



# WRED — Explicit Congestion Notification

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## Feature History

Release	Modification
12.2(8)T	This feature was introduced.

This document describes the WRED — Explicit Congestion Notification feature in Cisco IOS Release 12.2(8)T. It includes the following sections:

- [Feature Overview, page 1](#)
- [Supported Platforms, page 4](#)
- [Supported Standards, MIBs, and RFCs, page 5](#)
- [Prerequisites, page 5](#)
- [Configuration Tasks, page 6](#)
- [Configuration Examples, page 6](#)
- [Command Reference, page 8](#)

## Feature Overview

Currently, the congestion control and avoidance algorithms for Transmission Control Protocol (TCP) are based on the idea that packet loss is an appropriate indication of congestion on networks transmitting data using the best-effort service model. When a network uses the best-effort service model, the network delivers data if it can, without any assurance of reliability, delay bounds, or throughput. However, these algorithms and the best-effort service model are not suited to applications that are sensitive to delay or packet loss (for instance, interactive traffic including Telnet, web-browsing, and transfer of audio and video data). Weighted Random Early Detection (WRED), and by extension, Explicit Congestion Notification (ECN), helps to solve this problem.

RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*, states that with the addition of active queue management (for example, WRED) to the Internet infrastructure, routers are no longer limited to packet loss as an indication of congestion.

## How WRED Works

WRED makes early detection of congestion possible and provides a means for handling multiple classes of traffic. WRED can selectively discard lower priority traffic when the router begins to experience congestion and provide differentiated performance characteristics for different classes of service. It also protects against global synchronization. Global synchronization occurs as waves of congestion crest, only to be followed by periods of time during which the transmission link is not used to capacity. For these reasons, WRED is useful on any output interface or router where congestion is expected to occur.

WRED is implemented at the core routers of a network. Edge routers assign IP precedences to packets as the packets enter the network. With WRED, core routers then use these precedences to determine how to treat different types of traffic. WRED provides separate thresholds and weights for different IP precedences, enabling the network to provide different qualities of service, in regard to packet dropping, for different types of traffic. Standard traffic may be dropped more frequently than premium traffic during periods of congestion.

For more information about WRED, refer to the “Congestion Avoidance Overview” chapter of the *Cisco IOS Quality of Service Solutions Configuration Guide*, Release 12.2.

## ECN Extends WRED Functionality

WRED drops packets, based on the average queue length exceeding a specific threshold value, to indicate congestion. ECN is an extension to WRED in that ECN marks packets instead of dropping them when the average queue length exceeds a specific threshold value. When configured with the WRED — Explicit Congestion Notification feature, routers and end hosts would use this marking as a signal that the network is congested and slow down sending packets.

As stated in RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*, implementing ECN requires an ECN-specific field that has two bits—the ECN-capable Transport (ECT) bit and the CE (Congestion Experienced) bit—in the IP header. The ECT bit and the CE bit can be used to make four ECN field combinations of 00 to 11. The first number is the ECT bit and the second number is the CE bit. [Table 1](#) lists each of the ECT and CE bit combination settings in the ECN field and what the combinations indicate.

**Table 1**    *ECN Bit Setting*

ECT Bit	CE Bit	Combination Indicates
0	0	Not ECN-capable
0	1	Endpoints of the transport protocol are ECN-capable
1	0	Endpoints of the transport protocol are ECN-capable
1	1	Congestion experienced

The ECN field combination 00 indicates that a packet is not using ECN.

The ECN field combinations 01 and 10—called ECT(1) and ECT(0), respectively—are set by the data sender to indicate that the endpoints of the transport protocol are ECN-capable. Routers treat these two field combinations identically. Data senders can use either one or both of these two combinations. For more information about these two field combinations, and the implications of using one over the other, refer to RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*.

The ECN field combination 11 indicates congestion to the endpoints. Packets arriving a full queue of a router will be dropped.

