandwidth of the other queues that are not transmitting. Therefore, the shaping rate (PIR) is set to the physical interface bandwidth on these interfaces.

The configured and hardware-derived bandwidths for the undersubscribed PIR mode example are shown in [Table 6 on page 7](#). Note that the sum of the shaping rates configured on the logical interfaces (500 Mbps) is more than the physical interface bandwidth (400 Mbps).

Table 6: Undersubscribed PIR Mode Example for IQE PICs

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 0	NA	100 Mbps	NA	100 Mbps	100 Mbps	127
Unit 1	NA	200 Mbps	NA	200 Mbps	200 Mbps	63
Unit 2	NA	NA	NA	50 Mbps	400 Mbps	1

Table 6: Undersubscribed PIR Mode Example for IQE PICs (*continued*)

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 3	NA	NA	NA	50 Mbps	400 Mbps	1

In the oversubscribed PIR mode, where the sum of the configured shaping rates on the logical interfaces exceeds the physical interface bandwidth, we cannot set the guaranteed rate to the shaping rate because this might result in the sum of the guaranteed rates exceeding the physical interface bandwidth, which is not possible. In this mode, we want the logical interfaces with shaping rates configured to share the traffic proportionally when these logical interfaces are transmitting at full capacity. This could not happen if the guaranteed rate was set to the shaping rate. Instead, in hardware, we set the guaranteed rates to a “scaled down” shaping rate, so that the sum of the guaranteed rates of the logical interfaces do not exceed the physical interface bandwidth. Because there is no remaining bandwidth once this is done, the other logical interfaces receive a guaranteed rate of 0. Excess weights are set proportionally to the shaping rates and for logical interfaces without a shaping rate, the excess weight is set to a minimum value (1). Finally, the shaping rate is set to the shaping rate configured on the logical interface or to the physical interface bandwidth otherwise.



NOTE: When the sum of shaping rate at a logical interface is greater than the interface's bandwidth and a rate limit is applied to one of the logical interface queues, the bandwidth limit for the queue is based on a scaled down logical interface shaping rate value rather than the configured logical interface shaping rate.

The configured and hardware-derived bandwidths for the oversubscribed PIR mode example are shown in [Table 7 on page 8](#). Note that the sum of the shaping rates configured on the logical interfaces (300 Mbps) is less than the physical interface bandwidth (400 Mbps).

Table 7: Oversubscribed PIR Mode Example for IQE PICs

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 0	NA	100 Mbps	NA	80 Mbps	100 Mbps	50
Unit 1	NA	150 Mbps	NA	120 Mbps	150 Mbps	76
Unit 2	NA	250 Mbps	NA	200 Mbps	250 Mbps	127
Unit 3	NA	NA	NA	0 Mbps	400 Mbps	1

If none of the logical interfaces have an excess rate configured, but at least one of the logical interfaces has a guaranteed rate (CIR) configured, then the physical interface is in CIR mode. In this case, the guaranteed rates are set in hardware to the configured guaranteed rate on the logical interface. For logical interfaces that do not have a guaranteed rate configured, the guaranteed rate is set to 0. The hardware shaping rate is set to the value configured on the logical interface or to the full physical interface bandwidth otherwise. The excess weight is calculated proportional to the configured guaranteed rates. Logical interfaces without a configured guaranteed rate receive a minimum excess weight of 1.

The configured and hardware-derived bandwidths for the CIR mode example are shown in [Table 8 on page 9](#). In CIR mode, the shaping rates are ignored in the excess weight calculations. So although logical unit 1 has an explicitly configured PIR and logical unit 3 does not, they both receive the minimum excess weight of 1.

Table 8: CIR Mode Example for IQE PICs

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 0	50 Mbps	100 Mbps	NA	50 Mbps	100 Mbps	127
Unit 1	NA	150 Mbps	NA	0 Mbps	150 Mbps	1
Unit 2	100 Mbps	NA	NA	100 Mbps	400 Mbps	63
Unit 3	NA	NA	NA	0 Mbps	400 Mbps	1

If one of the logical interfaces has an excess rate configured, then the physical interface is in excess rate mode. Strictly speaking, this mode only matters for the calculation of excess weights on the logical interface. The hardware guaranteed and shaping rates are determined as described previously. In excess rate mode, the excess weights are set to a value based on the configured excess rate. Logical interfaces which do not have excess rates configured receive a minimum excess weight of 1.



NOTE: Because the excess rate only makes sense above the guaranteed rate, you cannot configure an excess rate in PIR mode (PIR mode has only shaping rates configured). You must configure at least one guaranteed rate (CIR) on a logical interface to configure an excess rate.

The excess rate is configured as a percentage in the range from 1 through 100. The configured value is used to determine the excess weight in the range from 1 through 127.

The configured and hardware-derived bandwidths for the excess rate mode example are shown in [Table 9 on page 10](#). When an excess rate is configured on one or more logical interfaces, the shaping rate and the guaranteed rate are both ignored in the excess

weight calculations. So logical unit 2 gets a minimum excess weight of 1, even though it has a guaranteed rate configured.

Table 9: Excess Rate Mode Example for IQE PICs

Logical Interface	Configured			Hardware		
	Guaranteed rate (CIR)	Shaping Rate (PIR)	Excess Rate	Guaranteed Rate	Shaping Rate	Excess Weight
Unit 0	50 Mbps	100 Mbps	20%	50 Mbps	100 Mbps	50
Unit 1	NA	150 Mbps	50%	0 Mbps	150 Mbps	127
Unit 2	100 Mbps	NA	NA	100 Mbps	400 Mbps	1
Unit 3	NA	NA	50%	0 Mbps	400 Mbps	127

Default Rates for Queues on IQE PICs

The IQE PIC operates at the queue level as well as at the logical unit level. This section discusses how the IQE PIC derives hardware values from the user configuration parameters. First, the default behavior without explicit configuration is investigated, along with the rules used to derive hardware parameters from the scheduler map configuration of the transmit rate, shaping rate, and excess rate. For more information about configuring schedulers and scheduler maps, see [Schedulers Overview](#).

When you do not configure any CoS parameters, a default scheduler map is used to establish four queues: best-effort, expedited-forwarding, assured-forwarding, and network-control. Each queue has the default transmit rate, shaping rate, and excess rate shown in [Table 10 on page 10](#).

Table 10: Default Queue Rates on the IQE PIC

Queue	Transmit Rate	Shaping Rate	Excess Rate
best-effort (Q0)	95%	100%	95%
expedited-forwarding (Q1)	0%	100%	0%
assured-forwarding (Q2)	0%	100%	0%
network-control (Q3)	5%	100%	5%

When you configure a scheduler map to change the defaults, the IQE PIC hardware derives the values for each of the three major parameters: transmit rate, shaping rate, and excess rate.

The transmit rate is determined as follows:

- If a transmit rate is configured, then:
 - If the transmit rate is configured as an absolute bandwidth value, the configured value is used by the hardware.
 - If the transmit rate is configured as a percentage, then the percentage is used to calculate an absolute value used by the hardware, based on the guaranteed rate (CIR) configured at the logical interface or physical interface level. The CIR itself can be a default, configured, or derived value.
 - If the transmit rate is configured as a remainder, then the remaining value of the logical interface (unit) guaranteed rate (CIR) is divided equally among the queues configured as remainder.
- If a transmit rate is not configured, then the default transmit rate is derived based on remainder (for backward compatibility).
- If an excess rate is configured on any of the queues in a scheduler map, then the transmit rate on the queue is set to 0.

The shaping rate is determined as follows:

- If a shaping rate is configured:
 - If the shaping rate is configured as an absolute bandwidth value, the configured value is used by the hardware.
 - If the shaping rate is configured as a percentage, then the percentage is used to calculate an absolute value used by the hardware, based on the guaranteed rate (CIR) configured at the logical interface or physical interface level. Although it seems odd to base a shaping rate (PIR) on the CIR instead of a PIR, this is done so the shaping rate can be derived on the same basis as the transmit rate.
- If a shaping rate is not configured, then the default shaping rate is set to the shaping rate configured at the logical interface or physical interface level.

The excess rate is determined as follows:

- If an excess rate is configured on a queue, the value is used to derive an excess weight used by the IQE PIC hardware. The excess weight determines the proportional share of the excess bandwidth for which each queue can contend. The excess rate can be:
 - Percentage in the range from 1 through 100. This value is scaled to a hardware excess weight. Excess rates can add up to more than 100% for all queues under a logical or physical interface.
- If an excess rate is not configured on a queue, then the default excess rate is one of the following:
 - If a transmit rate is configured on any of the queues, then the excess weight is proportional to the transmit rates. Queues that do not have a transmit rate configured receive a minimum weight of 1.

- If a transmit rate is not configured on any of the queues, but some queues have a shaping rate, then the excess weight is proportional to the shaping rates. Queues that do not have a shaping rate configured receive a minimum weight of 1.
- If no parameters are configured on a queue, then the queue receives a minimum weight of 1.

Sample Calculations of Excess Bandwidth Sharing on IQE PICs

The following four examples show calculations for the PIR mode. In PIR mode, the transmit rate and shaping rate calculations are based on the shaping rate of the logical interface. All calculations assume that one logical interface (unit) is configured with a shaping rate (PIR) of 10 Mbps and a scheduler map with four queues.

The first example has only a shaping rate (PIR) configured on the queues, as shown in [Table 11 on page 12](#).

Table 11: PIR Mode, with No Excess Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	NA	80%	NA	10 Mbps
Q1	NA	50%	NA	1 Mbps
Q2	NA	40%	NA	0 Mbps
Q3	NA	30%	NA	5 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 12 on page 12](#).

