Implement QoS Policies with Differentiated Services Code Point

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Introduction

This document describes how to set the Differentiated Services Code Point (DSCP) values in Quality of Service (QoS) configurations on a Cisco router.

Prerequisites

Requirements

You must be familiar with the fields in the IP header and Cisco IOS® CLI.

Components Used

This document is not restricted to specific software and hardware versions.

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, ensure that you understand the potential impact of any command.

Conventions

For more information on document conventions, refer to Cisco Technical Tips Conventions.

Background Information

Differentiated Services (DiffServ) is an architecture in which network nodes apply differentiated per-hop treatment based on the Differentiated Services (DS) field. Defined in RFC 2474 and RFC 2475, the DiffServ standard supersedes the original specification to define packet priority described in RFC 791. RFC 2474 redefines the IPv4 Type of Service (ToS) octet as the DS field and assigns its six most significant bits to the Differentiated Services Code Point (DSCP).

The DiffServ architecture defines the DiffServ (DS) field, which supersedes the ToS field in IPv4 to make per-hop behavior (PHB) decisions about packet classification and traffic conditioning functions, such as metering, marking, shaping, and policing.

The RFCs do not dictate the way to implement PHBs; this is the responsibility of the vendor. Cisco implements queuing techniques that can base their PHB on the IP precedence or DSCP value in the IP header of a packet. Based on DSCP or IP precedence, traffic can be put into a particular service class. Packets within a service class are treated the same way.



Note: Some methods and technologies referenced in this document, including Committed Access Rate (CAR), Priority Queuing (PQ), Custom Queuing (CQ), interface-based Weighted Fair Queuing (WFQ), Frame Relay QoS, and IP-precedence-based classification, are considered legacy on current Cisco platforms. This content is retained to provide foundational DSCP concepts and historical implementation context.

For current deployments, review Modular QoS CLI (MQC), class-based policing, Class-Based Weighted Fair Queuing (CBWFQ), Low-Latency Queuing (LLQ), and DSCP-based WRED. Verify feature availability and command syntax in the configuration guide for the target platform and software release.

Differentiated Services Code Point

The six most significant bits of the DS field form the DSCP. RFC 2474 initially designated the two least significant bits as Currently Unused (CU), and RFC 3168 defines those bits as the Explicit Congestion Notification (ECN) field. Routers at the edge of the network classify packets and mark them with either the IP Precedence or DSCP value in a Diffserv network. Other network devices in the core that support Diffserv use the DSCP value in the IP header to select a PHB behavior for the packet and provide the appropriate QoS treatment.

The diagrams in this section show a comparison between the ToS byte defined by RFC 791 and the DiffServ field.

ToS Byte

P2	P1	P0	T2	T1	T0	CU1	CU0

- IP precedence—three bits (P2 to P0)
- Delay, Throughput and Reliability—three bits (T2 to T0)
- CU (Currently Unused)—two bits(CU1-CU0)

DiffServ Field

DS5	DS4	DS3	DS2	DS1	DS0	ECN	ECN

- DSCP—six bits (DS5-DS0)
- ECN—two bits

The standardized DiffServ field of the packet is marked with a value so the packet receives a particular forwarding treatment or PHB, at each network node.

The default DSCP is 000 000 and class selector DSCPs are values that are backward compatible with IP precedence. When you convert between IP precedence and DSCP, match the three most significant bits. In other words:

```
<#root>
IP Prec
5
 (101) maps to IP DSCP 101 000
```

ToS Byte

1	0	1	T2	T1	T0	CU2	CU0

DiffServ Field

1	0	1	0	0	0	ECN	ECN

The DiffServ standard utilizes the same precedence bits (the most significant bits—DS5, DS4 and DS3) for priority setting, but further clarifies the definitions, which provides finer granularity through the use of the next three bits in the DSCP. DiffServ reorganizes and renames the precedence levels (still defined by the three most significant bits of the DSCP) into these categories (the levels are explained in greater detail in this document):

Precedence Level	Description
7	Stays the same (link layer and routing protocol keep alive)
6	Stays the same (used for IP routing protocols)
5	Express Forwarding (EF)
4	Class 4
3	Class 3
2	Class 2
1	Class 1
0	Best effort

With this system, a device prioritizes traffic by class first. Then it differentiates and prioritizes same-class traffic, and takes the drop probability into account.

