Note: I’ve removed comments that I think is resolved and accepted changes that I agree to.

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LDP Extensions for Hub & Spoke Multipoint Label Switched Path

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Abstract

This draft introduces a hub & spoke multipoint LSP (or HSMP

LSP for short), which allows traffic both from root to leaf through P2MP LSP

and also leaf to root along the co-routed reverse path. That means

traffic entering the HSMP LSP from application/customer at the root

node travels downstream to each leaf node, exactly as if it was travelling downstream

along a P2MP LSP to each leaf node. And upstream traffic entering the HSMP LSP

at any leaf node travels upstream along the tree to the root, as if it

is unicast to the root, and strictly follows the downstream path of the tree

rather than routing protocol based unicast path to the root.

Requirements Language

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 [RFC2119].

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1. Introduction

The point-to-multipoint LSP defined in [RFC6388] allows traffic to

transmit from root to several leaf nodes, and multipoint-to-

multipoint LSP allows traffic from every node to transmit to every

other node. This draft introduces a hub & spoke multipoint LSP

(or HSMP LSP for short), which allows traffic both from root to leaf

through P2MP LSP and also leaf to root along the co-routed reverse

path. That means traffic entering the HSMP LSP at the root node

travels downstream, exactly as if it was travelling downstream along a

P2MP LSP, and traffic entering the HSMP LSP at any other node travels

upstream along the tree to the root. A packet travelling upstream

should be thought of as being unicast to the root, except that it

follows the path of the tree rather than routing protocol based unicast path to the

root. The combination of upstream LSPs initiated from all leaf nodes forms a multipoint-to-point LSP.

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].

This document uses some terms and acronyms as follows:

HSMP LSP: hub & spoke multipoint LSP. An LSP allows traffic both

from root to leaf through P2MP LSP and also leaf to root along the

co-routed reverse path.

mLDP: Multipoint extensions for LDP

MP2MP LSP: An LSP that connects a set of nodes, such that traffic

sent by any node in the LSP is delivered to all others.

PTP: The timing and synchronization protocol used by IEEE1588

P2MP LSP: An LSP that has one Ingress LSR and one or more Egress

LSRs.

3. Applications

In some cases, the P2MP LSP may not have a reply path for the OAM

messages (e.g, LSP echo request). If P2MP LSP is provided by HSMP LSP instead, then

the upstream path could be used as the OAM message reply

path. This is especially useful in the case of P2MP LSP fault

detection, performance measurement, root node redundancy and etc.

There are several other applications that could take advantage of

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a LDP based HSMP LSP as described below.

3.1. Time synchronization scenario

[IEEE1588] over MPLS is defined in [I-D.ietf-tictoc-1588overmpls].

It is required that the LSP used to transport PTP event message

between a Master Clock and a Slave Clock, and the LSP between the

same Slave Clock and Master Clock must be co-routed. Using point-

to-multipoint technology to transmit PTP event messages from Master

Clock at root side to Slave Clock at leaf side will greatly improve

the bandwidth usage. Unfortunately current point-to-multipoint LSP

only provides unidirectional path from root to leaf, which cannot

provide a co-routed reverse path for the PTP event messages. LDP

based HSMP LSP described in this draft provides unidirectional point-

to-multipoint LSP from root to leaf and co-routed reverse path from

leaf to root.

3.2. Virtual Private Multicast Service scenario

Point to multipoint PW described in [I-D.ietf-pwe3-p2mp-pw] requires

to setup reverse path from leaf node (referred as egress PE) to root

node (referred as ingress PE), if HSMP LSP is used to multiplex P2MP

PW, the reverse path can also be multiplexed to HSMP upstream path to

avoid setup independent reverse path. In that case, the operational

cost will be reduced for maintaining only one HSMP LSP, instead of

P2MP LSP and n (number of leaf nodes) P2P reverse LSPs.

The VPMS defined in [I-D.ietf-l2vpn-vpms-frmwk-requirements] requires

reverse path from leaf to root node. The P2MP PW multiplexed to HSMP

LSP can provide VPMS with reverse path, without introducing

independent reverse path from each leaf to root.

3.3. Internet Protocol television (IPTV) scenario

The mLDP based HSMP LSP can also be applied in a typical IPTV

scenario. There is usually only one location with senders but there

are many receiver locations. If IGMP is used for signalling between

senders as IGMP querier[RFC3376] and receivers, the IGMP messages from the

receivers are travelling only from the leaves to the root (and from

root towards leaves) but not from leaf to leaf. In addition traffic

from the root is only replicated towards the leaves. Then leaf node

receiving IGMP report message (for source specific multicast case) will join HSMP LSP(reuse mechanism in [RFC6826] section 2), and then

send IGMP report message upstream to root along HSMP upstream LSP. Note that in

above case, there is no node redundancy for IGMP querier. And the

node redundancy for IGMP querier[RFC3376] could be provided by two independent

VPMS instances with HSMP applied.