Table 12: PIR Mode, with No Excess Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	2.5 Mbps	8.0 Mbps	50	6 Mbps
Q1	2.5 Mbps	5.0 Mbps	31	1 Mbps
Q2	2.5 Mbps	4.0 Mbps	25	0 Mbps
Q3	2.5 Mbps	3.0 Mbps	19	3 Mbps

In this first example, all four queues are initially serviced round-robin. Because there are no transmit rates configured on any of the queues, they receive a default “remainder” transmit rate of 2.5 Mbps per queue. But because there are shaping rates configured, the excess weights are calculated based on the shaping rates. For the traffic sent to each queue, Queue 0 and Queue 3 get their transmit rates of 2.5 Mbps and Queue 1 gets 1 Mbps. The remaining 4 Mbps is excess bandwidth and is divided between Queue 0 and Queue 3 in the ratio of the shaping rates (80/30). So Queue 3 expects an excess bandwidth of

$4 \text{ Mbps} * (30\% / (80\% + 30\%)) = 1.09 \text{ Mbps}$. However, because the shaping rate on Queue 3 is 3 Mbps, Queue 3 can transmit only 3 Mbps and Queue 0 receives the remaining excess bandwidth and can transmit at 6 Mbps.

Note that if there were equal transmit rates explicitly configured, such as 2.5 Mbps for each queue, the excess bandwidth would be split based on the transmit rate (equal in this case), as long as the result is below the shaping rate for the queue.

The second example has a shaping rate (PIR) and transmit rate (CIR) configured on the queues, as shown in [Table 13 on page 13](#).

Table 13: PIR Mode with Transmit Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	50%	80%	NA	10 Mbps
Q1	40%	50%	NA	5 Mbps
Q2	10%	20%	NA	5 Mbps
Q3	NA	5%	NA	1 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 14 on page 13](#).

Table 14: PIR Mode with Transmit Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	5.0 Mbps	8.0 Mbps	63	5 Mbps
Q1	4.0 Mbps	5.0 Mbps	50	4 Mbps
Q2	1.0 Mbps	2.0 Mbps	12	1 Mbps
Q3	0.0 Mbps	0.5 Mbps	1	0.0 Mbps

In this second example, because the transmit rates are less than the shaping rates, each queue receives its transmit rate.

The third example also has a shaping rate (PIR) and transmit rate (CIR) configured on the queues, as shown in [Table 15 on page 13](#).

Table 15: Second PIR Mode with Transmit Rate Configuration Example

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	50%	80%	NA	10 Mbps
Q1	40%	50%	NA	5 Mbps

Table 15: Second PIR Mode with Transmit Rate Configuration Example (*continued*)

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q2	5%	20%	NA	0 Mbps
Q3	NA	5%	NA	1 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 16 on page 14](#).

Table 16: Second PIR Mode with Transmit Rate Hardware Behavior Example

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	5.0 Mbps	8.0 Mbps	66	5.27 Mbps
Q1	4.0 Mbps	5.0 Mbps	53	4.23 Mbps
Q2	0.5 Mbps	2.0 Mbps	13	0.0 Mbps
Q3	0.5 Mbps	0.5 Mbps	1	0.5 Mbps

In this third example, all four queues are initially serviced round-robin. However, Queue 2 has no traffic sent to its queue. So Queue 0, Queue 1, and Queue 3 all get their respective transmit rates, a total of 9.5 Mbps. The remaining 0.5 Mbps is used by Queue 3, because the transmit rate is the same as the shaping rate. Once this traffic is sent, Queue 0 and Queue 1 share the excess bandwidth in the ratio of their transmit rates, which total 9 Mbps. In this case, Queue 0 = 5 Mbps + $(0.5 \text{ Mbps} * 5/9)$ = 5.27 Mbps. Queue 1 = 4 Mbps + $(0.5 \text{ Mbps} * 4/9)$ = 4.23 Mbps.

The fourth example has a shaping rate (PIR), transmit rate (CIR), and excess rate configured on the queues, as shown in [Table 17 on page 14](#).

Table 17: PIR Mode with Transmit Rate and Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	30%	80%	50%	10 Mbps
Q1	25%	50%	10%	5 Mbps
Q2	10%	20%	30%	0 Mbps
Q3	5%	5%	NA	1 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 18 on page 15](#).

Table 18: PIR Mode with Transmit Rate and Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	3.0 Mbps	8.0 Mbps	70	6.33 Mbps
Q1	2.5 Mbps	5.0 Mbps	14	3.17 Mbps
Q2	1.0 Mbps	2.0 Mbps	42	0.0 Mbps
Q3	0.5 Mbps	0.5 Mbps	1	0.5 Mbps

In this fourth example, all four queues are initially serviced round-robin. Queue 3 gets 0.5 Mbps of guaranteed bandwidth but cannot transmit more because the shaping rate is the same. Queue 2 has no traffic to worry about at all. Queue 0 and Queue 1 get the respective transmit rates of 3.0 Mbps and 2.5 Mbps. The excess bandwidth of 4 Mbps is divided between Queue 0 and Queue 1 in the ratio on their excess rates. So Queue 1 gets 2.5 Mbps (the guaranteed rate) + 4 Mbps (the excess) + $(10\% / (50\% + 10\%)) = 3.17$ Mbps. Queue 0 gets the rest, for a total of 6.33 Mbps.

You can configure only an excess rate on the queues, as shown in [Table 19 on page 15](#).

Table 19: Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	NA	NA	50%	10 Mbps
Q1	NA	NA	40%	10 Mbps
Q2	NA	NA	30%	10 Mbps
Q3	NA	NA	20%	10 Mbps

The way that the IQE PIC hardware interprets these excess rate parameters is shown in [Table 20 on page 15](#).

Table 20: Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	0 Mbps	10.0 Mbps	45	3.57 Mbps
Q1	0 Mbps	10.0 Mbps	40	2.86 Mbps
Q2	0 Mbps	10.0 Mbps	30	2.14 Mbps
Q3	0 Mbps	10.0 Mbps	20	1.43 Mbps

In this excess rate example, there are no transmit or shaping rates configured on any of the queues, only excess rates, so bandwidth division happens only on the basis of the

excess rates. Note that all the transmit (guaranteed) rates are set to 0. Usually, when there are no excess rates configured, the queue transmit rate is calculated by default. But when there is an excess rate configured on any of the queues, the transmit rate is set to 0. The excess bandwidth (all bandwidths in this case) is shared in the ratio of the excess weights. So Queue 0 receives $10 \text{ Mbps} * (50 / (50 + 40 + 30 + 20)) = 3.57 \text{ Mbps}$.

It is possible to configure rate limits that result in error conditions. For example, consider the configuration shown in [Table 21 on page 16](#).

Table 21: PIR Mode Generating Error Condition

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	NA	80%	NA	10 Mbps
Q1	NA	50%	NA	5 Mbps
Q2	NA	20%	NA	5 Mbps
Q3	NA	5%	NA	1 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 22 on page 16](#).

Table 22: PIR Mode Generating Error Condition Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	2.5 Mbps	8.0 Mbps	818	4.03 Mbps
Q1	2.5 Mbps	5.0 Mbps	511	3.47 Mbps
Q2	2.5 Mbps	2.0 Mbps	255	2 Mbps
Q3	2.5 Mbps	0.5 Mbps	51	0.1 Mbps

In the error example, note that the shaping rates calculated on Queue 2 and Queue 3 are less than the transmit rates on those queues (2.0 Mbps and 0.5 Mbps are each less than 2.5 Mbps). This is an error condition and results in a syslog error message.

The following set of five examples involve the IQE PIC operating in CIR mode. In CIR mode, the transmit rate and shaping rate calculations are based on the transmit rate of the logical interface. All calculations assume that the logical interface has a shaping rate (PIR) of 20 Mbps and a transmit rate (CIR) of 10 Mbps. The scheduler map has four queues.

The first example has only a shaping rate (PIR) with no excess rate configured on the queues, as shown in [Table 23 on page 17](#).

Table 23: CIR Mode with No Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	NA	80%	NA	10 Mbps
Q1	NA	70%	NA	10 Mbps
Q2	NA	40%	NA	10 Mbps
Q3	NA	30%	NA	10 Mbps



NOTE: The transmit rate (CIR) of 10 Mbps is configured on the logical interface (unit) not the queues in the scheduler map. This is why the queue transmit rates are labeled NA.

The way that the IQE PIC hardware interprets these parameters is shown in [Table 24 on page 17](#).

Table 24: CIR Mode with No Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	2.5 Mbps	8.0 Mbps	50	6.76 Mbps
Q1	2.5 Mbps	7.0 Mbps	31	6.23 Mbps
Q2	2.5 Mbps	4.0 Mbps	25	4.0 Mbps
Q3	2.5 Mbps	3.0 Mbps	19	3.0 Mbps

In this first example, all four queues split the 10-Mbps transmit rate equally and each get a transmit rate of 2.5 Mbps. However, the shaping rate on the interface is 20 Mbps. The 10-Mbps excess bandwidth is divided among the queues in the ratio of their shaping rates. But Queue 2 and Queue 3 are shaped at 3.0 and 4.0 Mbps, respectively, so they cannot use more bandwidth and get those rates. This accounts for 2 Mbps (the 7 Mbps shaped bandwidth minus the 5 Mbps guaranteed bandwidth for Queue 2 and Queue 3) of the 10-Mbps excess, leaving 8 Mbps for Queue 0 and Queue 1. So Queue 0 and Queue 1 share the 8-Mbps excess bandwidth in the ratio of their shaping rates, which total 15 Mbps. In this case, Queue 0 = $8.0 \text{ Mbps} \times 8/15 = 4.26 \text{ Mbps}$, for a total of $2.5 \text{ Mbps} + 4.26 \text{ Mbps} = 6.76 \text{ Mbps}$. Queue 1 = $8.0 \text{ Mbps} \times 7/15 = 3.73 \text{ Mbps}$, for a total of $2.5 \text{ Mbps} + 3.73 \text{ Mbps} = 6.23 \text{ Mbps}$.

