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S. Shah
P. Thubert
Cisco Systems
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Deterministic Forwarding PHB
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Abstract

This document defines a Differentiated Services Per-Hop-Behavior (PHB) Group called Deterministic Forwarding (DF). The document describes the purpose and semantics of this PHB. It also describes creation and forwarding treatment of the service class. The document also describes how the code-point can be mapped into one of the aggregated Diffserv service classes [RFC5127].

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1. Introduction

IP Networks typically implement Diffserv to provide differentiated forwarding behavior to different class of traffic. Networks that implement Diffserv relies on DSCP code-point in the IP header of a packet to select PHB as a specific forwarding treatment for that packet [RFC2474, RFC2475]. This document describes a particular PHB called Deterministic Forwarding (DF). The proposed new code-point defines a service class for the purpose of forwarding treatment of a packet at determined/fixed scheduled time providing no jitter service to the class of traffic (updates RFC4594 with the addition of a new Service Class).

DF PHB can be used for the network services that require the capability to ensure a predictable interaction between networked systems and guarantee a very strict time scheduled services. Applications of such networks may be able to absorb a loss but are very sensitive to end to end latency and jitter. Examples of such networks include Machine to Machine (M2M) control and monitoring deployment with IP over varieties of Layer 2 networks.

The definition of Expedited Forwarding (EF) [RFC2598] PHB is low latency and thus one can envision use of EF code-point for such service. However, even though EF defines low latency and low jitter, it does not guarantee deterministic/fixed scheduled time service. Depending on co-existence of the other traffic in the network, EF traffic may have more or less variance on jitter and thus not suitable for the deterministic service. DF PHB thus is more suitable for deterministic time sensitive traffic.

Typically for an application where end to end deterministic service is important, relevant traffic should be provisioned through DF PHB at every hop in that end to end path. However, in cases where intermediate hops (or DS domains) either do not support DF PHB or supports only aggregated service classes described in RFC5127, DF traffic in those DS domains MUST be mapped to Real Time Treatment class (EF PHB) defined in RFC5127. Traffic in such scenario MUST be conditioned at the Edge before entering and after exiting such DS domains. This is described further in later section.

1.1. Use-cases

With an introduction of machine to machine networks over IP, a new set of applications are emerging. Traffic types from such applications/networks are some-what different from the traditional traffic types. Though most traffic types have characteristics similar to that of traditional ones [LLN-DIFF], certain control signals for some of the applications are extremely sensitive to

such control signals to a specific Diffserv class would require Intserv support for LLN traffic in such networks. All traffic would be subject to flow classification to differentiate time sensitive control signals which can be a big scale concern. Supporting time sensitive control signals via newly proposed DF Diffserv class allows implementation of Diffserv in LLN Networks.

2. Terminology

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 RFC2119.

3. DF code-point Behavior

The DF PHB is to implement time scheduled forwarding treatment. Provisioning of such a service has two parts,

- 1) Provisioning of the fixed/relative time for scheduling of such service
- 2) Provisioning of the max size of the data to be transmitted at each scheduled time

Provisioned scheduled time may be absolute or relative. For example, a DF class may be provisioned to schedule packets (or bytes) at every fixed time. Fixed time can be time of a day or any other absolute definition. In a multi hop forwarding of DF traffic, absolute time service provisioning at each hop may require to be dependent on the clock synchronization (clock synchronization is not in the scope of this specification). In relative time scheduling, packets to be scheduled at every specific interval or it could be relative to any other specific event/trigger. The definition of the time interval or any other event is relevant to that specific provisioned node only.

The size of the data, to be transmitted at each scheduled time service, provisioned can be in the unit of bytes or time. Once DF PHB is provisioned and enabled, forwarding treatment MUST service packets (bytes) from this class at the scheduled time for max allowable data. Scheduling MUST pre-empt any other service, including EF, during the schedule time service for the DF class. In order to avoid incurred latency to EF class of traffic, it is expected to carefully provision DF class to limit scheduled time service to as minimal data transmission that would prevent larger than expected delays to EF class of traffic.

Provisioning can be done via any of multiple possible methods. It could be via command interface, or could be via external provisioning agents, or could be via some sort of signaling that may dynamically pre-negotiate time window of transmission at each node in a network path.

3.1. Potential implementation of DF scheduling

Following are examples of potential implementations. They are not any form of guidelines or recommendations.

There are at least two ways to implement scheduling for DF traffic class.

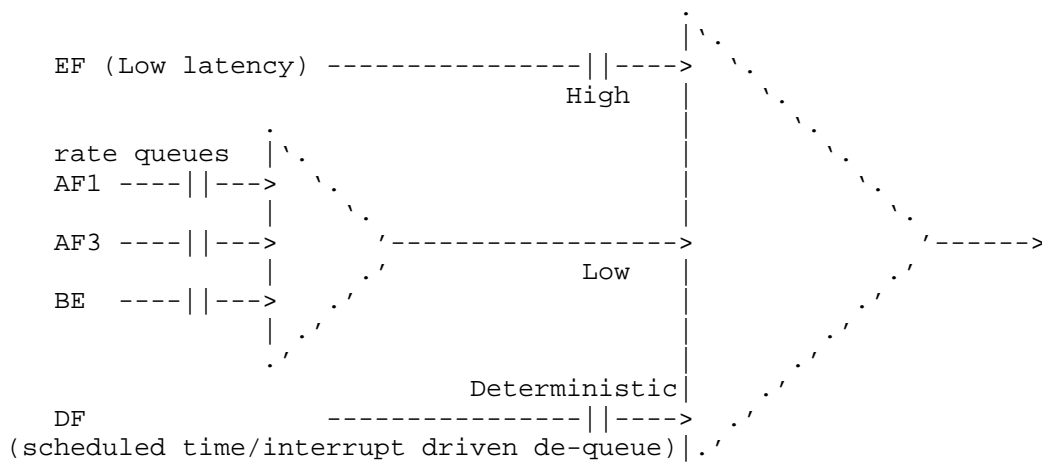
- 1) One queue to buffer and schedule all DF traffic (from all flows),
- 2) Multiple sub-queues for DF traffic class, one queue for each DF provisioned flow

Flow here represents macro definition, it does not have to be only 5-tuple.

