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TRILL Smart Endnodes
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Abstract

This draft addresses the problem of the size and freshness of the endnode learning table in edge RBridges, by allowing endnodes to volunteer for endnode learning and encapsulation/decapsulation. Such an endnode is known as a "Smart Endnode". Only the attached edge RBridge can distinguish a "Smart Endnode" from a "normal endnode". The smart endnode uses the nickname of the attached edge RBridge, so this solution does not consume extra nicknames. The solution also enables Fine Grained Label aware endnodes.

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1. Introduction

The IETF TRILL (Transparent Interconnection of Lots of Links) protocol [RFC6325] [RFC7780] provides optimal pair-wise data frame forwarding without configuration, safe forwarding even during periods of temporary loops, and support for multipathing of both unicast and multicast traffic. TRILL accomplishes this by using IS-IS [IS-IS] [RFC7176] link state routing and encapsulating traffic using a header that includes a hop count. Devices that implement TRILL are called "RBridges" (Routing Bridges) or "TRILL Switches".

An RBridge that attaches to endnodes is called an "edge RBridge" or "edge TRILL Switch", whereas one that exclusively forwards encapsulated frames is known as a "transit RBridge" or "transit TRILL Switch". An edge RBridge traditionally is the one that encapsulates a native Ethernet frame with a TRILL header, or that receives a TRILL-encapsulated packet and decapsulates the TRILL header. To encapsulate efficiently, the edge RBridge must keep an "endnode table" consisting of (MAC, Data Label, TRILL egress switch nickname) sets, for those remote MAC addresses in Data Labels currently communicating with endnodes to which the edge RBridge is attached.

These table entries might be configured, received from ESADI [RFC7357], looked up in a directory [RFC7067], or learned from decapsulating received traffic. If the edge RBridge has attached endnodes communicating with many remote endnodes, this table could become very large. Also, if one of the MAC addresses and Data Labels in the table has moved to a different remote TRILL switch, it might be difficult for the edge RBridge to notice this quickly, and because the edge RBridge is encapsulting to the incorrect egress RBridge, the traffic will get lost.

2. Solution Overview

The Smart Endnode solution proposed in this document addresses the problem of the size and freshness of the endnode learning table in edge RBridges. An endnode E, attached to an edge RBridge R, tells R that E would like to be a "Smart Endnode", which means that E will encapsulate and decapsulate the TRILL frame, using R's nickname. Because E uses R's nickname, this solution does not consume extra nicknames.

Take the below figure as the example Smart Endnode scenario: RB1, RB2 and RB3 are the RBridges in the TRILL domain, and smart SE1 and SE2 are the smart ennodes which can encapsulate and decapsulate the TRILL packets. RB1 is the edge RB and it is been attached by SE1 and SE2. RB1 assigns its nickname to SE1 and SE2.

Each Smart Endnode, SE1 and SE2, uses RB1's nickname when encapsulating, and maintains an endnode table of (MAC, label, TRILL egress switch nickname) for remote endnodes that it (SE1 or SE2) is corresponding with. RB1 does not decapsulate packets destined for SE1 or SE2, and does not learn (MAC, label, TRILL egress switch nickname) for endnodes corresponding with SE1 or SE2, but RB1 does decapsulate, and does learn (MAC, label, TRILL egress switch nickname) for any endnodes attached to RB1 that have not declared themselves to be Smart Endnodes.

Just as an RBridge learns and times out (MAC, label, TRILL egress switch nickname), Smart Endnodes SE1 and SE2 also learn and time out endnode entries. However, SE1 and SE2 might also determine, through ICMP messages or other techniques that an endnode entry is not successfully reaching the destination endnode, and can be deleted, even if the entry has not timed out.

If SE1 wishes to correspond with destination MAC D, and no endnode entry exists, SE1 will encapsulate the packet as an unknown destination, or examining updates to the ESADI link state database [RFC7357], or consulting a directory [RFC7067] (just as an RBridge would do if there was no endnode entry).

```
+----------+
|SE1(Smart |
|Endnode1) |  \      +-------------------------------+
+----------+   \    /                                \
                \  /+------+   +------+    +-----+    \   +----------+
                /-+-| RB 1 |---|  RB2 |----| RB3 |-----+--| Endnode1 |
               /  | +------+   +------+    +-----+     |  +----------+
+----------+ /     \                                  /
|SE2(Smart |        \                                /
| Endnode2)|         +-------------------------------+
+----------+
```

Figure 1 Smart Endnode Scenario

The mechanism in this draft is that the Smart Endnode SE1 issues a Smart-Hello, indicating SE1's desire to act as a Smart Endnode, together with the set of MAC addresses and Data Labels that SE1 owns, and whether SE1 would like to receive ESADI packets. The Smart-Hello is a light type of TRILL-hello formatted as a native RBridge Channel [RFC7178] message, which is used to announce the Smart Endnode capability and parameters (such as MAC address, VLAN ID etc.). The detailed content for a smart endnode's Smart-Hello is defined in section 4.

