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Directory Assisted TRILL Encapsulation
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Abstract

This draft describes how data center networks can benefit from non-RBridge nodes performing TRILL encapsulation with assistance from a directory service.

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1. Introduction

This document describes how data center networks can benefit from non-RBridge nodes performing TRILL encapsulation with assistance from a directory service and specifies a method for them to do so.

[RFC7067] and [RFC8171] describe the framework and methods for edge RBridges to get MAC&VLAN <-> Edge RBridge mapping from a directory service instead of flooding unknown destination MAC addresses across a TRILL domain. If it has the needed directory information, any node, even a non-RBridge node, can perform the TRILL data packet encapsulation. This draft describes the benefits of and a scheme for non-RBridge nodes performing TRILL encapsulation.

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 [RFC2119].

AF: Appointed Forwarder RBridge port [RFC8139].

Bridge: An IEEE 802.1Q compliant device. In this draft, Bridge is used interchangeably with Layer 2 switch.

DA: Destination Address.

ES-IS: End System to Intermediate Systems [RFC8171].

Host: A physical server or a virtual machine running applications. A host usually has at least one IP address and at least one MAC address.

IS-IS: Intermediate System to Intermediate System [RFC7176].

SA: Source Address.

TRILL-EN: TRILL Encapsulating node. A node that performs the TRILL encapsulation but doesn't participate in RBridge's IS-IS routing.

VM: Virtual Machine.

3. Directory Assistance to Non-RBridge

With directory assistance [RFC7067] [RFC8171], a non-RBridge node can learn if a data packet needs to be forwarded across the RBridge domain and if so the corresponding egress RBridge.

Suppose the RBridge domain boundary starts at network switches (not virtual switches embedded on servers). (See Figure 1 for a high level diagram of a typical data center network.) A directory can assist Virtual Switches embedded on servers to encapsulate with a proper TRILL header by providing the nickname of the egress RBridge edge to which the destination is attached. The other information needed to encapsulate can be either learned by listening to TRILL ES-IS and/or IS-IS Hellos [RFC7176] [RFC8171], which will indicate the MAC address and nickname of appropriate local edge RBridges, or by configuration.

If it is not known whether a destination is attached to one or more RBridge edge nodes, based on the directory, the non-RBridge node can forward the data frames natively, i.e. not encapsulating with any TRILL header. Or, if the directory is known to be complete, the non-RBridge node can discard such data frames.

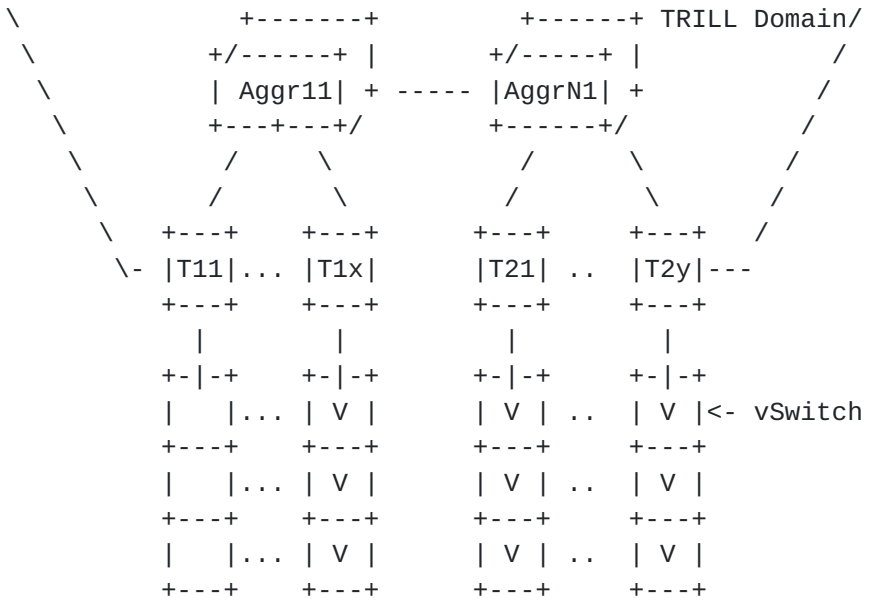

Figure 1. TRILL domain in a typical Data Center Network

When a TRILL encapsulated data packet reaches the ingress RBridge, that RBridge simply performs the usual TRILL processing and forwards the pre-encapsulated packet to the RBridge that is specified by the egress nickname field of the TRILL header. When an ingress RBridge receives a native Ethernet frame in an environment with complete

directory information, the ingress RBridge doesn't flood or forward the received data frames when the destination MAC address in the

Ethernet data frames is unknown.

