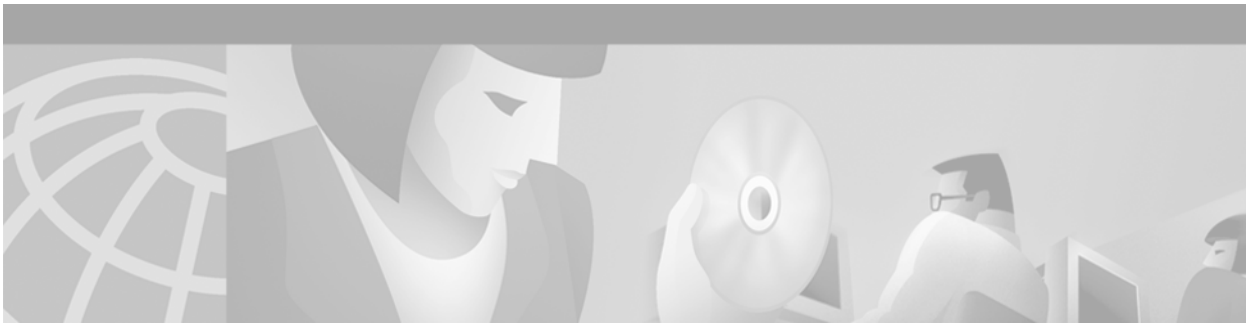


Class-Based Shaping

This feature module describes the Class-Based Shaping feature. This document includes the following sections:

- Feature Overview, page 1
- Supported Platforms, page 3
- Supported Standards, MIBs, and RFCs, page 4
- Configuration Tasks, page 4
- Configuration Examples, page 5
- Command Reference, page 10

Feature Overview

Traffic shaping allows you to control the traffic going out an interface in order to match its transmission to the speed of the remote, target interface and to ensure that the traffic conforms to policies contracted for it. Traffic adhering to a particular profile can be shaped to meet downstream requirements, thereby eliminating bottlenecks in topologies with data-rate mismatches.

Using the Class-Based Shaping feature, you can do the following:

- Configure generic traffic shaping (GTS) on a traffic class
- Specify average rate or peak rate traffic shaping
- Configure class-based weighted fair queueing (CBWFQ) inside GTS

Class-based shaping can be enabled on any interface that supports GTS.

Configuring GTS on a Traffic Class

Using the Class-Based Shaping feature, you can configure GTS on a class, rather than only on an access control list (ACL). In order to do so, you must first define traffic classes based on match criteria including protocols, ACLs, and input interfaces. You can then apply traffic shaping to each defined class.

Specifying Average Rate or Peak Rate Traffic Shaping

Traffic shaping limits the rate of transmission of data. In addition to using a specifically configured transmission rate, you can use GTS to specify a derived transmission rate based on the level of congestion.

You can specify two types of traffic shaping; average rate shaping and peak rate shaping. Average rate shaping limits the transmission rate to the committed information rate (CIR). Using the CIR ensures that the average amount of traffic being sent conforms to the rate expected by the network.

Peak rate shaping configures the router to send more traffic than the CIR. To determine the peak rate, the router uses the following formula:

peak rate = CIR(1+Be/Bc)

where:

- Be is the Excess Burst rate.
- Bc is the Committed Burst rate.

Peak rate shaping allows the router to burst higher than average rate shaping. However, using peak rate shaping, the traffic sent above the CIR (the delta) has the potential of being dropped if the network becomes congested.

If your network has additional bandwidth available (over the provisioned CIR) and the application or class can tolerate occasional packet loss, that extra bandwidth can be exploited through the use of peak rate shaping. However, there may be occasional packet drops when network congestion occurs. If the traffic being sent to the network must strictly conform to the configured network provisioned CIR, then you should use average traffic shaping.

Configuring CBWFQ Inside GTS

Prior to this release, when GTS queues packets that, when sent, cause the traffic flow to violate the configured rate, only flow-based WFQ was supported for the queued packets.

Using the Class-Based Shaping feature, CBWFQ is supported for the queued packets. You can use CBWQ to configure classes of queued traffic and provide relative or absolute bandwidth guarantees to those classes. Note that the relative or absolute bandwidth guarantees are with regard to the configured CIR.

Benefits

Flexibility of Match Criteria

Applying GTS to classes provides greater flexibility for configuring traffic shaping. Previously, this ability was limited to the use of ACLs.

Better Use of Bandwidth

Specifying peak rate shaping allows you to make better use of available bandwidth by allowing more data than the CIR to be sent if the bandwidth is available.

