

TRILL Working Group
INTERNET-DRAFT
Intended Status: Standards Track

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October 30, 2017

Expires: May 2018

Centralized Replication for Active-Active BUM Traffic
draft-ietf-trill-centralized-replication-10.txt

Abstract

In TRILL active-active access, an RPF check failure issue may occur when using the pseudo-nickname mechanism specified in [RFC 7781](#). This draft describes a solution to resolve this RPF check failure issue through centralized replication. All ingress RBridges send BUM (Broadcast, Unknown unicast and Multicast) traffic to a centralized node with unicast TRILL encapsulation. When the centralized node receives the BUM traffic, it decapsulates the packets and forwards them to their destination RBridges using a distribution tree established as per TRILL base protocol [RFC 6325](#). To avoid RPF check failure on a RBridge sitting between the ingress RBridge and the centralized replication node, some change in the RPF calculation algorithm is required. RPF checks on each RBridge should be calculated as if the centralized node was the ingress RBridge, instead of being calculated using the actual ingress RBridge.

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[1.](#) Introduction

The IETF TRILL (Transparent Interconnection of Lots of Links) [[RFC6325](#)] protocol provides loop free and per hop based multipath data forwarding with minimum configuration. TRILL uses IS-IS [[RFC6165](#)] [[RFC7176](#)] as its control plane routing protocol and defines a TRILL specific header for user data.

Customer Equipment (CE) devices can be multi-homed to a set of edge R Bridges forming an edge group where active-active service can be provided. In that case, all of the uplinks from a CE are handled via a Local Active-Active Link Protocol (LAALP [[RFC7379](#)]) such as Multi-Chassis Link Aggregation (MC-LAG) or Distributed Resilient Network Interconnect (DRNI) [802.1AX]. An active-active flow-based load sharing mechanism can achieve better load balancing and high reliability. A CE device can be a layer 3 end system by itself or a bridge switch through which layer 3 end systems access to TRILL campus.

In active-active access, the pseudo-nickname solution in [[RFC7781](#)] can be used to avoid MAC flip-flop on remote R Bridges. The basic idea is to use a virtual R Bridge RBv with a single pseudo-nickname to represent an edge group. Any member R Bridge of that edge group uses this pseudo-nickname rather than its own nickname as the ingress nickname when it injects TRILL data frames to TRILL campus. The use of the nickname solves the address flip-flop issue by setting the MAC address learnt by a remote R Bridge to the pseudo-nickname. However, it introduces another issue of incorrect packet dropping as follows: When a pseudo-nickname is used by an edge R Bridge as the ingress nickname to forward BUM (Broadcast, Unknown unicast and Multicast) traffic, any R Bridges (RBn) sitting between the ingress R Bridge and the distribution tree root will treat the traffic as if it was ingressed from the virtual R Bridge RBv. If the same distribution tree is used by different edge R Bridges of the same RBv, the traffic may arrive at some RBn from different ports. Then the RPF (Reverse Path Forwarding) check required by TRILL

[RFC6325] fails, and the BUM traffic received on unexpected ports will be dropped by RBn.

This document specifies a centralized replication solution for broadcast, unknown unicast and multicast (BUM) traffic forwarding to resolve the issue of incorrect packet drop caused by the RPF check failure in the virtual RBridge case. The basic idea is that all ingress RBridges send BUM traffic to a centralized node, which SHOULD be a distribution tree root, using unicast TRILL encapsulation. When the centralized node receives the packets, it decapsulates and forwards them to their destination RBridges using a distribution tree established as per the TRILL base protocol.

2. Conventions used in this document

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]. The acronyms and terminology in [RFC6325] are used herein with the following additions:

BUM - Broadcast, Unknown unicast, and Multicast

CE - As in [RFC7783], Customer Equipment device (end station or bridge). The device can be either physical or virtual equipment.

Data Label - VLAN or FGL [RFC7172]

DF - Designated Forwarder [RFC7781]

FGL - Fine Grained Label [RFC7172].

LAALP -Local Active-Active Link Protocol [RFC7379].

MAC flip flop - A problem where the attachment point of a MAC address appears to a remote switch to keep changing. See [Section 3.3 of \[RFC7379\]](#).

MC-LAG - Multi-Chassis Link Aggregation.

RPF - Reverse Path Forwarding.

