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TRILL: RBridge Channel Support
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Abstract

This document specifies a general channel mechanism for sending messages, such as BFD (Bidirectional Forwarding Detection) messages, between RBridges (Routing Bridges) and between RBridges and end stations in an RBridge campus through extensions to the TRILL (TRansparent Interconnection of Lots of Links) protocol.

Status of This Memo

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1. Introduction

RBridge campuses provide transparent least-cost path forwarding using the TRILL (TRansparent Interconnection of Lots of Links) protocol that builds on IS-IS (Intermediate System to Intermediate System) routing [IS-IS] [RFC1195] [RFC6326bis]. Devices that implement TRILL are called RBridges (Routing Bridges) or TRILL Switches. However, the TRILL base protocol standard [RFC6325] provides only for TRILL Data messages and TRILL IS-IS messages.

This document specifies a general channel mechanism for the transmission of other messages within an RBridge campus, such as BFD (Bidirectional Forwarding Detection, [RFC5880]) messages, between RBridges and end stations that are directly connected on the same link and between RBridges. This mechanism supports a requirement to be able to operate with minimal configuration.

Familiarity with [RFC6325] and [RFC6327] is assumed in this document.

1.1 RBridge Channel Requirements

It is anticipated that various protocols operating at the TRILL level will be desired in RBridge campuses. For example, there is a need for rapid response continuity checking with a protocol such as BFD [RFC5880] [RFC5882] and for a variety of optional reporting.

To avoid the requirement to design and specify a way to carry each such protocol, this document specifies a general channel for sending messages between RBridges in a campus at the TRILL level by extending the TRILL protocol. To accommodate a wide variety of protocols, this RBridge Channel facility accommodates all the regular modes of TRILL Data transmission including single and multiple hop unicast as well as VLAN scoped multi-destination distribution.

To minimize any unnecessary burden on transit RBridges and to provide a more realistic test of network continuity and the like, RBridge Channel messages are designed to look like TRILL Data frames and, in the case of multi-hop messages, can normally be handled by transit RBridges as if they were TRILL Data frames; however, to enable processing at transit RBridges when required by particular messages, they may optionally use the RBridge Channel Alert TRILL extended header flags [RFCext] that causes a transit RBridge implementing the flag to more closely examine a flagged frame.

This document also specifies a format for sending RBridge Channel messages between RBridges and end stations that are directly connected over a link, in either direction, when provided for by the

protocol involved. For the most part, this format is the same as the

format that is TRILL Data encapsulated for inter-RBridge channel messages.

Each particular protocol using the RBridge Channel facility will likely use only a subset of the facilities specified herein.

1.2 Relation to the MPLS Generic Channel

The RBridge Channel is similar to the MPLS Generic Channel specified in [RFC5586]. Instead of using a special MPLS label to indicate a special channel message, an RBridge Channel message is indicated by a special multicast Inner.MacDA and inner Ethertype.

1.3 Terminology

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].

The terminology and acronyms of [RFC6325] are used in this document with the additions listed below.

