Bridge Functions Consortium

Link Aggregation
Interoperability Test Suite
Version 2.6

Last Updated: 2008-08-04

Bridge Functions Consortium
University of New Hampshire
InterOperability Laboratory
www.iol.unh.edu

121 Technology Drive, Suite 2
Durham, NH 03824
Phone: +1-603-862-0090
Fax: +1-603-862-4181

TABLE OF CONTENTS

MODIFICATION RECORD

Version	Date	Editor(s)	Comments
0.9	1999-09-01	Calvin Bascom Gerard Goubert Benjamin Schultz	Initial Version
1.0	1999-11-05		Version 1.0
1.5	2002-09-03		Test Suite revised and updated
2.0	2004-08-30	Anthony Mwingira Curtis Simonson Jonathan Sterritt	Test Suite revised and updated
2.2	2005-01-27	Tyler Marcotte	Format Modification
2.5	2006-04-07	Andrew Corcoran	Test Suite revised and updated
2.6	2008-08-04	Gregory Roney	Test Suite revised and updated

ACKNOWLEDGEMENTS

The University of New Hampshire would like to acknowledge the efforts of the following individuals in the development of this test suite.

INTRODUCTION

The University of New Hampshire's InterOperability Laboratory (UNH-IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard. This suite of tests has been developed to help implementers evaluate the functionality of their Link Aggregation (IEEE Std. 802.3™-2002 Clause 43) capable products.

IEEE Std. 802.3™-2002 states:

> *"Link Aggregation allows one or more links to be aggregated together to form a Link Aggregation Group, such that a MAC Client can treat the Link Aggregation Group as if it were a single link. To this end, it specifies the establishment of DTE to DTE logical links, consisting of N parallel instances of full duplex point-to-point links operating at the same data rate."[1]*

This test suite has been designed based on the set of definitions, principles, requirements and terminologies that pertain to IEEE Std. 802.3™-2002 Clause 43. The test suite is designed to help determine whether or not the DUT will behave in accordance with the standard during normal operation.

These tests are not designed as performance tests. The relative performance of Link Aggregation capable devices (e.g. aggregation throughput, aggregation reconfiguration, etc.) is beyond the scope of this document.

These tests do not determine whether the DUT conforms to 802.3™-2002 Clause 43, nor are they designed as conformance tests. Rather, they provide one method to isolate problems within a Link Aggregation capable device that will affect interoperability. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other Link Aggregation capable devices. However, satisfactory completion of these tests provides a reasonable level of confidence that the DUT will function well in most Link Aggregation capable environments.

Please note that these tests are interoperability tests. Therefore, failure against a device(s) does not necessarily indicate nonconformance. Rather, it indicates that the two devices are unable to work together properly. Further work should be done to isolate the cause of the failure.

---

[1] IEEE Std 802.3™-2002 sub-clause 43.1 – [Link Aggregation] Overview

REFERENCES

The following documents are referenced in this text:

[IEEE Std. 802.3™-2002]	IEEE Computer Society LAN/MAN Standards Committee, "Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications"
[IEEE Std. 802.1D™-2004]	IEEE Computer Society LAN/MAN Standards Committee, "Part 3: Media Access Control (MAC) Bridges"

DEFINITION OF TERMS

Abbreviations and Acronyms:

DTE	Data Terminal Equipment
DUT	Device Under Test
LA	Link Aggregation
LP	Link Partner
LT	Line Tap
TS	Test Station

Definitions:

Aggregate	The action of forming a link aggregation.
Aggregation Key	*"A parameter associated with each port and with each aggregator of an Aggregation System identifying those ports that can be aggregated together. Ports in an Aggregation System that share the same Aggregation Key value are potentially able to aggregate together."* [2]
Conversation	*"A set of MAC frames transmitted from one end station to another, where all of the MAC frames form an ordered sequence, and where the communicating end stations require the ordering to be maintained among the set of MAC frames exchanged."* [2]
DTE	*"Any source or destination of data connected to the local area network."* [2]
End Station	*"A system attached to a LAN that is an initial source or a final destination of MAC frames transmitted across that LAN. A Network layer router is, from the perspective of the LAN, an end station; a MAC Bridge, in its role of forwarding MAC frames from one LAN to another, is not an end station."* [2]
Full Duplex	*"A mode of operation of a network...[that] allows for simultaneous communication between a pair of stations, provided that the Physical Layer is capable of supporting simultaneous transmission and reception without interference."* [2]
Half Duplex	*"A mode of operation of a CSMA/CD local area network (LAN) in which DTEs contend for access to a shared medium. Multiple, simultaneous transmissions in a half duplex mode CSMA/CD LAN result in interference, requiring resolution by the CSMA/CD access control protocol."* [2]
Line Tap	A pass through device, not seen as a network node nor a source of traffic, used to capture and view packets on a link between two systems.
Link	*"The transmission path between any two interfaces of generic cabling."* [2]
Link Partner	*"The device at the opposite end of a link segment from the local station. The link partner device may be either a DTE or a repeater."* [2]
Test Station	An end station used to generate and capture frames on a link.

---

[2] IEEE Std 802.3™-2002 Clause 1.4 – Definitions

TEST ORGANIZATION

This document organizes tests by group based on related test methodology or goals. Each group begins with a brief set of comments pertaining to all tests within that group. This is followed by a series of description blocks; each block describes a single test. The format of the description block is as follows:

Test Label: The test label and title comprise the first line of the test block. The test label is the concatenation of the short test suite name, group number, and the test number within the group, separated by periods. The test number is the group number and the test number, also separated by a period. So, test label LA.io.1.2 refers to the second test of the first test group in the Link Aggregation Interoperability suite. The test number is 1.2.

Purpose: The Purpose is a short statement describing what the test attempts to achieve. It is usually phrased as a simple assertion of the feature or capability to be tested.

References: The References section lists cross-references to the specifications and documentation that might be helpful in understanding and evaluating the test and results.

Resource Requirements: The Resource Requirements section specifies the software, hardware, and test equipment that will be needed to perform the test. The Discussion is a general discussion of the test and relevant section of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

Discussion: The Discussion is a general discussion of the test and relevant section of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

Test Layout: This diagram shows how the Test Systems, DUT, and any other Devices used should be connected for this test. Elements of the Procedure may change the Layout.

Procedure: This section of the test description contains the step-by-step instructions for carrying out the test. These steps include such things as enabling interfaces, disconnecting links between devices, and sending MAC frames from a Test Station. The test procedure also cues the tester to make observations, which are interpreted in accordance with the observable results given for that test part.

Observable Results: This section lists observable results that can be examined by the tester to verify that the DUT is operating properly. When multiple observable results are possible, this section provides a short discussion on how to interpret them. The determination of a PASS or FAIL for each test is usually based on how the behavior of the DUT compares to the results described in this section.