3. Centralized Replication Solution Overview

When an edge RBridge receives BUM traffic from a CE device, it uses unicast TRILL encapsulation instead of multicast encapsulation to send the packets to a centralized node. The centralized node MUST be a distribution tree root. Distribution tree roots are normally chosen to be high capacity core RBridges with many high bandwidth adjacencies and this constraint makes its practical, as described below, to support centralized replication with only software changes to transit RBridges.

The TRILL header of the unicast TRILL encapsulation contains an "ingress RBridge nickname" field and an "egress RBridge nickname" field [[RFC6325](#)]. If the ingress RBridge receives the BUM packet from a port that is in an active-active edge group using [[RFC7781](#)], it sets the ingress RBridge nickname to be the pseudo-nickname rather than its own nickname to avoid MAC flip-flop (see [Section 3.3 of \[RFC7379\]](#)) on remote RBridges. The egress RBridge nickname is set to a special nickname of the centralized node which is used to differentiate the centralized replication purpose unicast TRILL encapsulation from a normal unicast TRILL encapsulation. This special nickname is called an R-nickname.

When the centralized RBridge receives a unicast TRILL encapsulated packet with its R-nickname as egress nickname, it decapsulates the packet. Then the centralized RBridge replicates and forwards the BUM packet to the packet's destination RBridges using one of the distribution trees established as per TRILL base protocol. It MUST use a distribution tree whose tree root is the centralized RBridge itself. (An RBridge may be the root of more than one tree.) When the centralized RBridge forwards the BUM traffic, it simply sends it on the distribution tree as if it was a locally ingressed frame except that the ingress nickname remains the same as that in the packet it received to ensure that the MAC address learning by all egress RBridges is bound to the pseudo-nickname.

When the replicated packet is forwarded by each RBridge along the distribution tree starting from the centralized node, an RPF check is performed as per [[RFC6325](#)]. For any RBridge sitting between the ingress RBridge and the centralized replication node, the incoming port of such BUM packet should be the centralized node facing port as the multicast traffic always comes from the centralized node in this solution. However the RPF port as the result of distribution tree calculation as specified in [[RFC6325](#)] will be the real ingress RBridge facing port as it uses the edge group's virtual RBridge as the ingress RBridge, so the RPF check will fail.

To solve this problem, some change in the RPF test is required. In this case, the RPF calculation on each RBridge should use the centralized node as the ingress RBridge for each tree for which that node is the root instead of the real ingress virtual RBridge to perform the calculation. As a result, RPF check will accept traffic on the centralized node facing port of the RBridge for multi-destination traffic. This prevents incorrect frame drops by the RPF check.

The change in the actual RPF check on a received multi-destination TRILL data packet is easy. The [[RFC6325](#)] RPF check is a check to see if a triple of {ingress nickname, tree, receiving RBridge port} is allowed. (The tree is indicated by the nickname of its root which is stored in the TRILL Header "egress nickname" field.) When determining the RPF check, if "ingress nickname" is a C-nickname, then the check is based on distribution from the tree root. If "ingress nickname" is not a C-nickname, then the check is based on distribution from the RBridge having the ingress nickname.

To differentiate the centralized replication unicast TRILL encapsulation from normal unicast TRILL encapsulation, the R-nickname is introduced for centralized replication. When the centralized node receives unicast TRILL encapsulation traffic with the egress nickname R-nickname, it decapsulates the packet and then forwards the packet to the destination RBridges through a distribution tree for which it is the root by re-encapsulation as aforementioned. In TRILL, RBridges can hold multiple nicknames so the centralized RBridge simply obtains another nickname to use as the R-nickname. The centralized RBridge or RBridges should announce their R-nickname to all TRILL campus through the TRILL LSP extension specified in [Section 11](#).

4. Frame duplication from remote RBridge

Frame duplication may occur when a remote host sends a multi-destination frame to a local CE which has an active-active connection to the TRILL campus. To avoid local CE receiving multiple copies from a remote RBridge, the designated forwarder (DF) mechanism is supported for egress direction multicast traffic.

The DF election mechanism [[RFC7781](#)] allows only one port of one RBridge in an active-active group to forward multicast traffic from the TRILL campus to the local access side for each VLAN. The basic idea of DF is to elect one RBridge per VLAN from an edge group to be

responsible for egressing the BUM traffic. [RFC7781] describes the DF election mechanism among member RBridges involving in an edge group.

