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R. Aggarwal  
Juniper Networks

Y. Rekhter  
Juniper Networks

E. Rosen  
Cisco Systems, Inc.

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## MPLS Upstream Label Assignment and Context Specific Label Space

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### Abstract

[RFC 3031](#) limits the MPLS architecture to downstream assigned MPLS labels. This document introduces the notion of upstream assigned MPLS labels. It describes the procedures for upstream MPLS label assignment and introduces the concept of a "Context-Specific Label Space".

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## [1](#). Specification of requirements

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](#)].

## [2](#). Introduction

[RFC 3031](#) [[RFC3031](#)] limits the MPLS architecture to downstream assigned MPLS labels. To quote from [RFC 3031](#):

"In the MPLS architecture, the decision to bind a particular label L to a particular FEC F is made by the LSR which is DOWNSTREAM with respect to that binding. The downstream LSR then informs the upstream LSR of the binding. Thus labels are "downstream-assigned", and label bindings are distributed in the "downstream to upstream" direction."

before [[RFC3353](#), [MVPN](#)]. However the architecture for MPLS upstream label assignment and the associated procedures have not been described. This document introduces the notion of upstream assigned MPLS labels to the MPLS architecture. The procedures for upstream MPLS label assignment are described.

[RFC 3031](#) describes per-platform and per-interface label space. This document generalizes the latter to a "Context-Specific Label Space" and describes a "Neighbor Label Space" as an example of this. Upstream assigned labels are always looked up in a context-specific label space.

### [3.](#) Context-Specific Label Space

[RFC 3031](#) describes per-platform and per-interface label spaces. This document introduces the more general concept of a "Context-Specific Label Space". A LSR may contain one or more context-specific label spaces. In general, labels are looked up in the per-platform label space unless something about the context determines that a label be looked up in a particular context-specific label space.

One example of a context-specific label space is the per-interface label space discussed in [RFC 3031](#). When a MPLS packet is received over a particular interface the top label of the packet may need to be looked up in the receiving interface's per-interface label space. In this case the receiving interface determines the context of the packet. Whether MPLS packets received over a particular interface need to have their top labels looked up in a per-interface label space depends on some characteristic or configuration of the interface.

There may be more than one kind of context-specific label space. Context-specific label spaces can be used for downstream assigned labels or upstream assigned labels. Per-interface label space [[RFC3031](#)] is an example of a context-specific label space used for downstream assigned labels.

When MPLS labels are upstream assigned the context of a MPLS label L

is provided by the LSR that assigns the label and binds the label to a FEC F for a LSP LSP1. The LSR that assigns the label distributes the binding and context to a LSR Lr that then receives MPLS packets on LSP1 with label L. When Lr receives a MPLS packet on LSP1 it MUST be able to determine the context of this packet.

An example of such a context is a Tunnel over which MPLS packets on LSP1 may be received and in this case the top label of the MPLS packet is looked up in a "Tunnel Specific Label Space". This does

imply that Lr be able to determine the tunnel over which the packet was received. If the tunnel is a MPLS tunnel, penultimate-hop-popping (PHP) must be disabled for the tunnel. Another example of such a context is the neighbor from which MPLS packets on LSP1 may be received and in this case the top label of the MPLS packet is looked up in a "Neighbor Specific Label Space". These are further described in [section 7](#).

There may be other sorts of contexts as well. For instance, we define the notion of a MPLS label being used to establish a context, i.e. identify a label space.

#### [4. Upstream Label Assignment](#)

When two MPLS LSRs are adjacent in a MPLS label switched path (LSP) one of them can be termed an "upstream LSR" and the other a "downstream LSR" [[RFC3031](#)]. Consider two LSRs, Ru and Rd that have agreed to bind Label L to a Forwarding Equivalence Class (FEC), F, for packets sent from Ru to Rd. Then with respect to this binding, Ru is the "upstream LSR", and Rd is the "downstream LSR".

When the label binding for F is first made by Rd and distributed by Rd to Ru, the binding is said to be "downstream assigned". When the label binding for F is first made by Ru and distributed by Ru to Rd, the binding is said to be "upstream assigned".

An important observation is that the downstream LSR Rd that receives MPLS packets with a top label L is not the LSR that assigns and distributes label L. Rd must use a context-specific label space to lookup label L as described in [section 7](#).

#### 4.1. Upstream Assigned and Downstream Assigned Labels

It is possible that some LSRs on a LSP for FEC F, distribute downstream assigned label bindings for FEC F, while other LSRs distribute upstream assigned label bindings. It is possible for a LSR to distribute a downstream assigned label binding for FEC F to its upstream adjacent LSR AND distribute an upstream assigned label binding for FEC F to its downstream adjacent LSR. Two adjacent LSRs for a LSP that is bound to FEC F, MUST use either downstream assigned label distribution or upstream assigned label distribution, for FEC F, but NOT both. How these LSRs will determine which of the two is to be used is outside the scope of this document.