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4. Setting up HSMP LSP with LDP

HSMP LSP is similar with MP2MP LSP described in [RFC6388], with the

difference that the leaf LSRs can only send traffic to root node

along the same path of traffic from root node to leaf node.

HSMP LSP consists of a downstream path and upstream path. The

downstream path is same as MP2MP LSP, while the upstream path is only

from leaf to root node, without communication between leaf and leaf

nodes. The transmission of packets from the root node of a HSMP LSP

to the receivers is identical to that of a P2MP LSP. Traffic from a

leaf node follows the upstream path toward the root node, along the

a path that traverse the same nodes as the downstream node, but in reverse order.

For setting up the upstream path of a HSMP LSP, ordered mode MUST be

used which is same as MP2MP. Ordered mode can guarantee a leaf to

start sending packets to root immediately after the upstream path is

installed, without being dropped due to an incomplete LSP.

Due to much of similar behavior between HSMP LSP and MP2MP LSP, the

following sections only describe the difference between the two

entities.

4.1. Support for HSMP LSP setup with LDP

HSMP LSP requires the LDP capabilities [RFC5561] for nodes to indicate that they support setup of HSMP LSPs. An implementation supporting

the HSMP LSP procedures specified in this document MUST implement the

procedures for Capability Parameters in Initialization Messages.

Advertisement of the HSMP LSP Capability indicates support of the

procedures for HSMP LSP setup.

A new Capability Parameter TLV is defined, the HSMP LSP Capability Parameter.

Following is the format of the HSMP LSP Capability Parameter.

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

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

|1|0| HSMP LSP Cap(TBD IANA) | Length |

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

|S| Reserved |

+-+-+-+-+-+-+-+-+

Figure 1. HSMP LSP Capability Parameter encoding

The length SHOULD be 1, and the S bit and reserved bits are defined in [RFC5561] section 3.

The HSMP LSP capability Parameter type is to be assigned by IANA.

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4.2. HSMP FEC Elements

Similar as MP2MP LSP, we define two new protocol entities, the HSMP

Downstream FEC Element and Upstream FEC Element. If a FEC TLV contains one of the

HSMP FEC Elements, the HSMP FEC Element MUST be the only FEC Element

in the FEC TLV. The structure, encoding and error handling for the

HSMP Downstream FEC Element and Upstream FEC Element are the same as for the

MP2MP FEC Element described in [RFC6388] Section 4.2. The difference

is that two additional new FEC types are defined: HSMP Downstream FEC

(TBD, IANA) and HSMP Upstream FEC(TBD, IANA).

4.3. Using the HSMP FEC Elements

In order to describe the message processing clearly, the entries in the list below

define the processing of the HSMP FEC Elements, which are inherited

from [RFC6388] section 4.3.

1. HSMP downstream LSP <X, Y> (or simply downstream <X, Y>): a HSMP

LSP downstream path with root node address X and opaque value Y.

2. HSMP upstream LSP <X, Y> (or simply upstream <X, Y>): a HSMP LSP

upstream path for root node address X and opaque value Y which will

be used by any of downstream node to send traffic upstream to root

node.

3. HSMP downstream FEC Element <X, Y>: a FEC Element with root node

address X and opaque value Y used for a downstream HSMP LSP.

4. HSMP upstream FEC Element <X, Y>: a FEC Element with root node

address X and opaque value Y used for an upstream HSMP LSP.

5. HSMP-D Label Mapping <X, Y, L>: A Label Mapping message with a single

HSMP downstream FEC Element <X, Y> and label TLV with label L. Label

L MUST be allocated from the per-platform label space of the LSR

sending the Label Mapping Message.

6. HSMP-U Label Mapping <X, Y, Lu>: A Label Mapping message with a single

HSMP upstream FEC Element <X, Y> and label TLV with label Lu. Label

Lu MUST be allocated from the per-platform label space of the LSR

sending the Label Mapping Message.

4.3.1. HSMP LSP Label Mapping

This section specifies the procedures for originating HSMP Label Mapping

messages and processing received HSMP label mapping messages for a

particular HSMP LSP. The procedure of downstream HSMP LSP is same as

that of downstream MP2MP LSP described in [RFC6388]. When LDP operates in Ordered Label Distribution Control mode [RFC5036], the upstream LSP will be setup by sending

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HSMP LSP LDP Label Mapping message with a label which is allocated by upstream

LSR to its downstream LSR hop by hop from root to leaf node,

installing the upstream forwarding table by every node along the LSP.