The second example has only a few shaping rates (PIR) with no excess rate configured on the queues, as shown in [Table 25 on page 18](#).

Table 25: CIR Mode with Some Shaping Rates and No Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	NA	80%	NA	10 Mbps
Q1	NA	50%	NA	5 Mbps
Q2	NA	NA	NA	10 Mbps
Q3	NA	NA	NA	1 Mbps



NOTE: If a configuration results in the calculated transmit rate of the queue exceeding the shaping rate of the queue, an error message is generated. For example, setting the shaping rate on Queue 2 and Queue 3 in the above example to 20 percent and 5 percent, respectively, generates an error message because the calculated transmit rate for these queues (2.5 Mbps) is more than their calculated shaping rates (2.0 Mbps and 0.5 Mbps).

The way that the IQE PIC hardware interprets these parameters is shown in [Table 26 on page 18](#).

Table 26: CIR Mode with Some Shaping Rates and No Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	2.5 Mbps	8.0 Mbps	78	8.0 Mbps
Q1	2.5 Mbps	5.0 Mbps	48	5.0 Mbps
Q2	2.5 Mbps	20 Mbps	1	6.0 Mbps
Q3	2.5 Mbps	20 Mbps	1	1.0 Mbps

In this second example, all four queues split the 10-Mbps transmit rate equally and each get a transmit rate of 2.5 Mbps. Because of their configured queue shaping rates, Queue 0 and Queue 1 receive preference over Queue 2 and Queue 3 for the excess bandwidth. Queue 0 (8.0 Mbps) and Queue 1 (5.0 Mbps) account for 13 Mbps of the 20 Mbps shaping rate on the logical interface. The remaining 7 Mbps is divided equally between Queue 2 and Queue 3. However, because Queue 3 only has 1 Mbps to send, Queue 2 uses the remaining 6 Mbps.

The third example has shaping rates (PIR) and transmit rates with no excess rate configured on the queues, as shown in [Table 27 on page 19](#).

Table 27: CIR Mode with Shaping Rates and Transmit Rates and No Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	50%	80%	NA	10 Mbps
Q1	40%	50%	NA	5 Mbps
Q2	10%	20%	NA	5 Mbps
Q3	NA	10%	NA	1 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 28 on page 19](#).

Table 28: CIR Mode with Shaping Rates and Transmit Rates and No Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	5.0 Mbps	8.0 Mbps	63	8.0 Mbps
Q1	4.0 Mbps	5.0 Mbps	50	5.0 Mbps
Q2	1.0 Mbps	2.0 Mbps	12	2.0 Mbps
Q3	0.0 Mbps	0.5 Mbps	1	0.5 Mbps

In this third example, the first three queues get their configured transmit rates and are serviced in round-robin fashion. This adds up to 10 Mbps, leaving a 10-Mbps excess from the logical interface shaping rate of 20 Mbps. The excess is shared in the ratio of the transmit rates, or 5:4:1:0. Therefore, Queue 0 receives $5 \text{ Mbps} + (5 * 10/10) = 10 \text{ Mbps}$. This value is greater than the 8 Mbps shaping rate on Queue 0, so Queue 0 is limited to 8 Mbps. Queue 1 receives $4 \text{ Mbps} + (4 * 10/10) = 8 \text{ Mbps}$. This value is greater than the 5 Mbps shaping rate on Queue 1, so Queue 1 is limited to 5 Mbps. Queue 2 receives $1 \text{ Mbps} + (1 * 10/10) = 2 \text{ Mbps}$. This value is equal to the 2 Mbps shaping rate on Queue 2, so Queue 2 receives 2 Mbps. This still leaves 5 Mbps excess bandwidth, which can be used by Queue 3. Note that in this example bandwidth usage never reaches the shaping rate configured on the logical interface (20 Mbps).

The fourth example has shaping rates (PIR) and transmit rates with no excess rate configured on the queues. However, in this case the sum of the shaping rate percentages configured on the queues multiplied by the transmit rate configured on the logical interface is greater than the shaping rate configured on the logical interface. The configuration is shown in [Table 29 on page 20](#).

Table 29: CIR Mode with Shaping Rates Greater Than Logical Interface Shaping Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	50%	80%	NA	10 Mbps
Q1	40%	70%	NA	10 Mbps
Q2	10%	50%	NA	10 Mbps
Q3	NA	50%	NA	10 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 30 on page 20](#).

Table 30: CIR Mode with Shaping Rates Greater Than Logical Interface Shaping Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	5.0 Mbps	8.0 Mbps	63	8.0 Mbps
Q1	4.0 Mbps	7.0 Mbps	50	7.0 Mbps
Q2	1.0 Mbps	5.0 Mbps	12	5.0 Mbps
Q3	0.0 Mbps	5.0 Mbps	1	0.0 Mbps

In this fourth example, the first three queues get their configured transmit rates and are serviced in round-robin fashion. This adds up to 10 Mbps, leaving a 10-Mbps excess from the logical interface shaping rate of 20 Mbps. The excess is shared in the ratio of the transmit rates, or 5:4:1:0. Therefore, Queue 0 receives 5 Mbps + $(5 * 10/10) = 10$ Mbps. This value is greater than the 8 Mbps shaping rate on Queue 0, so Queue 0 is limited to 8 Mbps. Queue 1 receives 4 Mbps + $(4 * 10/10) = 8$ Mbps. This value is greater than the 7 Mbps shaping rate on Queue 1, so Queue 1 is limited to 7 Mbps. Queue 2 receives 1 Mbps + $(1 * 10/10) = 2$ Mbps. This value is less than the 5 Mbps shaping rate on Queue 2, so Queue 2 receives 2 Mbps. This still leaves 3 Mbps excess bandwidth, which can be used by Queue 2 (below its shaping rate) and Queue 3 (also below its shaping rate) in the ratio 1:0 (because of the transmit rate configuration). But 1:0 means Queue 3 cannot use this bandwidth, and Queue 2 utilizes 2 Mbps + $(3 \text{ Mbps} * 1/1) = 5$ Mbps. This is equal to the shaping rate of 5 Mbps, so Queue 2 receives 5 Mbps.

The fifth example has excess rates and transmit rates, but no shaping rates (PIR) configured on the queues. The configuration is shown in [Table 31 on page 20](#).

Table 31: CIR Mode with Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	30%	NA	50%	10 Mbps

Table 31: CIR Mode with Excess Rate Configuration (*continued*)

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q1	25%	NA	10%	10 Mbps
Q2	NA	NA	30%	10 Mbps
Q3	10%	NA	NA	10 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 32 on page 21](#).

Table 32: CIR Mode with Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	3.0 Mbps	20 Mbps	70	10.5 Mbps
Q1	2.5 Mbps	20 Mbps	14	4.0 Mbps
Q2	0.0 Mbps	20 Mbps	42	4.5 Mbps
Q3	1.0 Mbps	20 Mbps	1	1.0 Mbps

In this fifth example, Queue 2 does not have a transmit rate configured. If there were no excess rates configured, then Queue 2 would get a transmit rate equal to the remainder of the bandwidth (3.5 Mbps in this case). However, because there is an excess rate configured on some of the queues on this logical interface, the transmit rate for Queue 2 is set to 0 Mbps. The others queues get their transmit rates and there leaves 13.5 Mbps of excess bandwidth. This bandwidth is divided among Queue 0, Queue 1, and Queue 3 in the ratio of their excess rates. So Queue 0, for example, gets $3.0 \text{ Mbps} + 13.5 \text{ Mbps} * (50 / (50 + 10 + 30)) = 10.5 \text{ Mbps}$.

Four other examples calculating expected traffic distribution are of interest. The first case has three variations, so there are six more examples in all.

- Oversubscribed PIR mode at the logical interface with transmit rates, shaping rates, and excess rates configured at the queues (this example has three variations).
- CIR mode at the logical interface (a non-intuitive case is used).
- Excess priority configured.
- Default excess priority used.

The first three examples all concern oversubscribed PIR mode at the logical interface with transmit rates, shaping rates, and excess rates configured at the queues. They all use a configuration with a physical interface having a shaping rate of 40 Mbps. The physical interface has two logical units configured, logical unit 1 and logical unit 2, with a shaping rate of 30 Mbps and 20 Mbps, respectively. Because the sum of the logical interface shaping rates is more than the shaping rate on the physical interface, the physical

interface is in oversubscribed PIR mode. The CIRs (transmit rates) are set to the scaled values of 24 Mbps and 16 Mbps, respectively.

Assume that logical unit 1 has 40 Mbps of traffic to be sent. The traffic is capped at 30 Mbps because of the shaping rate of 30 Mbps. Because the CIR is scaled down to 24 Mbps, the remaining 6 Mbps (30 Mbps – 24 Mbps) qualifies as excess bandwidth.

The following three examples consider different parameters configured in a scheduler map and the expected traffic distributions that result.

The first example uses oversubscribed PIR mode with only transmit rates configured on the queues. The configuration is shown in [Table 33 on page 22](#).

Table 33: Oversubscribed PIR Mode with Transmit Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	40%	NA	NA	15 Mbps
Q1	30%	NA	NA	10 Mbps
Q2	25%	NA	NA	10 Mbps
Q3	5%	NA	NA	5 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 34 on page 22](#).

