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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

There is a demand to provide deterministic forwarding to certain type of traffic in machine to machine networks over IP. With an introduction of machine to machine networks over IP, a new set of IP 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 latency and jitter and thus timely scheduled delivery. End to end deterministic path for such traffic may be through one or more administered inter-connected machine to machine networks.

Deterministic Forwarding (DF) PHB group is a means for each node in machine to machine networks, in an end to end path, to deliver

required deterministic behavior. DF class in each DS node is allocated with a scheduled transmission time. DS node may be allocated one scheduled time for the whole aggregate DF traffic, or may be allocated with different schedule time for each micro-flow or set of micro-flows in a DF class. IP packets that wish to use deterministic service are assigned DF code-point, typically at the originator of such traffic.

In a DS node, the level of forwarding determinism of an IP packet depends on scheduled time, at which packet then serviced independent of existence and load of any other type of traffic. For example when a DF packet arrives at the DS node, it is queued until its provisioned scheduled time of service. At the trigger of that scheduled time, service to all other traffic is pre-empted to service DF traffic.

This document describes the DF PHB group. DF capability is not a required function for a DS-compliant node, but a DS-compliant node that implements DF PHB group MUST conform to the specification in this document.

Typically for an application where end to end deterministic service is important, relevant traffic can be serviced through DF PHB at every hop in the 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.

## 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 Per Hop Behavior

The DF PHB is to implement deterministic scheduled, deterministic in terms of a time, forwarding treatment. DF traffic MUST be serviced in a manner to meet configurable scheduled time. A DS node may pre-allocate dedicated resources available at configured scheduled time for optionally configurable maximum size of data. Every conforming packet, belonging to DF class, gets deterministic service irrespective of traffic in other Diffserv class and current load on the system. A DS node MAY allow though its dedicated scheduled

resources available to other Differentiated service classes when DF class does not have any packets to serve during its service time.

A DS node MAY be configured with the same parameters for the entire DF traffic class or different parameters for each micro-flow in a DF class. For the later case, DF traffic MUST be serviced in a manner to meet scheduled service time for each individual micro-flow. Per-flow DF parameters may be provisioned dynamically thru a signaling protocol. Use of any signaling protocol is agnostic to the DF PHB and thus out of scope of this specification [An example of such signaling protocol referred in 6TisCH]. What signaling protocol requires to convey, at minimum to each DS node in the end to end path, is request for DF service along with the flow classification and associated DF parameters, parameters like intended time of a service and size of data to be transmitted during time of service. In a packet path, packet first is classified if it belongs to DF PHB. Once classified for DF PHB, it gets deterministic treatment if provisioned for per-flow DF parameters or else gets aggregate DF treatment.

#### 4. Traffic Conditioning

A DF supported DS Domain MAY condition traffic at the ingress Edge of the domain. Traffic conditioning MUST discard any incoming packet that does not conform to the configured DF service. 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. 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 packet MUST also be checked against the size of the data. If size of the packet is bigger than max size of the data a scheduled time is provisioned to service then such packet MUST be discarded. In addition to DS node at the ingress Edge of the domain, other DS nodes in the path MAY implement Traffic Conditioning.

#### 5. Diffserv behavior through non-DF DS domain

In deployments if two DF domains are connected through a domain that does not support DF PHB, traffic from such intermediate domain MUST be forwarded with low latency. DF traffic at the egress Edge of the sender DF domain MUST be mapped to EF PHB aggregate service, defined as Real Time Service aggregation in RFC5127. Such traffic when entered in the receiving DF domain MUST be conditioned, as described in earlier section, at the ingress Edge of that receiving domain.

## 6. Potential implementation of DF scheduling

Following are examples of potential implementations. They are not any form of guidelines or recommendations but simply a reference to potential implementations.

