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TRILL: Link Security  
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## Abstract

The TRILL protocol supports arbitrary link technologies between TRILL switches, both point-to-point and broadcast links, and supports Ethernet links between edge TRILL switches and end stations. Communications links are constantly under attack by criminals and national intelligence agencies as discussed in RFC 7258. Link security is an important element of security in depth, particularly for links that are not entirely under the physical control of the TRILL network operator or that include device which may have been compromised. This document specifies link security recommendations for TRILL over Ethernet, PPP, and pseudowire links taking into account performance considerations. It updates RFC 6325, 6361, and 7173. It requires that all TRILL packets between links ports capable of encryption at line speed MUST default to being encrypted. [This is an early partial draft.]

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## 1. Introduction

[This is an early partial draft.]

The TRILL (Transparent Interconnection of Lots of Links or Tunned Routing in the Link Layer) protocol supports arbitrary link technologies including both point-to-point and broadcast links and supports Ethernet links between edge TRILL switches and end stations. Communications links are constantly under attack by criminals and national intelligence agencies as discussed in [RFC7258]. Link security is an important element of security in depth for links, particularly those that are not entirely under the physical control of the TRILL network operator or that include device which may have been compromised.

TRILL generally uses an existing link security method specified for the technology of the link in question. TRILL provides autoconfiguration assistance and default keying material, under most circumstances, to support the TRILL goal of having a minimal or zero configuration default. Where better security is not available, TRILL supports opportunistic security [RFC7435].

This document specifies security recommendations for TRILL over Ethernet [RFC6325], TRILL over PPP [RFC6361], and transport of TRILL by pseudowires [RFC7173], in Sections 3, 4, and 5 respectively. Although the Security Considerations sections of these RFCs mention link security, this document goes further, updating these RFCs as described in Appendix A and imposing the new encryption requirement summarized in Section 1.1.

[TRILL-IP] is expected to cover TRILL security over IP links.

### 1.1 Encryption Requirement and Adjacency

This document requires that all TRILL packets between TRILL switch ports that are capable of encryption at line speed MUST default to being encrypted and authenticated. It MUST require explicit configuration in such cases for the ports to communicate unencrypted or unsecured. Line speed encryption and authentication usually requires hardware assist but there are cases with slower ports and higher powered switch processors where it can be accomplished in software.

If line speed encryption and authentication is not available for communication between TRILL switch ports, it MUST still be possible to configure the TRILL switches and ports involved to encrypt and authenticate all TRILL packets sent for cases where the security provided outweighs any reduction in performance.

## 1.2 Terminology and Acronyms

This document uses the acronyms and terms defined in [RFC6325], some of which are repeated below for convenience, and additional acronyms and terms listed below.

HKDF: Hash based Key Derivation Function [RFC5869].

Link: The means by which adjacent TRILL switches are connected. May be various technologies and in the common case of Ethernet, can be a "bridged LAN", that is to say, some combination of Ethernet links with zero or more bridges, hubs, repeaters, or the like.

MACSEC: Media Access Control (MAC) Security. IEEE Std 802.1AE-2006.

MPLS: Multi-Protocol Label Switching.

PPP: Point-to-point protocol [RFC1661].

RBridge: An alternative name for a TRILL switch.

TRILL: Transparent Interconnection of Lots of Links or Tunneler Routing in the Link Layer.

TRILL switch: A device implementing the TRILL protocol. An alternative name for an RBridge.

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].

## 2. Link Security Default Keying

In some cases, it is possible to use keying material derived from the [RFC5310] IS-IS keying material already in place. In such cases, the two byte [RFC5310] Key ID identifies the IS-IS keying material. The keying material actually used in the link security protocol is derived from the IS-IS keying material as follows:

```
HKDF-Expand-SHA256 ( IS-IS-key, "TRILL Link" | custom, L )
```

where "|" indicates concatenation, HKDF is the Hash base Key Derivation Function in [RFC5869], SHA256 is as in [RFC6234], IS-IS-key is the input keying material, "TRILL Link" is the 10-character ASCII [RFC20] string indicated, "custom" is a byte string dependeng on the link security protocol being used, and L is the length of output keying material needed.

### 3. Ethernet Links

TRILL over Ethernet is specified in [RFC6325] with some additional material on Ethernet link MTU in [rfc7180bis].

Link security between TRILL switch Ethernet ports conforms to IEEE Std 802.1AE-2006 [802.1AE] as amended by IEEE Std 802.1AEbn-2011 [802.1AEbn] and IEEE Std 802.1AEbw-2013 [802.1AEbw]. This security is referred to as MACSEC.