Bandwidth Allocation

CBWFQ allows you to specify the exact amount of bandwidth to be allocated for a specific class of traffic. Taking into account available bandwidth on the interface, you can configure up to 64 classes and control distribution among them, which is not the case with flow-based WFQ.

Flow-based WFQ applies weights to traffic to classify it into conversations and determine how much bandwidth each conversation is allowed relative to other conversations. These weights, and traffic classification, are dependent on and limited to the seven IP Precedence levels.

Coarser Granularity and Scalability

CBWFQ allows you to define what constitutes a class based on criteria that exceed the confines of flow. CBWFQ allows you to use ACLs and protocols or input interface names to define how traffic will be classified, thereby providing coarser granularity. You need not maintain traffic classification on a flow basis. Moreover, you can configure up to 64 discrete classes in a service policy.

Restrictions

Peak and average traffic shaping is configured on a per-interface or per-class basis, and cannot be used in conjunction with commands used to configure GTS from previous versions of Cisco IOS. These commands include the following:

- **traffic-shape adaptive**
- **traffic-shape fecn-adaptive**
- **traffic-shape group**
- **traffic-shape rate**

Adaptive traffic shaping for Frame Relay networks is not supported using the Class-Based Shaping feature. To configure adaptive GTS for Frame Relay networks, you must use the commands from releases prior to Release 12.1(2) of Cisco IOS software.

Related Documents

For related information on this feature, refer to the following documents:

- *Cisco IOS Quality of Service Solutions Configuration Guide*, Cisco IOS Release 12.1
- *Cisco IOS Quality of Service Solutions Command Reference*, Cisco IOS Release 12.1

Supported Platforms

- Cisco 1600 series
- Cisco 2500 series
- Cisco 2600 series
- Cisco 3600 series
- Cisco 4500 series
- Cisco 4700 series
- Cisco 7200 with NPE150 or higher for T1/E1/Ethernet rates

- Cisco 7200 with NPE200 or higher for T3 rates
- Cisco Route Switch Processor (RSP)

Supported Standards, MIBs, and RFCs

Standards

None

MIBs

None

RFCs

None

Configuration Tasks

See the following sections for configuration tasks for the Class-Based Shaping feature. Each task in the list is identified as either optional or required.

- Configuring Class-Based Shaping (Required)
- Configuring CBWFQ Inside GTS (Optional)
- Verifying the Configuration of Policy Maps and Their Classes (Optional)

Configuring Class-Based Shaping

To configure Class-Based Shaping, use the first two commands in global configuration mode to specify the name of the policy map and the name of the class map. Use the remaining commands in class-map configuration mode to specify average or peak rate.

	Command	Purpose
Step 1	`Router(config)# policy-map` *policy-map*	Specifies the name of the policy map to be created or modified.
Step 2	`Router(config)# class-map` *class-map-name*	Specifies the name of the class map to be created.
Step 3	`Router(config-pmap-c)# shape {average | peak}` *cir* `[`*bc*`] [`*be*`]`	Specifies average or peak rate shaping.
Step 4	`Router(config-pmap-c)# shape max-buffers` *number-of-buffers*	(Optional) Specifies the maximum number of buffers allowed on shaping queues.

Configuring CBWFQ Inside GTS

To configure CBWFQ inside GTS, use the first two commands in global configuration mode to specify the name of the policy map and the name of the class map. Use the remaining commands in class-map configuration mode to specify average or peak rate and to attach the service policy to the class.

	Command	Purpose
Step 1	`Router(config)# policy-map policy-map`	Specifies the name of the policy map to be created or modified.
Step 2	`Router(config)# class-map class-map-name`	Specifies the name of the class map to be created.
Step 3	`Router(config-pmap-c)# shape {average | peak} cir [bc] [be]`	Specifies average or peak rate shaping.
Step 4	`Router(config-pmap-c)# service-policy policy-map`	Attaches the service policy to the class.

Verifying the Configuration of Policy Maps and Their Classes

To display the contents of a specific policy map, a specific class from a specific policy map, or all policy maps configured on an interface, use one of the following commands in global configuration mode:

Command	Purpose
`Router# show policy policy-map`	Displays the configuration of all classes comprising the specified policy map
`Router# show policy policy-map class class-name`	Displays the configuration of the specified class of the specified policy map
`Router# show policy interface interface-name`	Displays the configuration of all classes configured for all policy maps on the specified interface.

