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Further Testing of TRILL (TRansparent Interconnection of Lots of Links)

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Abstract

The University of New Hampshire InterOperability Laboratory (UNH-IOL) hosted its second TRansparent Interconnection of Lots of Links (TRILL) Interoperability Test Event the week of May 20 - May 24, 2013 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 Extreme Networks, Hewlett-Packard Networking, Huawei Technologies, and Ixia.

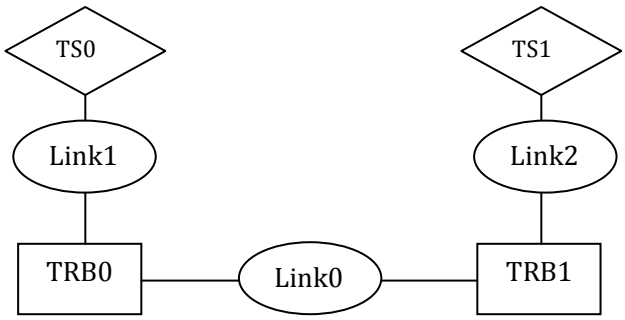
Introduction

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.

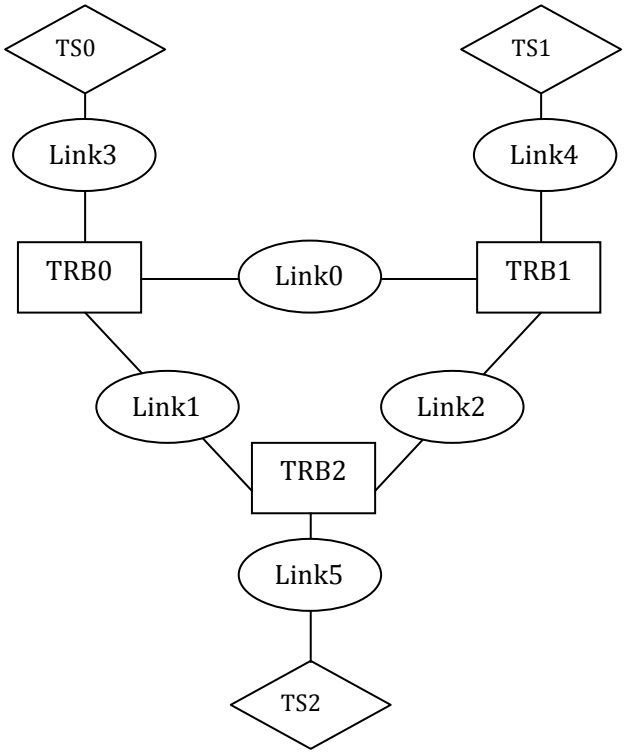
TRILL provides a solution to current STP limitations by combining Layer 2 and Layer 3 technologies. It applies link-state routing to Virtual Local Area Network (VLAN) aware switches, which allows for the deployment of larger-scale Layer 2 networks with better traffic spreading. Additionally, TRILL allows current Spanning Tree networks to be incrementally upgraded, isolating Spanning Tree to the areas of non-TRILL switches for improved network stability and link utilization. TRILL switches are also called RBridges (Routing Bridges).

During the UNH-IOL TRILL Test Event, participants tested their TRILL implementations against the UNH-IOL TRILL InterOperability Plugfest Test Suite. Based on the success of the preivous November 2012 Plugfest, the TRILL control plane was quickly proven in the test network and the majority of the testing focused on data plane testing.

