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Transparent Interconnection of Lots of Links (TRILL) Multilevel
Using Unique Nicknames

Abstract

TRILL (Transparent Interconnection of Lots of Links) routing can be extended to support multiple levels by building on the multilevel feature of IS-IS routing. Depending on how nicknames are managed, there are two primary alternatives to realize TRILL multilevel: the unique nickname approach and the aggregated nickname approach as discussed in RFC 8243. This document specifies a unique nickname approach. This approach gives unique nicknames to all TRILL switches across the multilevel TRILL campus.

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1. Introduction

The multiple-level feature of [IS-IS] can increase the scalability of TRILL as discussed in [RFC8243]. However, multilevel IS-IS needs some extensions to support the TRILL multilevel feature. The two most significant extensions are how TRILL switch nicknames are managed and how distribution trees are handled [RFC8243].

There are two primary alternatives to realize TRILL multilevel [RFC8243]. One approach, which is referred to as the "aggregated nickname" approach, involves assigning nicknames to the areas, and allowing nicknames to be reused in different areas by having the border TRILL switches rewrite nickname fields when entering or leaving an area. For more description of the aggregated nickname approach, one can refer to [RFC8243] and [SingleN]. The other approach, which is referred to as the "unique nickname" approach, is specified in this document. The unique nickname approach gives unique nicknames to all the TRILL switches in the multilevel campus by having the TRILL switches at the Level 1 / Level 2 border advertise into the Level 1 area those nicknames are not available for assignment in that area and advertising into the Level 2 area those nicknames that are used by the Level 1 area so that other areas cannot use them anymore. The advertising of Level 1 nicknames informs the rest of the campus how to reach the nicknames residing in that area. In this document, protocol extensions that support such advertisement are specified.

Each RBridge in a unique nickname area calculates two types of trees: local distribution trees and global distributions trees. For multi-destination traffic that is limited to an area, the packets will be flooded on a local distribution tree. Otherwise, the multi-destination packets will be flooded along a global distribution tree.

In the unique nickname approach, nicknames are globally valid so that border RBridges do not rewrite the nickname field of TRILL data packets that transition between Level 1 and Level 2, as border RBridges do in the aggregated nickname approach. If a border RBridge is a transit node on a forwarding path, it does not learn MAC addresses of the TRILL data packets forwarded along this path. Testing and maintenance operations that originate in one area and terminate in a different area are also simplified [RFC8243]. For these reasons, the unique nickname approach might realize simpler border RBridges than the aggregated nickname approach. However, the unique nickname approach is less scalable and may be less well suited for very large campuses.

2. Acronyms and Terminology

Border RBridge: An RBridge that is located on the border between two or more RBridge areas.

Data Label: VLAN or FGL [RFC7172]

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

RBridge: A device implementing the TRILL protocol.

TRILL: Transparent Interconnection of Lots of Links or Tunneled Routing in the Link Layer [RFC6325].

TRILL switch: An alternative name for an RBridge.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Data Routing

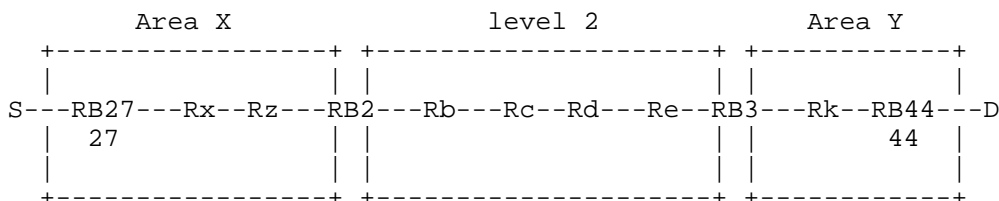


Figure 1: An Example Topology for TRILL Multilevel

Figure 1 is adapted from the example topology of [RFC8243], where S is Source, and D is Destination.

The routing processes are described in the following two subsections.

3.1. Unicast Routing

The plain RBridge RB27 has a different view of the topology of the TRILL campus than its border RBridge RB2. For an outward path that reaches an RBridge not in the same area (say, RB44), RB27 calculates the segment of the path in Area X, the border RBridge RB2 calculates the segment in Level 2, while the border RBridge to the destination area, RBridge RB3, calculates the segment from itself to RB44.

