

Network Working Group
Internet Draft
Expiration Date: October 2005
Updates RFCs 3032 and 4023

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April 2005

MPLS Multicast Encapsulations

[draft-rosen-mpls-multicast-encaps-00.txt](#)

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Abstract

[RFC 3032](#) established two data link layer codepoints for MPLS: one to indicate that the data link layer frame is carrying an MPLS unicast packet, and the other to indicate that the data link layer frame is carrying an MPLS multicast packet. This specification updates [RFC3032](#) by redefining the meaning of these two codepoints. The former "multicast codepoint" is now to be used only on multiaccess media, and it is to mean "the top label of the following label stack is an upstream-assigned label". The former "unicast codepoint" is to

be used in all other cases. Whether the data link layer payload is a unicast MPLS packet or a multicast MPLS packet is now to be determined by looking up the top label, rather than by the codepoint.

[RFC3032](#) does not specify the destination address to be placed in the "MAC DA" field of an ethernet frame which carries an MPLS multicast packet. This document provides that specification.

This document updates [RFC 3032](#) and [RFC 4023](#).

Contents

1	Introduction	2
2	Upstream-Assigned vs. Downstream-Assigned	3
3	Ethernet Codepoints	5
4	PPP Protocol Field	6
5	GRE Protocol Type	6
6	IP Protocol Number	6
7	Ethernet MAC DA for Multicast MPLS	7
8	IANA Considerations	7
9	Security Considerations	7
10	Normative References	7
11	Informative References	8
12	Authors' Addresses	8
13	Full Copyright Statement	8
14	Intellectual Property	9

[1](#). Introduction

[RFC 3031](#) defines the "Next Hop Label Forwarding Entry" (NHLFE). The NHLFE for a particular label maps the label into a next hop (among other things). When an MPLS packet is received, its top label is mapped to an NHLFE, and the packet is sent to the next hop specified by the NHLFE.

We define a particular MPLS label to be a "multicast label" in a

particular context if the NHLFE to which it is mapped in that context specifies a set of next hops, with the semantics that the packet is to be replicated, and a copy of the packet sent to each of the specified next hops. Note that this definition accommodates the case where the set of next hops contains a single member. What makes a

label a multicast label in a particular context is the semantics attached to the set, i.e., the intention to replicate the packet and transmit to all members of the set if the set has more than one member.

[RFC 3032](#) established two data link layer codepoints for MPLS: one to indicate that the data link layer frame is carrying an MPLS unicast packet, and the other to indicate that the data link layer frame is carrying an MPLS multicast packet. The term "multicast packet" is not precisely defined in [RFC 3032](#), though one may presume that the "multicast" codepoint is intended to identify the packet's top label as a multicast label. However, the multicast codepoint has never been deployed, and further development of the procedures for MPLS multicast have shown that, while there is a need for two codepoints, the use of the two codepoints is not properly captured by [RFC3032](#).

In particular, there is no need for the codepoint to indicate whether the top MPLS label is a multicast label. When the receiver of an MPLS packet looks up the top label, the NHLFE will specify whether the label is a multicast label or not.

This document updates [RFC 3032](#) and [RFC 4023](#) by re-specifying the use of the codepoints.

While [RFC 3032](#) allows an MPLS packet to be carried in an ethernet multicast frame, it fails to specify how the Medium Access Layer Destination Address (MAC DA) field is to be set in that case. This document provides that specification.

[2.](#) Upstream-Assigned vs. Downstream-Assigned

According to [RFC 3031](#), if two MPLS Label Switching Routers (LSRs) are adjacent in a label switched path (LSP), with respect to that LSP, one of them may be called the "upstream" LSR and the other the "downstream" LSR. Call these Ru and Rd respectively. Before Ru can

send an MPLS packet to Rd with label L at the top of the label stack, Ru and Rd must agree on the Forwarding Equivalence Class (FEC) which is bound to L. A particular binding of L to FEC F is called a "downstream-assigned" binding if the binding is first made by Rd and then advertised to Ru. If the binding is first made by Ru and then advertised to Rd, it is called an "upstream-assigned" binding.

If Ru and Rd are LSP adjacencies, then they transmit a MPLS packet to each other through one of the following mechanisms:

1. by putting the MPLS packet in a data link layer frame and transmitting the frame
2. by transmitting the MPLS packet through an MPLS tunnel, i.e., by pushing an additional label (or labels) onto the label stack, and then invoking mechanism 1,
3. by transmitting the MPLS packet through an IP-based tunnel (e.g., via [RFC 4023](#)), and then invoking mechanisms 1 and/or 2.

In short, an MPLS packet is transmitted either through a data link or through an MPLS tunnel or through an IP tunnel. In any of those cases, when the packet emerges through the tunnel, the downstream LSR must know whether the label that now appears at the top of the label stack has an upstream-assigned label binding or a downstream-assigned label binding. For convenience, we will speak of a label with an upstream-assigned label binding as an "upstream-assigned label".

Unicast labels MUST be downstream-assigned.

Under certain conditions, specified below, multicast labels MAY be upstream-assigned. The ability to use upstream-assigned labels is an OPTIONAL feature. Upstream-assigned labels 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.

We discuss three different types of data link or tunnel:

- Point-to-Point. A point-to-point data link or tunnel associates

two systems, such that transmissions on that link or tunnel made by the one are received by the other, and only by the other.