The detail procedure of setting up upstream HSMP LSP is different with that of

upstream MP2MP LSP, and is specified in below section.

All labels discussed here are downstream-assigned [RFC5332] except

those which are assigned using the procedures described in section 5.

Determining the upstream LSR for the HSMP LSP <X, Y> follows the

procedure for a MP2MP LSP described in [RFC6388] Section 4.3.1.1.

Determining one's downstream HSMP LSR procedure is much same as

defined in [RFC6388] section 4.3.1.2. An Upstream LDP peer which receives a

Label Mapping with HSMP downstream FEC Element from a LDP peer D will treat D as downstream HSMP

LDP peer.

Determining the forwarding interface to an LSR follows the same procedure as

defined in [RFC6388] section 2.4.1.2.

4.3.1.1. HSMP LSP leaf node operation

The leaf node operation is same as the operation of MP2MP LSP defined

in [RFC6388] section 4.3.1.4. The only is that different FEC elements are

and as specified below.

A leaf node Z will send a HSMP-D Label Mapping <X, Y, L> to U, instead of

MP2MP-D Label Mapping <X, Y, L>. and expects a HSMP-U Label Mapping <X, Y,

Lu> from node U and checks whether it already has forwarding state

for upstream <X, Y>. The created forwarding state on leaf node Z is

same as the leaf node of MP2MP LSP. Z will push label Lu onto the

traffic that Z wants to forward over the HSMP LSP.

4.3.1.2. HSMP LSP transit node operation

Suppose node Z receives a HSMP-D Label Mapping <X, Y, L> from LSR D, the

procedure is same as processing MP2MP-D Label Mapping message defined

in [RFC6388] section 4.3.1.5, and the processing protocol entity is

HSMP-D Label Mapping message. The different procedure is specified

below.

Node Z checks if upstream LSR U already has assigned a label Lu to

upstream <X, Y>. If not, transit node Z waits until it receives a

HSMP-U Label Mapping <X, Y, Lu> from LSR U. Once the HSMP-U Label Mapping is

received from LSR U, node Z checks whether it already has forwarding

state upstream <X, Y> with incoming label Lu' and outgoing label Lu.

If it does, Z sends a HSMP-U Label Mapping <X, Y, Lu'> to downstream

node. If it does not, it allocates a label Lu' and creates a new

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label swap for Lu' with Label Lu over interface Iu. Interface Iu is

determined via the procedures in Section 4.3.1. Node Z determines

the downstream HSMP LSR as per Section 4.3.1, and sends a HSMP-U

Label Mapping <X, Y, Lu'> to node D.

Since a packet from any downstream node is forwarded only to the

upstream node, the same label (representing the upstream path) can be

distributed to all downstream nodes. This differs from the

procedures for MPMP LSPs [RFC6388], where a distinct label must be

distributed to each downstream node. The forwarding state upstream

<X, Y> on node Z will be like this {<Lu'>, <Iu Lu>}. Iu means the

upstream interface over which Z receives HSMP-U Label Map <X, Y, Lu>

from LSR U. Packets from any downstream interface over which Z send

HSMP-U Label Map <X, Y, Lu'> with label Lu' will be forwarded to Iu

with label Lu' swap to Lu.

4.3.1.3. HSMP LSP root node operation

Suppose root node Z receives a HSMP-D Label Mapping <X, Y, L> from node

D, the procedure is much same as processing MP2MP-D Label Mapping

message defined in [RFC6388] section 4.3.1.6, and the processing

protocol entity is HSMP-D Label Mapping message. The different

procedure is specified below.

Node Z checks if it has forwarding state for upstream <X, Y>. If

not, Z creates a forwarding state for incoming label Lu' that

indicates that Z is the LSP egress. E.g., the forwarding state might

specify that the label stack is popped and the packet passed to some

specific application. Node Z determines the downstream HSMP LSR as

per section 4.3.1, and sends a HSMP-U Label Map <X, Y, Lu'> to node

D.

Since Z is the root of the tree, Z will not send a HSMP-D Label Map

and will not receive a HSMP-U Label Mapping.

4.3.2. HSMP LSP Label Withdraw

The HSMP Label Withdraw procedure is much same as MP2MP leaf

operation defined in [RFC6388] section 4.3.2, and the processing

protocol entities are HSMP FECs. The only difference is process of

HSMP-U Label Release message, which is specified below.