Table 34: Oversubscribed PIR Mode with Transmit Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	9.6 Mbps	30 Mbps	50	12 Mbps
Q1	7.2 Mbps	30 Mbps	38	9 Mbps
Q2	6.0 Mbps	30 Mbps	31	7.5 Mbps
Q3	1.2 Mbps	30 Mbps	6	1.5 Mbps

The first example has hardware queue transmit rates based on the parent (logical interface unit 1) transmit rate (CIR) value of 24 Mbps. Because there are no excess rates configured, the excess weights are determined by the transmit rates. Therefore, both the logical interface CIR and excess bandwidth are divided in the ratio of the transmit rates. This is essentially the same as the undersubscribed PIR mode and the traffic distribution should be the same. The only difference is that the result is achieved as a combination of guaranteed rate (CIR) and excess rate sharing.

The second example also uses oversubscribed PIR mode, but this time with only excess rate configured on the queues. In other words, the same ratios are established with excess rate percentages instead of transmit rate percentages. In this case, when excess rates

are configured, queues without a specific transmit rate are set to 0 Mbps. So the entire bandwidth qualifies as excess at the queue level and the bandwidth distribution is based on the configured excess rates. The expected output rate results are exactly the same as in the first example, except the calculation is based on different parameters.

The third example also uses oversubscribed PIR mode, but with both transmit rates and excess rates configured on the queues. The configuration is shown in [Table 35 on page 23](#).

Table 35: Oversubscribed PIR Mode with Transmit Rate and Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	40%	NA	50%	15 Mbps
Q1	30%	NA	50%	12 Mbps
Q2	25%	NA	NA	8 Mbps
Q3	5%	NA	NA	5 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 36 on page 23](#).

Table 36: Oversubscribed PIR Mode with Transmit Rate and Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	9.6 Mbps	30 Mbps	63	12.6 Mbps
Q1	7.2 Mbps	30 Mbps	63	10.2 Mbps
Q2	6.0 Mbps	30 Mbps	1	6.0 Mbps
Q3	1.2 Mbps	30 Mbps	1	1.2 Mbps

The third example has the configured queue transmit rate (CIR) divided according to the ratio of the transmit rates based on the logical interface unit 1 CIR of 25 Mbps. The rest of the excess bandwidth divided according the ratio of the excess rates. The excess 6-Mbps bandwidth is divided equally between Queue 0 and Queue 1 because the excess rates are both configured at 50%. This type of configuration is not recommended, however, because the CIR on the logical interface is a system-derived value based on the PIRs of the other logical units and the traffic distribution at the queue level is based on this value and, therefore, not under direct user control. We recommend that you either configure excess rates without transmit rates at the queue level when in PIR mode, or also define a CIR at the logical interface if you want to configure a combination of transmit rates and excess rates at the queue level. That is, you should use configurations of the CIR mode with excess rates types.

The fourth example uses CIR mode at the logical interface. For this example, assume that a physical interface is configured with a 40-Mbps shaping rate and logical interfaces unit 1 and unit 2. Logical interface unit 1 has a PIR of 30 Mbps and logical interface unit 2

has a PIR of 20 Mbps and a CIR of 10 Mbps. The configuration at the queue level of logical interface unit 1 is shown in [Table 37 on page 24](#).

Table 37: CIR Mode with Transmit Rate and Excess Rate Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	40%	NA	50%	15 Mbps
Q1	30%	NA	50%	12 Mbps
Q2	25%	NA	NA	8 Mbps
Q3	5%	NA	NA	5 Mbps

The way that the IQE PIC hardware interprets these parameters is shown in [Table 38 on page 24](#).

Table 38: CIR Mode with Transmit Rate and Excess Rate Hardware Behavior

Queue	Transmit Rate	Shaping Rate	Excess Weight	Expected Output Rate
Q0	0 Mbps	30 Mbps	63	15 Mbps
Q1	0 Mbps	30 Mbps	63	12 Mbps
Q2	0 Mbps	30 Mbps	1	1.5 Mbps
Q3	0 Mbps	30 Mbps	1	1.5 Mbps

The fourth example might be expected to divide the 40 Mbps of traffic between the two logical units in the ratio of the configured transmit rates. But note that because the logical interfaces are in CIR mode, and logical interface unit 1 does not have a CIR configured, the hardware CIR is set to 0 Mbps at the queue level. Bandwidth distribution happens based only on the excess weights. So Queue 0 and Queue 1 get to transmit up to 15 Mbps and 12 Mbps, respectively, while the remaining 3 Mbps is divided equally by Queue 2 and Queue 3.



NOTE: We recommend configuring a CIR value explicitly for the logical interface if you are configuring transmit rates and excess rates for the queues.

The fifth example associates an excess priority with the queues. Priorities are associated with every queue and propagated to the parent node (logical or physical interface). That is, when the scheduler picks a logical interface, the scheduler considers the logical interface priority as the priority of the highest priority queue under that logical interface. On the IQE PIC, you can configure an excess priority for every queue. The excess priority can differ from the priority used for guaranteed traffic and applies only to traffic in the excess region. The IQE PIC has three “regular” priorities and two excess priorities (high and low, which is the default). The excess priorities are lower than the regular priorities.

For more information about configuring excess bandwidth sharing and priorities, see “IQE PIC Excess Bandwidth Sharing Configuration” on page 34.

Consider a logical interface configured with a shaping rate of 10 Mbps and a guaranteed rate of 10 Mbps. At the queue level, parameters are configured as shown in Table 39 on page 25.

Table 39: Excess Priority Configuration

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Excess Rate	Traffic Sent To Queue
Q0	40%	NA	50%	10 Mbps
Q1	30%	NA	50%	10 Mbps
Q2	25%	NA	NA	0 Mbps
Q3	5%	NA	NA	1 Mbps

In this fifth example, Queue 0 is configured with an excess priority of **high** and all other queues have the default excess priority (**low**). Because there is no traffic on Queue 2, there is an excess bandwidth of 2.5 Mbps. Because Queue 0 has a higher excess priority, Queue 0 gets the entire excess bandwidth. So the expected output rates on the queues are 4 Mbps + 2.5 Mbps = 6.5 Mbps for Queue 0, 3 Mbps for Queue 1, 0 Mbps for Queue 2, and 0.5 Mbps for Queue 3. Note that this behavior is different than regular priorities. With regular priorities, the transmission is still governed by transmit rates and the priority controls only the order in which the packets are picked up by the scheduler. So without excess configuration, if Queue 0 had a regular priority of **high** and there was 10 Mbps of traffic on all four queues, the traffic distribution would be 4 Mbps for Queue 0, 3 Mbps for Queue 1, 2.5 Mbps for Queue 2, and 0.5 Mbps for Queue 3 instead of giving all 10 Mbps to Queue 0. Excess priority traffic distributions are governed first by the excess priority and then by the excess rates. Also note that in this example, although the queues are in the excess region because they are transmitting above their configured transmit rates, the logical interface is still within its guaranteed rate. So at the logical interface level, the priority of the queues get promoted to a regular priority and this priority is used by the scheduler at the logical interface level.

The sixth and final example considers the effects of the default excess priority. When the excess priority for a queue is not configured explicitly, the excess priority is based on the regular priority. A regular priority of **high** maps to an excess priority of **high**. All other regular priorities map to an excess priority of **low**. When there is no regular priority configured, the regular and excess priorities are both set to **low**.

PART 2

Configuration

- [Configuration Tasks on page 29](#)
- [Configuration Statements on page 43](#)

CHAPTER 2

Configuration Tasks

- [Configuring ToS Translation Tables on page 29](#)
- [Configuring Excess Bandwidth Sharing on IQE PICs on page 33](#)
- [Configuring Layer 2 Policing on IQE PICs on page 36](#)
- [Configuring Low-Latency Static Policers on IQE PICs on page 38](#)
- [Assigning Default Frame Relay Rewrite Rule to IQE PICs on page 40](#)
- [Defining Custom Frame Relay Rewrite Rule on IQE PICs on page 40](#)

Configuring ToS Translation Tables

On the IQE PICs, the behavior aggregate (BA) translation tables are included for every logical interface (unit) protocol family configured on the logical interface. The proper default translation table is active even if you do not include any explicit translation tables. You can display the current translation table values with the **show class-of-service classifiers** command.

On M40e, M120, M320, and T Series routers with IQE PICs, or on any system with IQ2 or Enhanced IQ2 PICs, you can replace the ToS bit value on the incoming packet header on a logical interface with a user-defined value. The new ToS value is used for all class-of-service processing and is applied before any other class-of-service or firewall treatment of the packet. On the IQE PIC, the values configured with the **translation-table** statement determines the new ToS bit values.

Four types of translation tables are supported: IP precedence, IPv4 DSCP, IPv6 DSCP, and MPLS EXP. You can configure a maximum of eight tables for each supported type. If a translation table is enabled for a particular type of traffic, then behavior aggregate (BA) classification of the same type must be configured for that logical interface. In other words, if you configure an IPv4 translation table, you must configure IPv4 BA classification on the same logical interface.

To configure ToS translation on the IQE PIC, include the **translation-table** statement at the **[edit class-of-service]** hierarchy level:

```
[edit class-of-service]
translation-table {
  (to-dscp-from-dscp | to-dscp-ipv6-from-dscp-ipv6 | to-exp-from-exp |
  to-inet-precedence-from-inet-precedence) table-name {
    to-code-point value from-code-points (* | [ values ]);
```

```
    }
}
```

The **from-code-points** statement establishes the values to match on the incoming packets. The **default** option is used to match all values not explicitly listed, and, as a single entry in the translation table, to mark all incoming packets on an interface the same way. The **to-code-point** statement establishes the target values for the translation. If an incoming packet header ToS bit configuration is not covered by the translation table list and a * option is not specified, the ToS bits in the incoming packet header are left unchanged.