When an MPLS packet is transmitted on a point-to-point data link or tunnel, its top label (before applying the data link or tunnel encapsulation) MUST be a downstream-assigned label.

- Point-to-Multipoint. A point-to-multipoint link or tunnel associates n systems, such that only one of them can transmit onto the link or tunnel, and the transmissions may be received by the other $n-1$ systems.

The top labels (before applying the data link or tunnel encapsulation) of all MPLS packets which are transmitted on a particular point-to-multipoint data link or tunnel MUST be of the same type; either all upstream-assigned or all downstream-assigned. This means that all the receivers on the MPLS or IP tunnel must know a priori whether upstream-assigned or downstream-assigned labels are being used in the tunnel. How

this is known is outside the scope of this document.

- Multipoint-to-Multipoint. A multipoint-to-multipoint link or tunnel associates n systems, such that any of them can transmit on the link or tunnel, and the transmissions may be received by the other $n-1$ systems.

If a set of MPLS packets are transmitted on a multipoint-to-multipoint link, their top labels (before applying the data link or tunnel encapsulation) MAY be of different types, i.e., there may be a mixture of upstream-assigned and downstream-assigned top labels.

However, if upstream-assigned labels are to be used, the data link or tunnel encapsulation MUST provide a codepoint which specifies whether the top label of the encapsulated MPLS packet is upstream-assigned or downstream-assigned. If a particular type of data link or tunnel does not provide such a codepoint, then upstream-assigned labels MUST NOT be used.

The remainder of this document specifies procedures for setting the data link layer codepoints and address fields.

3. Ethernet Codepoints

Ethernet is an example of a multipoint-to-multipoint data link.

Ethertype 0x8847 is used whenever a unicast ethernet frame carries an MPLS packet.

Ethertype 0x8847 is also used whenever a multicast ethernet frame carries an MPLS packet, EXCEPT for the case where the top label of the MPLS packet has been upstream-assigned.

Ethertype 0x8848, formerly known as the "MPLS multicast codepoint", is to be used only when an MPLS packet whose top label is upstream-assigned is carried in a multicast ethernet frame.

4. PPP Protocol Field

PPP is an example of a point-to-point data link. When a PPP frame is carrying an MPLS packet, the PPP Protocol field is always set to 0x0281.

5. GRE Protocol Type

[RFC 4023](#) is modified as described below.

If the IP destination address of the GRE encapsulation is a unicast IP address, then the ethertype value 0x8847 MUST be used in all cases for the MPLS-in-GRE encapsulation.

If the IP destination address of the GRE encapsulation is a multicast IP address, then:

- if both upstream-assigned and downstream-assigned labels may appear as the top label of the encapsulated MPLS packets, then the ethertype value 0x8847 MUST be used when the aforesaid label is downstream-assigned, and the ethertype value 0x8848 MUST be used when the aforesaid label is upstream-assigned.
- if all the encapsulated MPLS packets have an upstream-assigned top label, or if all the encapsulated MPLS packets have a downstream-assigned top label, then the ethertype value 0x8847 MUST be used.

Which of these two situations applies is determined by means outside the scope of this specification.

6. IP Protocol Number

[RFC 4023](#) is modified as follows: the IPv4 Protocol Number field or the IPv6 Next Header field is always set to 137, whether or not the encapsulated MPLS packet is an MPLS multicast packet.

If the IP destination address of the IP encapsulation is an IP multicast address, the IP tunnel may be considered to be a point-to-multipoint tunnel or a multipoint-to-multipoint tunnel. In either case, either all encapsulated MPLS packets in the particular tunnel have a downstream-assigned label at the top of the stack, or all encapsulated MPLS packets in that tunnel have an upstream-assigned label at the top of the stack. The means by which this is determined for a particular tunnel is outside the scope of this specification.

7. Ethernet MAC DA for Multicast MPLS

When a multicast MPLS packet is carried in a multicast ethernet frame, the Destination MAC Address shall be set to the value 01-00-5e-8a-bc-de, where abcde is the twenty-bit (4-nibble) value of the topmost MPLS label of the MPLS packet.

[8. IANA Considerations](#)

IANA already owns the set of ethernet multicast addresses in the range 01-00-5e-00-00-00 to 01-00-5e-ff-ff-ff. Addresses in the range 01-00-5e-00-00-00 to 01-00-5e-7f-ff-ff are reserved for use when an ethernet multicast frame carries an IP multicast packet. IANA shall reserve ethernet addresses in the range 01-00-5e-80-00-00 to 01-00-5e-8f-ff-ff for use when an ethernet multicast frame carries an MPLS multicast packet.

[9. Security Considerations](#)

The security considerations of [RFC 3032](#) and [RFC 4023](#) apply.

Malicious changing of the codepoint may result in loss or misrouting of packets. However, altering the codepoint without also altering the label does not result in a predictable effect.

Malicious alteration of the MAC DA on an ethernet can result in packets being received by a third party, rather than by the intended recipient.

[10. Normative References](#)

[RFC3031] "Multiprotocol Label Switching Architecture", Rosen, Viswanathan, Callon, January 2001

[RFC3032] "MPLS Label Stack Encoding", Rosen, et. al., January 2001

[RFC4023] "Encapsulating MPLS in IP or GRE", Worster, Rekhter, Rosen, March 2005

[11. Informative References](#)

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