BFD - Bidirectional Forwarding Detection

CHV - Channel Header Version

MH - Multi-Hop

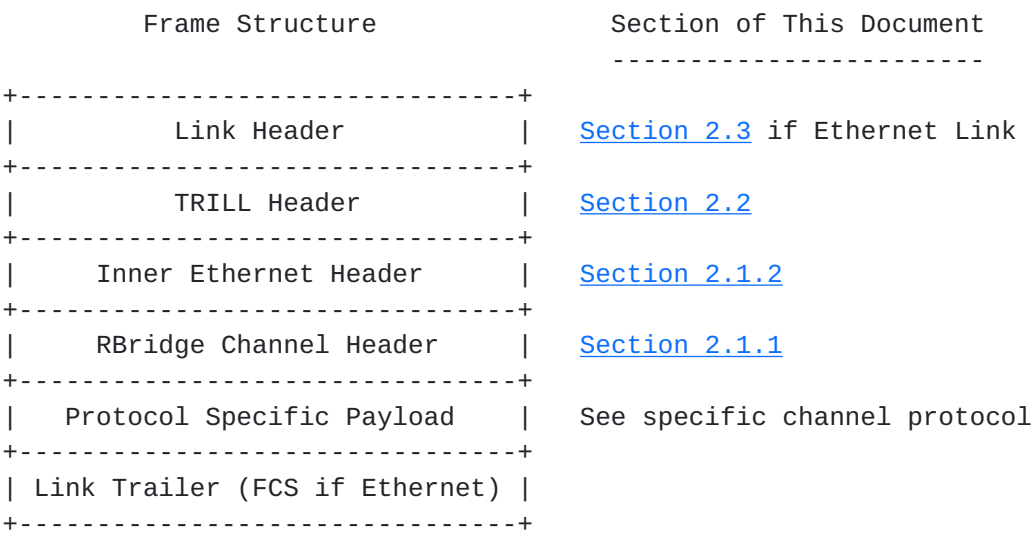
NA - Native

SL - Silent

2. Inter-RBridge Channel Messages

Channel messages between RBridges are transmitted as TRILL Data frames. (For information on channel messages that can be transmitted between RBridges and end stations that are directly connected by a link, see Section 4.) Inter-RBridge Channel messages are identified as such by their Inner.MacDA, which is the All-Egress-RBridges multicast address, together with their Inner Ethertype, which is the RBridge-Channel Ethertype. This Ethertype is part of and starts the RBridge Channel Header.

The diagram below shows the overall structure of a RBridge Channel Message frame on a link between two RBridges:



Optionally, some channel messages may require examination of the frame by transit RBridges that support the RBridge Channel feature, to determine if they need to take any action. To indicate this, such messages use a RBridge Channel Alert extended TRILL header flags as further described in Section 3 below.

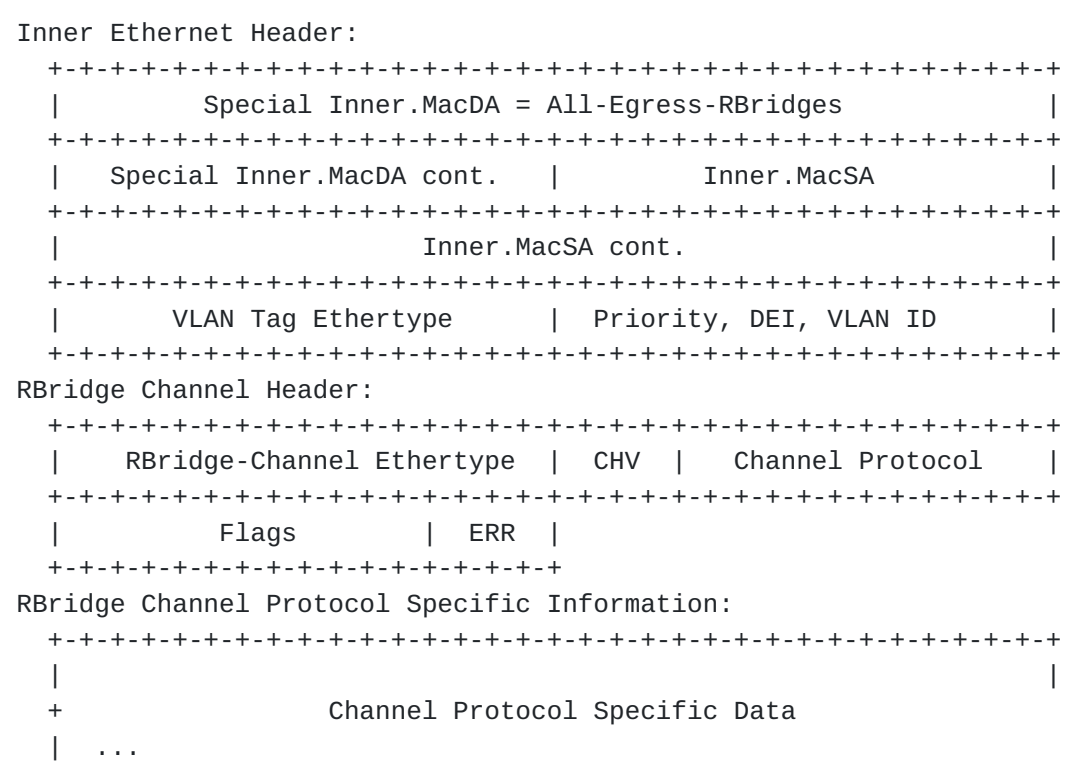
The Sections 2.1 and 2.2 below describe the Inner frame and the TRILL Header for frames sent in an RBridge Channel. As always, the Outer link header and trailer are whatever is needed to get a TRILL Data frame to the next hop RBridge, depending on the technology of the link, and can change with each hop for multi-hop messages. Section 2.3 describes the outer Link Header for Ethernet. And Section 2.4 discusses some special considerations for the first hop transmission of RBridge Channel messages.