The DiffServ standard does not specify a precise definition of low, medium, and high drop probability. Not all devices recognize the DiffServ (DS2 and DS1) settings; and even when these settings are recognized, they do not necessarily trigger the same PHB forwarding action at each network node. Each node implements its own response based on how it is configured.

Assured Forwarding

RFC 2597 defines the assured forwarding (AF) PHB and describes it as a means for a provider DS domain to offer different levels of forwarding assurances for IP packets received from a client DS domain. The Assured Forwarding PHB guarantees a certain amount of bandwidth to an AF class and allows access to extra bandwidth, if available. There are four AF classes, AF1x through AF4x. Within each class, there are three drop probabilities. Contingent on a given network policy, packets can be selected for a PHB based on required throughput, delay, jitter, loss, or by priority of access to network services.

Classes 1 to 4 are referred to as AF classes. This table illustrates the DSCP code that specifies the AF class with the probability. Bits DS5, DS4 and DS3 define the class; bits DS2 and DS1 specify the drop probability; bit DS0 is always zero.

Drop	Class 1	Class 2	Class 3	Class 4
Low	001010 AF11 DSCP 10	010010 AF21 DSCP 18	011010 AF31 DSCP 26	100010 AF41 DSCP 34
Medium	001100 AF12 DSCP 12	010100 AF 22 DSCP 20	011100 AF32 DSCP 28	100100 AF42 DSCP 36
High	001110 AF13 DSCP 14	010110 AF23 DSCP 22	011110 AF33 DSCP 30	100110 AF43 DSCP 38

Expedited Forwarding

RFC 3246, which obsoletes RFC 2598, defines the Expedited Forwarding (EF) PHB. The EF PHB can be used to build a low loss, low latency, low jitter, assured bandwidth, end-to-end service through DS (Diffserv) domains. This service appears to the endpoints like a point-to-point connection or a virtual leased line. This service has also been described as a Premium service. The recommended EF codepoint is binary 101110, which corresponds to DSCP 46.

Again, vendor-specific mechanisms must be configured to implement these PHBs. Refer to RFC 3246 for more information on EF PHB.

Use the DSCP Field

There are three ways you can use the DSCP field:

- **Classifier**: Select a packet based on the contents of some portions of the packet header and apply PHB based on service characteristic defined by the DSCP value.
- **Marker**: Set the DSCP field based on the traffic profile.

- Metering: Check compliance to the traffic profile with either a shaper or dropper function.

Cisco IOS software considers the precedence bits of the ToS field if there is traffic that is queued in Weighted Fair Queuing (WFQ), Weighted Random Early Detection (WRED) or Weighted Round Robin (WRR). The precedence bits are not considered when Policy Routing, Priority Queuing (PQ), Custom Queuing (CQ), or Class Based Weighted Fair Queuing (CBWFQ) are configured. For more information, see Class Based Weighted Fair Queuing (CBWFQ)

Packet Classification

Packet classification involves the use of a traffic descriptor to categorize a packet within a specific group and to make the packet accessible for the QoS that manages in the network. When you use packet classification, you can partition network traffic into multiple priority levels or a class of service (CoS).

You can use either access control lists (ACLs) or run the **match** command in the modular QoS CLI to match DSCP values. The Cisco IOS Software Release 12.1(5)T introduced the ability to select a DSCP value in the match command.

```
<#root>

Router1(config)#

access-list 101 permit ip any any ?

dscp       Match packets with given dscp value
fragments  Check non-initial fragments
log        Log matches against this entry
log-input  Log matches against this entry, including input interface
precedence Match packets with given precedence value
time-range Specify a time-range
tos        Match packets with given TOS value
```

