Quality-of-Service
The Differentiated Services Model

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The Challenge

Organizations delivering network-based services need powerful end-to-end solutions to effectively and predictably deliver the differing Quality-of-Service (QoS) requirements of voice, video, and data applications. Voice, for example, requires a small but assured amount of bandwidth, low delay, low jitter and low packet loss. A data application such as File Transfer Protocol (FTP) needs more bandwidth, but can tolerate the delay and jitter.

The Solution

Cisco IOS® Software DiffServ offers application-level QoS and traffic management in an architecture that incorporates mechanisms to control bandwidth, delay, jitter and packet loss. Cisco Diffserv complements the Cisco IntServ offering by providing a more scalable architecture for end-to-end QoS. This scalability is achieved by the mechanisms controlling QoS at an aggregate level. Application traffic can be categorized into multiple classes (aggregates), with QoS parameters defined for each class. A typical arrangement would be to categorize traffic into premium, gold, silver, bronze, and best-effort classes.

Standards-Based

Cisco IOS Software DiffServ is fully compliant with the Internet Engineering Task Force (IETF) standards defined in RFC 2474, RFC 2475, RFC 2597 and RFC 2598. This solution leverages the new IETF definition of the IPv4 Type of Service (ToS) octet in the IP packet-header by utilizing the Differentiated Services Code Point (DSCP) field to classify packets into any of the 64 possible classes. When the packets are classified, IETF-defined Per-Hop Behaviors (PHBs) including Assured Forwarding (AF) and Expedited Forwarding (EF) are implemented using Cisco QoS tool sets. Traffic that is characterized as EF will receive the lowest latency, jitter and assured bandwidth services which is suitable for applications such as Voice over IP (VoIP). AF allows carving out the bandwidth between multiple classes in a network according to desired policies. As a value-add, this implementation also allows a construction of user-defined PHBs, beyond the scope of AF and EF. DSCP code points other than the ones reserved for AF, EF and best effort service can be associated with an arbitrary PHB.

Cisco IOS Software: Quality-of-Service Applications

In the Enterprise environment, QoS policies must allow critical business applications to receive requisite resources, while ensuring other applications are not neglected. By classifying the application traffic into premium, gold, silver and other classes, a baseline methodology is set to provide end-to-end QoS. Diffserv enables this classification by utilizing the DSCP field. Using Cisco DiffServ, a properly designed network can deliver assured bandwidth, low latency, low jitter and packet loss for voice while simultaneously ensuring slices of available bandwidth to other classes.

Service Providers want to provide value-added services to their customers by providing blanket Service Level Agreements (SLAs), as well as application-specific assurances (aSLAs). It is possible, for example, to divide a customer's traffic at the network edge into gold, silver, and bronze classes (also referred to as olympic service) and provide relative / absolute assurances to each. Cisco also provides for mapping the per-class IP QoS requirements into Asynchronous Transfer Mode (ATM) Classification on Flows (CoS) parameters, providing mechanisms both at the edge and the core. Within the Service Provider network, Cisco enables end-to-end QoS, via Multi Protocol Label Switching (MPLS)-Diffserv. MPLS could also be used as a reference mechanism to translate the IP QoS to MPLS QoS.

Architectural Components

Packet Classification

Packets entering a DiffServ domain or region (collection of DiffServ routers) can be classified in a variety of ways—from IP source and destination addresses, Layer 4 protocol and port numbers, incoming interface, MAC address, IP precedence, the DSCP value, Layer 2 information (such as frame-relay DE bits, Ethernet 802.1p bits), and the Cisco value-added mechanism Network Based Application Recognition (NBAR). Once these packets are classified on the basis of the criteria mentioned above, they can be processed, conditioned and marked. Packet classification and other mechanisms can all be performed within the Cisco Modular QoS CLI (MQC), a modular technique to separate packet classification from the policy applied to the classes, from the application of the policy on an interface or sub-interface.

Packet Marking

The IPv4 Type of Service (ToS) octet has been redefined from the 3-bit IP-precedence to a 6-bit DSCP field (Figure 1). Packets can be marked with an arbitrary DSCP value / standard values, corresponding to the appropriate AF (Figure 2), EF or user defined class. For example, EF is designated by the codepoint "101110". Cisco IOS Software also supports class-selector codepoints, which is a method of marking the 6 DSCP bits that are compatible with systems that only support the IP-precedence scheme. These codepoints are in the form of "xyz000", where x, y, and z can represent a 1 or 0. The codepoint for best-effort traffic will be set to "000000". This implementation brings additional value-add by also allowing packets to be marked with an arbitrary DSCP, and mapping them to a locally significant (non-AF/EF/default) PHB. This allows for construction of new and previously unavailable services.