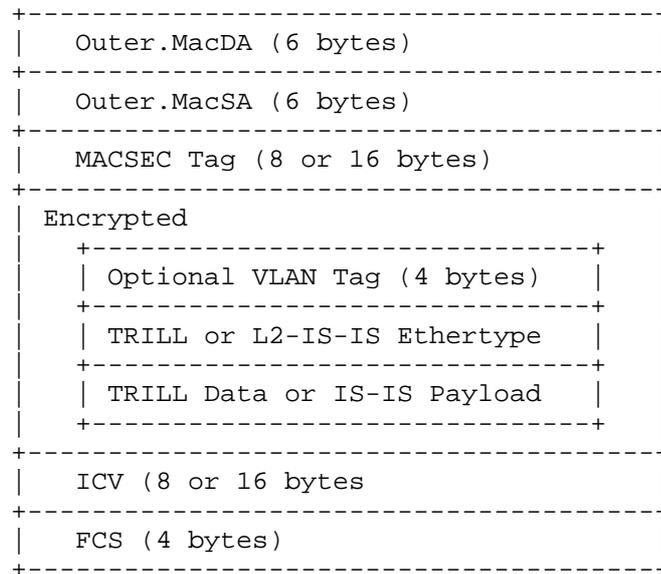
#### 3.1 Between TRILL Switches

TRILL switch Ethernet ports MUST implement MACSEC. When TRILL switch ports are directly connected by Ethernet with no intervening customer bridges, for example by a point to point Ethernet link, MACSEC between them operates as specified herein. There can be intervening Provider Bridges or other forms of transparent Ethernet tunnels.

However, if there are one or more customer bridges or similar devices in the path, MACSEC at the TRILL switch port will peer with the nearest such bridge port. This results, from the point of view of MACSEC, with a two or more hop path. Typically, the TRILL switch ports at the ends of such a path would be unable to negotiate security and agree on keys so, in cases where encryption and authentication are required, they would be unable to establish IS-IS communication and would not form an adjacency [RFC7177]. However, it may be possible to configure such bridge ports and distribute such keying material or the like to them so that encryption and authentication can be established on all hops of such multi-hop Ethernet paths. Methods for accomplishing such distribution to devices other than TRILL switches are beyond the scope of this document.

When MACSEC is established between adjacent TRILL switch ports, the frames are as shown in Figure 1. The optional VLAN tagging shown is superfluous in the case of TRILL Data and IS-IS packets. Unless there are VLAN sensitive devices intervening between the TRILL switch ports, or possibly attached to the link between those ports, TRILL Data and IS-IS packets SHOULD generally be sent untagged for efficiency.

Of course there may be other Ethernet control frames, such as link aggregation control messages or priority based flow control messages, that would also be sent within MACSEC. Typically only the [802.1X] messages used to establish and maintain MACSEC are sent unsecured.



Figures 1. MACSEC Between TRILL Switch Ports

Outer.MacDA: 48-bit destination MAC address

Outer.MacSA: 48-bit source MAC address

MACSEC Tag: See further description below.

Encrypted: The encrypted data

ICV: The MACSEC Integrity Check Value

FCS: Frame Check Sequence.

The structure of a MACSEC Tag is as follows:

tbd ...

### 3.1.1 Ethernet Link Security Maintenance

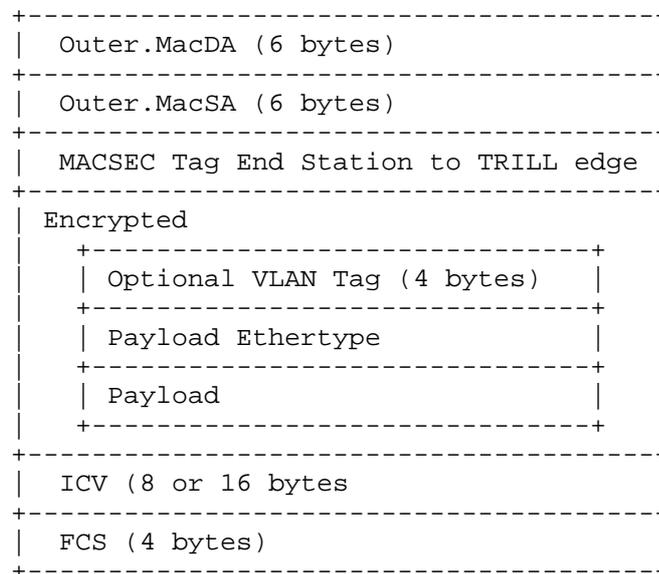
[802.1X] is used to establish keying and algorithms for Ethernet link security ... tbd ...