Any chosen DF scheduling implementation MUST run traffic conditioning at enqueue to decide if packets to be enqueued or discarded. Discussed more in later section.

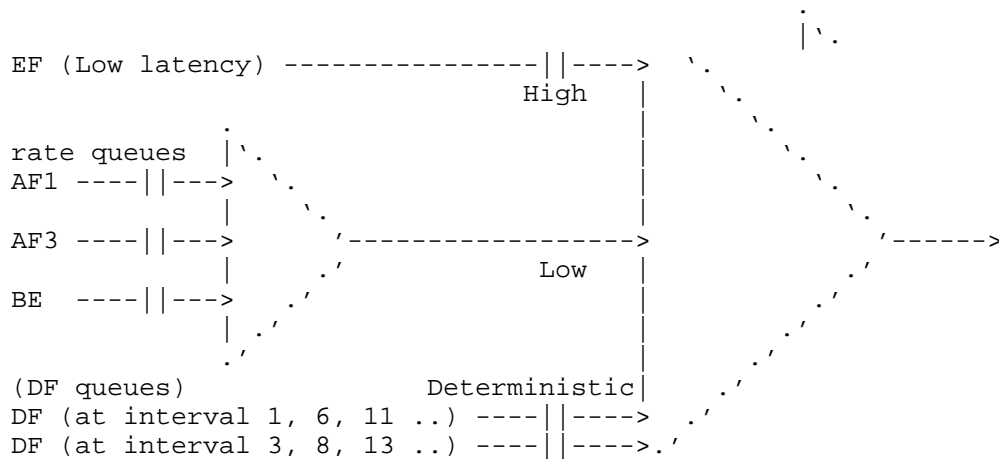
- 1) One data-plane queue to buffer all DF traffic

This one queue maintains, possibly a circular, indexed buffer list. Every time scheduled slot is an index in the buffer list. If enqueue conditioning decides not to discard a packet, packet gets en-queued at the relevant index in the buffer list in such a way that relevant index pointer, and thus buffered relevant packets for that index, at the head of the list is ready to be de-queued at next scheduled time. Subsequent buffer index is scheduled for the subsequent scheduled time slot and so forth. If a specific flow has not received any packet for a scheduled time then buffer index for that flow remains empty. A packet from other flows do not get buffered at that empty index. That means during dequeue, at a schedule time service, an empty index results in no packets to dequeue and thus nothing to be transmitted from the DF queue at that point in time.



2) multiple sub-queues for each DF flows

If enqueue conditioning decides not to discard a packet, packet gets enqueued in the relevant DF sub-queue designated for that flow. At a scheduled time slot, scheduler dequeues a packet from the respective sub-queue. Every scheduled time service interrupt is mapped to a specific DF sub-queue to dequeue a packet from.



3.2. Conditioning DF traffic at Enqueue

DF traffic MUST be conditioned at the enqueue. As per PHB definition, packets are required to be scheduled and delivered at a precise absolute or relative time interval. Any packet that has missed the window of its service time MUST be discarded. That would also mean any packet coming from the previous hop MUST be conditioned at the enqueue for validity of its scheduled service. For example if a DF queue is provisioned to serve a packet with less than x ms of jitter and for an arrived packet, if next scheduled time for a packet results in more than x ms of jitter then such packet MUST be discarded. The enqueued packet MUST also be checked against the size of the data. If size of the data to be enqueued in a DF queue is bigger than what scheduled time slot is provisioned for then such packet MUST be discarded.

4. Diffserv behavior through non-DF DS domains

In cases where DF traffic is forwarded through multiple DS domains, DS domains close to the source and receiver understand application's deterministic service requirement well and so MUST be provisioned for the precise time scheduled forwarding treatment. Intermediate DS domains MAY support DF PHB. Intermediate domains that can not support DF PHB, DF traffic from such domains SHOULD get EF treatment, as defined in RFC5127 for Real Time Service aggregation. Sender and Receiver DS domains, in such cases, MUST condition DF traffic at the respective Edge. If EF service through intermediate DS domains can have a predictable upper bound, receiver DS domain Edge can add a correction to an incurred latency/jitter with its own defined time interval for DF service.

5. Updates to RFC4594 and RFC5127

This specification updates RFC4594 with an addition of a new Diffserv Class. It also updates RFC5127 to aggregate DF class of traffic to Real Time Aggregation Class.

6. IANA Considerations

This document defines a new DSCP code-point DF. IANA maintains the list of existing DSCPs. Proposal is to allocate a new one for the DF code-point.

7. Security Considerations

There is no security considerations required besides ones already understood in the context of Differentiated services architecture

8. Acknowledgements

Fred Baker and Norm Finn.

9. References

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Authors' Addresses

Shitanshu Shah
Cisco Systems
170 W. Tasman Drive
San Jose, CA 95134
US

Email: svshah@cisco.com

Pascal Thubert
Cisco Systems
Village d'Entreprises Green Side
400, Avenue de Roumanille
Batiment T3
Biot - Sophia Antipolis 06410
FRANCE

Email: pthubert@cisco.com