Possible Problems: This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

TEST SETUP

Each test in this suite uses the following setup for both the DUT and LP, unless otherwise noted:

Before verifying/applying settings, reset DUT and LP to factory defaults.

Default Bridge Settings: DUT & LP

Parameter	Value
Bridge VLANs	Default VLAN only (VID 1)
Filtering Database Aging Time	300 seconds
GMRP operational state	Disabled
GVRP operational state	Disabled
IP Routing	Disabled
Spanning Tree operational state	Disabled

Default Port Settings: DUT & LP

Parameter	Value
Acceptable Frame Types	Admit All Frames
Duplex	Full Duplex
Enable Ingress Filtering	Reset
GMRP port state	Disabled
GVRP port state	Disabled
Port VLAN Membership	Default VLAN only (VID 1)
PVID	1
Speed	Maximum Common Supported Mb/s

TEST SETUP (cont.)
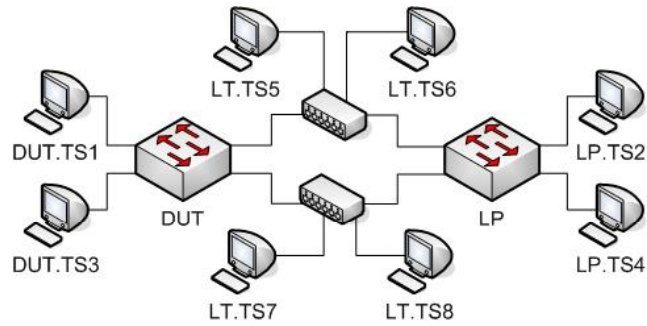
Test Setup 1 – Two-link Aggregation Setup
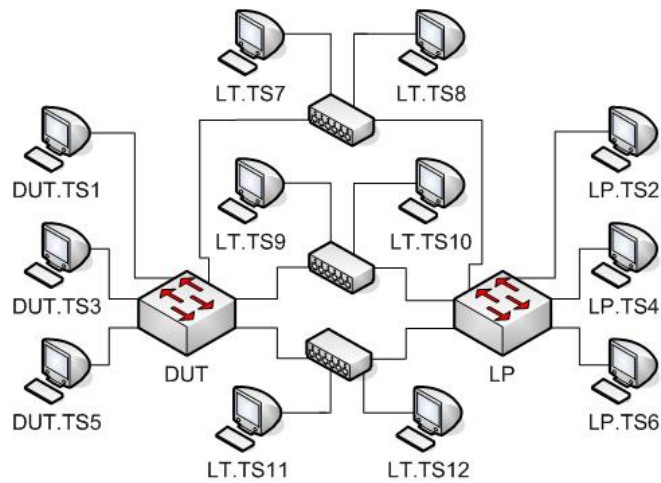
Test Setup 2 – Three-link Aggregation Setup

Test Setup 3 – Four-link Aggregation Setup

TEST SETUP (cont.)

The test setups pictured in the topology diagrams (Test Setup 1 – 3) demonstrate the use of Line Taps and the numbering/naming convention used for DUT.TSs, LP.TSs and LT.TSs.

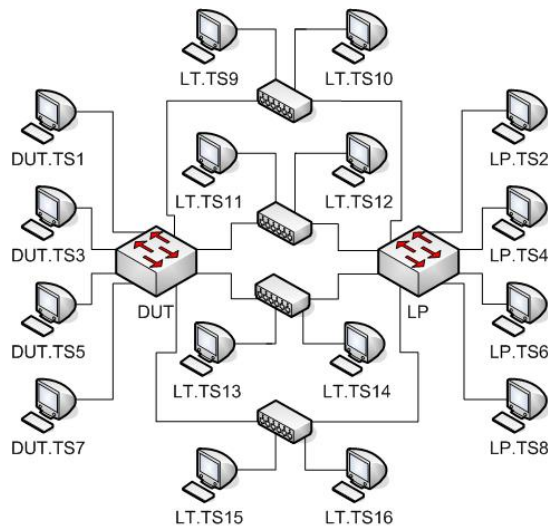In each Test Setup, Test Stations on the DUT are paired with Test Stations on the LP and communicate with each other via a conversation. For example, in *Test Setup 2*, DUT.TS1 is paired with LP.TS2. This numbering/naming convention is used throughout the entire test suite.

In *Test Setup 2*, the Link with the Line Tap connected to LT.TS7 and LT.TS8, could be used to carry the conversation between DUT.TS1 and LP.TS2. In this case, LT.TS3 would capture traffic originating from the LP (LP.TS2) and LT.TS4 would capture traffic originating from the DUT (DUT.TS1). This numbering/naming convention is used throughout the entire test suite.

SourceTraffic:

Rate	100 frames per second
Data Type	Random Byte
Frame Types/Amount	5 – 64-byte Unicast
	5 – 1518-byte Unicast
MAC source address	Unique to each Test Station
MAC destination address	Random

UniTestTraffic:

Rate	100 frames per second
Data Type	Random Byte
Frame Types/Amount	5 – 64-byte Unicast
	5 – 1518-byte Unicast
MAC source address	Unique to each Test Station (same as used in Test Station's *SourceTraffic*)
MAC destination address	Source address used by Test Station's paired Test Station (e.g. DUT.TS1 and LP.TS2 are paired Test Stations in *Test Setup 2*; DUT.TS1 uses a destination address equal to the source address used by LP.TS2 for its *SourceTraffic*)

MultBroadTestTraffic:

Rate	100 frames per second
Data Type	Random Byte
Frame Types/Amount	5 – 64-byte Multicast
	5 – 1518-byte Multicast
	5 – 64-byte Broadcast
	5 – 1518-byte Broadcast
MAC source address	Unique to each Test Station (same as used in Test Station's *SourceTraffic*)
MAC destination address	Multicast – 0x01 11 11 11 11 11
	Broadcast – 0XFF FF FF FF FF FF

GROUP 1: Link Aggregation Interoperability

Scope

The following tests are designed to verify the interoperability of DUT with other Link Aggregation capable devices. The tests verify that the aggregated links can be established and frames can be exchanged across the aggregation, and to other systems outside of the aggregation, without frame loss or misordering.

Overview

These tests verify that the DUT and Bridge Partner successfully interoperate under normal conditions. This provides a means of quickly identifying basic interoperability issues that must be addressed before proceeding with more complicated testing.

These tests verify the effect of a variety of conditions (e.g. Link Initialization, Link Failure, or Automatic (re)configuration) on an Aggregated Link. The tests verify end-to-end interoperability of the systems under test by exchanging various MAC frames across the aggregating systems.

For all tests in this group, two Link Aggregation capable systems are required. Aggregation is established between the two Link Aggregation capable systems using multiple full duplex physical links of the same speed.