Let us say that S transmits a frame to destination D and let us say that D's location is learned by the relevant TRILL switches already. These relevant switches have learned the following:

- 1) RB27 has learned that D is connected to nickname 44.
- 2) RB2 has learned that nickname 44 is accessible through RB3.

The following sequence of events will occur:

- S transmits an Ethernet frame with source MAC = S and destination MAC = D.
- RB27 encapsulates with a TRILL header with ingress RBridge nickname 27, and egress RBridge nickname 44 producing a TRILL Data packet.
- RB2 has announced in the Level 1 IS-IS instance in Area X that it owns all nicknames of other areas, including 44. Therefore, IS-IS routes the packet to RB2.
- The packet is forwarded through Level 2, from RB2 to RB3, which has advertised, in Level 2, it owns the nickname 44.
- RB3, when forwarding into Area Y, does not change the ingress nickname 27 or the egress nickname 44.
- RB44, when decapsulating, learns that S is attached to nickname 27.

3.2. Multi-destination Routing

The scope of Multi-destination routing is defined by the tree root nickname. A tree with a Level 2 tree root nickname is global, and a tree with a Level 1 tree root nickname is local. See Section 4.2 for the Level 1 and Level 2 nickname allocation.

Border RBridges announce the global trees to be calculated only for those Data Labels that span across areas. APPsub-TLVs as specified in Section 3.2 of [RFC7968] will be advertised for this purpose. Based on the Data Label, an ingress RBridge can determine whether a global tree or a local tree is to be used for a TRILL multi-destination Data packet.

If there are legacy TRILL switches that do not understand the APPsub-TLVs for tree selection, configuration MUST guarantee that Data Labels [RFC7172] being used globally in Level 2 are disabled on these legacy TRILL switches. (Otherwise, the legacy TRILL switches might use local trees for multi-destination traffic with a global scope.)

These legacy TRILL switches may use global trees to flood multi-destination packets with a scope of the local area. Those global trees MUST be pruned at the border TRILL switches based on Data Labels.

3.2.1. Local Distribution Trees

The root RBridge RB1 of a local distribution tree resides in the area. RBridges in this area calculate this local tree based on the link state information of this area, using RB1's nickname as the root. Protocol behaviors for local distribution trees have been specified in Section 4.5 of [RFC6325]. The sole difference is that the local distribution tree spans this area only. A multi-destination packet with an egress nickname of the root RBridge of a local tree MUST NOT be leaked into Level 2 at the border RBridge.

3.2.2. Global Distribution Trees

Within Level 2, the RBridge with the highest tree root priority advertises the set of global trees by providing a list of Level 2 RBridge nicknames as defined in Section 4.5 of [RFC6325].

According to [RFC6325], the RBridge with the highest root priority advertises the tree roots for a Level 1 area. There has to be a border RBridge with the highest root tree priority in each area so that it can advertise the global tree root nicknames into the area. Also, this border RBridge MUST advertise the set of local distribution trees by providing another set of nicknames. Since nicknames of global tree roots and local tree roots indicate different flooding scopes, these two sets MUST NOT overlap. If a border RBridge has been assigned both as a global tree root and a local tree root, it MUST acquire both global tree root nickname(s) and local tree root nickname(s). However, non-border RBridges in an area do not differentiate between a global tree root nickname and a local tree root nickname.

Suppose RB3 is the RBridge with the highest tree root priority within Level 2, and RB2 is the highest tree root priority in Area X. RB2 advertises in Area X that nickname RB3 is the root of a distribution tree. Figures 2 through 5 illustrate how different RBridges view the global distribution tree.