#### 5. Assigning Upstream Assigned Labels

The only requirement on an upstream LSR assigning upstream assigned labels is that an upstream assigned label must be unambiguous in the context-specific label space in which the downstream LSR will look it up. An upstream LSR which is the head end of multiple tunnels SHOULD by default assign the upstream-assigned labels from a single label space which is common to all those tunnels. Further an upstream LSR which is the head of multiple tunnels SHOULD use the same IP address as the head identifier of these tunnels, provided that the head identifier of these tunnels is an IP address. The LSR could assign the same label value to both a downstream-assigned and an upstream-assigned label. The downstream LSR always looks up upstream assigned MPLS labels in a context-specific label space as described in [section 7](#).

An entry for the upstream assigned labels is not created in the Incoming Label Map (ILM) [[RFC3031](#)] at the upstream LSR as these labels are not incoming labels. Instead an upstream label is an outgoing label, with respect to the upstream LSR, for MPLS packets transmitted on the MPLS LSP in which the upstream LSR is adjacent to the downstream LSR. Hence an upstream label is part of a Next Hop Label Forwarding Entry (NHLFE) at the upstream LSR.

When Ru advertises a binding of label L for FEC F to Rd, it creates a

NHLFE entry corresponding to L. This NHLFE entry results in imposing the label L on the MPLS label stack of the packet forwarded using the NHLFE entry. If Ru is a transit router on the LSP for FEC F, it binds the ILM for the LSP to this NHLFE. If Ru is an ingress router on the LSP for FEC F, it binds the FEC to the NHLFE entry.

## 6. Distributing Upstream Assigned Labels

Upstream-assigned label bindings MUST NOT be used unless it is known that the downstream LSR supports them. How this is known is outside the scope of this document.

MPLS upstream label assignment requires a label distribution protocol to distribute the binding from the upstream LSR to the downstream LSR. Considerations that pertain to a label distribution protocol that are described in [[RFC3031](#)] apply.

The distribution of the upstream-assigned labels is similar to either the ordered LSP control or independent LSP control of the downstream-assigned labels. In the former case a LSR distributes an upstream-assigned label binding for a FEC F if it is either (a) the ingress LSR for FEC F, or (b) if it has already received an upstream label

binding for that FEC from its adjacent upstream LSR for FEC F, or (c) if it has received a request for a downstream label binding from its upstream adjacent LSR. In the latter case each LSR, upon noting that it recognizes a particular FEC, makes an independent decision to bind an upstream-assigned label to that FEC and to distribute that binding to its label distribution peers.

## 7. Upstream Neighbor Label Space and Tunnel Label Space

If the top label of a MPLS packet being processed by LSR Rd is upstream assigned, the label is looked up in a context-specific label space, not in a per-platform label space.

Rd uses a context-specific label space that it maintains for Ru to "reserve" MPLS labels assigned by Ru. Hence if Ru distributes an upstream assigned label binding L for FEC F to Rd, then Rd reserves L in the separate ILM for Ru's context-specific label space. This is

the ILM that Rd uses to lookup a MPLS label which is upstream assigned by Ru. This label may be the top label on the label stack of a packet received from Ru or it may be exposed as the top label on the label stack as a result of Rd processing such a packet.

This implies that Rd MUST be able to determine whether the top label of a MPLS packet being processed is upstream assigned and if yes, the "context" of this packet. How this determination is made depends on the mechanism that is used by Ru to transmit the MPLS packet with an upstream assigned top label L, to Rd.

If Ru transmits this packet by encapsulating it in an IP or MPLS tunnel, then the fact that L is upstream assigned is determined by Rd by the tunnel on which the packet is received. A given tunnel can be used for transmitting either downstream assigned MPLS packets or upstream assigned MPLS packets, or both. There must be a mechanism for Ru to inform Rd that a particular tunnel from Ru to Rd will be used by Ru for transmitting MPLS packets with upstream assigned MPLS labels. The description of such a mechanism is outside the scope of this document. When Rd receives MPLS packets with a top label L on such a tunnel, it determines the "context" of this packet based on the tunnel that the packet is received on.

Rd may maintain a separate "Tunnel Label Space" for the tunnel or it may maintain an "Upstream Neighbor Label Space" for all tunnels that have the same root. If Rd uses the "Upstream Neighbor Label Space" for upstream assigned MPLS packets transmitted by Ru to Rd, over IP or MPLS tunnels, then Rd MUST be able to determine the root of these IP/MPLS tunnels. Rd would then use a separate label space for each unique root.

If the tunnel on which Rd receives MPLS packets with a top label L is a MPLS tunnel, then Rd determines a) That L is upstream assigned and b) The context for L, from the labels above L in the label stack. Note that one or more of these labels may also be upstream assigned labels.

