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Testing TRILL (TRansparent Interconnect for Lots of Links)

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Abstract

The University of New Hampshire InterOperability Laboratory (UNH-IOL) hosted its second TRansparent Interconnect of Lots of Links (TRILL) Interoperability Test Event the week of November 26 – December 1, 2012 at its 32,000+ square-foot facility in Durham, New Hampshire. The test event brought together implementers of TRILL as well as test equipment manufacturers that support TRILL. The purpose of the test event was to gain a perspective on the current status of TRILL implementation and interoperability. Participants included Hewlett-Packard Networking, Extreme Networks, Ixia and Spirent Communications.

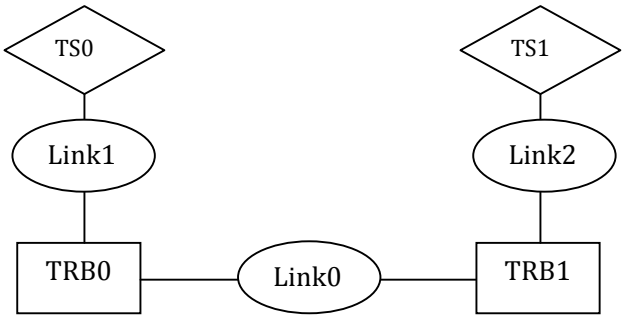
Introduction

The Spanning Tree Protocol (STP) was created to ensure a loop-free topology for bridged Ethernet despite having redundant links within the topology. These redundant links allow for automatic fail over in the case of an inactive link. At the time of the Spanning Tree Protocol's creation, data networking was in its infancy. Since then, as data communication networks have grown, and STP has been implemented in large scale networks, limitations of the protocol have come to light.

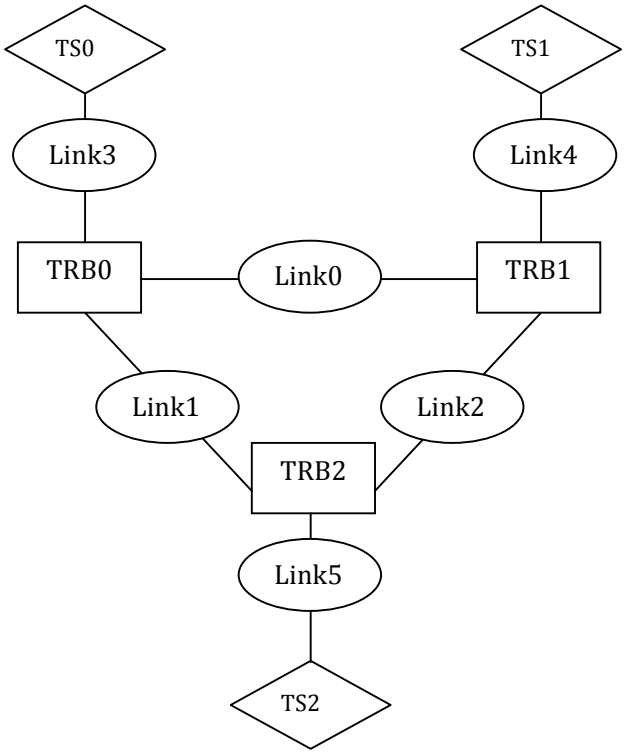
TRILL provides a solution to current STP limitations by combining Layer 2 and Layer 3 technologies. It applies link state routing to Virtual Local-Area Network (VLAN) aware bridges, which allows for the deployment of large scale Layer 2 networks. Additionally, TRILL allows the current Spanning Tree topology to still exist, essentially filling in the limitations of the Spanning Tree.

During the UNH-IOL TRILL Test Event, participants tested their TRILL implementations against the UNH-IOL TRILL Plugfest Test Suite. Due to the early stage implementation the focus of this Plugfest was the TRILL Control Plane. However, participants attending the event were able to resolve implementation issues quickly. This allowed them to proceed beyond the basic testing and validate more advanced TRILL features than anticipated at the outset, including some Data Plane features.

Network Design



Basic Topology



Extended Topology

Network:

- The Testing Stations (TS#) were emulated by Ixia and/or Spirent.
- In the Extended Topology, the Spirent emulated a TRB by sending TRILL control frames.
- A line tap was used on Link 0 to observe the traffic between TRB0 and TRB1.

Test Methodologies

The test cases executed during this event were performed to verify that the TRILL control plane worked properly between multiple implementations. Tests included verification that devices could exchange IS-IS Hellos, that a Designated RBridge was elected properly, that Nicknames were resolved between multiple devices, that a campus wide MTU was adopted, and that BPDUs were handled properly by each TRILL implementation. Tests were also designed to verify the data plane proving that the TRILL Campus supports end-to-end connectivity. Once the data plane was functional, Distribution trees were tested for proper Root Choice, Shortest path first calculation, RBridge link loss and RBridge loss handling, as well as End node address learning and forgetting.