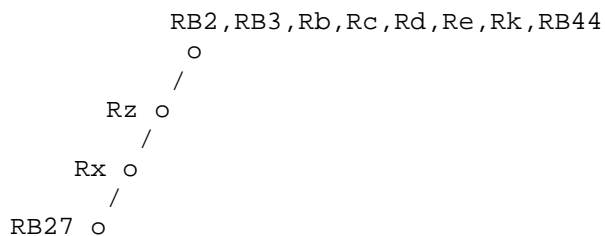


Figure 2: RB27's View of the Global Distribution Tree

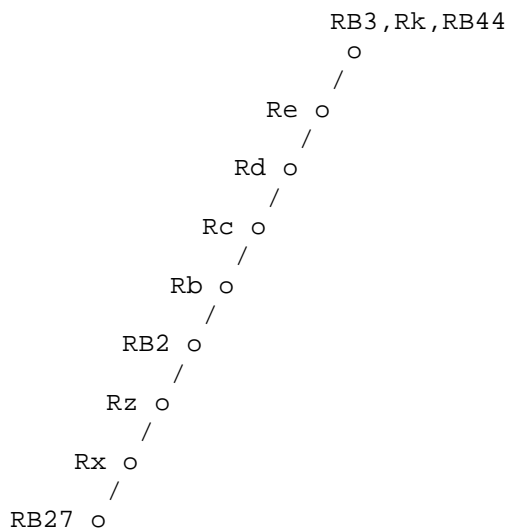


Figure 3: RB2's View of the Global Distribution Tree

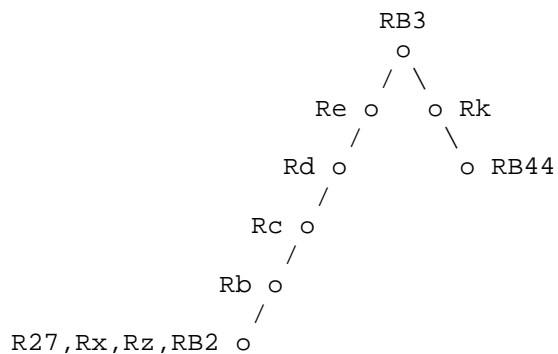


Figure 4: RB3's View of the Global Distribution Tree

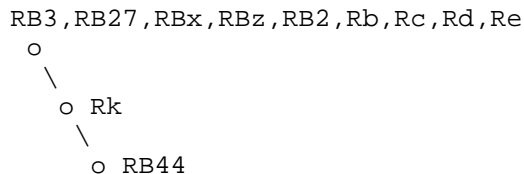


Figure 5: RB44's View of the Global Distribution Tree

The following sequence of events will occur when a multi-destination TRILL Data packet is forwarded using the global distribution tree:

- RB27 produces a multi-destination (M bit is one) TRILL Data packet with ingress RBridge nickname 27 and egress RBridge nickname 3. RB27 floods this packet using the segment of the global distribution tree that resides in Area X.
- RB2, when flooding the packet in Level 2, uses the segment of the global distribution tree that resides in Level 2.
- RB3, when flooding the packet into Area Y, uses the segment of the global distribution tree that resides in Area Y.
- The multicast listener RB44, when decapsulating the received packet, learns that S is attached to nickname 27.

4. Protocol Basics and Extensions

4.1. Multilevel TRILL Basics

Multilevel TRILL builds on the multilevel feature of [IS-IS]. Border RBridges are in both a Level 1 area and in Level 2. They establish adjacency with Level 1 RBridges as specified in [RFC7177] and [RFC6325]. They establish adjacency with Level 2 RBridges in exactly the same way except that (1) for a LAN link, the IS-IS Hellos used are Level 2 Hello PDUs [IS-IS] and (2) for a point-to-point link, the Level is configured and indicated in flags in the point-to-point Hello. The state machines for Level 1 and Level 2 adjacency are independent, and two RBridges on the same LAN link can have any adjacency state for Level 1 and, separately, any adjacency state for Level 2. Level 1 and Level 2 link state flooding are independent using Level 1 and Level 2 versions of the relevant IS-IS PDUs (LSP, CSNP, PSNP, FS-LSP, FS-CSNP, and FS-PSNP [RFC7356] [RFC7780]). Thus, Level 1 link state information stays within a Level 1 area and Level 2 link state information stays in Level 2 unless there are specific provisions for leaking (copying) information between levels. This is why multilevel can address the TRILL scalability issues as specified in Section 2 of [RFC8243].

The former "campus wide" minimum acceptable link size S_z is calculated as before: by Level 1 RBridges (including border RBridges) using the `originatingLSPBufferSize` advertised in the Level 1 LSP so it is area local in multilevel TRILL. A minimum acceptable link size in Level 2, called S_{z2} , is calculated by the RBridges participating in Level 2 in the same way as S_z is calculated but using the `originatingLSPBufferSize` distributed in Level 2 LSPs.