Section 3 describes some details of RBridge Channel message processing. Section 4 provides the specifications for native RBridge Channel frames between RBridges and end stations that are directly

connected over a link.

2.1 The RBridge Channel Message Inner Frame

The encapsulated inner frame within an RBridge Channel message frame is as shown below.



The Channel Protocol Specific Data contains the information related to the specific channel protocol used in the channel message. Details of that data are outside the scope of this document, except in the case of the RBridge Channel Error protocol specified below.

2.1.1 RBridge Channel Header

As shown in the diagram above, the RBridge Channel header starts with the RBridge-Channel Ethertype (see Section 6.2). Following that is a four-byte quantity with four sub-fields as follows:

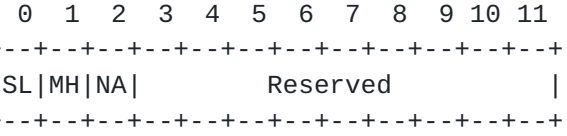
CHV: A 4-bit field that gives the RBridge Channel Header Version and MUST be zero.

Channel Protocol: A 12-bit unsigned integer that specifies the particular RBridge Channel protocol to which the message applies.

Flags: Provides 12 bits of flags described below.

ERR: A 4-bit unsigned integer used in connection with error reporting at the RBridge Channel level as described in Section 3.

The flag bits are numbered from 0 to 11 as shown below.



Bit 0, which is the high order bit in network order, is defined as the SL or Silent bit. If it is a one, it suppresses RBridge Channel Error messages (see Section 3).

Bit 1 is the MH or Multi-Hop bit. It is used to inform the destination RBridge protocol that the message may be multi-hop (MH=1) or was intended to be one-hop only (MH=0).

Bit 2 is the NA or Native bit. It is used as described in Section 4 below.

Reserved: Bits reserved for future specification that MUST be sent as zero and ignored on receipt.

The RBridge Channel Protocol field specifies the protocol that the channel message relates to. The initial defined value is listed below. See Section 6 for IANA Considerations.

Protocol	Name - Section of this Document
0x001	RBridge Channel Error - Section 3

2.1.2 Inner Ethernet Header

The special Inner.MacDA is the All-Egress-RBridges multicast MAC address to signal that the frame is intended for the egress (decapsulating) RBridge itself (or the egress RBridges themselves if the frame is multi-destination). (This address is called the All-ESADI-RBridges address in [RFC6325].) The RBridge-Channel Ethertype indicates that the frame is an RBridge Channel message. The only other Ethertype currently specified for use with the All-Egress-RBridges Inner.MacDA is L2-IS-IS to indicate an ESADI frame [RFC6325]. In the future additional Ethertypes may be specified for use with the All-Egress-RBridges multicast address.

The RBridge originating the channel message selects the Inner.MacSA.

The Inner.MacSA MUST be set by the originating RBridge to a MAC address unique within the campus owned by the originating RBridge. This MAC address can be considered, in effect, the MAC address of a virtual internal end station that handles the RBridge Channel frames originated by or destined for that RBridge. It MAY be the same as the Inner.MacSA used by the RBridge when it originates ESADI frames [RFC6325].

2.1.3 Inner.VLAN Tag

As with all frames formatted to be processed as a TRILL Data frame, an Inner.VLAN tag is present. Use of a VLAN tag Ethertype other than 0x8100 or stacked tags is beyond the scope of this document but is an obvious extension.

Multi-destination RBridge Channel messages are, like all multi-destination TRILL Data messages, VLAN scoped so the Inner.VLAN ID MUST be set to the VLAN of interest. To the extent that distribution tree pruning is in effect in the campus, such channel messages may only reach RBridges advertising that they have connectivity to that VLAN.

For channel messages sent as known unicast TRILL Data frames the default value for the Inner.VLAN ID is VLAN 1 but particular RBridge Channel protocols MAY specify other values.

The Inner.VLAN also specifies a three-bit frame priority for which the following recommendations apply:

1. For one-hop channel messages critical to network connectivity, such as one-hop BFD for rapid link failure detection in support of TRILL IS-IS, the RECOMMENDED priority is 7.

2. For single and multi-hop known unicast channel messages important to network operation but not critical for connectivity, the RECOMMENDED priority is 6.

3. For other known unicast channel messages and all multi-destination channel messages, it is RECOMMENDED that the default priority zero be used. In any case, priorities higher than 5 SHOULD NOT be used for such frames.