### 3.2 Ethernet Security to End Stations

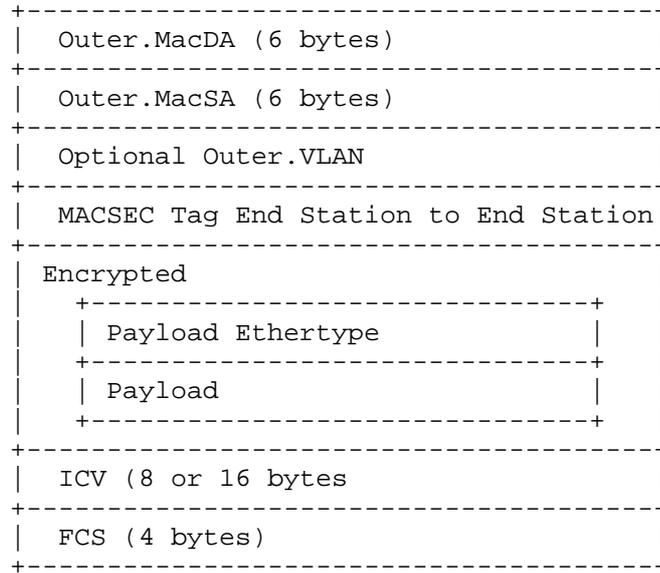
MACSEC may be used between end stations and their adjacent TRILL switch(es) or end-to-end between end stations or both. Since TRILL does not impose administrative requirements on end stations, the choice of keying and crypto suite are beyond the scope of this document.

The end station must be properly configured to know if it should apply MACSEC to secure its connection to an edge TRILL switch or to remote end stations or both.

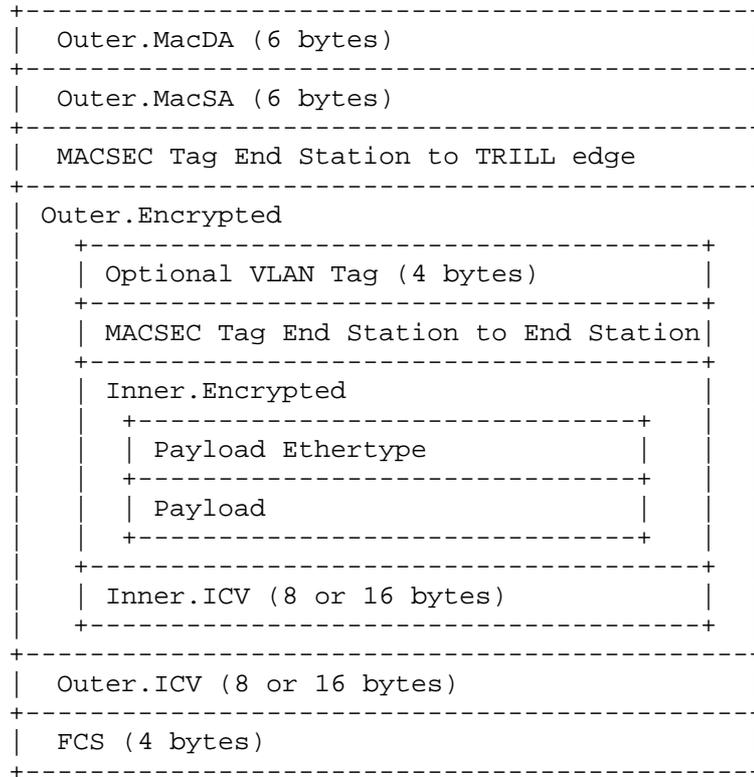
The Figure below show an Ethernet frame between a TRILL switch and the adjacent edge RBridge secured by MACSEC.



The Figure below shows an Ethernet frame between an end station and an adjacent edge RBridge where MACSEC is being used end-to-end between that end station and remote end stations.



The Figure below shows an Ethernet frame between an end station and an adjacent edge RBridge where MACSEC is being used end-to-end between that end station and remote end stations and, in addition, an outer application of MACSEC is securing traffic between the end station and the adjacent edge RBridge port.



#### 4. PPP Links

TRILL over PPP is specified in [RFC6361]. Currently specified native PPP security does not meet modern security standards. However, true PPP over HDLC is relatively uncommon today and PPP is normally being conveyed by another protocol, such as PPP over Ethernet or PPP over IP. In those cases it is RECOMMENDED that Ethernet security as described in Section 3 or IP security as described in [TRILL-IP] be used to secure PPP between TRILL switch ports.

If it is necessary to use native PPP security [RFC1968] [RFC1994]  
...tbd...

## 5. Pseudowire Links

TRILL transport over pseudowires is specified in [RFC7173].

No native security is provided for pseudowires as such; however, they are, by definition, carried by some PSN (Packet Switched Network). Link security must be provided by this PSN or by lower level protocols. This PSN is typically an MPLS or IP PSN.

In the case of a pseudowire over IP, security SHOULD be provided as is expected to be specified in [TRILL-IP]. If that is not possible but the IP path is only one IP hop, then it may be possible to provide link security at the layer of the link protocol supporting that hop, such as Ethernet (Section 3) or PPP (Section 4).

In the case of a pseudowire over MPLS, MPLS also does not have a native security scheme. Thus, security must be provided at the link layer being used, for example Ethernet (Section 3) or IP [TRILL-IP].

## 6. Security Considerations

This document is entirely about TRILL link security for Etherent, PPP, and pseudowire TRILL links. See sections of this document on those particular link technologies.

For general TRILL Security Considerations, see [RFC6325].

## 7. IANA Considerations

This document requires no IANA actions.

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