If the DF election mechanism is used for frame duplication prevention, access ports on an RBridge are categorized as one of three types: non-group, group DF port and group non-DF port. The last two types can be called group ports. Each of the group ports is associated with a pseudo-nickname. If consistent nickname allocation to edge group RBridges is used, it is possible that same pseudo-nickname is associated with more than one port on a single RBridge. A typical scenario is that CE1 is connected to RB1 & RB2 by LAALP1 while CE2 is connected to RB1 & RB2 by LAALP2. In order to conserve the number of pseudo-nicknames used, member ports for both LAALP1 and LAALP2 on RB1 & RB2 are all associated with the same pseudo-nickname.

5. Local forwarding behavior on ingress RBridge

When an ingress RBridge (RB1) receives BUM traffic from a local active-active connected CE (CE1) device, the traffic will be injected into the TRILL campus with TRILL encapsulation, and it will be replicated and forwarded to all destination RBridges through central replication, including the ingress RBridge itself, along a TRILL distribution tree. To avoid the traffic looping back to the original sender CE, an ingress nickname of the CE group's pseudo-nickname is used for traffic filtering.

However, if there are two CEs, say CE1 and CE2, connecting to the ingress RB1 and each associated with the same pseudo-nickname, RB1 needs to locally replicate and forward to CE2, because another copy of the BUM traffic between CE1 and CE2 through TRILL campus will be blocked by the traffic filtering.

If CE1 and CE2 are not associated with the same pseudo-nickname, the copy of the BUM traffic between CE1 and CE2 through TRILL campus won't be blocked by the traffic filtering. To avoid duplicated traffic on receiver CE, there cannot be local replicated BUM traffic between these two CEs on ingress RB1.

In summary, to ensure correct BUM traffic forwarding behavior for each CE, the local replication behavior on the ingress RBridge is as follows:

1. Replicate to the active-active group ports associated with the same pseudo-nickname as that associated with the incoming port.

2. Do not replicate to active-active group ports associated with other pseudo-nicknames.

3. Do not replicate to non-edge-group ports.

The above local forwarding behavior on the ingress RBridge of RB1 can be called centralized replication local forwarding behavior A.

If ingress RBridge RB1 itself is the centralized replication node, BUM traffic injected by RB1 into the TRILL campus won't loop back to RB1. In this case, the local forwarding behavior is called centralized replication local forwarding behavior B. Behavior B on RB1 is as follows:

1. Local replication to the ports associated with the same pseudo-nickname as that associated with the incoming port.

2. Local replication to the group DF port associated with different pseudo-nicknames. Do not replicate to group non-DF port associated with different pseudo-nicknames.

3. Local replication to non-edge-group ports.

6. Loop prevention among RBridges in a edge group

If a CE sends a broadcast, unknown unicast, or multicast (BUM) packet through a DF port to an ingress RBridge, that RBridge will forward that packet to all or a subset of the other RBridges that only have non-DF ports for that active-active group. Because BUM traffic forwarding to non-DF ports isn't allowed, in this case the frame won't loop back to the CE.

If a CE sends a BUM packet through a non-DF port to an ingress RBridge, say RB1, then RB1 will forward that packet to other RBridges that have a DF port for that active-active group. In this case the frame will loop back to the CE and the traffic split-horizon filtering mechanism is used to avoid looping back among RBridges in the edge group.

This split-horizon mechanism relies on the ingress nickname field in the TRILL header to check if a packet's egress port belongs to a same active-active group as the packet's incoming port to the TRILL campus.

When the ingress RBridge receives BUM traffic from an active-active connected CE device, the traffic will be sent through the TRILL campus with TRILL encapsulation to a centralized RBridge. There it will be replicated and forwarded to its destination RBridges, which include ingress RBridge itself, through a TRILL distribution tree. If the same pseudo-nickname is used for two active-active access CEs as ingress nickname, an egress RBridge can use that nickname to filter traffic forwarding to all local CEs. In this case, the traffic between these two CEs goes through the local RBridge and another copy of the traffic from the TRILL campus is filtered. If different ingress nicknames are used for two connecting CE devices, the access ports connecting to these two CEs should be isolated from each other. The BUM traffic between these two CEs should go through the TRILL campus, otherwise the destination CE connected to same RBridge with the sender CE will receive two copies of the traffic.