## How Packets Are Treated When ECN Is Enabled

- If the number of packets in the queue is below the minimum threshold, packets are transmitted. This happens whether or not ECN is enabled, and this treatment is identical to the treatment a packet receives when WRED only is being used on the network.
- If the number of packets in the queue is between the minimum threshold and the maximum threshold, one of the following three scenarios can occur:
  - If the ECN field on the packet indicates that the endpoints are ECN-capable (that is, the ECT bit is set to 1 and the CE bit is set to 0, or the ECT bit is set to 0 and the CE bit is set to 1)—and the WRED algorithm determines that the packet should have been dropped based on the drop probability—the ECT and CE bits for the packet are changed to 1, and the packet is transmitted. This happens because ECN is enabled and the packet gets marked instead of dropped.
  - If the ECN field on the packet indicates that neither endpoint is ECN-capable (that is, the ECT bit is set to 0 and the CE bit is set to 0), the packet may be dropped based on the WRED drop probability. This is the identical treatment that a packet receives when WRED is enabled without ECN configured on the router.
  - If the ECN field on the packet indicates that the network is experiencing congestion (that is, both the ECT bit and the CE bit are set to 1), the packet is transmitted. No further marking is required.
- If the number of packets in the queue is above the maximum threshold, packets are dropped based on the drop probability. This is the identical treatment a packet receives when WRED is enabled without ECN configured on the router.

## For More Information

For more information about implementing ECN and about the changes required at the routers and end hosts, refer to the following RFCs:

- RFC 2309, *Internet Performance Recommendations*
- RFC 2884, *Performance Evaluation of Explicit Congestion Notification (ECN) in IP Networks*
- RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*

## Benefits

### Improved Method for Congestion Avoidance

This feature provides an improved method for congestion avoidance by allowing the network to mark packets for transmission later, rather than dropping them from the queue. Marking the packets for transmission later accommodates applications that are sensitive to delay or packet loss and provides improved throughput and application performance.

### Enhanced Queue Management

Currently, dropped packets indicate that a queue is full and the network is experiencing congestion. When a network experiences congestion, this feature allows networks to mark the IP header of a packet with a CE bit. This marking, in turn, triggers the appropriate congestion avoidance mechanism and

allows the network to better manage the data queues. With this feature, ECN-capable routers and end hosts can respond to congestion before a queue overflows and packets are dropped, providing enhanced queue management.

For more information on the benefits associated with ECN, refer to RFC 2309, *Internet Performance Recommendations*.

## Related Documents

- *Cisco IOS Quality of Service Solutions Configuration Guide*, Release 12.2
- *Cisco IOS Quality of Service Solutions Command Reference*, Release 12.2
- RFC 2309, *Internet Performance Recommendations*
- RFC 2884, *Performance Evaluation of Explicit Congestion Notification (ECN) in IP Networks*
- RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*

## Supported Platforms

- Cisco 805
- Cisco 806
- Cisco 820
- Cisco 828
- Cisco 1400 series
- Cisco 1600 series
- Cisco 1751
- Cisco 2420
- Cisco 3631
- Cisco 3725
- Cisco 3745
- Cisco 7100 series
- Cisco 7200 series
- Cisco 7500
- Cisco 7700
- Cisco CVA120 series
- Cisco MC3810
- Cisco uBR7200 series
- URM (Universal Route Module)

### Determining Platform Support Through Cisco Feature Navigator

Cisco IOS software is packaged in feature sets that support specific platforms. To get updated information regarding platform support for this feature, access Cisco Feature Navigator. Cisco Feature Navigator dynamically updates the list of supported platforms as new platform support is added for the feature.

Cisco Feature Navigator is a web-based tool that enables you to quickly determine which Cisco IOS software images support a specific set of features and which features are supported in a specific Cisco IOS image. You can search by feature or release. Under the release section, you can compare releases side by side to display both the features unique to each software release and the features in common.

To access Cisco Feature Navigator, you must have an account on Cisco.com. If you have forgotten or lost your account information, send a blank e-mail to [cco-locksmith@cisco.com](mailto:cco-locksmith@cisco.com). An automatic check will verify that your e-mail address is registered with Cisco.com. If the check is successful, account details with a new random password will be e-mailed to you. Qualified users can establish an account on Cisco.com by following the directions at <http://www.cisco.com/register>.