4.2. Nickname Allocation

Level 2 RBridges contend for nicknames in the range from 0xF000 through 0xFFBF the same way as specified in [RFC6325]: using Level 2 LSPs. The highest-priority border router for a Level 1 area should contend with others in Level 2 for blocks of nicknames for the range from 0x0001 to 0xEFFF. Blocks of 64 aligned on boundaries of multiples of 64 are RECOMMENDED in this document.

The nickname contention in Level 2 will determine which blocks of nicknames are available for an area and which blocks of nicknames are used elsewhere. The `NickBlockFlags APPsub-TLV` as specified in Section 4.3 will be used by the border RBridge(s) to announce the nickname availability.

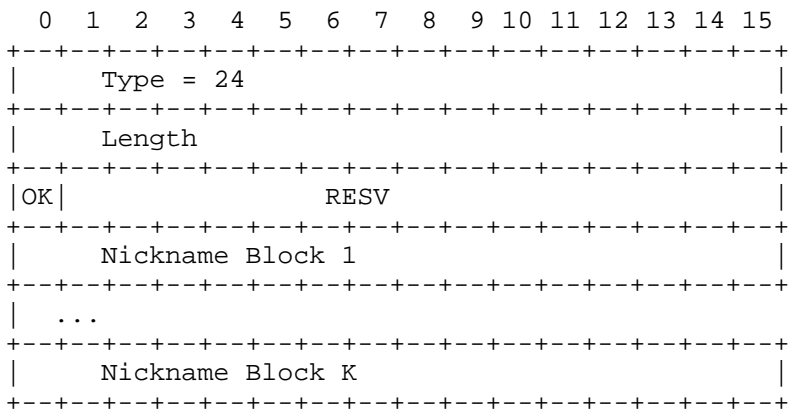
4.3. Nickname Announcements

Border RBridges need to exchange nickname information between Level 1 and Level 2; otherwise, forwarding paths inward or outward will not be calculated. For this purpose, border RBridges need to fabricate nickname announcements. Sub-TLVs used for such announcements are specified as follows.

Besides its own nickname(s), a border RBridge MUST announce, in its area, the ownership of all external nicknames that are reachable from this border RBridge. These external nicknames include nicknames used in other unique nickname areas and nicknames in Level 2. Non-border RBridge nicknames within aggregated nickname areas are excluded. Also, a border RBridge MUST announce, in Level 2, the ownership of all nicknames within its area. From listening to these Level 2 announcements, border RBridges can figure out the nicknames used by other areas.

RBridges in the TRILL base protocol use the `Nickname Sub-TLV` as specified in Section 2.3.2 of [RFC7176] to announce the ownership of nicknames. However, it becomes uneconomic to use this Sub-TLV to announce a mass of internal/external nicknames. To address this issue, border RBridges SHOULD make use of the `NickBlockFlags`

APPsub-TLV to advertise into the Level 1 area the inclusive range of nicknames that are or are not available for self allocation by the Level 1 RBridges in that area. Its structure is as follows:



- o Type: 24 (TRILL NickBlockFlags)
- o Length: 2 + 4*K, where K is the number of nickname blocks.
- o OK:
 - When this bit is set to 1, the blocks of nicknames in this APPsub-TLV are associated to the border RBridge's attached Level 1 area. The APPsub-TLV will be advertised in both Level 1 and Level 2. For nicknames that fall in the ranges of the nickname blocks, RBridges of Level 2 always route to the originating border RBridge, just as if this border RBridge owns these nicknames.
 - When this bit is set to 0, it indicates that the nicknames covered by the nickname blocks are being used in Level 2 or other areas so that they are not available for use in the border RBridge's attached Level 1 area. The APPsub-TLV will be advertised into Level 1 only. For nicknames that fall in the ranges of the nickname blocks, RBridges of the area always route to the originating border RBridge, just as if this border RBridge owns these nicknames. For nicknames in these ranges, other RBridges will deem that they are owned by the originating border RBridge. The paths to nicknames that fall in these ranges will be calculated to reach the originating border RBridge. TRILL Data packets with egress nicknames that are neither in these ranges nor announced by any RBridge in the area MUST be discarded.