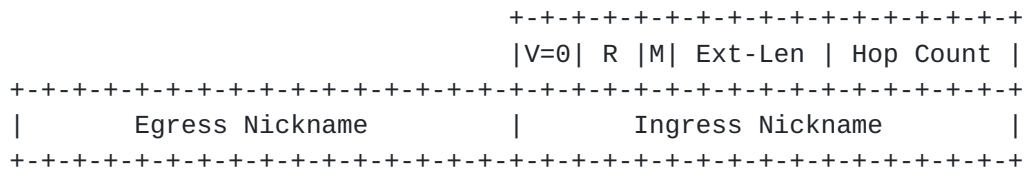
There is one additional bit in a VLAN tag value between the 12-bit VLAN ID and 3-bit priority, the Drop Eligibility Indicator (DEI, [ClearCorrect]). It is RECOMMENDED that this bit be zero for the first two categories of channel messages listed immediately above. The setting of this bit for channel messages in the third category

may be dependent on the channel protocol and no general

recommendation is made for that case.

2.2 The TRILL Header for RBridge Channel Messages

After the outer Link Header (that, for Ethernet, ends with the TRILL Ethertype) and before the encapsulated frame, the channel message's TRILL Header initially appears as follows:



The TRILL Header version V MUST be zero, the R bits are reserved, the M bit is set appropriately as the channel message is to be forwarded as known unicast (M=0) or multi-destination (M=1) regardless of the fact that the Inner.MacDA is always the All-Egress-RBridges multicast address, and Ext-Len is set appropriately for the length of the TRILL Header extensions area, if any, all as specified in [RFC6325] (where the extensions area is referred to as the options area and this field as Op-Len).

When an RBridge Channel message is originated, the Hop Count field defaults to the maximum value, 0x3F, but particular RBridge Channel protocols MAY specify other values. For messages sent a known number of hops, such as one-hop messages or a two-hop self-addressed message intended to loop back through an immediate neighbor RBridge, setting the Hops field to the maximum value and checking the Hop Count field on receipt provides an additional validity check as discussed in [RFC5082].

The RBridge originating a channel message places a nickname that it holds into the ingress nickname field.

There are several cases for the egress nickname field. If the channel message is multi-destination, then the egress nickname designates the distribution tree to use. If the channel message is a multi-hop unicast message, then the egress nickname is a nickname of the target RBridge; this includes the special case of a message intended to loop back from an immediate neighbor where the originator places one of its own nicknames in both the ingress and egress nickname fields. If the channel message is a one-hop unicast message, there are two possibilities for the egress nickname.

- The egress nickname can be set to a nickname of the target neighbor RBridge.

- The special nickname Any-RBridge may be used. RBridges supporting the RBridge Channel facility MUST recognize the Any-RBridge special nickname and accept TRILL Data frames having that value in the egress nickname field as being sent to them as the egress. Thus, for such RBridges, using this egress nickname guarantees processing by an immediate neighbor regardless of the state of nicknames.

2.3 Ethernet Link Header and Trailer

An RBridge Channel frame has the usual link header and trailer depending on the type of link on which it is sent.

For an Ethernet link [RFC6325] the Outer.MacSA is the MAC address of the port from which the frame is sent. The Outer.MacDA is the MAC address of the next-hop RBridge port for unicast RBridge Channel messages or the All-RBridges multicast address for multi-destination RBridge Channel messages. The Outer.VLAN tag specifies the Designated VLAN for that hop and the priority should be the same as in the Inner.VLAN tag; however, the output port may have been configured to strip VLAN tags, in which case no Outer.VLAN tag appears on the wire. And the link trailer is the Ethernet FCS.

2.4 Special Transmission and Rate Considerations

If a multi-hop RBridge Channel message is received by an RBridge, the criteria and method of forwarding it are the same as for any TRILL Data frame. If it is so forwarded, it will be on a link that was included in the routing topology because it was in the Report state as specified in [RFC6327].

However, special considerations apply to single hop messages because, for some RBridge Channel protocols, it may be desirable to send RBridge Channel messages over a link that is not yet fully up. In particular, it is permissible, if specified by the particular channel protocol, for the source RBridge that has created an RBridge Channel message to attempt to transmit it to a next hop RBridge when the link is in the Detect or Two-Way states, as specified in [RFC6327], as well as when it is in the Report state. Such messages can also be sent on point-to-point links that are not in the Up state.