LA.io.1.1: Link Aggregation Interoperability

Purpose: To verify that the DUT can properly interoperate with another Link Aggregation capable device and exchange frames through an aggregated link.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 8 Test Stations
- 2 Link Taps
- 1 Link Partner

Discussion:

Frame ordering must be maintained for certain sequences of frame exchanges between MAC Clients (known as conversations). The Distributor ensures that all frames of a given conversation are passed to a single port. For any given port, the Collector is required to pass frames to the MAC Client in the order that they are received from that port. The Collector is otherwise free to select frames received from the aggregated ports in any order. Since there are no means for frames to be misordered on a single link, this guarantees that frame ordering is maintained for any conversation. The above requirement to maintain frame ordering is met by ensuring that all frames that compose a given conversation are transmitted on a single link in the order that they are generated by the MAC Client.

Test Layout:
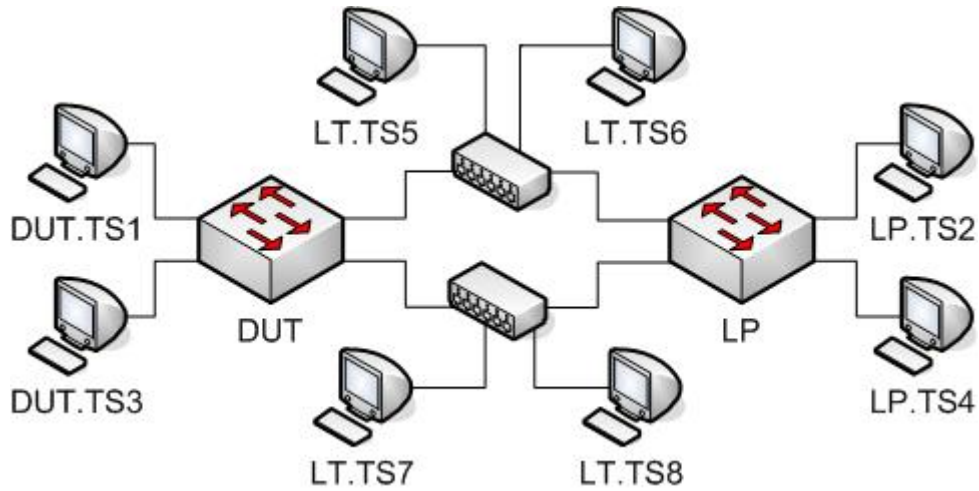
Part A – Link Aggregation Interoperability

Note – In Part A, more than two links may be used in the aggregated link between the DUT and LP. For each additional link added to the aggregation, four Test Stations and one Line Tap will be added to the test setup.

Procedure:

Part A: Link Aggregation Interoperability
1. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
2. Aggregate all links connecting the DUT to the LP.
3. Transmit, from all DUT.TSs, *SourceTraffic* frames.
4. Transmit, from all LP.TSs, *SourceTraffic* frames.
5. Start capture on all Test Stations.
6. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
7. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
8. Stop capture on all Test Stations, and observe the captured frames.
9. Repeat Steps 5 through 8 adding a third link to the aggregation.
10. Repeat Steps 5 through 8 adding a fourth link to the aggregation.

Observable Results:

- In Part A, during Step 8 and repetition of Step 8, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted via only one link (the conversation carrying link) in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.

Possible Problems:

- The maximum number of links is subject to practical considerations and device limitations.

LA.io.1.2: Link Aggregation Initialization

Purpose: To verify that, upon network initialization, the DUT can properly interoperate with another Link Aggregation capable device and exchange frames through an aggregated link consisting of two links.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.2.1
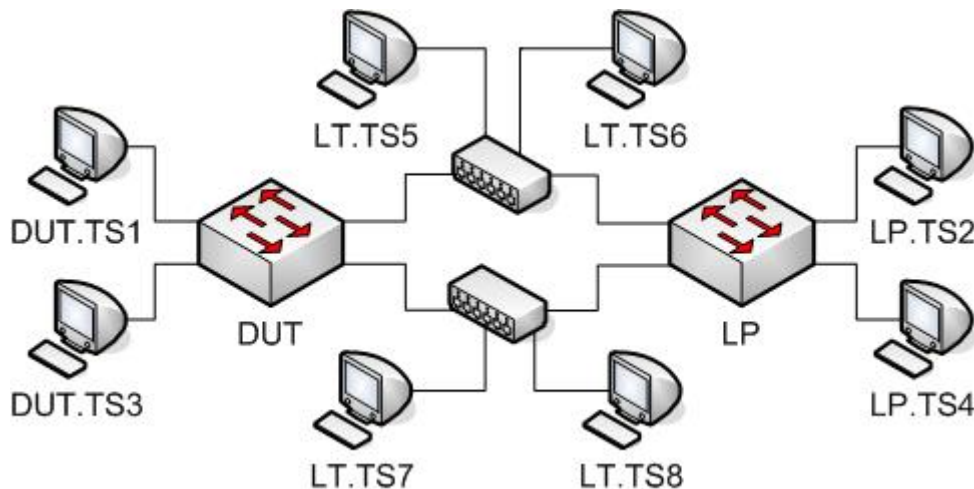- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 8 Test Stations
- 2 Link Taps
- 1 Link Partner

Discussion:

Frame ordering must be maintained for certain sequences of frame exchanges between MAC Clients (known as conversations). The Distributor ensures that all frames of a given conversation are passed to a single port. For any given port, the Collector is required to pass frames to the MAC Client in the order that they are received from that port. The Collector is otherwise free to select frames received from the aggregated ports in any order. Since there are no means for frames to be misordered on a single link, this guarantees that frame ordering is maintained for any conversation.

Test Layout:

Parts A & B – Link Aggregation Initialization

Procedure:

Part A: DUT Initialized, Linked to an Operational LP
1. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
2. Aggregate all links connecting the DUT to the LP.
3. Transmit, from all DUT.TSs, *SourceTraffic* frames.
4. Transmit, from all LP.TSs, *SourceTraffic* frames.
5. Start capture on all Test Stations.
6. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
7. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
8. Stop capture on all Test Stations, and observe the captured frames.
9. Ensure that the running configuration on the DUT and LP will be preserved after a power cycle.
10. Disconnect power from both the DUT and the LP.
11. Connect power to the DUT.
12. Wait until the DUT is initialized.
13. Connect power to the LP.
14. Wait until the LP is initialized.
15. Wait 60 seconds.
16. Repeat Steps 2-8.