When all end nodes attached to an ingress RBridge pre-encapsulate with a TRILL header for traffic across the TRILL domain, the ingress RBridge doesn't need to encapsulate any native Ethernet frames to the TRILL domain. The attached nodes can be connected to multiple edge RBridges by having multiple ports or through a bridged LAN. All RBridge edge ports connected to one bridged LAN can receive and forward pre-encapsulated traffic, which can greatly improve the overall network utilization. However, it is still necessary to designate AF ports to, for example, be sure that multi-destination packets from the TRILL campus are only egressed through one RBridge.

The TRILL base protocol specification [RFC6325] Section 4.6.2 Bullet 8 specifies that an RBridge port can be configured to accept TRILL encapsulated frames from a neighbor that is not an RBridge.

When a TRILL frame arrives at an RBridge whose nickname matches the destination nickname in the TRILL header of the frame, the processing is exactly as normal: as specified in [RFC6325] the RBridge decapsulates the received TRILL frame and forwards the decapsulated frame to the target attached to its edge ports. When the destination MAC address of the decapsulated Ethernet frame is not in the egress RBridge's local MAC attachment tables, the egress RBridge floods the decapsulated frame to all attached links in the frame's VLAN, or drops the frame (if the egress RBridge is configured with that policy).

We call a node that, as specified herein, only performs TRILL encapsulation, but doesn't participate in RBridge's IS-IS routing, a TRILL Encapsulating node (TRILL-EN). The TRILL Encapsulating Node can pull MAC&VLAN <-> Edge RBridge mapping from directory servers [RFC8171]. In order to do this, a TRILL-EN MUST support TRILL ES-IS [RFC8171].

Upon receiving or locally generating a native Ethernet frame, the TRILL-EN checks the MAC&VLAN <-> Edge RBridge mapping, and performs the corresponding TRILL encapsulation if the mapping entry is found as shown in Figure 2. If the destination MAC address and VLAN of the received Ethernet frame doesn't exist in the mapping table and there is no positive reply from pull requests to a directory, the Ethernet frame is dropped or is forwarded in native form to an edge RBridge, depending on the TRILL-EN configuration.

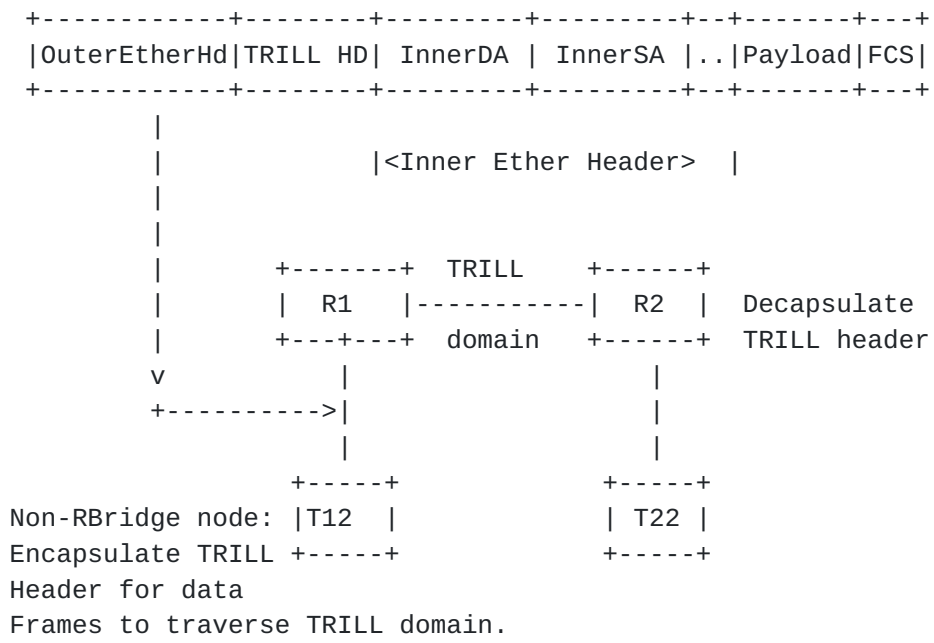

Figure 2. Data frames from a TRILL-EN

4. Source Nickname in Encapsulation by Non-RBridge Nodes

The TRILL header includes a Source RBridge's Nickname (ingress) and Destination RBridge's Nickname (egress). When a TRILL header is added to a data packet by a TRILL-EN, the Ingress RBridge nickname field in the TRILL header is set to a nickname of the AF for the data packet's VLAN. The TRILL-EN determines the AF by snooping on IS-IS Hellos from the edge RBridges on the link with the TRILL-EN in the same way that the RBridges on the link determine the AF [RFC8139]. A TRILL-EN is free to send the encapsulated data frame to any of the edge RBridges on its link.

5. Benefits of Non-RBridge Performing TRILL Encapsulation

This section summarizing benefits of having a non-RBridge node perform TRILL encapsulation.

