Network Working Group
Request for Comments: 2597
Category: Standards Track

J. Heinanen
Telia Finland
F. Baker
Cisco Systems
W. Weiss
Lucent Technologies
J. Wroclawski
MIT LCS

June 1999

Assured Forwarding PHB Group

Status of this Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

This document defines a general use Differentiated Services (DS) [Blake] Per-Hop-Behavior (PHB) Group called Assured Forwarding (AF). The AF PHB group provides delivery of IP packets in four independently forwarded AF classes. Within each AF class, an IP packet can be assigned one of three different levels of drop precedence. A DS node does not reorder IP packets of the same microflow if they belong to the same AF class.

1. Purpose and Overview

There is a demand to provide assured forwarding of IP packets over the Internet. In a typical application, a company uses the Internet to interconnect its geographically distributed sites and wants an assurance that IP packets within this intranet are forwarded with high probability as long as the aggregate traffic from each site does not exceed the subscribed information rate (profile). It is desirable that a site may exceed the subscribed profile with the understanding that the excess traffic is not delivered with as high probability as the traffic that is within the profile. It is also important that the network does not reorder packets that belong to the same microflow, as defined in [Nichols], no matter if they are in or out of the profile.

Assured Forwarding (AF) PHB group is a means for a provider DS domain to offer different levels of forwarding assurances for IP packets received from a customer DS domain. Four AF classes are defined, where each AF class is in each DS node allocated a certain amount of forwarding resources (buffer space and bandwidth). IP packets that wish to use the services provided by the AF PHB group are assigned by the customer or the provider DS domain into one or more of these AF classes according to the services that the customer has subscribed to. Further background about this capability and some ways to use it may be found in [Clark].

Within each AF class IP packets are marked (again by the customer or the provider DS domain) with one of three possible drop precedence values. In case of congestion, the drop precedence of a packet determines the relative importance of the packet within the AF class. A congested DS node tries to protect packets with a lower drop precedence value from being lost by preferably discarding packets with a higher drop precedence value.

In a DS node, the level of forwarding assurance of an IP packet thus depends on (1) how much forwarding resources has been allocated to the AF class that the packet belongs to, (2) what is the current load of the AF class, and, in case of congestion within the class, (3) what is the drop precedence of the packet.

For example, if traffic conditioning actions at the ingress of the provider DS domain make sure that an AF class in the DS nodes is only moderately loaded by packets with the lowest drop precedence value and is not overloaded by packets with the two lowest drop precedence values, then the AF class can offer a high level of forwarding assurance for packets that are within the subscribed profile (i.e., marked with the lowest drop precedence value) and offer up to two lower levels of forwarding assurance for the excess traffic.

This document describes the AF PHB group. An otherwise DS-compliant node is not required to implement this PHB group in order to be considered DS-compliant, but when a DS-compliant node is said to implement an AF PHB group, it must conform to the specification in this document.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [Bradner].

2. The AF PHB Group

Assured Forwarding (AF) PHB group provides forwarding of IP packets in N independent AF classes. Within each AF class, an IP packet is assigned one of M different levels of drop precedence. An IP packet that belongs to an AF class i and has drop precedence j is marked with the AF codepoint AFij, where 1 <= i <= N and 1 <= j <= M. Currently, four classes (N=4) with three levels of drop precedence in each class (M=3) are defined for general use. More AF classes or levels of drop precedence MAY be defined for local use.

A DS node SHOULD implement all four general use AF classes. Packets in one AF class MUST be forwarded independently from packets in another AF class, i.e., a DS node MUST NOT aggregate two or more AF classes together.

A DS node MUST allocate a configurable, minimum amount of forwarding resources (buffer space and bandwidth) to each implemented AF class. Each class SHOULD be serviced in a manner to achieve the configured service rate (bandwidth) over both small and large time scales.

An AF class MAY also be configurable to receive more forwarding resources than the minimum when excess resources are available either from other AF classes or from other PHB groups. This memo does not specify how the excess resources should be allocated, but implementations MUST specify what algorithms are actually supported and how they can be parameterized.