If RB1 supports having a Smart Endnode neighbor it also sends Smart-Hellos. The smart endnode learns from RB1's Smart-Hellos what RB1's nickname is and which trees RB1 can use when RB1 ingresses multi-destination frames. Although Smart Endnode SE1 transmits Smart-Hellos, it does not transmit or receive LSPs or E-L1FS FS-LSPs [RFC7780].

Since a Smart Endnode can encapsulate TRILL Data packets, it can cause the Inner.Lable to be a Fine Grained Label [RFC7172], thus this method supports FGL aware endnodes.

3. Terminology

Edge RBridge: An RBridge providing endnode service on at least one of its ports. It is also called an edge TRILL Switch.

Data Label: VLAN or FGL.

DRB: Designated RBridge [RFC6325].

ESADI: End Station Address Distribution Information [RFC7357].

FGL: Fine Grained Label [RFC7172].

IS-IS: Intermediate System to Intermediate System [IS-IS].

RBridge: Routing Bridge, an alternative name for a TRILL switch.

Smart Endnode: An endnode that has the capability specified in this document including learning and maintaining (MAC, Data Label, Nickname) entries and encapsulating/decapsulating TRILL frame.

Transit RBridge: An RBridge exclusively forwards encapsulated frames. It is also named as transit RBridge.

TRILL: Transparent Interconnection of Lots of Links [RFC6325][RFC7780].

TRILL Switch: a device that implements the TRILL protocol; an alternative term for an RBridge.

4. Smart-Hello Mechanism between Smart Endnode and RBridge

The subsections below describe Smart-Hello messages.

4.1. Smart-Hello Encapsulation

Although a Smart Endnode is not an RBridge, does not send LSPs or maintain a copy of the link state database, and does not perform routing calculations, it is required to have a "Hello" mechanism (1) to announce to edge RBridges that it is a Smart Endnode and (2) to tell them what MAC addresses it is handling in what Data Labels. Similarly, an edge RBridge that supports Smart Endnodes needs a message (1) to announce that support, (2) to inform Smart Endnodes what nickname to use for ingress and what nickname(s) can be used as egress nickname in a multi-destination TRILL Data packet, and (3) the list of smart end nodes it knows about on that link.

The messages sent by Smart Endnodes and by edge RBridges that support Smart Endnodes are called "Smart-Hellos", and are carried through native RBridge Channel messages (see Section 4 of [RFC7178]). They are structured as follows:

```
+----------+---------------+------------+----------+
| Ethernet | RBridge       | Smart-Hello | Ethernet |
| Header   | Channel Header | Payload    | FCS      |
+----------+---------------+------------+----------+
```

Figure 2 Smart-Hello Structure

In the Ethernet Header, the source MAC address is the address of the Smart Endnode or edge RBridge port on which the message is sent. If the Smart-Hello is sent by a Smart Endnode and is multicast, the destination MAC address is All-Edge-RBridges. If the Smart-Hello is unicast to an edge RBridge, the destination MAC address is the MAC address of the RBridge. If the Smart-Hello is sent by an Edge RBridge and is multicast, the destination MAC address is TRILL-End-Stations, and if it is unicast to a Smart Endnode, the MAC address is the MAC address of the Smart Endnode. The frame is sent in the Designated VLAN of the link so if a VLAN tag is present, it specifies that VLAN. It is RECOMMENDED that Smart-Hellos be sent with priority 7 to minimize the probability that they might be delayed or lost in any bridges that might be in the link.

The RBridge Channel Header begins with the RBridge Channel Ethertype. In the RBridge Channel Header, the Channel Protocol number is as assigned by IANA (see Section 8) and in the flags field, the NA bit is one, the MH bit is zero and the setting of the SL bit is an implementation choice.

