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Y. Rekhter
Juniper Networks
R. Aggarwal
Arktan
N. Leymann
Deutsche Telekom
W. Henderickx
Alcatel-Lucent
Q. Zhao
R. Li
Huawei

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Carrying Protocol Independent Multicast - Sparse Mode (PIM-SM) in Any-Source Multicast (ASM) Mode Trees over Multipoint LDP (mLDP)

Abstract

When IP multicast trees created by Protocol Independent Multicast - Sparse Mode (PIM-SM) in Any-Source Multicast (ASM) mode need to pass through an MPLS domain, it may be desirable to map such trees to Point-to-Multipoint Label Switched Paths (P2MP LSPs). This document describes how to accomplish this in the case where such P2MP LSPs are established using Label Distribution Protocol (LDP) Extensions for P2MP and Multipoint-to-Multipoint LSPs: Multipoint LDP (mLDP).

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

[RFC6826] describes how to map Point-to-Multipoint Label Switched Paths (P2MP LSPs) created by mLDP [RFC6388] to multicast trees created by Protocol Independent Multicast - Sparse Mode (PIM-SM) in Source-Specific Multicast (SSM) mode [RFC4607]. This document describes how to map mLDP P2MP trees to multicast trees created by PIM-SM in Any-Source Multicast (ASM) mode. It describes two possible mechanisms for doing this.

The first mechanism, described in Section 2, is OPTIONAL for implementations, but the second mechanism, described in Section 3, is REQUIRED for all implementations claiming conformance to this specification.

Note that from a deployment point of view these two mechanisms are mutually exclusive. That is, on the same network one could deploy either one of the mechanisms, but not both.

The reader of this document is expected to be familiar with PIM-SM [RFC4601] and mLDP [RFC6388].

This document relies on the procedures in [RFC6826] to support source trees. For example, following these procedures a Label Switching Router (LSR) may initiate an mLDP Label Map with the Transit IPv4/IPv6 Source TLV for (S,G) when receiving a PIM (S,G) Join.

This document uses BGP Source Active auto-discovery routes, as defined in [RFC6514]. For the sake of brevity in the rest of this document, we'll refer to these routes as just "Source Active auto-discovery routes".

Consider a deployment scenario where the service provider has provisioned the network in such a way that the Rendezvous Point (RP) for a particular ASM group G is always between the receivers and the sources. If the network is provisioned in this manner, the ingress Provider Edge (PE) for (S,G) is always the same as the ingress PE for the RP, and thus the Source Active auto-discovery (A-D) routes are never needed. If it is known a priori that the network is provisioned in this manner, mLDP in-band signaling can be supported using a different set of procedures, as specified in [RFC7438]. A service provider will provision the PE routers to use either the procedures in [RFC7438] or those described in this document.

Like [RFC6826], each IP multicast tree is mapped one-to-one to a P2MP LSP in the MPLS network. This type of service works well if the number of LSPs that are created is under the control of the MPLS network operator, or if the number of LSPs for a particular service is known to be limited.

It is to be noted that the existing BGP Multicast VPN (MVPN) procedures [RFC6514] can be used to map Internet IP multicast trees to P2MP LSPs. These procedures would accomplish this for IP multicast trees created by PIM-SM in SSM mode, as well as for IP multicast trees created by PIM-SM in ASM mode. Furthermore, these procedures would also support the ability to aggregate multiple IP multicast trees to one P2MP LSP in the MPLS network. The details of this particular approach are out of scope for this document.

This document assumes that a given LSR may have some interfaces that are IP multicast capable, while other interfaces would be MPLS capable.

1.1. 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 RFC 2119 [RFC2119].

2. Mechanism 1 - Non-transitive Mapping of IP Multicast Shared Trees

This mechanism does not transit IP multicast shared trees over the MPLS network. Therefore, when an LSR creates (*,G) state (as a result of receiving PIM messages on one of its IP multicast interfaces), the LSR does not propagate this state in mLDP.

2.1. Originating Source Active Auto-discovery Routes (Mechanism 1)

Whenever (as a result of receiving either PIM Register or Multicast Source Discovery Protocol (MSDP) messages) an RP discovers a new multicast source, the RP SHOULD originate a Source Active auto-discovery route. The route carries a single MCAST-VPN Network Layer Reachability Information (NLRI) [RFC6514], constructed as follows:

+ The Route Distinguisher (RD) in this NLRI is set to 0.

+ The Multicast Source field is set to S. This could be either an IPv4 or an IPv6 address. The Multicast Source Length field is set appropriately to reflect the address type.

+ The Multicast Group field is set to G. This could be either an IPv4 or an IPv6 address. The Multicast Group Length field is set appropriately to reflect this address type.