You can define many translation tables, as long as they have distinct names. You apply a translation table to a logical interface at the **[edit class-of-service interfaces]** hierarchy level. Translation tables always translate “like to like.” For example, a translation table applied to MPLS traffic can only translate from received EXP bit values to new EXP bit values. That is, translation tables cannot translate (for instance) from DSCP bits to INET precedence code points.

On the IQE PIC, incoming ToS bit translation is subject to the following rules:

- Locally generated traffic is not subject to translation.
- The **to-dscp-from-dscp** translation table type is not supported if an Internet precedence classifier is configured.
- The **to-inet-precedence-from-inet-precedence** translation table type is not supported if a DSCP classifier is configured.
- The **to-dscp-from-dscp** and **to-inet-precedence-from-inet-precedence** translation table types cannot be configured on the same unit.
- The **to-dscp-from-dscp** and **to-inet-precedence-from-inet-precedence** translation table types are supported for IPv4 packets.
- Only the **to-dscp-ipv6-from-dscp-ipv6** translation table type is supported for IPv6 packets.
- Only the **to-exp-from-exp** translation table type is supported for MPLS packets.



NOTE: Translation tables are not supported if fixed classification is configured on the logical interface.

The following example translates incoming DSCP values to the new values listed in the table. All incoming DSCP values other than 111111, 111110, 000111, and 100111 are translated to 000111.

```
[edit class-of-service]
translation-table {
  to-dscp-from-dscp dscp-trans-table {
    to-code-point 000000 from-code-points 111111;
    to-code-point 000001 from-code-points 111110;
    to-code-point 111000 from-code-points [ 000111 100111 ];
    to-code-point 000111 from-code-points *;
  }
}
```

You must apply the translation table to the logical interface input on the Enhanced IQ PIC:

```
[edit class-of-service interfaces so-1/0/0 unit 0]
translation-table to-dscp-from-dscp dscp-trans-table;
```

A maximum of 32 distinct translation tables are supported on each IQE PIC. However, this maximum is limited by the number of classifiers configured along with translation tables because on the IQE PIC the hardware tables are not always merged. For example, if a translation table and a classifier are both configured on the same logical interface (such as **unit 0**), there is only one hardware table and only one table added to the 32 translation table limit. However, if the translation table is configured on **unit 0** and the classifier on **unit 1** on the same physical interface, then two hardware tables are used and these two tables count toward the 32 maximum.

If you try to configure mutually exclusive translation tables on the same interface unit, you will get a warning message when you display or commit the configuration:

```
ge-0/1/1 {
  unit 0 {
    translation-table {
      ##
      ## Warning: to-dscp-from-dscp and
to-inet-precedence-from-inet-precedence not allowed on same unit
      ##
      to-inet-precedence-from-inet-precedence inet-trans-table;
      to-dscp-from-dscp dscp-trans-table;
    }
  }
}
```

You can issue the following operational mode commands to verify your configuration:

- **show class-of-service translation-table**
- **show class-of-service interface *interface-name***

To verify that the correct values are configured, use the **show class-of-service translation-table** command. The **show class-of-service translation-table** command displays the code points of all translation tables configured. All values are displayed, not just those configured:

```
user@host> show class-of-service translation-table
Translation Table: dscp-trans-table, Translation table type: dscp-to-dscp, Index:
6761
  From Code point    To Code Point
000000              000111
000001              000111
000010              000111
000011              000111
000100              000111
000101              000111
000110              000111
000111              111000
001000              000111
001001              000111
001010              000111
001011              000111
001100              000111
```

001101	000111
001110	000111
001111	000111
010000	000111
010001	000111
010010	000111
010011	000111
010100	000111
010101	000111
010110	000111
010111	000111
011000	000111
011001	000111
011010	000111
011011	000111
011100	000111
011101	000111
011110	000111
011111	000111
100000	000111
100001	000111
100010	000111
100011	000111
100100	000111
100101	000111
100110	000111
100111	111000
101000	000111
101001	000111
101010	000111
101011	000111
101100	000111
101101	000111
101110	000111
101111	000111
110000	000111
110001	000111
110010	000111
110011	000111
110100	000111
110101	000111
110110	000111
110111	000111
111000	000111
111001	000111
111010	000111
111011	000111
111100	000111
111101	000111
111110	000001
111111	000000

To verify that the configured translation table is applied to the correct interface, use the **show class-of-service interface *interface-name*** command. The **show class-of-service interface *interface-name*** command displays the translation tables applied to the IQE interface:

```
user@host> show class-of-service interface ge-0/1/1
Physical interface: ge-0/1/1, Index: 156  From Code point  To Code Point
Queues supported: 4, Queues in use: 4
Scheduler map: <default>, Index: 2
```

Chassis scheduler map: <default-chassis>, Index: 4

Logical interface: so-2/3/0.0, Index: 68

Object	Name	Type	Index
Rewrite	exp-default	exp (mpls-any)	29
Classifier	dscp-default	dscp	7
Classifier	exp-default	exp	10
Translation Table	exp-trans-table	EXP_TO_EXP	61925

ToS translation on the IQE PIC is a form of behavior aggregate (BA) classification. The IQE PIC does not support multifield classification of packets at the PIC level. For more information about multifield classification, see Multifield Classifier Overview.

Configuring Excess Bandwidth Sharing on IQE PICs

The IQE PIC gives users more control over excess bandwidth sharing. You can set a shaping rate and a guaranteed rate on a queue or logical interface and control the excess bandwidth (if any) that can be used after all bandwidth guarantees have been satisfied. This section discusses the following topics related to excess bandwidth sharing on the IQE PIC:

- [IQE PIC Excess Bandwidth Sharing Overview on page 33](#)
- [IQE PIC Excess Bandwidth Sharing Configuration on page 34](#)

IQE PIC Excess Bandwidth Sharing Overview

On some types of PICs, including the IQ and IQ2, and Enhanced Queuing DPCs, you can configure either a committed information rate (CIR) using the **guaranteed-rate** statement or a peak information rate (PIR) using the **shaping-rate** statement. You can configure both a PIR and CIR, and in most cases the CIR is less than the value of PIR. For bursty traffic, the CIR represents the average rate of traffic per unit time and the PIR represents the maximum amount of traffic that can be transmitted in a given interval. In other words, the PIR (**shaping-rate**) establishes the maximum bandwidth available. The CIR (**guaranteed-rate**) establishes the minimum bandwidth available if all sources are active at the same time. Theoretically, the PIR or CIR can be established at the queue, logical interface, or physical interface level. In this section, the PIRs or CIRs apply at the queue or logical interface (or both) levels.



NOTE: You can configure a shaping rate at the physical interface, logical interface, or queue level. You can configure a guaranteed rate or excess rate only at the logical interface and queue level.

Once all of the bandwidth guarantees (the sum of the CIRs at that level) are met, there could still be some excess bandwidth available for use. In existing PICs, you have no control over how this excess bandwidth is used. For example, consider the situation shown in [Table 40 on page 34](#) regarding a 10-Mbps physical interface. This example

assumes that all queues are of the same priority. Also, if you do not specify a priority for the excess bandwidth, the excess priority is the same as the normal priority.

Table 40: Default Handling of Excess Traffic

Queue	Transmit Rate (CIR)	Shaping Rate (PIR)	Traffic Rate	Guaranteed Rate (Total = 6 Mbps)	Maximum Rate	Excess Bandwidth (Part of 4 Mbps Excess)	Expected Transmit Rate (Guarantee + Excess)
Q0	10%	80%	10 Mbps	1 Mbps	8 Mbps	0.73 Mbps	1.73 Mbps
Q1	20%	50%	10 Mbps	2 Mbps	5 Mbps	1.45 Mbps	3.45 Mbps
Q2	5%	5%	10 Mbps	0.5 Mbps	0.5 Mbps	0 Mbps	0.5 Mbps
Q3	25%	NA ("100%")	10 Mbps	2.5 Mbps	10 Mbps	1.82 Mbps	4.32 Mbps

A 10-Mbps interface (the Traffic Rate column) has four queues, and the guaranteed rates are shown as percentages (Transmit Rate column) and in bits per second (Guaranteed Rate column). The table also shows the shaping rate (PIR) as a percentage (Shaping Rate column) and the actual maximum possible transmitted rate (Traffic Rate column) on the oversubscribed interface. Note the guaranteed rates (CIRs) add up to 60 percent of the physical port speed or 6 Mbps. This means that there are 4 Mbps of "excess" bandwidth that can be used by the queues. This excess bandwidth is used as shown in the last two columns. One column (the Excess Bandwidth column) shows the bandwidth partitioned to each queue as a part of the 4-Mbps excess. The excess 4 Mbps bandwidth is shared in the ratio of the transmit rate (CIR) percentages of 10, 20, 5, and 25, adjusted for granularity. The last column shows the transmit rate the users can expect: the sum of the guaranteed rate plus the proportion of the excess bandwidth assigned to the queue.

Note that on PICs other than the IQE PICs the user has no control over the partitioning of the excess bandwidth. Excess bandwidth partitioning is automatic, simply assuming that the distribution and priorities of the excess bandwidth should be the same as the distribution and priorities of the other traffic. However, this might not always be the case and the user might want more control over excess bandwidth usage.

For more information on how excess bandwidth sharing is handled on the Enhanced Queuing DPC, see [Configuring Excess Bandwidth Sharing](#).