The Smart-Hello Payload, both for Smart-Hellos sent by Smart Endnodes and for Smart-Hellos sent by Edge RBridges, consists of TRILL IS-IS TLVs as described in the following two sub-sections. The non-extended format is used so TLVs, sub-TLVs, and APPsub-TLVs have an 8-bit size and type field. Both types of Smart-Hellos MUST include a Smart-Parameters APPsub-TLV as follows inside a TRILL GENINFO TLV:

```
+-+-+-+-+-+-+-+-+-+-
|Smart-Parameters|                 (1 byte)
+-+-+-+-+-+-+-+-+-+-
|   Length       |                 (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Holding Time                  |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Flags                         |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3 Smart Parameters APPsub-TLV

Type: APPsub-TLV type Smart-Parameters, value is TBD1.

Length: 4.

Holding Time: A time in seconds as an unsigned integer. It has the same meaning as the Holding Time field in IS-IS Hellos [IS-IS] . A Smart Endnode and an Edge RBridge supporting Smart Endndoes MUST send a Smart-Hello at least three times during their Holding Time. If no Smart-Hellos is received from a Smart Endnode or Edge RBridge within the most recent Holding Time it sent, it is assumed that it is no longer available.

Flags: At this time all of the Flags are reserved and MUST be send as zero and ignored on receipt.

If more than one Smart Parameters APPsub-TLV appears in a Smart-Hello, the first one is used and any following ones are ignored. If no Smart Parameters APPsub-TLV appears in a Smart-Hello, that Smart-Hello is ignored.

4.2. Edge RBridge's Smart-Hello

The edge RBridge's Smart-Hello contains the following information in addition to the Smart-Parameters APPsub-TLV:

- o RBridge's nickname. The nickname sub-TLV, specified in section 2.3.2 in [RFC7176], is reused here carried inside a TLV 242 (IS-IS router capability) in a Smart-Hello frame. If more than one nickname appears in the Smart-Hello, the first one is used and the following ones are ignored.

- o Trees that RB1 can use when ingressing multi-destination frames. The Tree Identifiers Sub-TLV, specified in section 2.3.4 in [RFC7176], is reused here.

o Smart Endnode neighbor list. The TRILL Neighbor TLV, specified in section 2.5 in [RFC7176], is reused for this purpose.

o An Autentication TLV MAY also be included.

4.3. Smart Endnode's Smart-Hello

A new APPsub-TLV (Smart-MAC TLV) is defined for use by Smart Endnodes as defined below. In addition, there will be a Smart-Parameters APPsub-TLV and there MAY be an Authentication TLV in a Smart Endnode Smart-Hello.

If there are several VLANs/FGL Data Labels for that Smart Endnode, the Smart-MAC APPsub-TLV is included several times in Smart Endnode's Smart-Hello. This APPsub-TLV appears inside a TRILL GENINFO TLV.

```
 +-+-+-+-+-+-+-+-+
 |Type=Smart-MAC |                  (1 byte)
 +-+-+-+-+-+-+-+-+
 |   Length      |                  (1 byte)
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |E|F|RSV | VLAN/FGL Data Label  |  (2 bytes or 4 bytes)
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                          MAC (1)       (6 bytes)                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                      .................                             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                          MAC (N)       (6 bytes)                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4 Smart-MAC APPsub-TLV

o Type: TRILL APPsub-TLV Type Smart-MAC, value is TBD2.

o Length: Total number of bytes contained in the value field.

o E: one bit. If it sets to 1, which indicates that the endnode should receive ESADI frames for the VLAN or FGL in the APPsub-TLV.

o F: one bit. If it sets to 1, which indicates that the endnode supports FGL data label, otherwise, the VLAN/FGL Data Labels [RFC7172] and that this Smart-MAC APPsub-TLV has an FGL in the following VLAN/FGL field. Otherwise, the VLAN/FGL Data Label field is a VLAN ID.

o RSV: 2 bits or 6 bits, is reserved for the future use. If VLAN/ FGL Data Label indicates the VLAN ID(F flag sets to 0), the RESV field is 2 bits long. Otherwise it is 6 bits.

o VLAN/FGL Data Label: This carries a 12-bits VLAN identifier or 24-bits FGL Data Label that is valid for all subsequent MAC addresses in this APPsub-TLV, or the value zero if no VLAN/FGL data label is specified.

o MAC(i): This is a 48-bit MAC address reachable in the Data Label given from the Smart Endnode that is announcing this APPsub-TLV.