Detailed test cases for this event were developed from RFC 6325, Routing Bridges (RBridges): Base Protocol Specification and with guidance from the IETF TRILL Working Group Co-Chair, Donald Eastlake, based on his understanding of the current TRILL implementation progress.

Results

The implementations successfully demonstrated TRILL support for a wide variety of functions. Functionality was also tested with the test equipment manufacturers including emulation of a larger TRILL Campus.

Issues[·] that were observed during the test event affecting TRILL implementations are documented in this paper as follows:

- MTU Negotiation when MTU is less than minimum
- TRILL interaction with Spanning Tree
- TRILL Version number
- Outer Header VLAN tag
- Hello Messages Tag in outer header
- 16 bit Nicknames large enough
- LSP interval after Nickname Collision

MTU Negotiation - MTU Below Minimum

In a stable campus, there is an agreement among all RBridges on the value of 'Sz', the minimum acceptable inter-RBridge link size for the campus. For the proper operation of TRILL IS-IS, all RBridges must format their link state information messages to be in chunks of size no larger than what they believe Sz to be.

During the event it was observed that if an RBridge advertises a link MTU that is less than the specified minimum, RFC 6325 does not distinguish how to handle this information. An MTU mismatch that is within the acceptable range or above the range was clearly defined in the standard.

[·]Many of the issues identified during the test event were discussed and resolved on-site with Ralph Droms, IETF Regional Director for TRILL Working Group. Based on these discussions, proposals will be made to the IETF in regards to the unresolved issues.

TRILL Interaction with Spanning Tree
If an RBridge campus topology were static, RBridges would simply be end stations from a bridging perspective, terminating but not otherwise interacting with Spanning Tree. Even when RBridges listen to and transmit BPDUs, this is a local RBridge port activity. The ports of a particular RBridge never interact so as to make the RBridge as a whole a Spanning Tree node.

Because TRILL is Spanning Tree Protocol aware, some implementers noted the need to have Spanning Tree "turned on" in order for TRILL to intercept and process Spanning Tree BPDUs. The question was raised whether this was implicit in the IETF RFC6325. Further clarification is needed to ensure that implementations are interpreting the requirements surrounding Spanning Tree properly.

TRILL Version Number
Despite the standardization of the protocol the TRILL Version Number in LSP generation has remained 0. The concern was that implementations based on the draft of the RFC and implementations based on the Standardized version of the RFC will both be advertising the Version number as 0. The implementers were curious as to how their devices will distinguish pre-standard implementations if there was no change in the version number.

This question was raised to the IETF TRILL Working Group and the response was that the TRILL Working Group has followed traditional IETF best practices; which is to only change the version number when changes are made to the standard, not prior to it becoming a standard. As such, the current TRILL Version number is 0.

VLAN tag in the outer header
A question was raised regarding the placement of the VLAN tag in the outer header. Since the tag information is carried in the inner header, implementers regarded the VLAN tag as redundant information.

According to RFC6325, "*TRILL frames sent by an RBridge, except for some TRILL-Hello frames, use an Outer.VLAN ID specified by the Designated RBridge (DRB) for the link onto which they are being sent, referred to as the Designated VLAN.*" Thus the Outer.VLAN tag needs to be present if there are VLAN sensitive devices on the link between the RBridges. Its purpose is to get TRILL data and TRILL IS-IS frames from one RBridge to the next. If the link is just a point-to-point Ethernet link, then the Outer.VLAN tag serves no purpose and, according to the standard, can be omitted.

HELLO Messages Tag
An additional implementation question was raised regarding whether or not hello messages should have a tag in the outer header. A TRILL IS-IS Hello frame is no different than any other TRILL IS-IS PDU or TRILL Data PDU. The considerations for including an Outer.VLAN tag are the same as noted in the *VLAN Tag in the Outer Header* discussion noted above.

16 Bit Nicknames
Concern was raised regarding the 16 bit limitation to Nicknames. As data communications networks continue to grow and the need for TRILL grows with it, will 16 bits for Nicknames become a limitation.

This question was discussed early in TRILL design by the IETF as well. According to Donald Eastlake, "Generally, 16-bits is believe to be big enough for the current TRILL with single level IS-IS. If you do multi-level IS-IS TRILL with nickname aggregation, then you are still fine and have effectively doubled the number of nickname bits, solving it for the foreseeable future. If you do multi-levelIS-IS TRILL with campus wide unique nicknames, then you might need a bigger nickname. Draft-tissa-trill-mt-encode includes away to expand the nickname space to 24-bits but it would require additional changes beyond that draft. The issues between nickname aggregation and unique nicknames for multi-level TRILL are discussed in draft-perlman-trill-rbridge-multi-level."