If the tunnel on which Rd receives MPLS packets with a top label L is an IP/GRE tunnel then Rd determines a) That L is upstream assigned [[MPLS-MCAST-ENCAPS](#)] and b) The context for L, from the source address in the IP header.

When Ru and Rd are adjacent to each other on a multi-access data link media, if Ru would transmit the packet, with top label L, by encapsulating it in a data link frame, then whether L is upstream assigned or downstream assigned can be determined by Rd as described in [[MPLS-MCAST-ENCAPS](#)]. This is because if L is upstream assigned then [[MPLS-MCAST-ENCAPS](#)] uses a different ether type in the data link frame. However this is not sufficient for Rd to determine the context of this packet. In order for Rd to determine the context of this packet, Ru encapsulates the packet, in a one hop MPLS tunnel. This tunnel uses an MPLS context label that is assigned by Ru. [Section 8](#) describes how the context label is assigned. Rd maintains a separate "Upstream Neighbor Label Space" for Ru. The "context" of this packet, i.e. Ru's upstream neighbor label space, in which L was reserved, is determined by Rd from the top context label and the interface on which the packet is received. The ether type in the data link frame is set to indicate that the top label is upstream assigned. The second label in the stack is L.

#### [8](#). Context Label on LANs

The procedure described below applies to LSRs using IPv4 and does not apply to LSRs only using IPv6. A solution for IPv6 LSRs is outside the scope of this document.

For a labeled packet with an ether type of 'upstream label assignment' the top label is used as the context. The context label value is assigned by the upstream LSR and advertised to the downstream LSRs. Mechanisms for advertising the context label are outside the scope of this document.

The context label assigned by a LSR on a LAN interface MUST be unique across all the context labels assigned by other LSRs on the same LAN. Each LAN interface is normally configured with a primary IPv4 address that is unique on that LAN. The host part of the IPv4 address, identified by the network mask, is unique. If the IPv4 network mask is greater than 12 bits, it is possible to map the remaining 20 bits

into an unique context label value. This enables the LSRs on the LAN to assign an unique context label without the need for additional configuration. To avoid assigning context label values that fall into the reserved label space range [[RFC 3032](#)], the value of the host is



offset with 0x10 if the host is not greater than 0xFFFFEF. Host values greater than 0xFFFFEF are not allowed to be used as the context label.

Consider LSRs Rm (middle) connected to Ru (upstream) on a LAN interface and to Rd (downstream) on a different LAN interface. Rm could receive a context label value derived from the LAN interface from Rd and from Ru. It is possible that the context label values used by Ru and Rd are the same. This would occur if the LAN interfaces of both Ru and Rd are configured with a primary IPv4 address where the lowest 20 bits are equal. To avoid these conflicts the context label MUST be looked up in the context of the LAN interface identifier on which the packet is received. A receiving LSR that receives a packet with a context label of Lc over LAN interface identified by X, MUST use the label space specific to X to lookup Lc. This determines the context to lookup the label below Lc on the label stack.

## 9. Usage of Upstream Assigned Labels

A typical usage of upstream assigned labels is when an upstream LSR Ru is adjacent to more than downstream LSRs <Rd1..Rdn> in a LSP LSP1 AND Ru is connected to <Rd1..Rdn> via a multi-access media or tunnel AND Ru wants to transmit a single copy of a MPLS packet on the LSP to <Rd1..Rdn>. In this case Ru can distribute an upstream assigned label L that is bound to the FEC for LSP1, to <Rd1..Rdn> and transmit a MPLS packet, the top label of which is L, on the multi-access media or tunnel. Each of <Rd1..Rdn> will then interpret this MPLS packet in the context of Ru and forward it appropriately. This implies that <Rd1..Rdn> MUST all be able to support an Upstream Neighbor Label Space for Ru and Ru MUST be able to determine this. The mechanisms for determining this are specific to the application that is using upstream assigned labels and is outside the scope of this document.

## 10. Acknowledgements

Thanks to IJsbrand Wijnands's contribution, specifically for the text on which [section 8](#) is based.

## 11. References

### 11.1. Normative References

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[RFC2119] "Key words for use in RFCs to Indicate Requirement Levels.", Bradner, March 1997

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### 11.2. Informative References

[MVPN] E. Rosen, R. Aggarwal [Editors], "Multicast in BGP/MPLS VPNs", [draft-ietf-l3vn-2547bis-mcast-02.txt](#)

## 12. Author Information

Rahul Aggarwal  
Juniper Networks  
1194 North Mathilda Ave.  
Sunnyvale, CA 94089  
Email: rahul@juniper.net

Yakov Rekhter  
Juniper Networks  
1194 North Mathilda Ave.  
Sunnyvale, CA 94089  
Email: yakov@juniper.net

Eric C. Rosen  
Cisco Systems, Inc.  
1414 Massachusetts Avenue  
Boxborough, MA 01719  
Email: erosen@cisco.com

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