Part B: LP Initialized, Linked to an Operational DUT
17. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
18. Aggregate all links connecting the DUT to the LP.
19. Transmit, from all DUT.TSs, *SourceTraffic* frames.
20. Transmit, from all LP.TSs, *SourceTraffic* frames.
21. Start capture on all Test Stations.
22. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
23. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
24. Stop capture on all Test Stations, and observe the captured frames.
25. Ensure that the running configuration on the DUT and LP will be preserved after a power cycle.
26. Disconnect power from both the DUT and the LP.
27. Connect power to the LP.
28. Wait until the LP is initialized.
29. Connect power to the DUT.
30. Wait until the DUT is initialized.
31. Wait 60 seconds.
32. Repeat Steps 18-23.

Observable Results:

- In Part A, during Steps 8 and 16, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted over only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.
- In Part B, during Steps 24 and 32, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted over only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.

Possible Problems:

- In Part A, Steps 1 and 2 must be repeated at the beginning of Step 15-16 if the DUT and/or LP does not preserve the Bridge and Port values through a power cycle.
- In Part B, Steps 17 and 18 must be repeated at the beginning of Step 31-32 if the DUT and/or LP does not preserve the Bridge and Port values through a power cycle.

LA.io.1.3: Link Failure and Automatic (re)Configuration

Purpose: To verify that, after a single link failure within an established link aggregation, the DUT can properly reconfigure and interoperate with another Link Aggregation capable device and exchange frames through an aggregated link.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.1.2
- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.3.12
- IEEE Std. 802.3™-2002, sub-clause 43.3.13
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 8 Test Stations
- 2 Link Taps
- 1 Link Partner

Discussion:

A port may be detached from the Aggregator used by its Link Aggregation Group as a result of protocol (e.g., Key) changes, or because of System constraints (e.g., exceeding a maximum allowable number of aggregated links, or device failures) at either end of the link. Both classes of events will cause the LAG ID information for the link to change, and it will be necessary for Link Aggregation Control to detach the link from its current Aggregator and move it to a new LAG (if possible). Any conversation that is reallocated to a different link as a result of detaching a link from an Aggregator shall have its frame ordering preserved.

Test Layout:
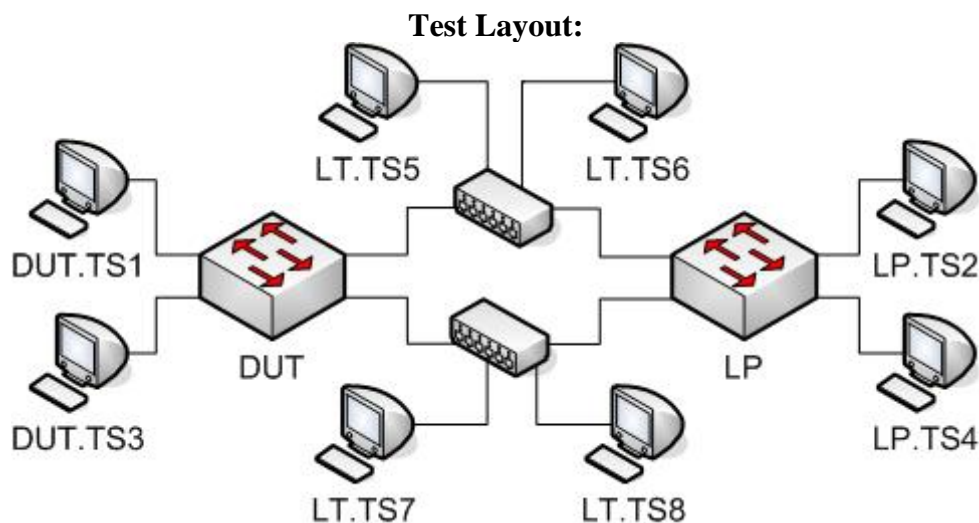
Parts A & B: Link Failure within a Link Aggregation

Procedure:

Part A: Conversation-carrying Link Failure within a Link Aggregation
1. Ensure that the <u>default</u> bridge and port values are configured on the DUT and LP.
2. Aggregate the links connecting the DUT to the LP.
3. Transmit, from all DUT.TSs, *SourceTraffic* frames.
4. Transmit, from all LP.TSs, *SourceTraffic* frames.
5. Start capture on all Test Stations.
6. Continuously transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
7. Continuously transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
8. Disconnect a link currently used for a conversation within the link aggregation between the DUT and LP.
9. Stop transmitting, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
10. Stop transmitting, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
11. Stop capture on all Test Stations, and observe the captured frames.

Part B: Non-conversation-carrying Link Failure within a Link Aggregation
12. Ensure that the <u>default</u> bridge and port values are configured on the DUT and LP.
13. Aggregate the links connecting the DUT to the LP.
14. Transmit, from all DUT.TSs, *SourceTraffic* frames.
15. Transmit, from all LP.TSs, *SourceTraffic* frames.
16. Start capture on all Test Stations.
17. Continuously transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
18. Continuously transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
19. Disconnect a link not currently used to for a conversation within the link aggregation between the DUT and LP.
20. Stop transmitting, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
21. Stop transmitting, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
22. Stop capture on all Test Stations, and observe the captured frames.

Observable Results:

- In Part A, during Step 11, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted via only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. The DUT and LP must remove the disconnected link from the aggregation and transmit traffic through the other link on the aggregation. All conversations previously transmitted via the disconnected link must be reassigned to a link in the new aggregation. Frames belonging to conversations transmitted over the disconnected link must not be lost for more than one second, and must not be disordered or duplicated. All other frames must not be lost, disordered or duplicated.
- In Part B, during Step 22, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted via only one link in the link aggregation. The DUT and LP must form a new aggregation without the disconnected link. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.

Possible Problems:

- None.

LA.io.1.4: Link Aggregation Interoperability in a Spanning Tree Environment

Purpose: To verify that the DUT can properly interoperate in a Spanning Tree environment with another Link Aggregation capable device and exchange frames through an aggregated link.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.1.2
- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.2.8
- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 12 Test Stations
- 3 Link Taps
- 1 Link Partner

Discussion:

Link Aggregation allows one or more links to be aggregated together to form a Link Aggregation Group, such that a MAC Client can treat the Link Aggregation Group as if it were a single link. When a System assigns an administrative Key value to a set of ports, it signifies that the set of ports have the potential to aggregate together, subject to the considerations discussed in 43.6.2. Any port that is not enabled, [i.e., has MAC_Operational (6.4.2) False or has been excluded from the active topology by management setting of the Administrative Bridge Port State to Disabled (14.8.2.2)] or has been dynamically excluded from forwarding and learning from MAC frames, is assigned the Port State *Discarding*. Any Port that has learning enabled but forwarding disabled has the Port State *Learning*, and a Port that both learns and forwards frames has the Port State *Forwarding*.