5. Data Packet Processing

The subsections below specify Smart Endnode data packet processing. All TRILL Data packets sent to or from Smart Endnodes are sent in the Designated VLAN [RFC6325] of the local link but do not necessarily have to be VLAN tagged.

5.1. Data Packet Processing for Smart Endnode

A Smart Endnode does not issue or receive LSPs or E-L1FS FS-LSPs or calculate topology. It does the following:

o Smart Endnode maintains an endnode table of (the MAC address of remote endnode, Data Label, the nickname of the edge RBridge's attached) entries of end nodes with which the Smart Endnode is communicating. Entries in this table are populated the same way that an edge RBridge populates the entries in its table:

  * learning from (source MAC address ingress nickname) on packets it decapsulates.

  * from ESADI [RFC7357].

  * by querying a directory [RFC7067].

  * by having some entries configured.

o When Smart Endnode SE1 wishes to send unicast frame to remote node D, if (MAC address of remote endnode D, Data Label, nickname) entry is in SE1's endnode table, SE1 encapsulates with ingress nickname=the nicknamae of the RBridge(RB1), egress nickname as indicated in D's table entry. If D is unknown, SE1 either queries a directory or runs ESADI protocol, or encapsulates the packet as a multi-destination frame, using one of the trees that RB1 has specified in RB1's Smart-Hello. The mechanism for querying a directory or running ESADI is out of scope for this document.

o When SE1 wishes to send a a multi-destination (multicast, unknown unicast, or broadcast) to the TRILL campus, SE1 encapsulates the packet using one of the trees that RB1 has specified.

Whether the Smart Endnode SE1 sends a multi-destination TRILL Data packet, the destination MAC of the outer Ethernet is the MAC address of RB1's port.

The Smart Endnode SE1 need not send Smart-Hellos as frequently as normal RBridges. These Smart-Hellos could be periodically unicast to the Appointed Forwarder RB1 through native RBridge Channel messages. In case RB1 crashes and restarts, or the DRB changes and SE1 receives the Smart-Hello without mentioning SE1, SE1 SHOULD send a Smart-Hello immediately. If RB1 is Appointed Forwarder for any of the VLANs that SE1 claims, RB1 MUST list SE1 in its Smart-Hellos as a Smart Endnode neighbor.

5.2. Data Packet Processing for Edge RBridge

The attached edge RBridge processes and forwards TRILL Data packets based on the endnode property rather than for encapsulation and forwarding the native frames the same way as the traditional RBridges. There are several situations for the edge RBridges as follows:

o If receiving an encapsulated unicast TRILL Data packet from a port with a Smart Endnode, with RB1's nickname as ingress, the edge RBridge RB1 forwards the frame to the specified egress nickname, as with any encapsulated frame. However, RB1 MAY filter the encapsulation frame based on the inner source MAC and Data Label as specified for the Smart Endnode. If the MAC (or Data Label) are not among the expected entries of the Smart Endnode, the frame would be dropped by the edge RBridge.

o If receiving a unicast TRILL Data packet with RB1's nickname as egress from the TRILL campus, and the destination MAC address in the enclosed packet is listed as "smart endnode", RB1 leaves the packet encapsulated when forwarding to the smart endnode, and both the outer and inner Ethernet destination MAC is the destination smart endnod's MAC address, and the outer Ethernet source MAC address is the RB1's port MAC address. The edge RBridge still decreases the Hop count value by 1, for there is one hop between the RB1 and Smart Endnode.

o If receiving an multi-destination TRILL Data packet from a port with a Smart Endnode, RBridge RB1 forwards the TRILL encapsulation to the TRILL campus based on the distribution tree indicated by the egress nickname. If the egress nickname does not correspond to a distribution tree, the packet is discarded. If there are any normal endnodes (i.e, non-Smart Endnodes) attached to the edge RBridge RB1, RB1 decapsulates the frame and sends the native frame to these ports possibly pruned based on multicast listeners, in

addition to forwarding the multi-destination TRILL frame to the rest of the campus.