Cisco Feature Navigator is updated regularly when major Cisco IOS software releases and technology releases occur. For the most current information, go to the Cisco Feature Navigator home page at the following URL:

<http://www.cisco.com/go/fn>

## Supported Standards, MIBs, and RFCs

### Standards

No new or modified standards are supported by this feature.

### MIBs

No new or modified MIBs are supported by this feature.

To obtain lists of supported MIBs by platform and Cisco IOS release, and to download MIB modules, go to the Cisco MIB website on Cisco.com at the following URL:

<http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml>

### RFCs

- RFC 2309, *Internet Performance Recommendations*
- RFC 2884, *Performance Evaluation of Explicit Congestion Notification (ECN) in IP Networks*
- RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*

## Prerequisites

ECN must be configured through the Modular Quality of Service Command-Line Interface (MQC). For more information about MQC, refer to the “Modular Quality of Service Command-Line Interface” part of the *Cisco IOS Quality of Service Solutions Configuration Guide*, Release 12.2.

## Configuration Tasks

See the following sections for configuration tasks for the WRED — Explicit Congestion Notification feature. Each task in the list is identified as either required or optional.

- [Configuring Explicit Congestion Notification](#) (required)
- [Verifying the Explicit Congestion Notification Configuration](#) (optional)

## Configuring Explicit Congestion Notification

To configure ECN, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>policy-map</b> <i>policy-map-name</i>	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy. Enters QoS policy-map configuration mode.
Step 2	Router(config-pmap)# <b>class</b> <i>class-default</i>	Specifies the name of the class whose policy you want to create or change or specifies the default class (commonly known as the class-default class) before you configure its policy.
Step 3	Router(config-pmap)# <b>bandwidth</b> { <i>bandwidth-kbps</i>   <b>percent</b> <i>percent</i> }	Specifies or modifies the bandwidth (either in kbps or a percentage) allocated for a class belonging to a policy map. Enters policy-map class configuration mode.
Step 4	Router(config-pmap-c)# <b>random-detect</b>	Enables WRED or distributed WRED (dWRED).
Step 5	Router(config-pmap-c)# <b>random-detect</b> <i>ecn</i>	Enables ECN.

## Verifying the Explicit Congestion Notification Configuration

To verify the ECN configuration, use the following commands in EXEC or privileged EXEC mode, as needed:

Command	Purpose
Router# <b>show policy-map</b>	If ECN is enabled, displays ECN marking information for a specified policy map.
Router# <b>show policy-map interface</b>	If ECN is enabled, displays ECN marking information for a specified interface.

## Configuration Examples

This section provides the following configuration examples:

- [Enabling ECN Example](#)
- [Verifying the ECN Configuration Example](#)

## Enabling ECN Example

The following example enables ECN in the policy map called poll:

```
Router(config)# policy-map poll
Router(config-pmap)# class class-default
Router(config-pmap)# bandwidth per 70
Router(config-pmap-c)# random-detect
Router(config-pmap-c)# random-detect ecn
```

## Verifying the ECN Configuration Example

The following is sample output from the **show policy-map** command. The words “explicit congestion notification” (along with the ECN marking information) included in the output indicate that ECN has been enabled.

```
Router# show policy-map

Policy Map poll
Class class-default
  Weighted Fair Queueing
    Bandwidth 70 (%)
    exponential weight 9
    explicit congestion notification
    class      min-threshold  max-threshold  mark-probability
    -----
    -----
    0          -              -              1/10
    1          -              -              1/10
    2          -              -              1/10
    3          -              -              1/10
    4          -              -              1/10
    5          -              -              1/10
    6          -              -              1/10
    7          -              -              1/10
    rsvp      -              -              1/10
```