RBridge Channel messages represent a burden on the RBridges and links in a campus and should be rate limited, especially if they are sent as high priority, multi-destination, or multi-hop frames or have an RBridge Channel Alert extended header flag set.

3. Processing RBridge Channel TRILL Data Messages

RBridge Channel TRILL Data messages are designed to look like and, to the extent practical, be forwarded as regular TRILL Data frames. On receiving a channel message, the initial tests on the Outer.MacDA, Outer Ethertype, TRILL Header V and Hop Count fields and the Reverse Path Forwarding Check if the frame is multi-destination, are all performed as usual. The forwarding and/or decapsulation decisions are the same as for a regular TRILL Data frame with following exceptions for RBridges implementing the RBridge Channel facility:

1. An RBridge implementing the RBridge Channel facility MUST recognize the Any-RBridge egress nickname in TRILL Data frames, decapsulating such frames if they meet other checks. (Such a frame cannot be a valid multi-destination frame because the Any-RBridge nickname is not a valid distribution tree root.)

2. If an RBridge Channel Alert extended header flag is set, then the RBridge MUST process the RBridge Channel message as described below even if it is not egressing the frame. If it is egressing the frame, then no additional processing beyond egress processing is needed even if an RBridge Channel Alert flag is set.

3. On decapsulation, the special Inner.MacDA value of All-Egress-RBridges MUST be recognized to trigger checking the Inner.Ethertype and processing as an RBridge Channel message if that Ethertype is RBridge-Channel.

RBridge Channel messages SHOULD only be sent to RBridges that advertise support for the channel protocol involved as described in Section 5.

All RBridges supporting the RBridge Channel facility MUST recognize the RBridge-Channel inner Ethertype.

3.1 Processing the RBridge Channel Header

Knowing that it has an RBridge Channel message, the egress RBridge, and any transit RBridge if an RBridge Channel Alert bit is set in the TRILL Header, looks at the CHV (RBridge Channel Header Version) and Channel Protocol fields.

If any of the following conditions occur at an egress RBridge, the frame is not processed, an error may be generated as specified in Section 3.2, and the frame is discarded. The behavior is the same if the frame is being processed at a transit RBridge because the

critical RBridge Channel Alert flag is set [RFCext]. However, if

these conditions are detected at a transit RBridge examining the message because the non-critical RBridge Channel Alert flag is set [RFCext] but the critical flag is not set, no error is generated and the frame is still forwarded normally.

1. The Ethertype is not RBridge-Channel and not any other Ethertype known to the RBridge as usable with the All-Egress-RBridges Inner.MacDA, or the frame is so short that the Ethertype is truncated.

2. The CHV field is non-zero or the frame is so short that the version zero Channel Header is truncated.

3. The Channel Protocol field is a reserved value or a value unknown to the processing RBridge.

4. The ERR field is non-zero and Channel Protocol is a value other than 0x001.

5. The RBridge Channel Header NA flag is set to one indicating that the frame should have been received as a native frame rather than a TRILL Data frame.

If the CHV field and NA flag are zero and the processing RBridge recognizes the Channel Protocol value, it processes the message in accordance with that channel protocol. The processing model is as if the received frame starting with and including the TRILL Header is delivered to the Channel protocol along with a flag indicating whether this is (a) transit RBridge processing due to an RBridge Channel Alert flag being set or (b) egress processing.

Errors within a recognized Channel Protocol are handled by that channel protocol itself and do not produce RBridge Channel Error frames.

3.2 RBridge Channel Errors

A variety of problems at the RBridge Channel level cause the return of an RBridge Channel Error frame unless (a) the "SL" (Silent) flag is a one in the channel message for which the problem was detected, (b) the processing is due to the non-critical RBridge Channel Alert bit being set, (c) the frame in error appears, itself, to be an RBridge Channel error frame (has a non-zero ERR field or a Channel Protocol of 0x001), or (d) the error is suppressed due to rate limiting.

An RBridge Channel Error frame is a multi-hop unicast RBridge Channel

message with the ingress nickname set to the nickname of the RBridge

detecting the error, and the egress nickname set to the value of the ingress nickname in the channel message for which the error was detected. No per-hop transit processing is specified for such error frames, so the RBridge Channel Alert extended header flags SHOULD, if an extension is present, be set to zero. The SL and MH flags SHOULD be set to one, the NA flag MUST be zero, and the ERR field MUST be non-zero as described below. For the protocol specific data area, an RBridge Channel Message Error frame has at least the first 256 bytes (or less if less are available) of the erroneous decapsulated channel message starting with the TRILL Header. (Note: The TRILL Header does not include the TRILL Ethertype that is part of the Link Header on Ethernet Links.)