When you specify the IP dscp value in the **class map** command, you have:

```
<#root>

Router(config)#

class-map match-all VOIP


 1751-uut1(config-cmap)#

match ip dscp ?


   <0-63>   Differentiated services codepoint value
```

```
  af11     Match packets with AF11 dscp (001010)
  af12     Match packets with AF12 dscp (001100)
  af13     Match packets with AF13 dscp (001110)
  af21     Match packets with AF21 dscp (010010)
  af22     Match packets with AF22 dscp (010100)
  af23     Match packets with AF23 dscp (010110)
  af31     Match packets with AF31 dscp (011010)
  af32     Match packets with AF32 dscp (011100)
  af33     Match packets with AF33 dscp (011110)
  af41     Match packets with AF41 dscp (100010)
  af42     Match packets with AF42 dscp (100100)
  af43     Match packets with AF43 dscp (100110)
  cs1      Match packets with CS1(precedence 1) dscp (001000)
  cs2      Match packets with CS2(precedence 2) dscp (010000)
  cs3      Match packets with CS3(precedence 3) dscp (011000)
  cs4      Match packets with CS4(precedence 4) dscp (100000)
  cs5      Match packets with CS5(precedence 5) dscp (101000)
  cs6      Match packets with CS6(precedence 6) dscp (110000)
  cs7      Match packets with CS7(precedence 7) dscp (111000)
  default  Match packets with default dscp (000000)
  ef       Match packets with EF dscp (101110)
 Router1(config-cmap)#
```

```
match ip dscp af31
```

Marking

The DSCP can be set to a desired value at the edge of the network to allow for core devices to classify the packet as shown in the Packet Classification section and provide a suitable level of service. Class-Based Packet Marking can be used to set the DSCP value:

```
policy-map pack-multimedia-5M

!--- Creates a policy map named pack-multimedia-5M.

  class management

!--- Specifies the policy to be created for the !--- traffic classified by class management.

    bandwidth 50
    set ip dscp 8

!--- Sets the DSCP value of the packets matching !--- class management to 8.

  class C1
    priority 1248
    set ip dscp 40
  class voice-signalling
    bandwidth 120
    set ip dscp 24
```

Use Committed Access Rate or Class-Based Policing

Committed Access Rate and Class-Based Policing are traffic regulation mechanisms, used to regulate traffic flow to conform with the agreed upon service parameters. These mechanisms along with DSCP can be used to provide different levels of service that do not and do conform to traffic when it appropriately modifies the DSCP value, as shown in this section.

Refer to Configuring Traffic Policing and Comparing Class-Based Policing and Committed Access Rate for more information.

```
interface Serial1/0.1 point-to-point
 bandwidth 5000
 ip address 192.168.126.134 255.255.255.252
rate-limit output access-group 150 8000 1500 2000 conform-action
  set-dscp-transmit 10 exceed-action set-dscp-transmit 20

!--- For traffic matching access list 150, sets the DSCP value of conforming traffic !--- to 10 ar

rate-limit output access-group 152 8000 1500 2000 conform-action
  set-dscp-transmit 15 exceed-action set-dscp-transmit 25
rate-limit output access-group 154 8000 1500 2000 conform-action
  set-dscp-transmit 18 exceed-action set-dscp-transmit 28
frame-relay interface-dlci 17
class shaper-multimedia-5M
```

DSCP-Compliant WRED

Weighted Random Early Detection (WRED), selectively discards lower-priority traffic when the interface begins to get congested. WRED can provide differentiated performance characteristics for different CoS. This differentiated service can be on basis of the DSCP:

```
class C2
 bandwidth 1750
 random-detect dscp-based

!--- Enable dscp-based WRED as drop policy.

 random-detect exponential-weighting-constant 7

!--- Specifies the exponential weight factor for the !--- average queue size calculation for the c
```

```
 random-detect dscp 16 48 145 10

!--- Specifies the minimum and maximum queue thresholds !--- for each DSCP value.

 random-detect dscp 32 145 435 10
```

Refer to the DiffServ Compliant WRED section of Congestion Avoidance Overview for more information.

Related Information

- Technical Support - Cisco Systems
- QoS: Congestion Avoidance Configuration Guide