- o RESV: reserved for future flag allocation. MUST be sent as zero and ignored on receipt.
- o Nickname Block: a starting and ending nickname as follows:

```

+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|   starting nickname   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|   ending nickname    |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Nickname Sub-TLV as specified in Section 2.3.2 of [RFC7176] is still allowed to be used, given the above NickBlockFlags APPsub-TLV is being used.

There might be multiple border RBridges connected to the same area. Each border RBridge may advertise a subset of the entire internal/external nickname space in order to realize load balance. However, optimization of such load balance is an implementation issue and is outside the scope of this document.

As specified in Section 4.2.6 of [RFC6325], multiple border RBridges may claim the same nicknames outwardly and/or inwardly. Other RBridges add those nicknames as if they are attached to all of those border RBridges.

4.4. Capability Indication

All border RBridges MUST understand the NickBlockFlags APPsub-TLV. Non-border RBridges in an area should understand the NickBlockFlags APPsub-TLV. If an RBridge within an area understands the NickBlockFlags APPsub-TLV, it MUST indicate this capability by announcing it in its TRILL-VER Sub-TLV. (See Section 7.)

If there are RBridges that do not understand the NickBlockFlags APPsub-TLV, border RBridges of the area MUST also use the traditional Nickname Sub-TLV [RFC7176] to announce into the area those nicknames covered by the nickname blocks of the NickBlockFlags APPsub-TLV whose OK is 0. The available range of nicknames for this area should be configured on these traditional RBridges.

5. Mix with Aggregated Nickname Areas

The design of TRILL multilevel allows a mixture of unique nickname areas and aggregated nickname areas (see Section 1.2 of [RFC8243]). Usage of nickname space MUST be planned so that nicknames used in any one unique nickname area and Level 2 are never used in any other areas, including unique nickname areas as well as aggregated nickname

areas. In other words, nickname reusage is merely allowed among aggregated nickname areas.

Border RBridges of an aggregated area MUST announce nicknames heard from Level 2 into their area like just like a unique nickname border RBridge. However, these RBridges do not announce nicknames of their area into Level 2.

Each border RBridge of the aggregated areas will appear on the global tree, as specified in Section 4.1, as a single node. The global trees for unique nickname areas span unique nickname areas and Level 2 but never reach the inside of aggregated areas.

6. Security Considerations

Since TRILL multilevel uses the existing IS-IS multilevel facilities [IS-IS], flooding of control traffic for link-state information is automatically confined to a Level 1 area or to Level 2 (except for limited types of information that can be specifically flagged for wider flooding). This addresses the TRILL scalability issues as specified in Section 2 of [RFC8243], and also, except for the wider flooding case, this confines the scope of the effects of malicious events that could be communicated through the link state. However, due to the fact that unique nickname areas share a common nickname space, border RBridges still have to leak nickname information between levels. Such leaking means that nickname-related events in one area can affect other areas.

For this purpose, border RBridges need to fabricate the nickname announcements as specified in Section 4.3. Malicious devices may also fake the NickBlockFlags APPsub-TLV to announce a range of nicknames. By doing this, the attacker can attract TRILL data packets that were originally sent to a bunch of other RBridges. For this reason, RBridges SHOULD be configured to use the IS-IS Authentication TLV (10) in the IS-IS PDUs, particularly those containing the NickBlockFlags APPsub-TLV, so that IS-IS security [RFC5310] can be used to authenticate those PDUs and discard them if they are forged.

If border RBridges do not prune multi-destination distribution tree traffic in Data Labels that are configured to be area local, then traffic that should have been contained within an area might be wrongly delivered to end stations in that Data Label in other areas. That is, the Data Label would no longer be area local. This would generally violate security constraints that require traffic to be delivered only to end stations in that Data Label in a single area.

For general TRILL Security Considerations, see [RFC6325].

7. IANA Considerations

IANA has registered a new flag bit under the "TRILL-VER Sub-TLV Capability Flags" registry.

Bit	Description	Reference
---	-----	-----
5	Able to handle the NickBlockFlags APPsub-TLV	RFC 8397

IANA has assigned a new type for the NickBlockFlags APPsub-TLV from the range available below 256 and add the following entry to the "TRILL APPsub-TLV Types under IS-IS TLV 251 Application Identifier 1" registry as follows:

Type	Name	Reference
---	-----	-----
24	NickBlockFlags	RFC 8397

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8.1. Normative References

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