To constrain distribution of the Source Active auto-discovery route to the Autonomous System (AS) of the advertising RP, this route SHOULD carry the NO_EXPORT Community ([RFC1997]).

Using the normal BGP procedures, the Source Active auto-discovery route is propagated to all other LSRs within the AS.

Whenever the RP discovers that the source is no longer active, the RP MUST withdraw the Source Active auto-discovery route if such a route was previously advertised by the RP.

2.2. Receiving Source Active Auto-discovery Routes by LSR

Consider an LSR that has some of its interfaces capable of IP multicast and some capable of MPLS multicast.

When, as a result of receiving PIM messages on one of its IP multicast interfaces, an LSR creates in its Tree Information Base (TIB) a new (*,G) entry with a non-empty outgoing interface list that contains one or more IP multicast interfaces, the LSR MUST check to see if it has any Source Active auto-discovery routes for that G. If there is such a route, S of that route is reachable via an MPLS interface, and the LSR does not have (S,G) state in its TIB for (S,G) carried in the route, then the LSR originates the mLDP Label Map with the Transit IPv4/IPv6 Source TLV carrying (S,G), as specified in [RFC6826].

When an LSR receives a new Source Active auto-discovery route, the LSR MUST check to see if its TIB contains a (*,G) entry with the same G as that carried in the Source Active auto-discovery route. If such an entry is found, S is reachable via an MPLS interface, and the LSR does not have (S,G) state in its TIB for (S,G) carried in the route, then the LSR originates an mLDP Label Map with the Transit IPv4/IPv6 Source TLV carrying (S,G), as specified in [RFC6826].

2.3. Handling (S,G,RPT-bit) State

The creation and deletion of (S,G,RPT-bit) PIM state ([RFC4601]) on an LSR that resulted from receiving PIM messages on one of its IP multicast interfaces do not result in any mLDP and/or BGP actions by the LSR.

3. Mechanism 2 - Transitive Mapping of IP Multicast Shared Trees

This mechanism enables transit of IP multicast shared trees over the MPLS network. Therefore, when an LSR creates (*,G) state as a result of receiving PIM messages on one of its IP multicast interfaces, the LSR propagates this state in mLDP, as described below.

Note that in the deployment scenarios where, for a given G, none of the PEs originate an (S,G) mLDP Label Map with the Transit IPv4/IPv6 Source TLV, no Source Active auto-discovery routes will be used. One other scenario where no Source Active auto-discovery routes will be used is described in Section 3.2 ("Originating Source Active Auto-discovery Routes (Mechanism 2)"). In all of these scenarios, the only part of Mechanism 2 that is used is the in-band signaling for IP Multicast Shared Trees, as described in the next section.

3.1. In-Band Signaling for IP Multicast Shared Trees

To provide support for in-band mLDP signaling of IP multicast shared trees, this document defines two new mLDP TLVs: the Transit IPv4 Shared Tree TLV and the Transit IPv6 Shared Tree TLV.

These two TLVs have exactly the same encoding/format as the IPv4/IPv6 Source Tree TLVs defined in [RFC6826], except that instead of the Source field they have an RP field that carries the address of the RP, as follows:

Transit IPv4 Shared Tree TLV:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Type          | Length                        | RP            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                               | Group         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 11

Length: 8

RP: IPv4 RP address, 4 octets.

Group: IPv4 multicast group address, 4 octets.

Transit IPv6 Shared Tree TLV:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Type          | Length                        | RP            ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                               | Group         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 12

Length: 32

RP: IPv6 RP address, 16 octets.

Group: IPv6 multicast group address, 16 octets.

Procedures for in-band signaling for IP multicast shared trees with mLDP follow the same procedures as those for in-band signaling for IP multicast source trees, as specified in [RFC6826], except that while the latter signals (S,G) state using Transit IPv4/IPv6 Source TLVs, the former signals (*,G) state using Transit IPv4/IPv6 Shared Tree TLVs.

3.2. Originating Source Active Auto-discovery Routes (Mechanism 2)

Consider an LSR that has some of its interfaces capable of IP multicast and some capable of MPLS multicast.

Whenever such an LSR creates an (S,G) state as a result of receiving an mLDP Label Map with the Transit IPv4/IPv6 Source TLV for (S,G), the LSR MUST originate a Source Active auto-discovery route if all of the following are true:

+ S is reachable via one of the IP-multicast-capable interfaces,

+ the LSR determines that G is in the PIM-SM in ASM mode range, and

+ the LSR does not have a (*,G) state with one of the IP-multicast-capable interfaces as an incoming interface (iif) for that state.

The route carries a single MCAST-VPN NLRI, constructed as follows:

+ The RD in this NLRI is set to 0.

+ The Multicast Source field is set to S. The Multicast Source Length field is set appropriately to reflect this address type.

+ The Multicast Group field is set to G. The Multicast Group Length field is set appropriately to reflect this address type.