5.1. Avoid Nickname Exhaustion Issue

For a large Data Center with hundreds of thousands of virtualized servers, setting the TRILL boundary at the servers' virtual switches will create a TRILL domain with hundreds of thousands of RBridge nodes, which has issues of TRILL Nickname exhaustion and challenges to IS-IS. On the other hand, setting the TRILL boundary at aggregation switches that have many virtualized servers attached can limit the number of RBridge nodes in a TRILL domain, but introduces the issue of very large MAC&VLAN <-> Edge RBridge mapping tables to be maintained by RBridge edge nodes.

Allowing Non-RBridge nodes to pre-encapsulate data frames with TRILL headers makes it possible to have a TRILL domain with a reasonable number of RBridge nodes in a large data center. All the TRILL-ENs attached to one RBridge can be represented by one TRILL nickname, which can avoid the Nickname exhaustion problem.

5.2. Reduce MAC Tables for Switches on Bridged LANs

When hosts in a VLAN (or subnet) span across multiple RBridge edge nodes and each RBridge edge has multiple VLANs enabled, the switches on the bridged LANs attached to the RBridge edge are exposed to all MAC addresses among all the VLANs enabled.

For example, for an Access Switch with 40 physical servers attached, where each server has 100 VMs, there are 4000 hosts under the Access Switch. If indeed hosts/VMs can be moved anywhere, the worst case for the Access Switch is when all those 4000 VMs belong to different VLANs, i.e. the access switch has 4000 VLANs enabled. If each VLAN has 200 hosts, this access switch's MAC table potentially has 200*4000 = 800,000 entries.

If the virtual switches on servers pre-encapsulate the data frames destined for hosts attached to remote RBridge Edge nodes, the outer MAC destination address of those TRILL encapsulated data frames will be the MAC address of a local RBridge edge, i.e. the ingress RBridge. The switches on the local bridged LAN don't need to keep the MAC entries for remote hosts attached to other edge RBridges.

But the TRILL traffic from nodes attached to other RBridges is

decapsulated and has the true source and destination MACs. One simple way to prevent local bridges from learning remote hosts' MACs and adding to their MAC tables, if that would be a problem, is to disable this data plane learning on local bridges. The local bridges can be pre-configured with MAC addresses of local hosts with the assistance of a directory. The local bridges can always send frames with unknown destination MAC addresses to the ingress RBridge. In an environment where a large number of VMs are instantiated in one server, the number of remote MAC addresses could be very large. If it is not feasible to disable learning and pre- configure MAC tables for local bridges and all important traffic is IP, one effective method to minimize local bridges' MAC table size is to use the server's MAC address to hide MAC addresses of the attached VMs. I.e., the server acting as an edge node uses its own MAC address in the source MAC address field of the packets originated from a host (or VM) embedded. When the Ethernet frame arrives at the target edge node (the egress), the target edge node can send the packet to the corresponding destination host based on the packet's IP address. Very often, the target edge node communicates with the embedded VMs via a layer 2 virtual switch. In this case, the target edge node can construct the proper Ethernet header with the assistance of the directory. The information from the directory includes the proper host IP to MAC mapping information.

6. Manageability Considerations

Directory assistance [RFC8171] is required to make it possible for a non-TRILL node to pre-encapsulate packets destined towards remote RBridges. TRILL-ENs have the same configuration options as any pull directory client. See Section 4 of [RFC8171].

7. Security Considerations

The mechanism described in this document requires TRILL-ENs to be aware of the MAC address(es) of the TRILL edge RBridge(s) to which the TRILL-EN is attached and the egress RBridge nickname from which the destination of the packets is reachable. With that information, TRILL-ENs can learn a substantial amount about the topology of the TRILL domain. Therefore, there could be a potential security risk when the TRILL-ENs are not trusted. In addition, if the path between the directory and the TRILL-ENs are attacked, false mappings can be sent to the TRILL-EN causing packets from the TRILL-EN to be sent to wrong destinations, possibly violating security policy. Therefore, a combination of authentication and encryption should be used between the Directory and TRILL-EN. The entities involved will need to properly authenticate with each other to protect sensitive information.

Use of directory assisted encapslation by TRILL-ENs essentially involves those TRILL-ENs spoofing edge RBridges to which they are connected, which is another reason that TRILL-ENs should be trusted nodes. Such spoofing cannot cause looping traffic because TRILL has a hop count in the TRILL header [RFC6325] so that, should there be a loop, a TRILL packet caught in that loop (i.e., an encapsulated frame) will be discarded. (In the potentially more dangerous case of multi-destination packets, as compared with known unicast, where copies could multiply due to forks in the distribution tree, a Reverse Path Forwarding Check is also used [RFC6325] to discard packets that appear to be on the wrong link or when there is disagreement about the distribution tree.)

For Pull Directory and TRILL ES-IS security considerations, see [RFC8171].

For general TRILL security considerations, see [RFC6325].

8. IANA Considerations

This document requires no IANA actions. RFC Editor: please remove this section before publication.

Normative References

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