o When RB1 receives a multi-destination TRILL Data packet from a remote RBridge, and the exit port includes hybrid endnodes(Smart Endnodes and non-Smart Endnodes), it sends two copies of multicast frames out the port, one as native and the other as TRILL encapsulated frame. When Smart Endnode receives multi-destination TRILL Data packet, it learns the remote (MAC address, Data Label, Nickname) entry, A Smart Endnodes ignores native data frames. A normal (non-smart) endnode receives the native frame and learns the remote MAC address and ignores the TRILL data packet. This transit solution may bring some complexity for the edge RBridge and waste network bandwidth resource, so avoiding the hybrid endnodes scenario by attaching the Smart Endnodes and non-Smart Endnodes to different ports is RECOMMENDED. Another solution is that if there are one or more endnodes on a link, the non-Smart Endnodes are ignored on a link; but we can configure a port to support mixed links. If RB1 is configured that the link is "Smart Endnode only", then it will only send and receive TRILL-encapsulated frames on that link. If it is configured to "non-smart-endnodes only" on a port, it will only send and receive native frames from that port.

6. Multi-homing Scenario

Multi-homing is a common scenario for the Smart Endnode. The Smart Endnode is on a link attached to the TRILL domain in two places: to edge RBridge RB1 and RB2. Take the figure below as example. The Smart Endnode SE1 is attached to the TRILL domain by RB1 and RB2 separately. Both RB1 and RB2 could announce their nicknames to SE1.

```
                     . ......................
                     .  +------+            .
                     .  | RB1  |            .
                     . /+------+            .
        +----------+ ./           +-----+ .    +----------+
        |SE1(Smart |/.            | RB3 |......| Smart    |
        | Endnode1)| .\           +-----+ .    | Endnode2 |
        +----------+ . \                  .    +----------+
                     .  +-----+             .
                     .  | RB2 |   TRILL     .
                     .  +-----+   Domain    .
                     .......................
```

Figure 5 Multi-homing Scenario

There are several solutions for this scenario:

(1) Smart Endnode SE1 can choose either RB1 or RB2's nickname, when encapsulating a frame, whether the encapsulated frame is sent via RB1 or RB2. If SE1 uses RB1's nickname, in this scenario, SE1 will encapsulate with TRILL ingress nickname RB1 when transmitting on either port. This is simple, but means that all return traffic will be via RB1. If Smart Endnode SE1 wants to do active-active load splitting, and uses RB1's nickname when forwarding through RB1, and RB2's nickname when forwarding through RB2, this will cause MAC flip-flopping(see [RFC7379]) of the endnode table entry in the remote RBridges (or Smart Endnodes). One solution is to set a multi- homing bit in the RSV field of the TRILL data packet. When remote RBridge RB3 or Smart Endnodes receives a data packet with the multi-homed bit set, the endnode entries (SE1's MAC address, label, RB1's nickname) and (SE1's MAC address, label, RB2's nickname) will coexist as endnode entries in the remote RBridge. Another solution is to use the ESADI protocol to distribute multiple attachments of a MAC address of a multi-homing group (See section 5.3 of [RFC7357]).

(2) RB1 and RB2 might indicate, in their Smart-Hellos, a virtual nickname that attached end nodes may use if they are multihomed to RB1 and RB2, separate from RB1 and RB2's nicknames (which they would also list in their Smart-Hellos). This would be useful if there were many end nodes multihomed to the same set of RBridges. This would be analogous to a pseudonode nickname; return traffic would go via the shortest path from the source to the endnode, whether it is RB1 or RB2. If Smart Endnode SE1 loses connectivity to RB2, then SE1 would revert to using RB1's nickname. In order to avoid RPF check issue for multi-destination frame, the affinity TLV [RFC7783] could be used in this solution.

7. Security Considerations

Smart-Hellos can be secured by using Authentication TLVs based on [RFC5310].

For general TRILL Security Considerations, see [RFC6325].

For native RBridge channel Security Considerations, see [RFC7178].

8. IANA Considerations

IANA is requested to allocate an RBridge Channel Protocol number (0x005 suggested) to indicate a Smart-Hello frame and update the "RBridge Channel Protocols" registry as follows.

Protocol	Description	Reference
TBD[0x005]	Smart-Hello	[this document]

Table 1

IANA is requested to allocate APPsub-TLV type numbers for the Smart-MAC and Smart-Parameters APPsub-TLVs from the range below 256 and update the "TRILL APPsub-TLV Types under IS-IS TLV 251 Application Identifier 1" registry as follows.

Protocol	Description	Reference
TBD1	Smart-Hello	[this document]
TBD2	Smart-MAC	[this document]

Table 2

9. Acknowledgements

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