When a transit node Z receives a HSMP-U Label Release message from

downstream node D, Z should check if there are any incoming interface

in forwarding state upstream <X, Y>. If all downstream nodes are

released and there is no incoming interface, Z should delete the

forwarding state upstream <X, Y> and send HSMP-U Label Release

message to its upstream node.

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4.3.3. HSMP LSP upstream LSR change

The procedure for changing the upstream LSR is the same as defined in

[RFC6388] section 4.3.3, except it is applied to HSMP FECs.

5. HSMP LSP on a LAN

The procedure to process P2MP LSP on a LAN has been described in

[RFC6388]. When the LSR forwards a packet downstream on one of those

LSPs, the packet's top label must be the "upstream LSR label", and

the packet's second label is "LSP label".

When establishing the downstream path of a HSMP LSP, as defined in

[RFC6389], a Label Request for an LSP label is sent to the upstream

LSR. The upstream LSR should send Label Mapping that contains the

LSP label for the downstream HSMP FEC and the upstream LSR context

label. At the same time, it must also send label mapping for

upstream HSMP FEC to downstream node. Packets sent by the upstream

router can be forwarded downstream using this forwarding state based

on a two label lookup. Packets travelling upstream need to be

forwarded in the direction of the root by using the label allocated

by upstream LSR.

6. Redundancy considerations

In some scenario, it is necessary to provide two root nodes for

redundancy purpose. One way to implement this is to use two

independent HSMP LSPs acting as active/standby. At one time, only

one HSMP LSP will be active, and the other will be standby. After

detecting the failure of active HSMP LSP, the root and leaf nodes

will switch the traffic to the standby HSMP LSP which takes on the role as active HSMP LSP. The detail of redundancy mechanism will be

for future study.

7. Co-routed path exceptions

There are some exceptional cases when mLDP based HSMP LSP could not

achieve co-routed path. One possible case is using static routing

between LDP neighbors; another possible case is IGP cost asymmetric

generated by physical link cost asymmetric, or TE-Tunnels used

between LDP neighbors. The LSR/LER in HSMP LSP could detect if the

path is co-routed or not, if not co-routed, an indication could be

generated to the management system.

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8. Failure Detection of HSMP LSP

The idea of LSP ping for HSMP LSPs could be expressed as an intention

to test the LSP echo request packets that enter at the root along a particular

downstream path of HSMP LSP, and end their MPLS path on the leaf.

The leaf node then sends the LSP ping echo reply along the co-routed

upstream path of HSMP LSP, and end on the root that are the

(intended) root node.

New sub-TLVs are required to be assigned by IANA in Target FEC Stack

TLV to define the corresponding HSMP-upstream FEC type and HSMP-

downstream FEC type. In order to ensure the leaf node to send the

LSP ping response along the HSMP upstream path, the R bit (Validate

Reverse Path) in Global Flags Field defined in [RFC6426] is reused

here.

The node processing mechanism of LSP echo request and reply for HSMP LSP is inherited

from [RFC6425] and [RFC6426] section 3.4, except the following:

1. The root node sending LSP echo request message for HSMP LSP MUST attach

Target FEC Stack with HSMP downstream FEC, and set R bit to '1' in

Global Flags Field.

2. When the leaf node receiving the LSP echo request, it MUST send the LSP

echo reply to the associated HSMP upstream path. The Reverse-path

Target FEC Stack TLV attached by leaf node in echo reply message SHOULD

contain the sub-TLV of associated HSMP upstream FEC.

9. Security Considerations

The same security considerations apply as for the MP2MP LSP described

in [RFC6388] and [RFC6425].

Although this document introduces new FEC Elements and corresponding procedures, the protocol does not bring any new security issues compared to [RFC6388] and [RFC6425].

10. IANA Considerations

This document requires allocation of two new LDP FEC Element types

from the "Label Distribution Protocol (LDP) Parameters registry" the

"Forwarding Equivalence Class (FEC) Type Name Space":

1. the HSMP-upstream FEC type - requested value TBD

2. the HSMP-downstream FEC type - requested value TBD

This document requires allocation of one new code points for the HSMP

LSP capability TLV from "Label Distribution Protocol (LDP) Parameters

registry" the "TLV Type Name Space":

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HSMP LSP Capability Parameter - requested value TBD

This document requires allocation of two new sub-TLV types for

inclusion within the LSP ping [RFC4379] Target FEC Stack TLV (TLV

type 1).

1. the HSMP upstream LDP FEC Stack - requested value TBD

2. the HSMP downstream LDP FEC Stack - requested value TBD

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