The following is sample output from the **show policy-map interface** command. The words “explicit congestion notification” included in the output indicate that ECN has been enabled.

```
Router# show policy-map interface Serial4/1

Serial4/1

Service-policy output:policy_ecn
Class-map:precl (match-all)
  1000 packets, 125000 bytes
  30 second offered rate 14000 bps, drop rate 5000 bps
Match:ip precedence 1
  Weighted Fair Queueing
    Output Queue:Conversation 42
    Bandwidth 20 (%)
    Bandwidth 100 (kbps)
    (pkts matched/bytes matched) 989/123625
    (depth/total drops/no-buffer drops) 0/455/0
    exponential weight:9
    explicit congestion notification
    mean queue depth:0
```

class	Transmitted pkts/bytes	Random drop pkts/bytes	Tail drop pkts/bytes	Minimum threshold	Maximum threshold	Mark probability
0	0/0	0/0	0/0	20	40	1/10
1	545/68125	0/0	0/0	22	40	1/10
2	0/0	0/0	0/0	24	40	1/10
3	0/0	0/0	0/0	26	40	1/10
4	0/0	0/0	0/0	28	40	1/10
5	0/0	0/0	0/0	30	40	1/10
6	0/0	0/0	0/0	32	40	1/10
7	0/0	0/0	0/0	34	40	1/10
rsvp	0/0	0/0	0/0	36	40	1/10

class	ECN Mark pkts/bytes
0	0/0
1	43/5375
2	0/0
3	0/0
4	0/0
5	0/0
6	0/0
7	0/0
rsvp	0/0

## Command Reference

This section documents new and modified commands. All other commands used with this feature are documented in the Cisco IOS Release 12.2 command reference publications.

### New Commands

- [random-detect ecn](#)

### Modified Commands

- [show policy-map](#)
- [show policy-map interface](#)

# random-detect ecn

To enable explicit congestion notification (ECN), use the **random-detect ecn** command in policy-map class configuration mode. To disable ECN, use the **no** form of this command.

**random-detect ecn**

**no random-detect ecn**

**Syntax Description** This command has no arguments or keywords.

**Defaults** By default, ECN is disabled.

**Command Modes** Policy-map class configuration

Command History	Release	Modification
	12.2(8)T	This command was introduced.

**Usage Guidelines** If ECN is enabled, ECN can be used whether WRED is based on the IP precedence value or the differentiated services code point (DSCP) value.

**Examples** The following example enables ECN in a policy map called poll1:

```
Router(config)# policy-map poll1
Router(config-pmap)# class class-default
Router(config-pmap)# bandwidth per 70
Router(config-pmap-c)# random-detect
Router(config-pmap-c)# random-detect ecn
```

Related Commands	Command	Description
	<b>show policy map</b>	Displays the configuration of all classes for a specified service policy map or all classes for all existing policy maps.
	<b>show policy-map interface</b>	Displays the configuration of all classes configured for all service policies on the specified interface or displays the classes for the service policy for a specific PVC on the interface.

# show policy-map

To display the configuration of all classes for a specified service policy map or all classes for all existing policy maps, use the **show policy-map** command in EXEC or privileged EXEC mode.

```
show policy-map [policy-map]
```

<b>Syntax Description</b>	<i>policy-map</i>	(Optional) Name of the service policy map whose complete configuration is to be displayed.
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**Defaults** All existing policy map configurations are displayed.

**Command Modes** EXEC or privileged EXEC

<b>Command History</b>	<b>Release</b>	<b>Modification</b>
	12.0(5)T	This command was introduced.
	12.0(5)XE	This command was integrated into Cisco IOS Release 12.0(5)XE.
	12.0(7)S	This command was integrated into Cisco IOS Release 12.0(7)S.
	12.1(1)E	This command was integrated into Cisco IOS Release 12.1(1)E.
	12.2(4)T	This command was modified for the Two-Rate Policer. It now can display burst parameters and associated actions.
	12.2(8)T	This command was modified for the WRED — Explicit Congestion Notification (ECN) feature. It can now display ECN marking information.

**Usage Guidelines** The **show policy-map** command displays the configuration of a service policy map created using the **policy-map** command. You can use the **show policy-map** command to display all class configurations comprising any existing service policy map, whether or not that service policy map has been attached to an interface.

The **show policy-map** command will display ECN marking information only if ECN is enabled on the interface.