IQE PIC Excess Bandwidth Sharing Configuration

On PICs other than IQE PICs, you can limit a queue's transmission rate by including the **transmit-rate** statement with the **exact** option at the **[edit class-of-service schedulers scheduler-name]** hierarchy level. However, on the IQE PIC, you can set a shaping rate independent of the transmit rate by including the **shaping-rate** statement at the **[edit class-of-service schedulers scheduler-name]** hierarchy level. Also, other PICs share excess bandwidth (bandwidth left over once the guaranteed transmit rate is met) in an automatic,

nonconfigurable fashion. You cannot configure the priority of the queues for the excess traffic on other PICs either.

To share excess bandwidth on IQE PICs, include the **excess-rate** statement along with the **guaranteed-rate** statement (to define the CIR) and the **shaping-rate** statement (to define the PIR):

```
[edit class-of-service traffic-control-profile profile-name]
[edit class-of-service schedulers scheduler-name]
excess-rate percent percentage;
guaranteed-rate (percent percentage | rate);
shaping-rate (percent percentage | rate);
```

To apply these limits to a logical interface, configure the statements at the **[edit class-of-service traffic-control-profile *profile-name*]** hierarchy level. To apply these limits to a specific queue, configure the statements at the **[edit class-of-service schedulers *scheduler-name*]** hierarchy level. You must also complete the configuration by applying the scheduler map or traffic control profile correctly.

You configure the excess rate as a percentage from 1 through 100. By default, excess bandwidth is automatically distributed as on other PIC types.

You can also configure a high or low priority for excess bandwidth by including the **excess-priority** statement with the **high** or **low** option at the **[edit class-of-service schedulers *scheduler-name*]** hierarchy level. This statement establishes the priority at the queue level, which then applies also at the logical and physical interface levels.

```
[edit class-of-service schedulers scheduler-name]
excess-priority (high | low);
```



NOTE: You cannot configure an excess rate for a logical interface if there is no guaranteed rate configured on any logical interface belonging to the physical interface.

The following example configures the excess rate in a traffic control profile:

```
[edit class-of-service traffic-control-profiles]
for-unit-0-percent {
  shaping-rate 10k;
  guaranteed-rate 1k;
  excess-rate percent 30;
}
for-unit-1-proportion {
  shaping-rate 20k;
  guaranteed-rate 10k;
  excess-rate percent 35;
}
```

The following example configures the excess rate in a scheduler.

```
[edit class-of-service schedulers]
scheduler-for-excess-low {
  transmit-rate 1m;
  shaping-rate 5m;
  excess-rate percent 30;
```

```
    excess-priority low;  
  }  
  scheduler-for-excess-high {  
    transmit-rate percent 20;  
    shaping-rate percent 30;  
    excess-rate percent 25;  
    excess-priority high;  
  }
```



NOTE: All of these parameters apply to egress traffic only and only for per-unit schedulers. That is, there is no hierarchical or shared scheduler support.

You can issue the following operational mode commands to verify your configuration:

- **show class-of-service scheduler-map**
- **show class-of-service traffic-control-profile**

Configuring Layer 2 Policing on IQE PICs

The IQE PIC can police traffic at Layer 2 in a hierarchical manner. *Policing* is the practice of making sure that different streams of incoming traffic conform to certain parameters and limits. If the incoming traffic exceeds the established boundaries, that traffic can be marked or even ignored, depending on configuration. Hierarchical policing maintains two rates: an aggregate rate and a high-priority rate. The traffic is marked differently depending on service class (currently, the classes are expedited forwarding and nonexpedited forwarding). The expedited traffic has an additional rate configured, the guaranteed rate (CIR), which is only marked above that limit. If there is no expedited traffic present, then the non-expedited traffic is able to use the aggregate bandwidth rate before being marked with a packet loss priority. When expedited traffic is present, it is marked above the guaranteed rate, but also uses bandwidth from the nonexpedited range.

For example, consider an aggregate rate of 10 Mbps and a high-priority rate of 2 Mbps of a Fast Ethernet interface. The guaranteed rate is also set at 2 Mbps for expedited forwarding traffic. If there is no expedited traffic present, then nonexpedited traffic can use up to 10 Mbps before being marked. When expedited forwarding traffic is present, the expedited traffic is guaranteed 2 Mbps (of the 10 Mbps) without being marked, but is marked above the 2 Mbps limit. In this case, the nonexpedited forwarding traffic can use the remaining 8 Mbps before being marked.

This section discusses the following IQE PIC Layer 2 policing topics:

- [Layer 2 Policer Limitations on page 37](#)
- [Configuring Layer 2 Policers on IQE PICs on page 37](#)

Layer 2 Policer Limitations

Layer 2 policers configured on IQE PICs have the following limitations:

- Only one kind of policer is supported on a physical or logical interface. For example, a hierarchical or two- or three-color policer in the same direction on the same logical interface is not supported.
- Applying policers to both physical port and logical interface (policer chaining) is not supported.
- If there is no behavior aggregate classification, there is a limit of 64 policers per interface. (Usually, there will be a single policer per DLCI in frame relay and other logical interface types.)
- The policer should be independent of behavior aggregate classification. (Without a behavior aggregate, all traffic is treated as either expedited or non-expedited forwarding, depending on configuration.)
- With a behavior aggregate, traffic not matching any classification bits (such as DSCP or EXP) is policed as nonexpedited forwarding traffic.
- Only two levels of traffic policing are supported: **aggregate** and **premium**.

Configuring Layer 2 Policers on IQE PICs

To configure Layer 2 policing on the IQE PIC, for each forwarding class include the **class** statement with the **policing-priority** option at the **[edit class-of-service forwarding-classes]** hierarchy level. One forwarding class has the **premium** option and the others are configured as **normal**.

```
[edit class-of-service forwarding-classes]
{
  class fc1 queue-num 0 priority high policing-priority premium;
  class fc2 queue-num 1 priority low policing-priority normal;
  class fc3 queue-num 2 priority low policing-priority normal;
  class fc4 queue-num 3 priority low policing-priority normal;
}
```

You must also configure the **aggregate** and **premium** statements in the firewall filter performing the policing.

```
[edit firewall]
hierarchical-policer hier_example1 {
  aggregate {
    if-exceeding {
      bandwidth-limit 70m;
      burst-size-limit 1800;
    }
    then {
      discard;
    }
  }
  premium {
    if-exceeding {
      bandwidth-limit 70m;
    }
  }
}
```

```
        burst-size-limit 3600;
    }
    then {
        discard;
    }
}
}
```

You must also apply the policer to the logical or physical interface on the IQE PIC:

```
[edit interfaces]
so-6/0/0 {
    unit 0 {
        layer2-policer {
            input-hierarchical-policer hier_example1; # Apply policer to logical unit.
        }
        family inet {
            address 10.0.22.1/30;
        }
        family iso;
        family mpls;
    }
}

so-5/0/0 {
    layer2-policer {
        input-hierarchical-policer hier_example1; # Apply policer to physical interface.
    }
    unit 0 {
        family inet {
            address 10.0.22.1/30;
        }
        family iso;
        family mpls;
    }
}
```

For SONET/SDH physical interfaces, the hierarchical policer configuration statements will only be visible for IQE PICs.

Configuring Low-Latency Static Policers on IQE PICs

You can rate-limit the strict-high and high queues on the IQE PIC. Without this limiting, traffic that requires low latency (delay) such as voice can block the transmission of medium-priority and low-priority packets. Unless limited, high and strict-high traffic is always sent before lower priority traffic, causing the lower priority queues to “starve” and cause timeouts and unnecessarily resent packets.

On the IQE PIC you can rate-limit queues before the packets are queued for output. All packets exceeding the configured rate limit are dropped, so care is required when establishing this limit. This model is also supported on IQ2 PICs and is the only way to perform egress policing on IQE PICs. This feature introduces no new configuration statements.

Although intended for low-latency traffic classes such as voice, the configuration allows any queue to be rate-limited. However, the configuration requires the rate-limited queue to have either a high or strict-high priority.



NOTE: You can configure a low-latency static policer for only one rate-limited queue per scheduler map. You can configure up to 1024 low-latency static policers.

This example limits the transmit rate of a strict-high expedited-forwarding queue to 1 Mbps. The scheduler and scheduler map are defined, and then applied to the traffic at the **[edit interfaces]** and **[edit class-of-service]** hierarchy levels:

```
[edit class-of-service]
schedulers {
  scheduler-1 {
    transmit-rate 1m rate-limit;
    priority strict-high;
  }
}
scheduler-maps {
  scheduler-map-1 {
    forwarding-class expedited-forwarding scheduler scheduler-1;
  }
}

[edit interfaces]
so-2/0/0 {
  per-unit-scheduler;
  encapsulation frame-relay;
  unit 0 {
    dlci 1;
  }
}

[edit class-of-service]
interfaces {
  so-2/0/0 {
    unit 0 {
      scheduler-map scheduler-map-1;
      shaping-rate 2m;
    }
  }
}
```

You can issue the following operational mode commands to verify your configuration (the first shows the rate limit in effect):

- **show class-of-service scheduler-map *scheduler-map-name***
- **show class-of-service interface *interface-name***

Assigning Default Frame Relay Rewrite Rule to IQE PICs

On the Enhanced IQ (IQE) PICs with the Frame Relay encapsulation, you can rewrite the discard eligibility (DE) bit based on the loss priority of the Frame Relay traffic. A rewrite rule sets the DE bit to the class-of-service (CoS) value **0** or **1**, based on the assigned loss priority of low, medium-low, medium-high, or high for each outgoing frame.

The default Frame Relay rewrite rule contains the following settings:

```
loss-priority low code-point 0;
loss-priority medium-low code-point 0;
loss-priority medium-high code-point 1;
loss-priority high code-point 1;
```

The default rule sets the DE CoS value to **0** for each outgoing frame with the loss priority set to low or medium-low. The default rule sets the DE CoS value to **1** for each outgoing frame with the loss priority set to medium-high or high.