Configuration Examples

This section provides the following configuration examples:

- Class-Based Shaping Example
- CBWFQ in Conjunction with GTS Example
- CBWFQ Inside GTS Examples

Class-Based Shaping Example

The following example defines one class, c1. Class c1 is configured to shape traffic to 384 kbps, with a normal burst size of 15440 bits.

```
Router(config)# policy-map shape
Router(config-pmap)# class c1
Router(config-pmap-c)# shape average 38400 15440
Router(config-pmap-c)# configure terminal
Router(config)# interface Serial 3/3
Router(config-if)# service out shape
```

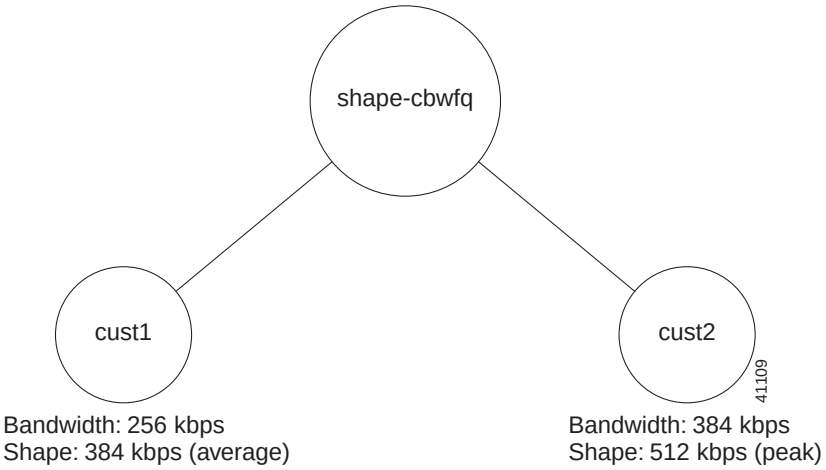
CBWFQ in Conjunction with GTS Example

The following example uses CBWFQ at the interface and shapes the traffic before it is queued to CBWFQ.

In this example, two classes are defined—cust1 and cust2. The class cust1 is ensured a bandwidth of 256 kbps, and the output is shaped to 384 kbps. The class cust2 is ensured a bandwidth of 384 kbps, but if enough bandwidth is available on the interface, the class can obtain throughput up to a peak of 512 kbps.

Figure 1 illustrates this example.

Figure 1 CBWFQ in Conjunction with GTS



The following commands are used to configure this example:

```
Router(config)# policy-map shape-cbwfq
Router(config-pmap)# class cust1
Router(config-pmap-c)# shape average 384000
Router(config-pmap-c)# bandwidth 256
Router(config-pmap)# class cust2
Router(config-pmap-c)# shape peak 512000
Router(config-pmap-c)# bandwidth 384
Router(config-pmap-c)# configure terminal
Router(config)# interface Serial 3/3
Router(config-if)# service out shape-cbwfq
```

CBWFQ Inside GTS Examples

This section provides two examples of configuring CBWFQ inside GTS.

Example 1

The first example uses hierarchical policy maps and configures CBWFQ inside GTS.

In the following example, three policy maps are defined—cust1-classes, cust2-classes, and cust-policy. The policy maps cust1-classes and cust2-classes have three classes defined—gold, silver, and bronze.