**Examples**

The following is sample output from the **show policy-map** command. The words “explicit congestion notification” (along with the ECN marking information) included in the output indicate that ECN has been enabled.

```
Router# show policy-map

Policy Map poll
Class class-default
  Weighted Fair Queueing
  Bandwidth 70 (%)
  exponential weight 9
  explicit congestion notification
  class      min-threshold  max-threshold  mark-probability
  -----
  -----
  0          -             -             1/10
  1          -             -             1/10
  2          -             -             1/10
  3          -             -             1/10
  4          -             -             1/10
  5          -             -             1/10
  6          -             -             1/10
  7          -             -             1/10
  rsvp      -             -             1/10
```

Table 2 describes the significant fields shown in this display.

**Table 2** show policy-map Field Descriptions

Field	Description
explicit congestion notification	Indication that Explicit Congestion Notification is enabled.
class	IP precedence value.
min-threshold	Minimum threshold. Minimum WRED threshold in number of packets.
max-threshold	Maximum threshold. Maximum WRED threshold in number of packets.
mark-probability	Fraction of packets dropped when the average queue depth is at the maximum threshold.

**Related Commands**

Command	Description
<b>policy-map</b>	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>random-detect ecn</b>	Enables ECN.
<b>show policy-map class</b>	Displays the configuration for the specified class of the specified policy map.
<b>show policy-map interface</b>	Displays the configuration of all classes configured for all service policies on the specified interface or displays the classes for the service policy for a specific PVC on the interface.

## show policy-map interface

To display the configuration of all classes configured for all service policies on the specified interface or to display the classes for the service policy for a specific permanent virtual circuit (PVC) on the interface, use the **show policy-map interface** command in EXEC or privileged EXEC mode.

```
show policy-map interface interface-name [vc [vpi] vci][dcli dcli]
```

Syntax	Description
<i>interface-name</i>	Name of the interface or subinterface whose policy configuration is to be displayed.
<b>vc</b>	(Optional) For ATM interfaces only, shows the policy configuration for a specified PVC. The name can be up to 16 characters long.
<i>vpi</i>	(Optional) ATM network virtual path identifier (VPI) for this PVC. The absence of the “/” and a <i>vpi</i> value defaults the <i>vpi</i> value to 0.  On the Cisco 7200 and 7500 series routers, this value ranges from 0 to 255.  The <i>vpi</i> and <i>vci</i> arguments cannot both be set to 0; if one is 0, the other cannot be 0.  If this value is omitted, information for all VCs on the specified ATM interface or subinterface is displayed.
<i>vci</i>	(Optional) ATM network virtual channel identifier (VCI) for this PVC. This value ranges from 0 to 1 less than the maximum value set for this interface by the <b>atm vc-per-vc</b> command. Typically, lower values 0 to 31 are reserved for specific traffic (F4 Operation, Administration, and Maintenance (OAM), switched virtual circuit (SVC) signaling, Integrated Local Management Interface (ILMI), and so on) and should not be used.  The VCI is a 16-bit field in the header of the ATM cell. The VCI value is unique only on a single link, not throughout the ATM network, because it has local significance only.  The <i>vpi</i> and <i>vci</i> arguments cannot both be set to 0; if one is 0, the other cannot be 0.
<b>dcli</b>	(Optional) Indicates a specific PVC for which policy configuration will be displayed.
<i>dcli</i>	(Optional) A specific data-link connection identifier (DLCI) number used on the interface. Policy configuration for the corresponding PVC will be displayed when a DLCI is specified.

**Defaults** This command has no default behavior or values.

**Command Modes** EXEC or privileged EXEC

Command History	Release	Modification
	12.0(5)T	This command was introduced.
	12.0(5)XE	This command was integrated into Cisco IOS Release 12.0(5)XE.
	12.0(7)S	This command was integrated into Cisco IOS Release 12.0(7)S.
	12.1(1)E	This command was integrated into Cisco IOS Release 12.1(1)E.
	12.1(2)T	This command was integrated into Cisco IOS Release 12.1(2)T. This command was modified to display information about the policy for all Frame Relay PVCs on the interface, or, if a DLCI is specified, the policy for that specific PVC. This command was also modified to display the total number of packets marked by the QoS set action.
	12.1(3)T	This command was integrated into Cisco IOS Release 12.1(3)T. This command was modified to display per-class accounting statistics.
	12.2(4)T	This command was modified for the Two-Rate Policer. It now can display burst parameters and associated actions.
	12.2(8)T	This command was modified for the WRED — Explicit Congestion Notification (ECN) feature. It can now display ECN marking information.