The following values for ERR are specified:

ERR	Meaning
0	- Not an RBridge Channel error frame.
1	Frame too short (truncated Ethertype or RBridge Channel Header)
2	Unrecognized Ethertype
3	Unimplemented value of CHV
4	Wrong value of NA flag
5	Channel Protocol is reserved or unimplemented
6-14	- Available for allocation, see Section 6.
15	Reserved

All RBridges implementing the RBridge Channel feature MUST recognize the RBridge Channel Error protocol value (0x001). They MUST NOT generate an RBridge Channel Error message in response to a RBridge Channel Error message, that is, a channel message with a protocol value of 0x001 or with a non-zero ERR field.

4. Native RBridge Channel Frames

Other sections of this document specify non-native RBridge Channel messages and their processing, that is, RBridge Channel messages formatted as TRILL Data frames and sent between RBridges. This section specifies the differences for native RBridge Channel messages.

If provided for by the channel protocol involved, native RBridge channel messages may be sent between end-stations and RBridges that are directly connected over a link, in either direction. On an Ethernet link, such native frames have the RBridge-Channel Ethertype and are like the encapsulated frame inside an RBridge Channel message except as follows:

1. TRILL does not require the presence of a VLAN tag on such native RBridge channel frames. However, port configuration, link characteristics, or the channel protocol involved may require such tagging.

2. If the frame is unicast, the destination MAC address is the unicast MAC address of the RBridge or end-station port that is its intended destination. If the frame is multicast by an end station to all the RBridges on a link that support an RBridge Channel protocol that uses this transport, the destination MAC address is the All-Edge-RBridges multicast address (see Section 6). A native RBridge Channel frame received at an ingress RBridge with a destination MAC address that is a unicast address different from that of the port or multicast address different from All-Edge-RBridges, is discarded. If the frame is multicast by an RBridge to all the devices that TRILL considers to be end stations on a link that support an RBridge Channel protocol that uses this transport, the destination MAC address is the TRILL-End-Stations multicast address (see Section 6). A native RBridge Channel frame received at an end station with a destination MAC address that is a unicast address different from that of the port or multicast address different from TRILL-End-Stations, is discarded.

   3. The RBridge-Channel outer Ethertype must be present. In the future there may be other protocols using the All-Edge-RBridges and/or TRILL-End-Stations multicast addresses on native frames distinguished by different Ethertypes.

4. The NA or native bit in the RBridge Channel Header flags must be a one.

5. There might be additional tags present between the Outer.MacDA,

Outer.MacSA pair and the RBridge-Channel Ethertype.

The RBridge Channel protocol number space for native RBridge Channel messages and TRILL Data formatted RBridge Channel messages is the same. If provided for by the channel protocol involved, the receipt of a native RBridge Channel frame MAY lead to the generation and transmission of one or more Inter-RBridge Channel frames. The decapsulation and processing of a TRILL Data RBridge Channel frame MAY, if provided for by the channel protocol involved, result in the sending of one or more native RBridge channel frames to one or more end stations. Thus, there could be an RBridge Channel protocol that involved an RBridge Channel message sent from an origin RBridge where the message is created, through one or more other RBridges and from the last as a native RBridge channel message to and end station or the reverse of such a path; however, to do this the RBridge channel protocol involved must be implemented at the RBridge where the channel message is changed between a native frame and a TRILL Data format frame and must change the channel message itself, at a minimum complementing the NA flag in the Channel Header and making appropriate MAC address changes.

An erroneous native channel message results in a native RBridge channel error message under the same conditions for which an TRILL Data RBridge Channel message would result in a TRILL Data RBridge channel error message. However, in a native RBridge Channel error message, the NA flag MUST be one. Also, since there is no TRILL Header in native RBridge Channel protocol frames, the beginning part of the frame in which the error was detected that is included in native RBridge Channel error frames starts with the RBridge Channel Header (including the RBridge-Channel Ethertype). The destination MAC address of such error messages is set to the source MAC address of the native RBridge Channel message that was in error.

5. Indicating Support for RBridge Channel Protocols

Support for RBridge Channel protocols is indicated by the presence of one or more TLVs and/or sub-TLVs in an RBridge's LSP as documented in [RFC6326bis].