Test Layout:
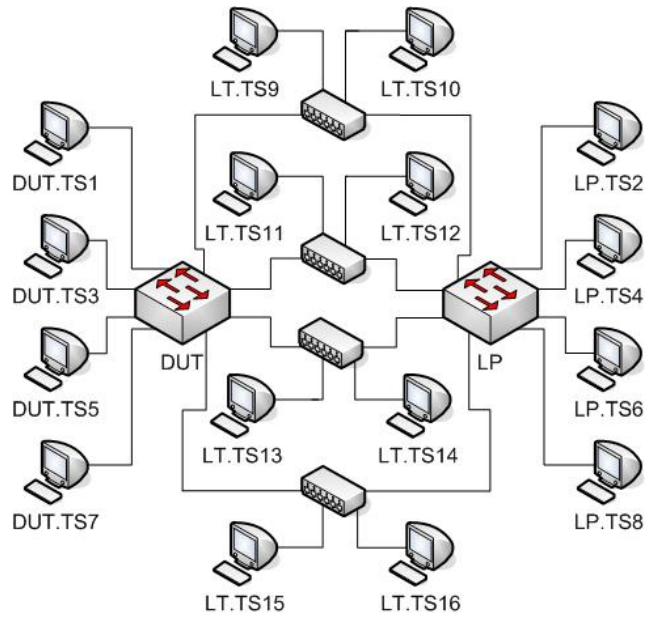
Part A and B: Link Aggregation Interoperability in a Spanning Tree Environment

Procedure:

Part A: Multiple Aggregation Interoperability in a Spanning Tree Environment (DUT as the Root)

1. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
2. Configure the DUT's Spanning Tree operational state to enable.
3. Configure the DUT's Spanning Tree version to the most recent supported.
4. Configure all the Ports on the DUT to participate in the Spanning Tree.
5. Configure the DUT to be the Root Bridge.
6. Aggregate Links DUT.TS1, LP.TS2, DUT.TS3, and LP.TS4 as one aggregation..
7. Aggregate Links DUT.TS5, LP.TS6, DUT.TS7, and LP.TS8 as another, separate aggregation.
8. Transmit, from all DUT.TSs, *SourceTraffic* frames.
9. Transmit, from all LP.TSs, *SourceTraffic* frames.
10. Start capture on all Test Stations.
11. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
12. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
13. Stop capture on all Test Stations, and observe the captured frames.
14. Ensure that the running configuration on the DUT and LP will be preserved after a power cycle.
15. Disconnect power from both the DUT and LP.
16. Connect power to the DUT and LP.
17. Wait until the DUT and LP are initialized.
18. Wait 60 seconds.
19. Repeat Steps 8-13.

Part B: Multiple Aggregation Interoperability in a Spanning Tree Environment (LP as the Root)

20. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
21. Configure the DUT's Spanning Tree operational state to enable.
22. Configure the DUT's Spanning Tree version to the most recent supported.
23. Configure all the Ports on the DUT to participate in the Spanning Tree.
24. Configure the LP to be the Root Bridge.
25. Aggregate Links DUT.TS1, LP.TS2, DUT.TS3, and LP.TS4 as one aggregation.
26. Aggregate Links DUT.TS5, LP.TS6, DUT.TS7, and LP.TS8 as another, separate aggregation.
27. Transmit, from all DUT.TSs, *SourceTraffic* frames.
28. Transmit, from all LP.TSs, *SourceTraffic* frames.
29. Start capture on all Test Stations.
30. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
31. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
32. Stop capture on all Test Stations, and observe the captured frames.
33. Ensure that the running configuration on the DUT and LP will be preserved after a power cycle.
34. Disconnect power from both the DUT and LP.
35. Connect power to the DUT and LP.
36. Wait until the DUT and LP are initialized.

37. Wait 60 seconds.
38. Repeat Steps 27-32.

Observable Results:

- In Part A, during step 13 and repetitions of 13, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and a LP.TS must be transmitted over only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.
- In Part B, during step 32 and repetitions of 32, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted over only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.

Possible Problems:

- This test cannot be completed if the DUT does not support Spanning Tree.
- In Part A, this test cannot be completed if the DUT does not support more than one aggregation at a time.
- In Part A, Steps 1 and 2 must be repeated at the beginning of Step 23 if the DUT and/or the LP does not preserve the Bridge and/or Port values through a power cycle.
- In Part B, this test cannot be completed if the LP does not support more than one aggregation at a time.
- In Part B, Steps 16 and 17must be repeated at the beginning of Step if the DUT and/or the LP does not preserve the Bridge and/or Port values through a power cycle.

LA.io.1.5 : Active Spanning Tree Link Addition

Purpose: To verify that the DUT can properly interoperate, in a Spanning Tree environment, with another Link Aggregation capable device, and exchange frames through an aggregated link, and that addition of links into the aggregation in real-time does not affect interoperability.

References:

- IEEE Std. 802.3™-2002: Clause 43 – Link Aggregation
- IEEE Std 802.1D™-2004: Clause 6 – Support of the MAC Service

Resource Requirements:

- 8 Test Stations
- 2 Link Taps
- 1 Link partner

Discussion:

Link Aggregation allows one or more links to be aggregated together to form a Link Aggregation Group, such that a MAC Client can treat the Link Aggregation Group as if it were a single link. Any port that is not enabled, [i.e., has MAC_Operational (6.4.2) False or has been excluded from the active topology by management setting of the Administrative Bridge Port State to Disabled (14.8.2.2)] or has been dynamically excluded from forwarding and learning from MAC frames, is assigned the Port State *Discarding*. Any Port that has learning enabled but forwarding disabled has the Port State *Learning*, and a Port that both learns and forwards frames has the Port State *Forwarding*.

Test Layout:
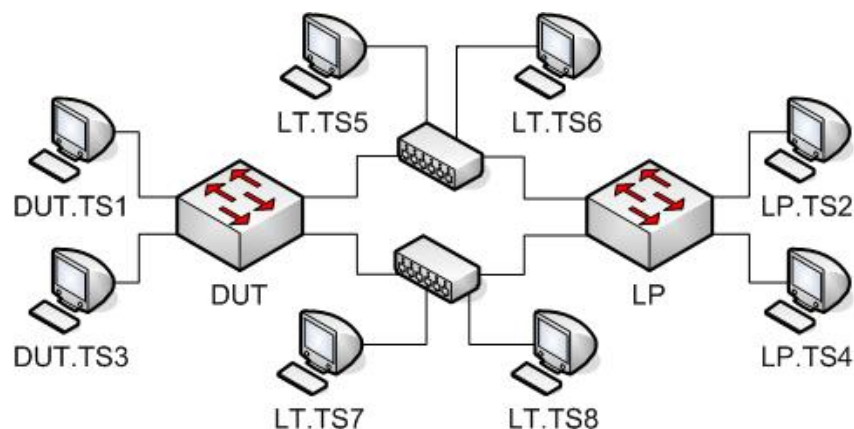
Parts A & B – Active Spanning Tree Link Addition Interoperability
Note – In Parts A and B, another link will be added between the DUT and the LP. For the additional link, four Test Stations and one Line Tap will be added to the test setup.