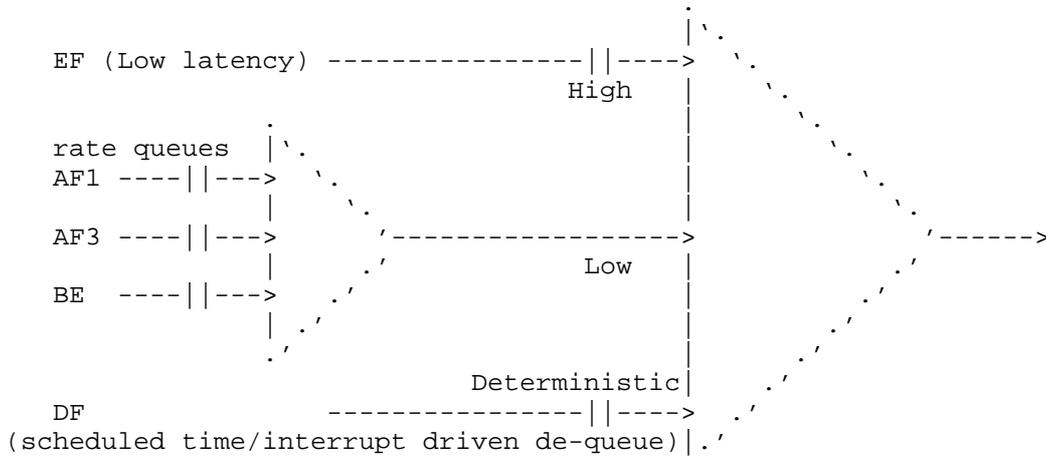
There are at least two ways to implement scheduling for DF traffic class.

- 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

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.

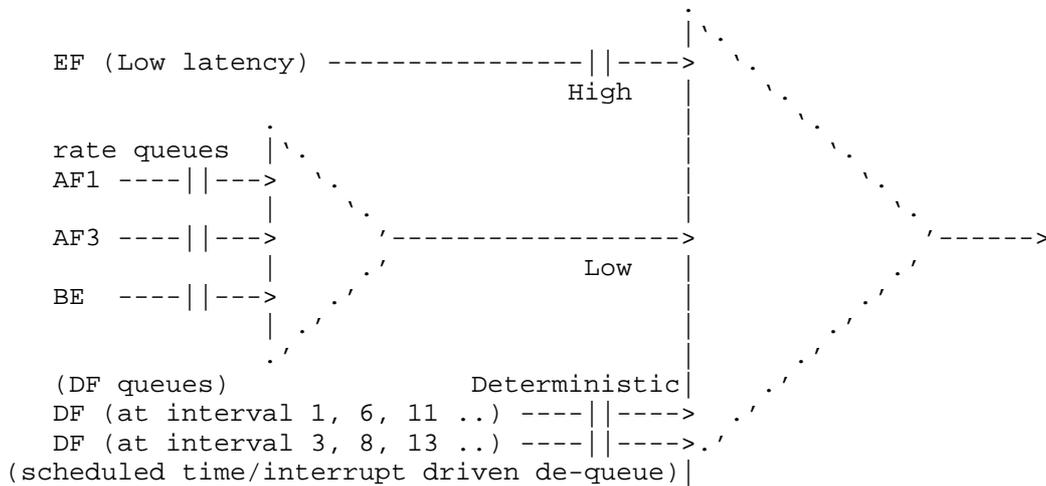
- 1) Single queue to buffer all DF traffic

This single queue maintains, possibly a circular, indexed buffer list. Each index logically maps to each scheduled time service. If conditioning results in not to discard a packet, packet gets enqueued at a relevant index in the buffer list that maps to a relevant scheduled time slot. If there is no packet(s) received for a specific scheduled time service then buffer index for that scheduled service remains empty. This also means that during dequeue, at a schedule time service, an empty index results in no dequeued packets from the DF queue and thus nothing to be transmitted from the DF queue at that point in time. Queuing system may de-queue packets from non-DF queues when an index in DF buffer list found to be an empty during a specific scheduled time service.



2) multiple queues to buffer each DF traffic flows

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



## 7. 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.

## 8. 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.

## 9. Security Considerations

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

## 10. Acknowledgements

Fred Baker, Norm Finn, David Black, Brian Carpenter for their comments and feed-back.

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## Authors' Addresses

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

Email: [svshah@cisco.com](mailto: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](mailto:pthubert@cisco.com)