Network Design



Basic Topology



Extended Topology

Network:

- The Testing Stations (TS#) were emulated by Ixia.
- A line tap was used on Link0 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 as well as to verify that the TRILL data plane was functional. The initial campus deployment implicitly verified that IS-IS Hellos were properly exchanged, a Designated RBridge was elected properly, that Nicknames were resolved between multiple devices, that a campus wide MTU was adopted, and that LSPs were properly exchanged by TRILL implementations. Tests for this Plugfest were designed to verify the data plane, thus proving that the TRILL Campus supports end-to-end connectivity. Once the unicast data plane was functional, Distribution trees for multi-destination traffic were tested for proper Root Choice, Shortest path first calculation, RBridge link loss and RBridge loss handling. Proper end node address learning and forgetting was also verified. Some of these tests were taken directly from the 2012 TRILL Plugfest Test Plan as they were tests which could not be completed properly during that test event.

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 both in the control and data planes.

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

- Number of Distribution Trees
- Pseudo Node Creation
- Proper Path Chosen - Inconsistent Egress
- End-Station Forgetting

Number of Distribution Trees

RBridges use distributions trees to forward multi-destination frames. (Unicast traffic is sent via least cost paths.) Each RBridge advertises in its LSP the maximum number of distributions trees that it can compute as well as the number of trees it wants all RBridges in the campus to compute. Ultimately, the number of trees that are computed for the campus can be no more than the number of trees supported by the RBridge in the campus that supports the fewest trees.

During the test event it was noted that one of the vendors consistently advertised that it could only support one distribution tree. Despite this, the other devices in the campus continued to calculate two distribution trees, however all devices participated in the same distribution tree so distribution of multi-destination traffic was successful.

*Many of the issues identified during the test event were discussed and troubleshot on-site with Donald Eastlake, Co-Chair of the IETF TRILL Working Group.

Pseudo Node Creation
In TRILL, a pseudo node should not be created for a link unless/until there have been three or more RBridges adjacent on that link. When a pseudo node is created, the Designated RBridge (DRB) on the link creates it. Since the tests conducted did not include more than two RBridges on a link (see network diagrams above), no pseudo nodes should have been created.

However, one RBrigde participating in the test always created a pseudo node for every link to which it was connected, including links to end nodes, and even when it was not DRB. However, the neighboring RBridges acted properly and robustly, ignoring the pseudo node for a link if created by a non-DRB and announcing adjacency to the pseudo node if it was created by the DRB. As a result, this extra pseudo node creation had no negative effect on the data plane.

Proper Path Chosen - Inconsistent Egress
Many of the tests in the Plugfest test plan rely on the proper calculation of the shortest path and distribution trees. In some instances, the proper calculation of shortest path and distribution trees directly impacted the test resulting in a PASS/FAIL, while others were observations of the campus which were notable and recorded but not necessary to the actual test result.

In many instances it was observed that the traffic flow on campus was taking the correct route, meaning all RBridges had correctly calculated the shortest path and distribution trees; however, in some cases, multi-destination traffic that should have been egressing to end-stations was not. In every instance that this behavior was observed, it did not directly impact the test results. Additionally, this observation occurred consistently enough throughout the testing that it was seen on each of the RBridges individually, but again, not enough to impact test results.

End-Station Forgetting
While RBridges need to learn end-station addresses in order for traffic to flow properly in a campus, it is equally important that RBridges forget end-stations when they are no longer active on the campus, or have moved to a different location on the campus. If they are not forgotten, frames destined to an end station that has moved could be indefinitely black-holed by RBridges with stale information.

During the test event it was observed that one of participating RBridges had trouble 'forgetting'. Despite the end station leaving the campus, the device maintained the frames destined to the end station as known unicasts.

Conclusion

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

The experience and knowledge gained during this event has been documented and presented to each of the participants for the betterment of their devices. It has generated 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.

This Plugfest and the limited number of issues observed demonstrate the maturity of the TRILL protocol as well as the success of the implementations tested. These results furthered the confidence of TRILL implementations enabling the attendees to have a better understanding of how their implementations will fair when deployed in a larger TRILL Campus.

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 placement lead for the executive steering body at the University of New Hampshire InterOperability Laboratory (UNH-IOL). In her role, Christina manages the Bridge Functions, Data Center Bridging, and Fibre Channel Consortiums, 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 experience.