To assign the default Frame Relay rewrite rule to an interface:

1. Include the **frame-relay-de default** statement at the **[edit class-of-service interfaces interface *interface-name* unit *logical-unit-number* loss-priority-rewrites]** hierarchy level.

For example:

```
[edit class-of-service interfaces so-1/0/0 unit 0 loss-priority-rewrites]
user@host# set frame-relay-de default;
```

2. Verify the configuration in operational mode.

```
user@host> show class-of-service loss-priority-rewrite
Loss-priority-rewrite: frame-relay-de-default, Code point type: frame-relay-de,
Index: 38
  Loss priority      Code point
  ----
  low                0
  high               1
  medium-low         0
  medium-high        1
```

Defining Custom Frame Relay Rewrite Rule on IQE PICs

For Juniper Networks device interfaces with the Frame Relay encapsulation, you can rewrite the discard eligibility (DE) bit based on the loss priority of the Frame Relay traffic. A rewrite rule sets the DE bit to the class-of-service (CoS) value **0** or **1** based on the assigned loss priority of low, medium-low, medium-high, or high for each outgoing frame.

To define a Frame Relay DE bit rewrite rule:

1. Specify the rewrite rule for Frame Relay DE bit based on the loss priority at the **[edit class-of-service loss-priority-rewrites]** hierarchy level.

```
[edit class-of-service loss-priority-rewrites]
user@host# set frame-relay-de name loss-priority level code-point [ alias | bits ];
```

For example:

```
[edit class-of-service loss-priority-rewrites]
user@host# set frame-relay-de fr_rw loss-priority low code-point 0;
user@host# set frame-relay-de fr_rw loss-priority high code-point 0;
user@host# set frame-relay-de fr_rw loss-priority medium-low code-point 1;
user@host# set frame-relay-de fr_rw loss-priority medium-high code-point 1;
```



NOTE: The rewrite rule does not take effect until you apply it to a logical interface.

2. Apply a rule to a logical interface.

```
[edit class-of-service interfaces interface-name unit logical-unit-number
  loss-priority-rewrites]
user@host# set frame-relay-de name;
```

For example:

```
[edit class-of-service interfaces so-1/0/0 unit 0 loss-priority-rewrites]
user@host# set frame-relay-de fr_rw;
```

3. Verify the configuration in operational mode.

```
user@host> show class-of-service loss-priority-rewrite
Loss-priority-rewrite: frame-relay-de-fr_rw, Code point type: frame-relay-de,
Index: 38
  Loss priority      Code point
  low                0
  high               0
  medium-low         1
  medium-high        1
```


CHAPTER 3

Configuration Statements

excess-priority


Syntax	<code>excess-priority [low medium-low medium-high high none];</code>
Hierarchy Level	[edit class-of-service schedulers <i>scheduler-name</i>]
Release Information	Statement introduced in Junos OS Release 9.3. Option none introduced in Junos OS Release 11.4.
Description	Determine the priority of excess bandwidth traffic on a scheduler.



NOTE: For Link Services IQ (LSQ) PICs or Multiservices PIC (MS-PICs), the **excess-priority** statement is allowed for consistency, but ignored. If an explicit priority is not configured for these interfaces, a default low priority is used. This default priority is also used in the excess region.

Options	low —Excess traffic for this scheduler has low priority. medium-low —Excess traffic for this scheduler has medium-low priority. medium-high —Excess traffic for this scheduler has medium-high priority. high —Excess traffic for this scheduler has high priority. none —System does not demote the priority of guaranteed traffic when the bandwidth exceeds the shaping rate or the guaranteed rate.
Required Privilege Level	interface—To view this statement in the configuration. interface-control—To add this statement to the configuration.
Related Documentation	<ul style="list-style-type: none">• Configuring Excess Bandwidth Sharing on IQE PICs on page 33• Bandwidth Sharing on Nonqueueing Packet Forwarding Engines Overview• Managing Excess Bandwidth Distribution on Static Interfaces on MICs and MPCs

excess-rate

Syntax	<code>excess-rate (percent <i>percentage</i> proportion <i>value</i>);</code>
Hierarchy Level	[edit class-of-service schedulers <i>scheduler-name</i>], [edit class-of-service traffic-control-profiles <i>traffic-control-profile-name</i>]
Release Information	Statement introduced in Junos OS Release 9.3. Application to the Multiservices PIC added in Junos OS Release 9.5. Application to the MIC and MPC interfaces added in Junos OS Release 10.1. Statement introduced in Junos OS Release 12.1X48R2 for PTX Series Packet Transport Switches.
Description	For an Enhanced IQ PIC interfaces, Multiservices PIC interfaces, or MX Series router interfaces on MPCs or MICs, and T4000 router interfaces on Type 5 FPCs, determine the percentage or proportion of excess bandwidth traffic to share.
<div>  <p>NOTE: The proportion option provides a greater range of values over the percent option and hence influences the priorities assigned to the queues.</p> </div>	
Options	<p><i>percentage</i>—Percentage of the excess bandwidth to share. Range: 0 through 100 percent Default: Excess bandwidth is shared in proportion to the configured transmit rate of each queue.</p> <p><i>value</i>—(M Series, MX Series, and T Series routers only) Proportion of the excess bandwidth to share. Option available at the [edit class-of-service traffic-class-profiles <i>traffic-control-profile-name</i>] hierarchy level only. Range: 0 through 1000</p>
Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none"> Configuring Scheduler Transmission Rate Configuring Excess Bandwidth Sharing on IQE PICs on page 33 Allocating Excess Bandwidth Among Frame Relay DLCIs on Multiservices PICs Managing Excess Bandwidth Distribution on Static Interfaces on MICs and MPCs

forwarding-classes (Class-of-Service)

Syntax	<pre>forwarding-classes { class queue-num <i>queue-number</i> priority (high low); queue <i>queue-number class-name</i> priority (high low) [policing-priority (premium normal)]; }</pre>
Hierarchy Level	[edit class-of-service]
Release Information	<p>Statement introduced before Junos OS Release 7.4.</p> <p>policing-priority option introduced in Junos OS Release 9.5.</p> <p>Statement introduced on PTX Series Packet Transport Switches in Junos OS Release 12.1.</p>
Description	Associate the forwarding class with a queue name and number. For M320, MX Series, and T Series routers only, you can configure fabric priority queuing by including the priority statement. For Enhanced IQ PICs, you can include the policing-priority option.



NOTE: The **priority** and **policing-priority** options are not supported on PTX Series Packet Transport Switches.

The statements are explained separately.

Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none"> Configuring Forwarding Classes Forwarding Classes and Fabric Priority Queues Example: Configuring CoS for a PBB Network on MX Series Routers Configuring Layer 2 Policers on IQE PICs on page 37 Classifying Packets by Egress Interface

frame-relay-de (Defining Loss Priority Rewrites)

Syntax	<pre>frame-relay-de <i>name</i> { loss-priority <i>level</i> code-point [<i>alias</i> <i>bits</i>]; }</pre>
Hierarchy Level	[edit class-of-service loss-priority-rewrites]
Release Information	Statement introduced in Junos OS Release 11.4.
Description	Define a Frame Relay discard eligibility (DE) bit loss priority rewrite.
Options	<p><i>name</i>—Name of the loss priority rewrite.</p> <p>loss-priority <i>level</i>—Level of the loss priority to be applied based on the specified CoS values. The loss priority level can be one of the following:</p> <ul style="list-style-type: none">• high—Packet has high loss priority.• low—Packet has low loss priority.• medium-high—Packet has medium-high loss priority.• medium-low—Packet has medium-low loss priority. <p>The remaining statements are explained separately.</p>
Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none">• Defining Custom Frame Relay Rewrite Rule on IQE PICs on page 40

guaranteed-rate

Syntax	<code>guaranteed-rate (percent <i>percentage</i> <i>rate</i>) <burst-size <i>bytes</i>>;</code>
Hierarchy Level	<code>[edit class-of-service traffic-control-profiles <i>profile-name</i>]</code>
Release Information	<p>Statement introduced in Junos OS Release 7.6.</p> <p>Option burst-size introduced for Enhanced Queuing (EQ) DPC interfaces in Junos OS Release 9.4.</p> <p>Option burst-size introduced for MIC and MPC interfaces in Junos OS Release 11.4.</p> <p>Option burst-size introduced for IQ2 and IQ2E interfaces in Junos OS Release 12.3</p>
Description	For Gigabit Ethernet IQ, Channelized IQ PICs, AS PIC FRF.16 LSQ interfaces, and EQ DPCs only, configure a guaranteed minimum rate. You can also configure an optional burst size for a logical interface on EQ DPCs and on IQ2 and IQ2E PICs. This can help to ensure that higher priority services do not starve lower priority services.
Default	If you do not include this statement and you do not include the delay-buffer-rate statement, the logical interface receives a minimal delay-buffer rate and minimal bandwidth equal to 2 MTU-sized packets.
Options	<p>percent <i>percentage</i>—For LSQ interfaces, guaranteed rate as a percentage of the available interface bandwidth.</p> <p>Range: 1 through 100 percent</p> <p><i>rate</i>—For IQ and IQ2 interfaces, guaranteed rate, in bits per second (bps). You can specify a value in bits per second either as a complete decimal number or as a decimal number followed by the abbreviation k (1000), m (1,000,000), or g (1,000,000,000).</p> <p>Range: 1000 through 160,000,000,000 bps</p> <p>burst-size <i>bytes</i>—(Optional) Maximum burst size, in bytes.</p>
Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none"> Providing a Guaranteed Minimum Rate Configuring Traffic Control Profiles for Shared Scheduling and Shaping output-traffic-control-profile

loss-priority-rewrites

Syntax	<pre>loss-priority-rewrites { frame-relay-de <i>rewrite-name</i> { loss-priority <i>level</i> { code-points [<i>bit-patterns</i>]; } } }</pre>
Hierarchy Level	[edit class-of-service]
Release Information	Statement introduced in Junos OS Release 11.4.
Description	Specify the Frame Relay discard eligibility (DE) bit rewrite rule on the enhanced IQ PIC.
Options	<p>frame-relay-de <i>rewrite-name</i>—Name of the Frame Relay DE bit loss priority rewrite rule.</p> <p>loss-priority <i>level</i>—The loss priority level can be one of the following:</p> <ul style="list-style-type: none">• high—Packet has high loss priority.• low—Packet has low loss priority.• medium-high—Packet has medium-high loss priority.• medium-low—Packet has medium-low loss priority. <p>The remaining statements are explained separately.</p>
Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none">• Defining Custom Frame Relay Rewrite Rule on IQE PICs on page 40

loss-priority-rewrites (Assigning to an Interface)