Within an AF class, a DS node MUST NOT forward an IP packet with smaller probability if it contains a drop precedence value p than if it contains a drop precedence value q when p < q. Note that this requirement can be fulfilled without needing to dequeue and discard already-queued packets.

Within each AF class, a DS node MUST accept all three drop precedence codepoints and they MUST yield at least two different levels of loss probability. In some networks, particularly in enterprise networks, where transient congestion is a rare and brief occurrence, it may be reasonable for a DS node to implement only two different levels of loss probability per AF class. While this may suffice for some networks, three different levels of loss probability SHOULD be supported in DS domains where congestion is a common occurrence.

If a DS node only implements two different levels of loss probability for an AF class x, the codepoint AFx1 MUST yield the lower loss probability and the codepoints AFx2 and AFx3 MUST yield the higher loss probability.

A DS node MUST NOT reorder AF packets of the same microflow when they belong to the same AF class regardless of their drop precedence. There are no quantifiable timing requirements (delay or delay variation) associated with the forwarding of AF packets.

The relationship between AF classes and other PHBs is described in Section 7 of this memo.

The AF PHB group MAY be used to implement both end-to-end and domain edge-to-domain edge services.

3. Traffic Conditioning Actions

A DS domain MAY at the edge of a domain control the amount of AF traffic that enters or exits the domain at various levels of drop precedence. Such traffic conditioning actions MAY include traffic shaping, discarding of packets, increasing or decreasing the drop precedence of packets, and reassigning of packets to other AF classes. However, the traffic conditioning actions MUST NOT cause reordering of packets of the same microflow.

4. Queueing and Discard Behavior

This section defines the queueing and discard behavior of the AF PHB group. Other aspects of the PHB group's behavior are defined in Section 2.

An AF implementation MUST attempt to minimize long-term congestion within each class, while allowing short-term congestion resulting from bursts. This requires an active queue management algorithm. An example of such an algorithm is Random Early Drop (RED) [Floyd]. This memo does not specify the use of a particular algorithm, but does require that several properties hold.

An AF implementation MUST detect and respond to long-term congestion within each class by dropping packets, while handling short-term congestion (packet bursts) by queueing packets. This implies the presence of a smoothing or filtering function that monitors the instantaneous congestion level and computes a smoothed congestion level. The dropping algorithm uses this smoothed congestion level to determine when packets should be discarded.

The dropping algorithm MUST be insensitive to the short-term traffic characteristics of the microflows using an AF class. That is, flows with different short-term burst shapes but identical longer-term packet rates should have packets discarded with essentially equal probability. One way to achieve this is to use randomness within the dropping function.

The dropping algorithm MUST treat all packets within a single class and precedence level identically. This implies that for any given smoothed congestion level, the discard rate of a particular microflow's packets within a single precedence level will be proportional to that flow's percentage of the total amount of traffic passing through that precedence level.

The congestion indication feedback to the end nodes, and thus the level of packet discard at each drop precedence in relation to congestion, MUST be gradual rather than abrupt, to allow the overall system to reach a stable operating point. One way to do this (RED) uses two (configurable) smoothed congestion level thresholds. When the smoothed congestion level is below the first threshold, no packets of the relevant precedence are discarded. When the smoothed congestion level is between the first and the second threshold, packets are discarded with linearly increasing probability, ranging from zero to a configurable value reached just prior to the second threshold. When the smoothed congestion level is above the second threshold, packets of the relevant precedence are discarded with 100% probability.

To allow the AF PHB to be used in many different operating environments, the dropping algorithm control parameters MUST be independently configurable for each packet drop precedence and for each AF class.

Within the limits above, this specification allows for a range of packet discard behaviors. Inconsistent discard behaviors lead to inconsistent end-to-end service semantics and limit the range of possible uses of the AF PHB in a multi-vendor environment. As experience is gained, future versions of this document may more tightly define specific aspects of the desirable behavior.

5. Tunneling

When AF packets are tunneled, the PHB of the tunneling packet MUST NOT reduce the forwarding assurance of the tunneled AF packet nor cause reordering of AF packets belonging to the same microflow.

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