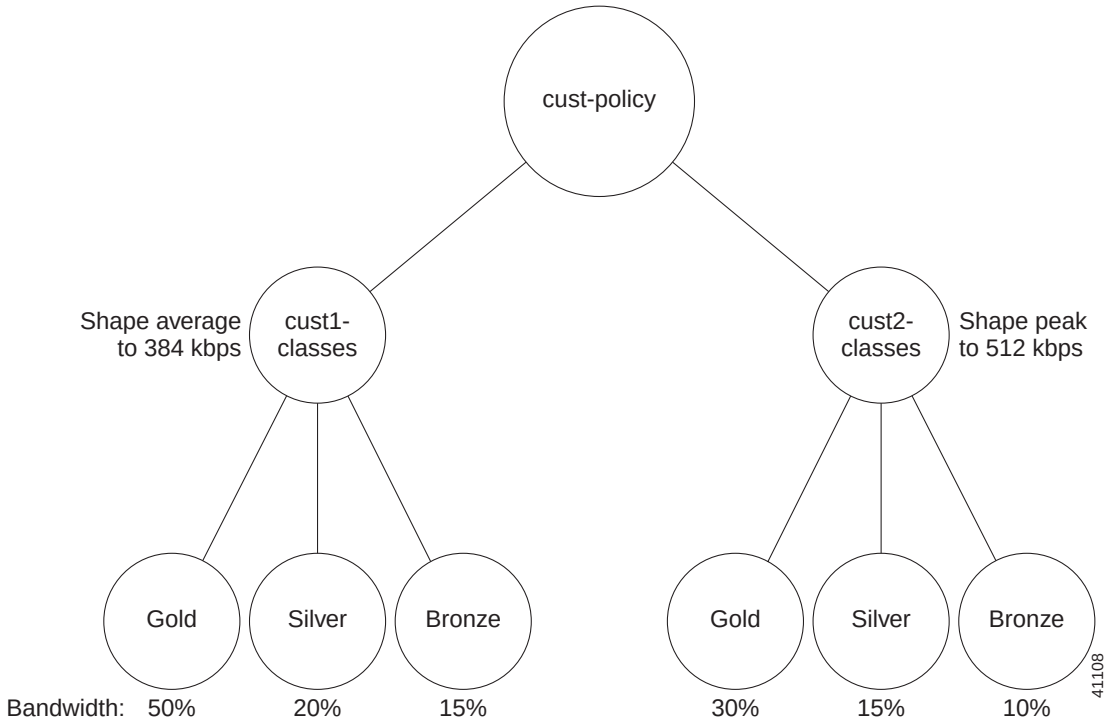
For cust1-classes, gold is configured to use 50 percent of the bandwidth. Silver is configured to use 20 percent of the bandwidth, and bronze is configured to use 15 percent of the bandwidth.

For cust2-classes, gold is configured to use 30 percent of the bandwidth. Silver is configured to use 15 percent of the bandwidth, and bronze is configured to use 10 percent of the bandwidth.

The policy map cust-policy specifies average rate shaping of 384 kbps and assigns the service policy cust1-classes to the class cust1. The policy map cust-policy specifies peak rate shaping of 512 kbps and assigns the service policy cust2-classes to the class cust2.

Figure 2 illustrates this example.

Figure 2 Hierarchical Policy Maps Using Class-Based Shaping



Configuration for cust1-classes

```
Router(config)# policy-map cust1-classes
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth percent 50
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth percent 20
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth percent 15
```

Configuration for cust2-classes

```
Router(config)# policy-map cust2-classes
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth percent 30
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth percent 15
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth percent 10
```

Configuration for Customer Policy and QoS Features

```
Router(config)# policy-map cust-policy
Router(config-pmap)# class cust1
Router(config-pmap-c)# shape average 38400
Router(config-pmap-c)# service-policy cust1-classes
Router(config-pmap)# class cust2
Router(config-pmap-c)# shape peak 51200
Router(config-pmap-c)# service-policy cust2-classes
Router(config-pmap-c)# interface Serial 3/2
Router(config-if)# service out cust-policy
```

Example 2

In this example, the Class-Based Shaping feature is configured for the class named shaped in the policy map named GTS_in_ModCLI. The class shaped is shaped to an average rate of 241,000 bits per second (bps). CBWFQ is also enabled on the class, which guarantees a bandwidth of 241 kbps during times of congestion at the interface.

The shaped class is a congestion point for all the subclasses that comprise that class. Therefore, the subclasses can be further differentiated in the shaped class. All these subclasses are part of the policy map, CBWFQ_in_GTS, that is attached to the shaped class.

Configuration for Policy Map GTS_in_ModCLI

```
Router(config)# policy-map GTS_in_ModCLI
Router(config-pmap)# class shaped
Router(config-pmap-c)# bandwidth 241
Router(config-pmap-c)# shape average 241000
Router(config-pmap-c)# service-policy CBWFQ_in_GTS
```

Configuration for Policy Map CBWFQ_in_GTS

The policy map, CBWFQ_in_GTS, has four CBWFQ classes:

```
Router(config)# policy-map CBWFQ_in_GTS
Router(config-pmap)# class cust_A
Router(config-pmap-c)# bandwidth percent 25
Router(config-pmap)# class cust_B
Router(config-pmap-c)# bandwidth percent 25
Router(config-pmap)# class cust_C
Router(config-pmap-c)# bandwidth percent 25
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair
```