7. Centralized replication forwarding process

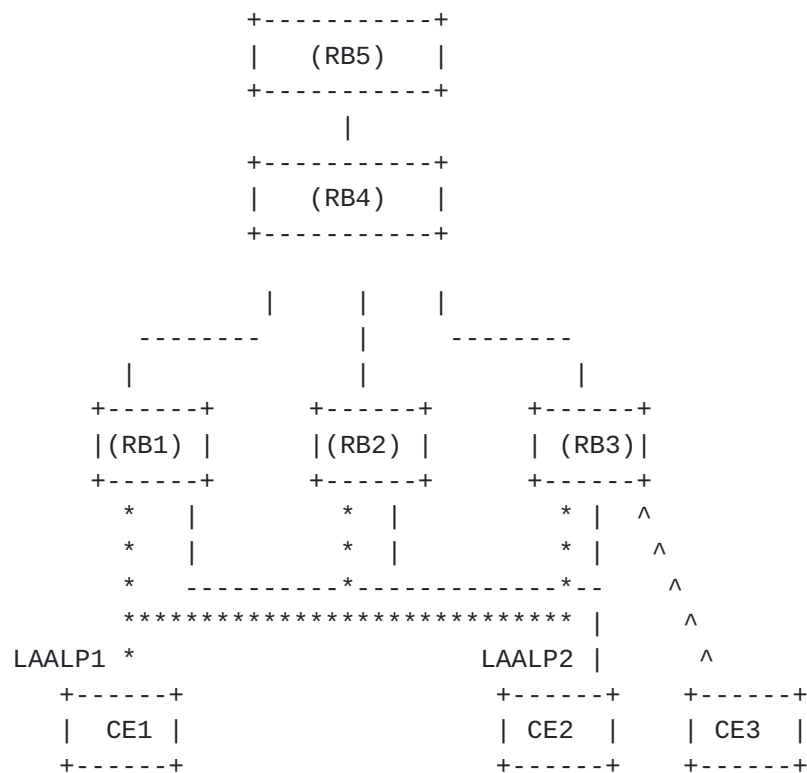


Figure 1 TRILL Active-active access

Assuming the centralized replication solution is used in the example network of above figure 1, RB5 is the distribution tree root and

centralized replication node, CE1 and CE2 are active-active accessed to RB1, RB2, and RB3 through LAALP1 and LAALP2 respectively, CE3 is single homed to RB3. The RBridge's own nicknames of RB1 to RB5 are nick1 to nick5 respectively. RB1, RB2, and RB3 use the same pseudo-nickname for LAALP1 and LAALP2; that pseudo-nickname is P-nick. The R-nickname on the centralized replication node of RB5 is S-nick.

The BUM traffic forwarding process from CE1 to CE2 and CE3 is as follows:

1. CE1 sends BUM traffic to RB3.
2. RB3 replicates and sends the BUM traffic to CE2 locally. RB2 also sends the traffic to RB5 using unicast TRILL encapsulation. In the TRILL Header, the ingress nickname is set as P-nick and the egress nickname is set as S-nick.
3. RB5 decapsulates the unicast TRILL Data packet. Then it uses a distribution tree for which it is the root to forward the packet as a multi-destination TRILL Data packet. The egress nickname in the multi-destination TRILL Header is the nick5 and the ingress nickname is still P-nick. If RB3 had sent the unicast to some nickname that was not an R-nickname, the packet will not be re-encapsulate. If it is sent to an R-nickname that is not a tree root, it will either be not forwarded at all or, if it is re-encapsulated and forwarded, will be subject to incorrect pruning and will not be delivered to all of its intended recipients.
4. RB4 receives multicast TRILL traffic from RB5. Traffic incoming port is the up port facing the distribution tree root, RB4's RPF check will be correct based on the changed RPF port calculation algorithm in this document. After the RPF check is performed, it forwards the traffic to all other egress RBridges (RB1, RB2, and RB3).
5. RB3 receives multicast TRILL traffic from RB4. It decapsulates the multi-destination TRILL Data packet. Because the ingress nickname of P-nick is equivalent to the nickname of local LAALPs connecting to CE1 and CE2, RB3 doesn't forward the traffic to CE1 and CE2 to avoid duplicated frame. RB3 only forwards the packet to CE3.
6. RB1 and RB2 receive multicast TRILL traffic from RB4. The forwarding process is similar to the process on RB3, i.e., because the ingress nickname of P-nick is equivalent to the nickname of the

local LAALPs connecting CE1 and CE2, they also don't forward the traffic to local CE1 and CE2.