To constrain distribution of the Source Active auto-discovery route to the AS of the advertising LSR, this route SHOULD carry the NO_EXPORT Community ([RFC1997]).

Using the normal BGP procedures, the Source Active auto-discovery route is propagated to all other LSRs within the AS.

Whenever the LSR receiving an mLDP Label Map with the Transit IPv4/IPv6 Source TLV for (S,G) deletes the (S,G) state that was previously created, the LSR that deletes the state MUST also withdraw the Source Active auto-discovery route, if such a route was advertised when the state was created.

Note that whenever an LSR creates an (S,G) state as a result of receiving an mLDP Label Map with the Transit IPv4/IPv6 Source TLV for (S,G) with S reachable via one of the IP-multicast-capable interfaces, and the LSR already has a (*,G) state with the RP reachable via one of the IP-multicast-capable interfaces as a result of receiving an mLDP Label Map with the Transit IPv4/IPv6 Shared Tree TLV for (*,G), the LSR does not originate a Source Active auto-discovery route.

3.3. Receiving Source Active Auto-discovery Routes

Procedures for receiving Source Active auto-discovery routes are the same as those for Mechanism 1.

3.4. Pruning Sources Off the Shared Tree

If, after receiving a new Source Active auto-discovery route for (S,G), the LSR determines that (a) it has the (*,G) entry in its TIB, (b) the incoming interface (iif) list for that entry contains one of the IP interfaces, (c) at least one of the MPLS interfaces is in the outgoing interface (oif) list for that entry, and (d) the LSR does not originate an mLDP Label Mapping message for (S,G) with the Transit IPv4/IPv6 Source TLV, then the LSR MUST transition the (S,G,RPT-bit) downstream state to the Prune state. (Conceptually, the PIM state machine on the LSR will act "as if" it had received

Prune(S,G,rpt) on one of its MPLS interfaces, without actually having received one.) Depending on the (S,G,RPT-bit) state on the iif, this may result in the LSR using PIM procedures to prune S off the Shared (*,G) tree.

The LSR MUST keep the (S,G,RPT-bit) downstream state machine in the Prune state for as long as (a) the outgoing interface (oif) list for (*,G) contains one of the MPLS interfaces, (b) the LSR has at least one Source Active auto-discovery route for (S,G), and (c) the LSR does not originate the mLDP Label Mapping message for (S,G) with the Transit IPv4/IPv6 Source TLV. Once one or more of these conditions become no longer valid, the LSR MUST transition the (S,G,RPT-bit) downstream state machine to the NoInfo state.

Note that except for the scenario described in the first paragraph of this section, it is sufficient to rely solely on the PIM procedures on the LSR to ensure the correct behavior when pruning sources off the shared tree.

3.5. More on Handling (S,G,RPT-bit) State

The creation and deletion of (S,G,RPT-bit) state on an LSR that resulted from receiving PIM messages on one of its IP multicast interfaces do not result in any mLDP and/or BGP actions by the LSR.

4. IANA Considerations

IANA maintains a registry called "Label Distribution Protocol (LDP) Parameters" with a subregistry called "LDP MP Opaque Value Element basic type". IANA has allocated two new values, as follows:

Value	Name	Reference
11	Transit IPv4 Shared Tree TLV	[RFC7442]
12	Transit IPv6 Shared Tree TLV	[RFC7442]

5. Security Considerations

All of the security considerations for mLDP ([RFC6388]) apply here.

From the security considerations point of view, the use of Shared Tree TLVs is no different than the use of Source TLVs [RFC6826].

6. References

6.1. Normative References

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[RFC6826] Wijnands, IJ., Ed., Eckert, T., Leymann, N., and M. Napierala, "Multipoint LDP In-Band Signaling for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths", RFC 6826, January 2013, <http://www.rfc-editor.org/info/rfc6826>.

6.2. Informative References

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[RFC7438] Wijnands, IJ., Ed., Rosen, E., Gulko, A., Joorde, U., and J. Tantsura, "Multipoint LDP (mLDP) In-Band Signaling with Wildcards", RFC 7438, January 2015, <http://www.rfc-editor.org/info/rfc7438>.

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Authors' Addresses

Yakov Rekhter
Juniper Networks, Inc.
EMail: yakov@juniper.net

Rahul Aggarwal
Arktan
EMail: raggarwa_1@yahoo.com

Nicolai Leymann
Deutsche Telekom
Winterfeldtstrasse 21
Berlin 10781
Germany
EMail: N.Leymann@telekom.de

Wim Henderickx
Alcatel-Lucent
EMail: wim.henderickx@alcatel-lucent.com

Quintin Zhao
Huawei
EMail: quintin.zhao@huawei.com

Richard Li
Huawei
EMail: renwei.li@huawei.com