Syntax	<pre>loss-priority-rewrites { frame-relay-de (<i>loss-priority-rewrite-name</i> default); }</pre>
Hierarchy Level	[edit class-of-service interfaces <i>interface-name</i> unit <i>logical-unit-number</i>]
Release Information	Statement introduced in Junos OS Release 11.4.
Description	Associate the loss priority rewrites to an outgoing packet.
Options	<p><i>loss-priority-rewrite-name</i>—Name of the loss priority rewrite to be applied to an interface.</p> <p>default—Default loss priority rewrite to be applied to an interface.</p>
Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none">• Defining Custom Frame Relay Rewrite Rule on IQE PICs on page 40• Assigning Default Frame Relay Rewrite Rule to IQE PICs on page 40

schedulers (Class of Service)

Syntax	<pre>schedulers { scheduler-name { adjust-minimum <i>rate</i>; adjust-percent <i>percentage</i>; buffer-size (<i>seconds</i> percent <i>percentage</i> remainder temporal <i>microseconds</i>); drop-profile-map loss-priority (any low medium-low medium-high high) protocol (any non-tcp tcp) drop-profile <i>profile-name</i>; excess-priority [low medium-low medium-high high none]; excess-rate (percent <i>percentage</i> proportion <i>value</i>); priority <i>priority-level</i>; shaping-rate (percent <i>percentage</i> <i>rate</i>); transmit-rate (percent <i>percentage</i> <i>rate</i> remainder) <exact rate-limit>; } }</pre>
Hierarchy Level	[edit class-of-service]
Release Information	Statement introduced before Junos OS Release 7.4. Statement introduced in Junos OS Release 12.1X48 for PTX Series switches.
Description	Specify the scheduler name and parameter values.
Options	<p>scheduler-name—Name of the scheduler to be configured.</p> <p>The remaining statements are explained separately.</p>
Required Privilege Level	interface—To view this statement in the configuration. interface-control—To add this statement to the configuration.
Related Documentation	<ul style="list-style-type: none">• Schedulers Overview• Default Schedulers Overview• Configuring Schedulers• Configuring a Scheduler• Example: Configuring CoS for a PBB Network on MX Series Routers

shaping-rate (Limiting Excess Bandwidth Usage)

Syntax	<code>shaping-rate (percent <i>percentage</i> <i>rate</i>) <burst-size <i>bytes</i>>;</code>
Hierarchy Level	<code>[edit class-of-service schedulers <i>scheduler-name</i>]</code>
Release Information	<p>Statement introduced before Junos OS Release 7.4.</p> <p>The burst-size option added for MIC and MPC interfaces on MX Series routers in Junos OS Release 11.4.</p> <p>Statement introduced in Junos OS Release 12.2 for ACX Series Routers.</p>
Description	<p>Define a limit on excess bandwidth usage for J Series routers and for MIC and MPC interfaces on MX Series routers.</p> <p>The transmit-rate statement at the <code>[edit class-of-service schedulers <i>scheduler-name</i>]</code> hierarchy level configures the minimum bandwidth allocated to a queue. The transmission bandwidth can be configured as an exact value or allowed to exceed the configured rate if additional bandwidth is available from other queues. For J Series routers only, you limit the excess bandwidth usage with this statement.</p> <p>You should configure the shaping rate as an absolute maximum usage and not the additional usage beyond the configured transmit rate.</p>
Default	If you do not include this statement, the default shaping rate is 100 percent, which is the same as no shaping at all.
Options	<p>percent <i>percentage</i>—Shaping rate as a percentage of the available interface bandwidth. Range: 0 through 100 percent</p> <p><i>rate</i>—Peak rate, in bits per second (bps). You can specify a value in bits per second either as a complete decimal number or as a decimal number followed by the abbreviation k (1000), m (1,000,000), or g (1,000,000,000). Range: 3200 through 32,000,000,000 bps</p> <p>burst-size <i>bytes</i>—Maximum burst size, in bytes. The burst value determines the number of rate credits that can accrue when the queue or scheduler node is held in the inactive round robin. Range: 0 through 1,000,000,000</p>
Required Privilege Level	<p>interface—To view this statement in the configuration.</p> <p>interface-control—To add this statement to the configuration.</p>
Related Documentation	<ul style="list-style-type: none"> Applying Scheduler Maps Overview

translation-table

Syntax	<pre>translation-table { (to-dscp-from-dscp to-dscp-ipv6-from-dscp-ipv6 to-exp-from-exp to-inet-precedence-from-inet-precedence) <i>table-name</i> { to-code-point <i>value</i> from-code-points (* [<i>values</i>]); } }</pre>
Hierarchy Level	[edit class-of-service]
Release Information	Statement introduced in Junos OS Release 9.3. Support on Multiservices PIC added in Junos OS Release 9.5.
Description	For an Enhanced IQ PIC or Multiservices PIC, specify the input translation tables. You must also apply the translation table to a logical interface on the Enhanced IQ PIC or Multiservices PIC.
Default	If you do not include this statement, the ToS bit values in received packet headers are not changed by the PIC.
Options	<p>to-dscp-from-dscp—(Optional) Translate incoming IPv4 DSCP values to new values. You must also configure and apply a DSCP classifier.</p> <p>to-dscp-ipv6-from-dscp-ipv6—(Optional) Translate incoming IPv6 DSCP values to new values. You must also configure and apply an IPv6 DSCP classifier.</p> <p>to-inet-precedence-from-inet-precedence—(Optional) Translate incoming INET precedence values to new values.</p> <p>to-exp-from-exp—(Optional) Translate incoming MPLS EXP values to new values.</p> <p><i>table-name</i>—The name of the translation table.</p> <p><i>value</i>—The bit string to which to translate the incoming bit value.</p> <p><i>value(s)</i>—The bit string(s) from which the incoming bit value(s) are translated.</p> <p>*—(Optional) This translation matches all bit patterns not explicitly listed.</p>
Required Privilege Level	interface—To view this statement in the configuration. interface-control—To add this statement to the configuration.
Related Documentation	<ul style="list-style-type: none">• Configuring ToS Translation Tables on page 29• Multiservices PIC ToS Translation

PART 3

Index

- [Index on page 55](#)

Index

Symbols

#, comments in configuration statements.....	x
(), in syntax descriptions.....	x
< >, in syntax descriptions.....	x
[], in configuration statements.....	x
{ }, in configuration statements.....	x
(pipe), in syntax descriptions.....	x

B

braces, in configuration statements.....	x
brackets	
angle, in syntax descriptions.....	x
square, in configuration statements.....	x

C

comments, in configuration statements.....	x
conventions	
text and syntax.....	ix
CoS	
Enhanced IQ interfaces.....	3, 29, 36
IQE default rates.....	10
IQE excess bandwidth.....	12
IQE interfaces.....	33, 38
IQE modes.....	6
IQE terminology.....	4
IQE traffic.....	3, 4
low latency static policer.....	38
curly braces, in configuration statements.....	x
customer support.....	xi
contacting JTAC.....	xi

D

documentation	
comments on.....	xi

E

Enhanced IQ interfaces	
CoS and.....	3
Enhanced IQ PICs	
interface speeds.....	3
ToS translation.....	29

excess-bandwidth statement	
configuration guidelines.....	34
excess-priority statement	43
usage guidelines.....	33
excess-rate statement	44
usage guidelines.....	33

F

font conventions.....	ix
forwarding-classes statement.....	45
frame relay custom rewrite rule	
IQE PIC.....	40
frame relay default rewrite rule	
IQE PIC.....	40
frame-relay-de statement	
defining loss priority rewrites.....	46

G

guaranteed-rate statement.....	47
--------------------------------	----

H

hierarchical scheduling	
Enhanced IQ interfaces.....	3

I

interfaces	
Enhanced IQ CoS.....	3
IQE PIC	
excess bandwidth.....	12
frame relay custom rewrite rule.....	40
frame relay default rewrite rule.....	40
interface modes.....	6
queue default rates.....	10
traffic calculation.....	3
Traffic calculation.....	4
traffic terminology.....	4
IQE PICs	
excess bandwidth sharing.....	33
L2 policing.....	36
low latency static policer.....	38

L

loss-priority-rewrites statement.....	48
assigning to Interface.....	49

M

manuals	
comments on.....	xi

P

parentheses, in syntax descriptions.....	x
policer	
IQE interfaces.....	38

S

support, technical See technical support	
syntax conventions.....	ix

T

technical support	
contacting JTAC.....	xi
translation-table statement.....	52
usage guidelines.....	29