8. BUM traffic load balancing among multiple centralized nodes

To support unicast TRILL encapsulation BUM traffic load balancing, multiple centralized replication nodes can be deployed and the traffic can be spread over these nodes based on data label (VLAN or FGL). Furthermore, if it was desirable for a centralized node to be sent more of this BUM traffic, it could hold two or more R-nicknames. The share of BUM traffic it would receive would be proportional to the number of R-nicknames it held.

Assuming there are k different R-nicknames held by centralized nodes in a TRILL campus. The VLAN-based (or FGL-based [[RFC7172](#)]) load balancing algorithm used by ingress active-active access RBridge is as follows:

1. All R-nicknames are ordered and numbered from 0 to $k-1$ in ascending order treating the nicknames as unsigned 16-bit integers.

2. For data label ID m , choose the R-nickname whose number equals $(m \bmod k)$ as egress nickname for BUM traffic unicast TRILL encapsulation.

For examples, there are 3 R-Nicknames (RN). The RNs will be ordered RN0 to RN2. Assuming there are 5 VLANs from VLAN ID 1 to ID 5 spreading among edge RBridges, the traffic in VLAN 1 will go to RN1, VLAN 2 will go to RN2, and so on.

When an ingress RBridge participating in active-active connection receives BUM traffic from local CE, the RBridge decides which R-nickname to send the traffic to based on the VLAN-based load spreading algorithm, thus data-label-based load balancing for the BUM traffic can be achieved using multiple centralized nodes/ multiple R-nicknames.

9. Co-existing with the CMT solution

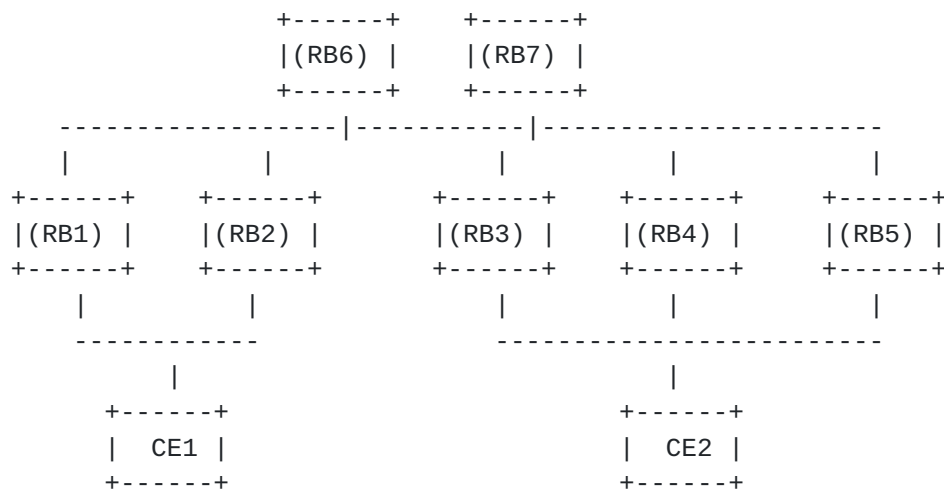


Figure 2 CMT and centralized replication co-existing scenario

Both the centralized replication solution and the CMT [\[RFC7783\]](#) solution rely on using pseudo-nicknames to avoid MAC flip-flop on remote Rbridges. These two solutions can co-exist in a single TRILL campus. Each solution can be selected by each active-active edge group of Rbridges independently.

As illustrated in Figure 2, RB1 and RB2 use CMT for CE1's active-active access, RB3, RB4, and RB5 use the centralized replication for CE2's active-active access.

For the centralized replication solution, edge group Rbridges MUST announce the local pseudo-nickname using Nickname Flags APPsub-TLV with C-flag set. A nickname with the C-flag set is called a "C-nickname". A transit RBridge will perform the centralized replication specific RPF check algorithm if it receives TRILL Data packets with a C-nickname as ingress nickname.

An edge group using CMT [\[RFC7783\]](#) MUST NOT set the C-nickname flag on the pseudo-nickname it is using. This is already mandatory behavior because any RBridge originating a Nickname Flags APPsub-TLV is required by [\[RFC7780\]](#) to set any flag bit it does not know about to zero. If a edge RBridge using CMT [\[RFC7783\]](#) nevertheless set the C-bit for an edge group pseudo-nickname, it is very likely that BUM traffic encapsulated with that nickname as ingress would be incorrectly pruned early in its distribution and would thus reach few (possibly none) of its intended targets. To avoid confusion, a

pseudo-nickname MUST NOT be shared between a centralized replication edge group and a CMT-based edge group.