Procedure:

Part A: Active Spanning Tree Link Addition (DUT as Root)
2. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
3. Configure the DUT's Spanning Tree operational state to enable.
4. Configure the DUT's Spanning Tree version to the most recent supported.
5. Configure all the Ports on the DUT to participate in the Spanning Tree.
6. Configure the DUT to be the Root Bridge.
7. Aggregate all links connecting the DUT to the LP.
8. Transmit, from all DUT.TSs, *SourceTraffic* frames.
9. Transmit, from all LP.TSs, *SourceTraffic* frames.
10. Start capture on all Test Stations.
11. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
12. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
13. Stop capture on all Test Stations, and observe the captured frames.
14. Add another non-aggregated link connecting the DUT to the LP.
15. Repeat Steps 8-13.

Part B: Active Spanning Tree Link Addition (LP as Root)
16. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
17. Configure the DUT's Spanning Tree operational state to enable.
18. Configure the DUT's Spanning Tree version to the most recent supported.
19. Configure all the Ports on the DUT to participate in the Spanning Tree.
20. Configure the LP to be the Root Bridge.
21. Aggregate all links connecting the DUT to the LP.
22. Transmit, from all DUT.TSs, *SourceTraffic* frames.
23. Transmit, from all LP.TSs, *SourceTraffic* frames.
24. Start capture on all Test Stations.
25. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
26. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
27. Stop capture on all Test Stations, and observe the captured frames.
28. Add another non-aggregated link connecting the DUT to the LP.
29. Repeat Steps 22-27.

Observable Results:

- In Part A, during Step 13 and repetitions of Step 13, all links connecting the DUT and the LP should form an aggregation between the two devices. All DUT.TSs should receive *UniTestTraffic* from their paired LP.TS, and vice versa. All DUT.TSs and LP.TSs should receive *MultiBroadTestTraffic* from all other DUT.TSs and LP.TSs. Frames should not be lost, disordered, or duplicated.
- In Part B, during Step 18 and repetitions of Step 18, all links connecting the DUT and the LP should form an aggregation between the two devices. All DUT.TSs should receive *UniTestTraffic* from their paired LP.TS, and vice versa. All DUT.TSs and LP.TSs should receive *MultiBroadTestTraffic* from all other DUT.TSs and LP.TSs. Frames should not be lost, disordered, or duplicated.

Possible Problems:

- This test cannot be completed if the DUT does not support Spanning Tree.

GROUP 2: Link Aggregation Control Protocol Interoperability

Scope

The following tests are designed to verify the interoperability of the Link Aggregation Control Protocol used to control the Aggregated Link between the DUT and another Link Aggregation capable device.

Overview

These tests verify that the Link Aggregation Control Protocol on the DUT and Bridge Partner successfully interoperate under specific conditions. This provides a means of quickly identifying issues with the interoperability of the DUT's Link Aggregation Control Protocol.

These tests verify the affect of a variety of conditions (e.g. Worst Case Delay, Multipoint Aggregations, or Multiple Data rates) on the Link Aggregation Control Protocol for an Aggregated Link. The tests verify end-to-end interoperability of the systems under test by exchanging various MAC frames across the aggregating systems.

For all tests in this group, two Link Aggregation capable systems are required. Aggregation is established between the two Link Aggregation capable systems using multiple physical links of the same speed (except test LA.io.2.3). These links are specified to be in full-duplex operation only, unless specifically noted otherwise.

LA.io.2.1: Worst-Case Delay Interoperability

Purpose: To verify that the DUT can properly interoperate with another Link Aggregation capable device and exchange frames through an aggregated link, containing a link that exhibits worst-case delay.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std. 802.3™-2002, sub-clause 43.4.1
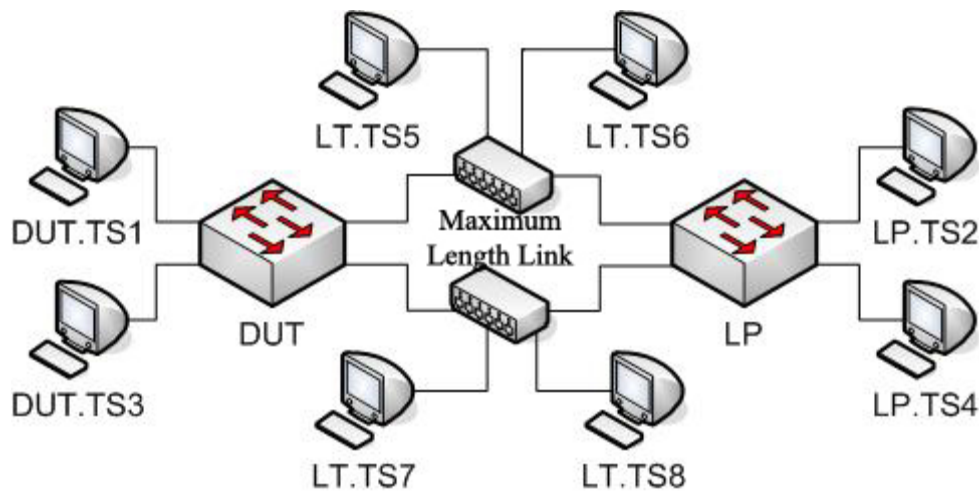- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 8 Test Stations
- 2 Link Taps
- 1 Link Partner

Discussion:

Frame ordering must be maintained for certain sequences of frame exchanges between MAC Clients (known as conversations). The Distributor ensures that all frames of a given conversation are passed to a single port. For any given port, the Collector is required to pass frames to the MAC Client in the order that they are received from that port. The Collector is otherwise free to select frames received from the aggregated ports in any order. Since there are no means for frames to be misordered on a single link, this guarantees that frame ordering is maintained for any conversation.

Test Layout:

Part A: Link Aggregation with worst-case delay

Procedure:

Part A: Link Aggregation with worst-case delay
1. Ensure that the default Bridge and Port values are configured on the DUT and LP.
2. Aggregate the links connecting the DUT to the LP using a cable of maximum length for the conversation-carrying link.
3. Transmit, from all DUT.TSs, *SourceTraffic* frames.
4. Transmit, from all LP.TSs, *SourceTraffic* frames.
5. Start capture on all Test Stations.
6. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
7. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
8. Stop capture on all Test Stations, and observe the captured frames.

Observable Results:

- In Part A, during Step 8, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and LP.TS pair must be transmitted over only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.