RBridge Channel protocols 0 and 0xFFF are reserved and protocol 1, the RBridge Channel error protocol, MUST be implemented as part of the RBridge Channel feature. Thus, if an RBridge supports the RBridge Channel feature, it should be advertising support for protocol 1 and not advertising support for protocols 0 or 0xFFF in its LSP. However, indication of support or non-support for RBridge Channel protocol 1 is ignored on receipt and support for it is always assumed, if support for any RBridge Channel is indicated in the RBridge's LSP.

6. Allocation Considerations

The following subsections give IANA and IEEE allocation considerations. In this document, the allocation procedure specifications are as defined in [RFC5226].

6.1 IANA Considerations

IANA is requested to allocate a previously unassigned TRILL Nickname as follows:

Any-RBridge	TBD (0xFFCO suggested)

IANA is requested to add "All-Egress-RBridges" to the TRILL Parameter Registry as an alternative name for the "All-ESADI-RBridges" multicast address.

IANA is requested to allocate two previously unassigned TRILL Multicast address as follows:

TRILL-End-Stations	TBD (01-80-C2-00-00-45 suggested)
All-Edge-RBridges	TBD (01-80-C2-00-00-46 suggested)

IANA is requested to create an additional sub-registry in the TRILL Parameter Registry for RBridge Channel Protocols, with initial contents as follows:

Protocol	Description	Reference
0x000	Reserved	(This document)
0x001	RBridge Channel Error	(This document)
0x002-0x0FF	Available (1)	
0x100-0xFF7	Available (2)	
0xFF8-0xFFE	Private Use	
0xFFF	Reserved	(This document)

(1) RBridge Channel protocol code points from 0x002 to 0x0FF require a Standards Action, as modified by [RFC4020], for allocation.

(2) RBridge Channel protocol code points from 0x100 to 0xFF7 require RFC Publication to allocate a single value or IETF Review to allocate multiple values.

IANA is requested to create an additional sub-registry in the TRILL Parameter Registry for RBridge Channel Header Flags with initial contents as follows:

Flag Bit	Mnemonic	Allocation
0	SL	Silent
1	MH	Multi-hop
2	NA	Native
3-11	-	Available for allocation

Allocation of an RBridge Channel Header Flag is based on Standards Action as modified by [RFC4020].

IANA is requested to create an additional sub-registry in the TRILL Parameter Registry for RBridge Channel Error codes with initial contents as listed in Section 3.2 above and with available values allocated by Standards Action as modified by [RFC4020].

6.2 IEEE Registration Authority Considerations

The IEEE Registration Authority has been assigned the Ethertype <TBD> for RBridge-Channel.

7. Security Considerations

See [RFC6325] for general TRILL Security Considerations.

No general integrity, authentication, or encryption mechanisms are provided herein for RBridge Channel messages. If these services are required for a particular RBridge Channel protocol, they must be supplied by that channel protocol. See, for example, the BFD Authentication mechanism [RFC5880].

If indication of RBridge Channel Protocol support are improperly absent from an RBridge's LSP, it could deny all RBridge Channel services, for example some BFD services, for the RBridge in question. If a particular RBridge channel protocol is incorrectly not advertised as supported, it would deny the service of that channel protocol to the RBridge in question.

Incorrect presence of indication of RBridge Channel Protocol support or incorrect assertion of support for a channel protocol could encourage RBridge channel messages to be sent to an RBridge that does not support the channel feature or the particular channel protocol used. The inner frame of such messages could be decapsulated and that inner frame could be sent out all ports that are appointed forwarders for the frame's Inner.VLAN. However, this is unlikely to cause much harm; in particuclar, there are two possibilities as follows: (a) If end stations do not recognize the RBridge-Channel Ethertype of the frame, they will drop it. (b) If end stations do recognize the RBridge-Channel Ethertype and the channel protocol indicated in the frame, they should refuse to process the frame due to an incorrect value of the RBridge Channel Header NA flag.

No protection is provided against forging or the ingress nickname in a TRILL Data formatted channel message or the Outer.MacSA in a native RBridge Channel frame. This may result in misdirected return responses or error messages.

8. References

The following sections list normative and informative references for this document.

8.1 Normative References

[IS-IS] - ISO/IEC 10589:2002, Second Edition, "Intermediate System to Intermediate System Intra-Domain Routing Exchange Protocol for use in Conjunction with the Protocol for Providing the Connectionless-mode Network Service (ISO 8473)", 2002.