Verifying the Configurations

The output of the **show policy-map** command for GTS_in_ModCLI displays an expanded configuration, including the subclasses:

```
Router# show policy-map GTS_in_ModCLI
  Policy Map GTS_in_ModCLI
   Class shaped
   Weighted Fair Queueing
       Bandwidth 241 (kbps)  Max Threshold 64 (packets)
   Traffic Shaping
    Average Rate Traffic Shaping
            CIR 241000 (bps) Max. Buffers Limit 1000 (Packets)
     Policy Map CBWFQ_in_GTS
     Class cust_A
     Weighted Fair Queueing
         Bandwidth 25 (%)    Max Threshold 64 (packets)
     Class cust_B
     Weighted Fair Queueing
         Bandwidth 25 (%)    Max Threshold 64 (packets)
     Class cust_C
     Weighted Fair Queueing
         Bandwidth 25 (%)    Max Threshold 64 (packets)
     Class class-default
     Weighted Fair Queueing
         Flow based Fair Queueing
```

The policy map GTS_in_ModCLI can be attached to any logical interface that provides a congestion point. Run-time statistics after attaching to interface Serial 3/0 are shown.

```
Router# show policy interface Serial 3/0
 Serial3/0
 output : GTS_in_ModCLI
  Class shaped
   Weighted Fair Queueing
       Output Queue: Conversation 267
         Bandwidth 241 (kbps) Max Threshold 64 (packets)
         (pkts matched/bytes matched) 3852/947384
         (pkts discards/bytes discards/tail drops) 0/0/0
   Traffic Shaping
     Target    Byte   Sustain   Excess    Interval  Increment Adapt
     Rate      Limit  bits/int  bits/int  (ms)      (bytes)   Active
     241000    1928   7712      7712      32        964       -

     Queue     Packets   Bytes     Packets   Bytes
     Depth                         Delayed   Delayed   Active
     41        3980      978872    3967      975686    yes
    Class cust_A
     Weighted Fair Queueing
```

```
     Output Queue: Conversation 41
       Bandwidth 25 (%) Max Threshold 64 (packets)
       (pkts matched/bytes matched) 0/0
       (pkts discards/bytes discards/tail drops) 0/0/0
Class cust_B
 Weighted Fair Queueing
     Output Queue: Conversation 42
       Bandwidth 25 (%) Max Threshold 64 (packets)
       (pkts matched/bytes matched) 0/0
       (pkts discards/bytes discards/tail drops) 0/0/0
Class cust_C
 Weighted Fair Queueing
     Output Queue: Conversation 43
       Bandwidth 25 (%) Max Threshold 64 (packets)
       (pkts matched/bytes matched) 0/0
       (pkts discards/bytes discards/tail drops) 0/0/0
Class class-default
 Weighted Fair Queueing
     Flow Based Fair Queueing
     Maximum Number of Hashed Queues 32
```

Command Reference

This section documents new or modified commands. All other commands used with this feature are documented in the Cisco IOS Release 12.1 command reference publications.

- **service-policy (class map)**
- **shape**
- **shape max-buffers**

service-policy (class map)

To attach a policy map to a class, use the **service-policy** class-map configuration command. To remove a service policy from a class, use the **no** form of this command.

service-policy *policy-map*

no service-policy

Syntax Description

policy-map	The name of a service policy map (created using the **policy-map** command) to be attached.

Defaults

No service policy is specified.

Command Modes

Class-map configuration within policy map

Command History

Release	Modification
12.1(2)T	This command was introduced.

Usage Guidelines

You can attach a single policy map to one or more classes to specify the service policy for those classes. This command is only available for the output interface, which is assumed.

Examples

In the following example, three policy maps are defined—cust1-classes, cust2-classes, and cust-policy. The policy maps cust1-classes and cust2-classes have three classes defined—gold, silver, and bronze.

For cust1-classes, gold is configured to use 50 percent of the bandwidth. Silver is configured to use 20 percent of the bandwidth, and bronze is configured to use 15 percent of the bandwidth.

For cust2-classes, gold is configured to use 30 percent of the bandwidth. Silver is configured to use 15 percent of the bandwidth, and bronze is configured to use 10 percent of the bandwidth.

The policy map cust-policy specifies average rate shaping of 384 kbps and assigns the service policy cust1-classes to the policy map cust1-classes. The policy map cust-policy specifies peak rate shaping of 512 kbps and assigns the service policy cust2-classes to the policy map cust2-classes.