Possible Problems:

- None.

LA.io.2.2: Multi-Aggregation Interoperability

Purpose: To verify that the DUT properly forms two separate Link Aggregations when connected to a Link Partner which contains two separate groups of Ports each with different Keys.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 16 Test Stations
- 4 Link Taps
- 1 Link Partner

Discussion:

Link Aggregation allows one or more links to be aggregated together to form a Link Aggregation Group, such that a MAC Client can treat the Link Aggregation Group as if it were a single link. When a System assigns an administrative Key value to a set of ports, it signifies that the set of ports have the potential to aggregate together, subject to the considerations discussed in IEEE Std. 802.3 – 2002 sub-clause 43.6.2.

Test Layout:
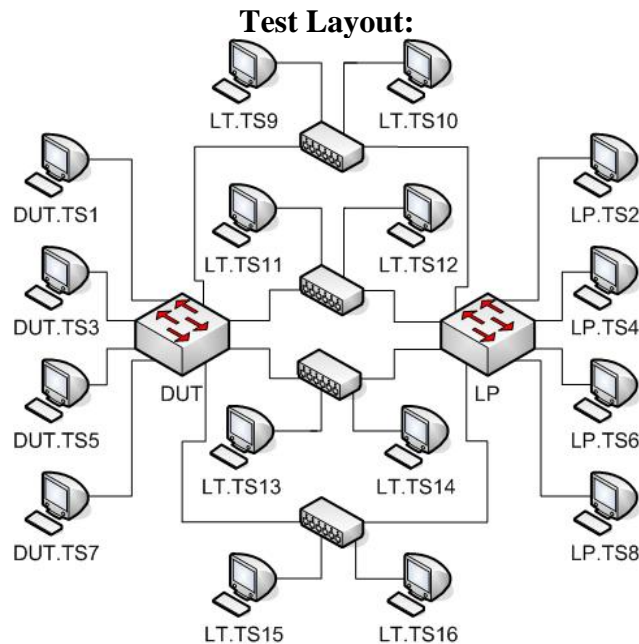
Part A: Multi-Aggregation Interoperability

Procedure:

Part A: Multi-Aggregation Interoperability
1. Ensure that the default Bridge and Port values are configured on the DUT and LP.
2. Aggregate Links DUT.TS1, LP.TS2, DUT.TS3, and LP.TS4 as one aggregation.
3. Aggregate Links DUT.TS5, LP.TS6, DUT.TS7, and LP.TS8 as another, separate aggregation.
4. Transmit, from all DUT.TSs, *SourceTraffic* frames.
5. Transmit, from all LP.TSs, *SourceTraffic* frames.
6. Start capture on all Test Stations.
7. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
8. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
9. Stop capture on all Test Stations, and observe the captured frames.

Observable Results:

- In Part A, during Step 9, in the absence of Spanning Tree a traffic loop will be formed consisting of the multiple aggregations between the DUT and LP. All TSs must capture traffic from all other TSs. Two Aggregations must been formed between the DUT and LP. A multipoint aggregation must not be formed.

Possible Problems:

- This test cannot be completed, if the DUT and/or the LP do not support more than one aggregation at a time.

LA.io.2.3: Non-Default/Non-Uniform Data Rate Interoperability

Purpose: To verify that the DUT can properly interoperate with another Link Aggregation capable device in a non-default data rate environment.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 8 Test Stations
- 2 Link Taps
- 1 Link Partner

Discussion:

Link Aggregation is supported only on point-to-point links with MACs operating in full duplex mode. All links in a Link Aggregation Group operate at the same data rate (e.g., 10 Mb/s, 100 Mb/s, or 1000 Mb/s). Frame ordering must be maintained for certain sequences of frame exchanges between MAC Clients (known as conversations). The Distributor ensures that all frames of given conversation are passed to a single port. For any given port, the Collector is required to pass frames to the MAC Client in the order that they are received from that port. The Collector is otherwise free to select frames received from the aggregated ports in any order. Since there are no means for frames to be misordered on a single link, this guarantees that frame ordering is maintained for any conversation. Conversations may be moved among ports within an aggregation, both for load balancing and to maintain availability in the event of link failures

Test Layout:
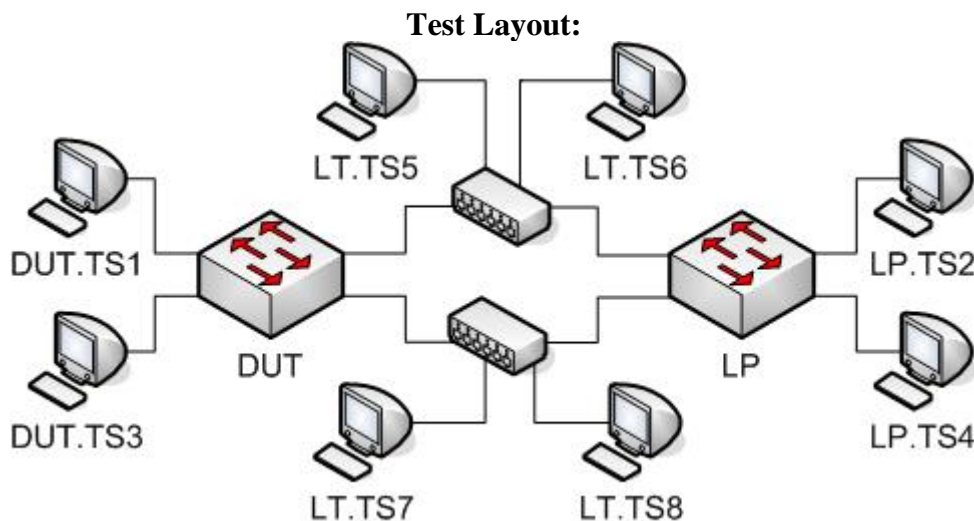
Parts A & B – Non-Default/Non-Uniform Data Rate Interoperability

---

Procedure:

Part A: Non-default Data Rate Interoperability
1. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
2. Configure all DUT.TS and LP.TS Speeds to N Mb/s, where N is a non-default Port speed.
3. Aggregate the links connecting the DUT to the LP.
4. Transmit, from all DUT.TSs, *SourceTraffic* frames.
5. Transmit, from all LP.TSs, *SourceTraffic* frames.
6. Start capture on all Test Stations.
7. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
8. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
9. Stop capture on all Test Stations, and observe the captured frames.

Part B: Non-Uniform Data Rate Interoperability
10. Ensure that the <u>default</u> Bridge and Port values are configured on the DUT and LP.
11. Configure the DUT.TS1 and LP.TS2 to the default Port speed.
12. Configure the DUT.TS3 and LP.TS4 to N Mb/s, where N is a non-default Port speed.
13. Aggregate the links connecting the DUT to the LP.
14. Start capture on all Test Stations.
15. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
16. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
17. Stop capture on all Test Stations, and observe the captured frames.