[RFC1195] - Callon, R., "Use of OSI IS-IS for routing in TCP/IP and dual environments", RFC 1195, December 1990.

[RFC2119] - Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997

[RFC4020] - Kompella, K. and A. Zinin, "Early IANA Allocation of Standards Track Code Points", BCP 100, RFC 4020, February 2005.

[RFC5226] - Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, May 2008.

[RFC6325] - Perlman, R., Eastlake 3rd, D., Dutt, D., Gai, S., and A. Ghanwani, "Routing Bridges (RBridges): Base Protocol Specification", RFC 6325, July 2011.

[RFC6327] - Eastlake 3rd, D., Perlman, R., Ghanwani, A., Dutt, D., and V. Manral, "Routing Bridges (RBridges): Adjacency", RFC 6327, July 2011.

[RFCext] - D. Eastlake, A. Ghanwani, V. Manral, Y. Li, C. Bestler, "TRILL: TRILL Header Extension", draft-ietf-trill-rbridge-extension, work in progress.

[RFC6326bis] - Eastlake, D., A. Banerjee, D. Dutt, A. Ghanwani, R. Perlman, "TRILL Use of IS-IS", draft-eastlake-isis-rfc6326bis, work in progress.

8.2 Informative References

[RFC5082] - Gill, V., Heasley, J., Meyer, D., Savola, P., Ed., and C. Pignataro, "The Generalized TTL Security Mechanism (GTSM)", RFC

[RFC5586] - Bocci, M., Ed., Vigoureux, M., Ed., and S. Bryant, Ed., "MPLS Generic Associated Channel", RFC 5586, June 2009.

[RFC5880] - D. Katz, D. Ward, "Bidirectional Forwarding Detection (BFD)", June 2010.

[RFC5882] - D. Katz, D. Ward, "Generic Application of Bidirectional Forwarding Detection (BFD)", June 2010.

[ClearCorrect] - D. Eastlake, M. Zhang, A. Ghanwani, A. Banerjee, V. Manral, "TRILL: Clarifications, Corrections, and Updates", draft-ietf-trill-clear-correct, work in progress.

Appendix: Change History

RFC Editor: please delete this appendix before publication.

Changes from -00 to -01

1. Spell out more acronyms.
2. Add reference to "Guidelines for the Use of OAM" draft.
3. Move definition of Alert flag to draft-ietf-trill-rbridge-options and refer to it as an extended header flag.
4. Change name of "Egress-RBridges" multicast address to "All-Egress-RBridges". Merge with All-ESADI-RBridges (i.e., they are two names for the same MAC address).
5. Add detailed bit vector description for indicating support of RBridge channel protocols. Add GENAPP and an APPsub-TLV to hold one or more bit vectors.
6. Assorted editorial changes.

Changes from -01 to -02

1. Update for drafts that have been issued as RFCs.
2. Change to specification of Inner.VLAN in RBridge channel messages.
3. Remove GENAPP and move RBridge Channels supported information to another document.
4. Clarify native RBridge Channel error messages.
5. Assorted editorial changes.

Changes from -02 to -03

1. Liberalize restrictions on RBridge acceptance of native RBridge Channel messages. These are typically messages and should generally be accepted unless in a VLAN not enabled at the port or the like.
2. Change multi-cast address used by end stations in sending a native

RBridge Channel message to all RBridges on the link from All-Egress-RBridges to All-Edge-RBridges to avoid possible confusion if such a frame were encapsulated resulting in an All-Egress-RBridges Inner.MacDA.

3. Reword references to "two-hop echo" and the like for clarity. (This meant an echo frame that went to an immediate neighbor and back.)

4. Add reference to and move some material to the RFC 6326bis draft.

5. Assorted editorial changes.

Changes from -03 to -04

1. Update for the replacement of the CFI bit by the DEI bit (see [ClearCorrect]).

2. Update for the existence of both critical and non-critical RBridge Channel alert flags.

3. Update author information.

4. Assorted editorial changes.

Changes from -04 to -05

1. Clarify the distinction between native and non-native RBridge Channel messages and that native channel messages are only intended to be transmitted between RBridge and end stations on the same link.

2. Add a paragraph to the Security Considerations section about forged ingress nicknames / source MAC addresses in channel messages.

3. Add acknowledgements section.

4. Replace "OAM" references with "BFD" references in Abstract and Introduction.

5. Very minor editorial changes.

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