### Usage Guidelines

The **show policy-map interface** command displays the configuration for classes on the specified interface or the specified PVC only if a service policy has been attached to the interface or the PVC. You can use the *interface-name* argument to display output for a PVC only for Enhanced ATM port adapters (PA-A3) that support per-VC queueing.

The counters displayed after the **show policy-map interface** command is entered are updated only if congestion is present on the interface.

The **show policy-map interface** command displays ECN marking information only if ECN is enabled on the interface.

### Examples

The following is sample output from the **show policy-map interface** command. The words “explicit congestion notification” included in the output indicate that ECN has been enabled.

```
Router# show policy-map interface Serial4/1

Serial4/1

Service-policy output:policy_ecn
Class-map:precl (match-all)
  1000 packets, 125000 bytes
  30 second offered rate 14000 bps, drop rate 5000 bps
Match:ip precedence 1
Weighted Fair Queueing
  Output Queue:Conversation 42
  Bandwidth 20 (%)
  Bandwidth 100 (kbps)
  (pkts matched/bytes matched) 989/123625
  (depth/total drops/no-buffer drops) 0/455/0
  exponential weight:9
  explicit congestion notification
  mean queue depth:0
```

```
show policy-map interface
```

```

class Transmitted Random drop Tail drop Minimum Maximum Mark
      pkts/bytes   pkts/bytes   pkts/bytes threshold threshold probability
  0      0/0        0/0         0/0         20         40         1/10
  1    545/68125   0/0         0/0         22         40         1/10
  2      0/0        0/0         0/0         24         40         1/10
  3      0/0        0/0         0/0         26         40         1/10
  4      0/0        0/0         0/0         28         40         1/10
  5      0/0        0/0         0/0         30         40         1/10
  6      0/0        0/0         0/0         32         40         1/10
  7      0/0        0/0         0/0         34         40         1/10
 rsvp    0/0        0/0         0/0         36         40         1/10

class ECN Mark
      pkts/bytes
  0      0/0
  1    43/5375
  2      0/0
  3      0/0
  4      0/0
  5      0/0
  6      0/0
  7      0/0
 rsvp    0/0

```

Table 3 describes the fields associated with the WRED — Explicit Congestion Notification feature shown in this display. For more information about the other fields shown in this display, refer to the documentation for the **show policy-map interface** command in the *Cisco IOS Quality of Service Command Reference*, Release 12.2.

**Table 3** *show policy-map interface Field Descriptions*

Field	Description
explicit congestion notification	Indication that Explicit Congestion Notification is enabled.
mean queue depth	Average queue depth based on the actual queue depth on the interface and the exponential weighting constant. It is a moving average. The minimum and maximum thresholds are compared against this value to determine drop decisions.
class	IP precedence value.
Transmitted pkts/bytes	Number of packets (also shown in bytes) transmitted.
Random drop pkts/bytes	Number of packets (also shown in bytes) randomly dropped when the mean queue depth is between the minimum threshold value and the maximum threshold value for the specified IP precedence value.
Tail drop pkts/bytes	Number of packets dropped when the mean queue depth is greater than the maximum threshold value for the specified IP precedence value.
Minimum threshold	Minimum WRED threshold in number of packets.
Maximum threshold	Maximum WRED threshold in number of packets.
Mark probability	Fraction of packets dropped when the average queue depth is at the maximum threshold.
ECN Mark pkts/bytes	Number of packets (also shown in bytes) marked by ECN.

Related Commands	Command	Description
	<a href="#">random-detect ecn</a>	Enables ECN.
	<a href="#">show frame-relay pvc</a>	Displays statistics about PVCs for Frame Relay interfaces.
	<a href="#">show policy-map</a>	Displays the configuration of all classes for a specified service policy map or all classes for all existing policy maps.
	<a href="#">show policy-map class</a>	Displays the configuration for the specified class of the specified policy map.

■ show policy-map interface