Observable Results:

- In Part A, during Step 9, all DUT.TSs must only capture all *UniTestTraffic* transmitted from its paired LP.TS. All LP.TSs must only capture all *UniTestTraffic* transmitted from its paired DUT.TS. Each conversation between a DUT.TS and a LP.TS must be transmitted over only one link in the link aggregation. All Test Stations must capture *MultiBroadTestTraffic* from all other Test Stations. Frames must not be lost, disordered or duplicated.
- In Part B, during Step 17, the DUT and LP must not form an aggregation; the DUT and LP, in the absence of Spanning Tree, must form a data loop resulting in all DUT.TSs and LP.TSs capturing all *UniTestTraffic* and *MultiBroadTestTraffic* transmitted from all DUT.TSs and LP.TSs.

Possible Problems:

- This test cannot be completed, if the DUT and/or the LP do not support the ability to configure a Port's speed.

LA.io.2.4 : Active/Passive LACP Interoperability

Purpose: To verify that the DUT interoperates with a Link Aggregation capable Link Partner when combinations of Active and Passive LACP are configured.

References:

- IEEE Std. 802.3™-2002, sub-clause 43.2.1
- IEEE Std. 802.3™-2002, sub-clause 43.3
- IEEE Std. 802.3™-2002, sub-clause 43.4.16
- IEEE Std 802.1D™-2004, Clause 6

Resource Requirements:

- 8 Test Stations
- 2 Line Taps
- 1 Link Partner

Discussion:

Active or passive participation in LACP is controlled by LACP_Activity, an administrative control associated with each port, that can take the value Active LACP or Passive LACP. Passive LACP indicates the port's preference for not transmitting LACPDUs unless its Partner's control value is Active LACP (i.e., a preference not to speak unless spoken to). Active LACP indicates the port's preference to participate in the protocol regardless of the Partner's control value (i.e., a preference to speak regardless).

Test Layout:
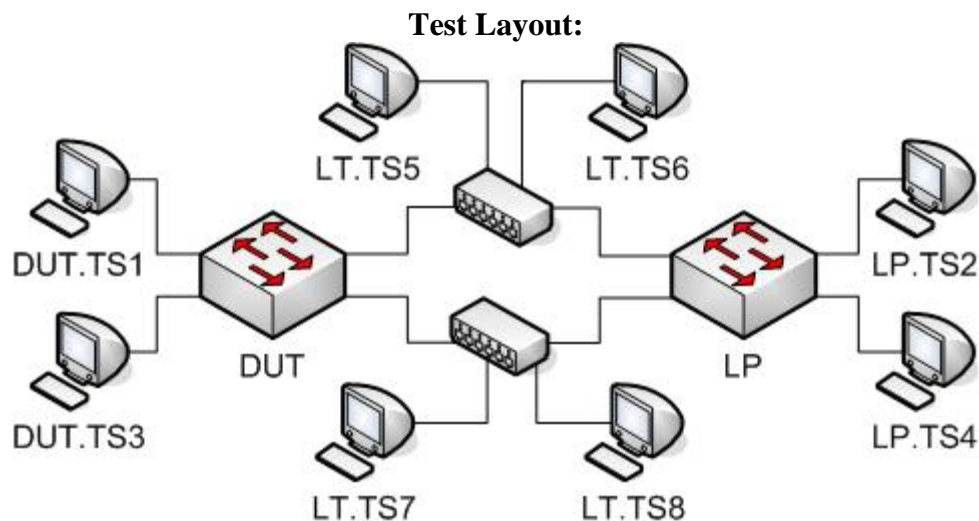
Parts A, B, & C – Active/Passive LACP Interoperability

Procedure:

Part A: DUT.LACP_Activity = ACTIVE / LP.LACP_Activity = PASSIVE
1. Ensure that the default Bridge and Port values are configured on the DUT and LP.
2. Configure the LACP Activity parameter on all ports on the DUT to Active.
3. Configure the LACP Activity parameter on all ports on the LP to Passive.
4. Aggregate all links connecting the DUT to the LP.
5. Transmit, from all DUT.TSs, *SourceTraffic* frames.
6. Transmit, from all LP.TSs, *SourceTraffic* frames.
7. Start capture on all Test Stations.
8. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
9. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
10. Stop capture on all Test Stations, and observe the captured frames.

Part B: DUT.LACP_Activity = PASSIVE / LP.LACP_Activity = ACTIVE
11. Ensure that the default Bridge and Port values are configured on the DUT and LP.
12. Configure the LACP Activity parameter on all ports on the DUT to Passive.
13. Configure the LACP Activity parameter on all ports on the LP to Active.
14. Aggregate all links connecting the DUT to the LP.
15. Transmit, from all DUT.TSs, *SourceTraffic* frames.
16. Transmit, from all LP.TSs, *SourceTraffic* frames.
17. Start capture on all Test Stations.
18. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
19. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
20. Stop capture on all Test Stations, and observe the captured frames.

Part C: DUT.LACP_Activity = LP.LACP_Activity = PASSIVE
21. Ensure that the default Bridge and Port values are configured on the DUT and LP.
22. Configure the LACP Activity parameter on all ports on the DUT to Passive.
23. Configure the LACP Activity parameter on all ports on the LP to Passive.
24. Aggregate all links connecting the DUT to the LP.
25. Transmit, from all DUT.TSs, *SourceTraffic* frames.
26. Transmit, from all LP.TSs, *SourceTraffic* frames.
27. Start capture on all Test Stations.
28. Transmit, from all DUT.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
29. Transmit, from all LP.TSs, *UniTestTraffic* and *MultiBroadTestTraffic* frames.
30. Stop capture on all Test Stations, and observe the captured frames.

Observable Results:

- In Part A, during Step 10, the DUT and LP should form an aggregation consisting of the links connecting the two devices. All DUT.TSs should receive *UniTestTraffic* from their paired LP.TS, and vice versa. All DUT.TSs and LP.TSs should receive *MultiBroadTestTraffic* from all other Test Stations. Frames should not be lost, disordered, or duplicated.
- In Part B, during Step 20, the DUT and LP should form an aggregation consisting of the links connecting the two devices. All DUT.TSs should receive *UniTestTraffic* from their paired LP.TS, and vice versa. All DUT.TSs and LP.TSs should receive *MultiBroadTestTraffic* from all other Test Stations. Frames should not be lost, disordered, or duplicated.
- In Part C, during Step 30, the DUT and LP should not form an aggregation. The individual links configured to be aggregated should act as individual links, and form a data loop.

Possible Problems:

- This Test cannot be completed if the LP does not support configuring the LACP Activity parameter to Passive.