LSP Interval after a Nickname Collision
In TRILL, it is possible to spread additional information in the link state packets, such as a protocol for acquiring a unique nickname. Each RBridge chooses a nickname at random, avoiding nicknames already acquired by other RBridges (as discovered by examining the LSP database). If two RBridges choose the same nickname, there is a tie-breaker, based on configured priority and 6-byte system ID. One of the RBridges gets to keep the nickname. The other RBridge has to choose another nickname that is not in use. Additionally, it is possible to configure a nickname on an RBridge. In that case, a configured nickname takes priority over automatically generated nicknames.

During the test event it was observed that when a nickname collision occurs, there seems to be no indication in the current standard that an RBridge should send a new LSP after changing its nickname. Without this communication of the change, there will be stale information in the Distribution Tree which may lead to other communication issues.

As the Nickname information is no different than any other information in the LSP, the IS-IS Standard, ISO 10589-2002, was referenced. Clause 7.3.6 specifies Event Driven LSP Generation and does not indicate the need to generate an LSP in this circumstance.

Conclusion

The TRILL Plugfest gave early implementers the opportunity to test their TRILL implementations in a neutral environment against other early implementers. In the process of these tests, a keen focus was placed on interpretation of the standard.

The experience and knowledge gained during this event has been documented and presented to the IETF, generating awareness of the issues that may need to be further addressed either in implementations or standards to ensure a seamless deployment of TRILL Campuses. The test events will continue to support new functionality and standards development as TRILL becomes more widely deployed.

Going forward the UNH-IOL will focus on testing the Data Plane capabilities of TRILL implementations as well as larger TRILL Campus deployments.

About the UNH-IOL

Founded in 1988, the UNH-IOL provides independent, broad-based interoperability and standards conformance testing for data, telecommunications and storage networking products and technologies. Combining extensive staff experience, standards bodies' participation and a 32,000+ square-foot facility, the UNH-IOL helps companies efficiently and cost effectively deliver products to the market. For more information, visit http://www.iol.unh.edu/.

The UNH-IOL hosts multi-vendor group test events (often called "plugfests") as often as four times a month. These group test events complement over 20 year-round standards-based testing programs that are managed and operated by the UNH-IOL. Each of the testing groups, called "consortiums," represents a collaboration of industry forums, service providers, test equipment vendors and otherwise competing companies who benefit each other by:

- Distributing the cost of testing
- Lowering R&D and QA expenses
- Reducing product time to market
- Obtaining trusted, vendor-neutral verification

The laboratory maintains a strong reputation for independent, vendor-neutral testing with a focus on quality assurance. The confidential test reports the UNH-IOL provides to its members are recognized throughout the data communications industry as evidence of interoperability and conformance to technical standards.

References

The following documents were referenced during the test event:

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

[RFC 6326] D. Eastlake, A. Banerjee, D. Dutt, R. Perlman, A. Ghanwani. Transparent Interconnection of Lots of Links (TRILL) Use of IS-IS, RFC 6326 July 2011.

ISO/IEC 10589:2002
Information technology -- Telecommunications and information exchange between systems -- Intermediate System to Intermediate System intra-domain routeing information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode network service (ISO 8473)

Biography for Christina Dube:

Christina Dube is a Senior Manager and acts as the student recruitment and training lead for the executive steering body at the University of New Hampshire InterOperability Laboratory (UNH-IOL). In her role Christina manages the Bridge Functions Consortium, is involved with the AVnu Testing Consortium developments, performs internal auditing for the ISO 17025 IPv6 accreditation and oversees all technical training for the students in the lab. Additionally, she works closely with the student employees from recruitment to placement in industry post-graduation.

Since joining the UNH-IOL in 2010, Christina has managed the USGv6 Test Program routing testing with a focus on improving operational efficiencies. Demonstrating key strengths in developing students while keeping up with the commercial testing demands she quickly expanded her role and moved to manage other areas of the lab.

After receiving her Bachelor of Science in Electrical Engineering in 1992 from the University of New Hampshire, Christina began her career as a Firmware Engineer at Cabletron Systems, working on both repeater and bridge technologies in the MMAC product line. Over time Christina moved into a Design Assurance role responsible for validating the design of Cabletron's flagship product line, the SmartSwitch. After a 5 year hiatus to stay home with her children, Christina returned to the Industry working for Enterasys Networks as a Manager of a System Test team, again supporting Enterasys' flagship product line. While in this role at Enterasys, Christina had the fortuity of hiring many UNH-IOL graduates and quickly recognized the value of their hands-on experiences here.