To configure classes for cust1-classes, use the following commands:

```
Router(config)# policy-map cust1-classes
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth percent 50
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth percent 20
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth percent 15
```

To configure classes for cust2, use the following commands:

```
Router(config)# policy-map cust2-classes
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth percent 30
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth percent 15
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth percent 10
```

To define the customer policy with cust1-classes and cust2-classes and QoS features, use the following commands:

```
Router(config)# policy-map cust-policy
Router(config-pmap)# class cust1
Router(config-pmap-c)# shape average 38400
Router(config-pmap-c)# service-policy cust1-classes
Router(config-pmap)# class cust2
Router(config-pmap-c)# shape peak 51200
Router(config-pmap-c)# service-policy cust2-classes
Router(config-pmap-c)# interface Serial 3/2
Router(config-if)# service out cust-policy
```

Related Commands

Command	Description
policy-map	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
show policy-map	Displays the configuration for the specified class of the specified policy map.

shape

To specify average or peak rate traffic shaping, use the **shape** class-map configuration command. To remove traffic shaping, use the **no** form of this command,

shape {**average** | **peak**} *cir* [*bc*] [*be*]

no shape {**average** | **peak**} *cir* [*bc*] [*be*]

Syntax Description

average	Specifies average rate shaping.
peak	Specifies peak rate shaping.
cir	Specifies the committed information rate (CIR) in bits per second (bps).
bc	Specifies the Committed Burst rate in bits.
be	Specifies the Excess Burst rate in bits.

Defaults

No default behavior or values.

Command Modes

Class-map configuration within policy map

Command History

Release	Modification
12.1(2)T	This command was introduced.

Usage Guidelines

Traffic shaping limits the rate of transmission of data. In addition to using a specifically configured transmission rate, you can use generic traffic shaping (GTS) to specify a derived transmission rate based on the level of congestion.

You can specify two types of traffic shaping; average rate shaping and peak rate shaping. Average rate shaping limits the transmission rate to the CIR. Using the CIR ensures that the average amount of traffic being sent conforms to the rate expected by the network.

Peak rate shaping configures the router to send more traffic than the CIR. To determine the peak rate, the router uses the following formula:

peak rate = CIR(1+Be/Bc)

where:

- Be is the Excess Burst rate.
- Bc is the Committed Burst rate.

Peak rate shaping allows the router to burst higher than average rate shaping. However, using peak rate shaping, the traffic sent above the CIR (the delta) has the potential of being dropped if the network becomes congested.

If your network has additional bandwidth available (over the provisioned CIR) and the application or class can tolerate occasional packet loss, that extra bandwidth can be exploited through the use of peak rate shaping. However, there may be occasional packet drops when network congestion occurs. If the traffic being sent to the network must strictly conform to the configured network provisioned CIR, then you should use average traffic shaping.

Examples

The following example sets the uses average rate shaping to ensure a bandwidth of 256 kbps:

```
shape average 256000
```

The following example uses peak rate shaping to ensure a bandwidth of 300 kbps, but allow throughput up to 512 kbps if enough bandwidth is available on the interface:

```
bandwidth 300
shape peak 512000
```

Related Commands

Command	Description
bandwidth	Specifies or modifies the bandwidth allocated for a class belonging to a policy map.
class (policy map)	Specifies the name of the class whose policy you want to create or change, and the default class (commonly known as the class-default class) before you configure its policy.
policy-map	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
service-policy	Attaches a policy map to an input interface or VC, or an output interface or VC, to be used as the service policy for that interface or VC.
shape max-buffers	Specifies the maximum number of buffers allowed on shaping queues.

shape max-buffers

To specify the maximum number of buffers allowed on shaping queues, use the **shape max-buffers** class-map configuration command. To remove the maximum number of buffers, use the **no** form of this command.

shape max-buffers *number-of-buffers*

no shape max-buffers *number-of-buffers*

Syntax Description

number-of-buffers	Specifies the maximum number of buffers. The minimum number of buffers is 1, the maximum number of buffers is 4096.

Defaults

The default setting is 1000 buffers.

Command Modes

Class-map configuration within policy map

Command History

Release	Modification
12.1(2)T	This command was introduced.

Usage Guidelines

You can specify the maximum number of buffers allowed on shaping queues for each class configured to use generic traffic shaping (GTS).

Examples

The following example configures shaping and sets the maximum buffer limit to 100:

```
shape average 350000
shape max-buffers 100
```

Related Commands

Command	Description
bandwidth	Specifies or modifies the bandwidth allocated for a class belonging to a policy map.
class (policy map)	Specifies the name of the class whose policy you want to create or change, and the default class (commonly known as the class-default class) before you configure its policy.
policy-map	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
service-policy	Attaches a policy map to an input interface or VC, or an output interface or VC, to be used as the service policy for that interface or VC.
shape	Specifies average or peak rate traffic shaping.