10. Network Upgrade Analysis

Centralized nodes will typically need software and hardware upgrades to support centralized replication, which stitches together the TRILL unicast traffic decapsulation process and the process of normal TRILL multicast traffic forwarding along distribution tree.

Active-active connection edge RBridges will typically need software and hardware upgrade to support unicast TRILL encapsulation for BUM traffic; the process is similar to other head-end replication processes.

Transit nodes typically need only a software upgrade to support the changed RPF port calculation algorithm.

11. TRILL protocol extensions

Two new flags, "R" and "C", are specified in the Nickname Flags APPsub-TLV [[RFC7780](#)]. A nickname with the "R" flag set is called an R-nickname and a nickname with the the "C" flag set is called a C-nickname. The R-nickname is a specialized nickname attached to a centralized node to differentiate unicast TRILL encapsulated BUM traffic from normal unicast TRILL traffic. The C-nickname flag is set on the psudo-nickname for each edge group that uses the centralized replication. A C-nickname is a specialized pseudo-nickname for which transit RBridges perform a different RPF check algorithm for TRILL data packets with the C-nickname in the ingress nickname field.

When active-active edge RBridges use centralized replication to forward BUM traffic, the R-nickname is used as the egress nickname and the C-nickname is used as ingress nickname in the TRILL header for the unicast TRILL encapsulation of BUM traffic.

11.1. "R" and "C" Flag in the Nickname Flags APPsub-TLV

If this APPsub-TLV is being advertised by an RBridge that does not have the nickname appearing in the Nickname Flags APPsub-TLV, the R and C flag bits in the APPsub-TLV MUST be treated as if they were zero. If an RBridge that is not a distribution tree root advertises an R-nickname, that nickname MUST NOT be treated as an R-nickname but rather as an ordinary nickname, that is, the R-nickname flag is

ignored for all purposes if the nickname is held by an RBridge that is not a tree root.

```

    0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|  Nickname                                     |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|IN|SE|R | C|      RESV                         |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
                        NICKFLAG RECORD

```

o R = If R flag is one, it indicates that the advertising TRILL switch holding Nickname is a centralized replication node, and Nickname is used as egress nickname for edge group R Bridges to inject BUM traffic into the TRILL campus when the edge group R Bridges use this centralized replication solution for active-active access. If flag is zero, that nickname will not be used for that purpose.

o C = If C flag is one, it indicates that the TRILL traffic with this nickname as an ingress nickname that requires the special RPF check algorithm specified in [Section 3](#). If flag is zero, that nickname will not be used for that purpose.

It is possible, due to errors or due to transient inconsistent LSPs when the link state database is converging after a configuration change or the like for there to be inconsistent Nickname Flags APPsub-TLVs for the same nickname. In this case it is RECOMMENDED that the nickname be treated as if the R / C flag was set if any Nickname Flags APPsub-TLV for that nickname has the R / C flag set.

12. Security Considerations

This draft does not introduce any extra security risks. A rogue RBridge that is a tree root can attract traffic by advertising an R-nickname. However, this does not represent a substantial increase in risk as R Bridges could cause problems in a number of other ways by advertising low cost adjacencies or making themselves the highest priority tree root or the like. In general, the protection against an untrusted device acting as an RBridge and wrecking havoc is to use IS-IS authentication [[RFC5310](#)] and configure and administer the TRILL campus so that only trusted R Bridges have the authentication key.

For general TRILL Security Considerations, see [RFC6325]. For Security Considerations related to pseudo-nickname active-active, see [RFC7781].

13. IANA Considerations

IANA is requested to assign two bits in the Nickname Flags APPsubTLV flags for the R and C bits discussed in [Section 11.1](#) [Bits 3 and 4 suggested] and update the "NickFlags" Bits registry on the TRILL Parameters page as follows:

Bit	Mnemonic	Description	Reference
---	-----	-----	-----
3	R	Replication Nickname	[This document]
4	C	Special RFC Check	[This document]

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15. Acknowledgments

The authors wish to acknowledge the important contributions of Donald Eastlake, Hongjun Zhai, Xiaomin Wu, Liang Xia.

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