Figure 1. DiffServ Codepoint Field

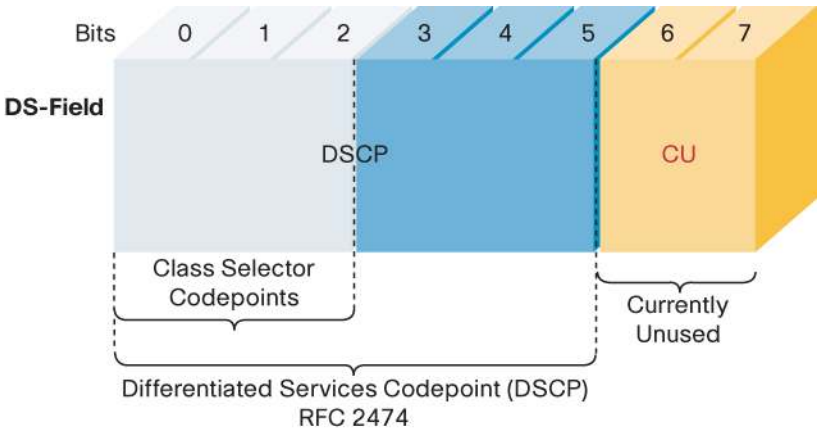

Figure 2. The Original IPv4 ToS Byte

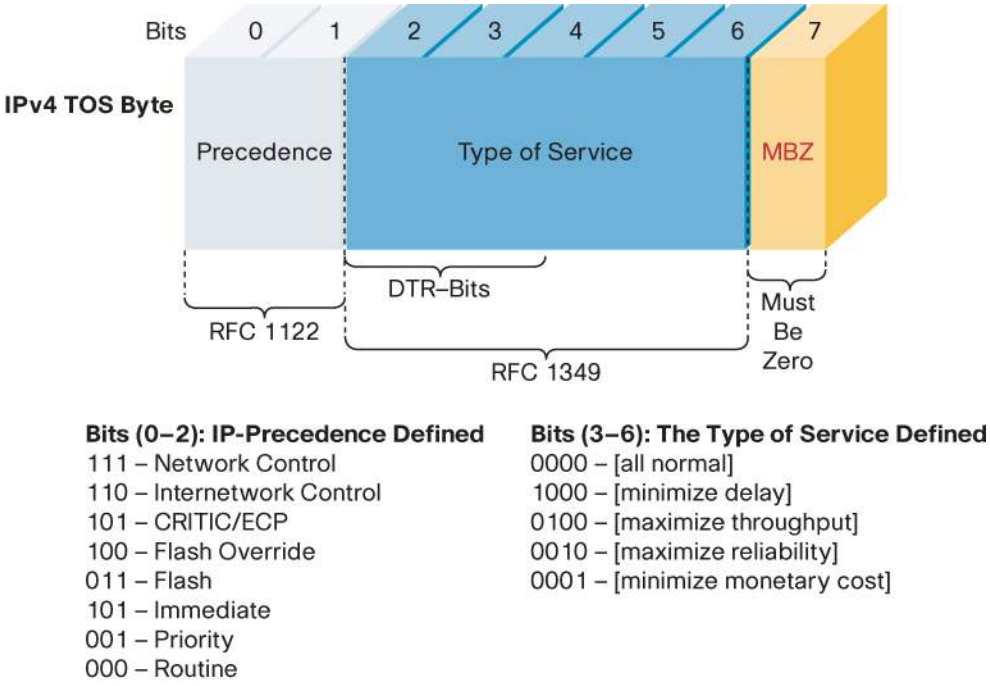

Table 1. DiffServ AF Codepoint Table

DROP Precedence	Class #1	Class #2	Class #3	Class #4
Low Drop Precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
Medium Drop Precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
High Drop Precedence	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

Traffic Conditioning

At the edge of the network, this component is logically responsible for classifying, marking, metering, and shaping or policing the packets entering the network. In the Cisco IOS Diffserv model, classification and marking are done using the MQC. Metering is done using a token bucket algorithm, shaping is done using class-based traffic shaping or class-based frame relay traffic shaping and policing is done using class-based policing. On the value add side, Cisco also provides for the per-class accounting Management Information Base (MIB) and statistics for each class (regardless of congestion) can be gathered for management purposes.

Policy/PHB Enforcing

As the packet leaves the Ingress Router, and enters the network core, PHBs are enforced, depending on the packet marking, with the appropriate DSCP. EF can be implemented using Low Latency Queueing (LLQ). AFxy PHBs can be implemented using Class Based Weighted Fair Queuing (CBWFQ) and Weighted Random Early Detect (WRED), Class Based Policing, or Class Based Traffic Shaping (CBTS). Locally defined PHBs can also be constructed using the same tools—LLQ, CBWFQ, and WRED.

Table 2. Key Cisco IOS Diffserv Features and Benefits

Features	Benefits
Full IETF Compliancy	Standards based QoS that can be applied end-to-end
Packet Classifications via DSCP	Scalability—Fewer states are stored at the core of the network
Standard and User Defined PHBs	End-to-end construction of well-defined services for applications
Modular QoS CLI	Granular traffic control and flexible management
AF,EF and Arbitrary Classes	Flexible classification and service offerings

Software Support

Cisco IOS Software Release 12.1(5) T and later versions

Additional Information

Additional information about Cisco IOS QoS technology can be found at http://www.cisco.com or by contacting your local Cisco representative.

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
Cisco Systems International BV
Amsterdam, The Netherlands

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