MPLS Layer 2 VPNs
Functional and Performance Testing
Sample Test Plans
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This Test Plan Primer contains a general outline for testing a particular technology. Not all the capabilities of Ixia technology have been exposed in this document. Please feel free to contact us if additional capabilities are required.
Overview

Layer 2 MPLS VPNs (often called Martini VPNs after the primary author of the IETF draft) allow service providers to deliver to their customers secure, Layer 2 connections over MPLS core networks. The configuration and deployment of L2 VPN technology is a complex endeavor involving multiple protocols and signaling mechanisms. The objective of this test plan is to introduce a set of tests that can be used to validate L2 VPN implementations prior to deployment. These tests provide a foundation that can be expanded upon to create more complex or custom testing scenarios.

1. L2 VPN Padding Verification Test

1.1 Objective

Measure the device under test’s (DUT’s) ability to pad frames entering a Martini pseudowire (PW) that do not fit the minimum transmission unit (MTU) specified for a given MPLS tunnel. The test also verifies traffic throughput between the ingress and egress sides of the PW.

![Figure 1. L2 VPN padding verification test topology](chart)

1.2 Setup

A minimum of two network connections are required between the test tool and the DUT — one port will emulate a single CE connection to the DUT and produce small size frames of 54 bytes or less. Test port 2 will emulate the PE side and build the pseudowire with a minimum frame size of 64 by default. Ixia’s IxExplorer with routing protocol emulations can be used to construct the topology and fulfill the control and data plane requirements for this test.
1.3 Input Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC ID</td>
<td>Pseudowire identifier used to categorize a particular VPN</td>
</tr>
<tr>
<td>Minimum Transmission Unit</td>
<td>Smallest value in bytes that a frame must be to traverse the pseudowire. This is configurable on some devices.</td>
</tr>
<tr>
<td>Maximum Transmission Unit</td>
<td>Configurable value in bytes for the maximum allowed frame size allowed over the pseudowire</td>
</tr>
<tr>
<td>Encapsulation type (CE)</td>
<td>Type of CE side interfaces – can be HDLC, PPP, Frame Relay, Ethernet, VLAN, or ATM.</td>
</tr>
<tr>
<td>Frame size</td>
<td>The size of the frames being transmitted from CE side interface</td>
</tr>
</tbody>
</table>

Table 1. L2 VPN padding verification test input parameters

1.4 Methodology

1. Tester port 2 (PE) initiates IGP (e.g. OSPF, ISIS) and LDP basic sessions with the DUT to learn and update loopback addresses.

2. Tester port 2 then activates targeted Martini sessions with the DUT to construct the L2 PW. In this example, we use HDLC as our encapsulation and pseudowire type – see Figure 2.

3. Tester port 1 (CE) originates traffic destined to the prefix advertised by the emulated PE on tester port 2. The frame size of this traffic is set to 54 bytes or less.

4. The test tool is used to display the received frames and bytes throughput on tester port 2.
1.5 Results

The desired result is that tester port 2 should receive padded 64 byte frames at the rate being transmitted by tester port 1, proving that the DUT is adhering to the 64 byte minimum transmission unit policy on the PW. The bytes transmitted and received should be graphed on both tester ports 1 and 2 for comparison in real-time to show that the padding feature is functioning as designed. An example of this is shown in Figure 3. In addition, a decoded view of the captured received packets can be used to confirm the addition of PW padding. Figure 4 shows the embedded encapsulated HDLC packet with padding.
Figure 3. L2 VPN padding verification test results – graph of bytes sent/received
Figure 4. L2 VPN padding verification test results – capture view of properly padded packets
2. L2 VPN Pseudowire Convergence Test

2.1 Objective
Test the device's capability to converge L2 VPN topology changes, resulting in a measurement of convergence time. Preferred IGP administrative distance is removed from the test, forcing higher-level control plane changes to occur on the MPLS control plane.

2.2 Setup
The test requires three tester ports — one to transmit traffic and two to advertise similar paths to the destination. One test port emulates a CE router and two emulate PE routers. Test port 2 advertises the emulated PE via OSPF, while test port 3 represents the same PE via ISIS. Test port 1 transmits traffic to the PE via a pseudowire or set of pseudowires, then topological changes are induced. Ixia’s IxExplorer with routing protocol emulations can be used to construct the topology and fulfill the control and data plane requirements for this test.

![Figure 5. L2 VPN pseudowire convergence test topology](image)

2.3 Input Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCID</td>
<td>Pseudowire identifier used to categorize a particular VPN</td>
</tr>
<tr>
<td>Prefix</td>
<td>Destination identifier for the L2 traffic, in this case a VLAN identifier</td>
</tr>
<tr>
<td>Administrative distance</td>
<td>Distance given to IGP protocol paths</td>
</tr>
<tr>
<td>Encapsulation type</td>
<td>Type of VC traffic encapsulation being used across the PW</td>
</tr>
</tbody>
</table>

Table 2. L2 VPN pseudowire convergence test input parameters
2.4 Methodology

1. Tester port 3 initiates ISIS, LDP Basic and LDP Extended Martini sessions with the DUT to establish a Martini PW with routes setup to tunnel destinations.

2. Tester port 1 initiates traffic to the destination prefix, and proper forwarding of traffic is verified.

3. Tester port 2 now initiates OSPF, LDP Basic and LDP Extended Martini sessions from the same emulated PE. OSPF is configured with a shorter administrative distance compared to ISIS.

4. LDP should now target the Martini session via OSPF because of its preferred path.

5. Traffic should shift to the OSPF path with lower configured administrative distance. A graph of traffic flow such as in Figure 7 can be used to monitor the switchover.

6. Introduce a shutdown on the DUT interface to tester port 2, thereby causing an event that will trigger a switchover between the two paths. Measure the convergence time for this switchover to the next best IGP.

2.5 Results

The convergence time result is calculated from the time difference between the last packet received on primary path and first packet received on the secondary path. The last frame received on tester port 2 is logged with timestamp T1. The first packet received on the secondary ISIS path to tester port 3 is marked with time T2. The time difference T2-T1 indicates how long the MPLS pseudowire took to converge from a lower level IGP topological change. Figure 7 provides a visual indication of the traffic switch over. The latency view in Figure 8 allows the actual time for the switchover to occur to be calculated from the timestamps on the packets, corresponding to the time to place the ISIS route into the forwarding table and build a Martini session.
Figure 7. L2 VPN pseudowire convergence test results

Figure 8. L2 VPN pseudowire convergence test results – timestamp conversion
3. L2 VPN Label Withdrawal Test

3.1 Objective
Verifies a router properly stops forwarding traffic over Martini pseudowires that have been withdrawn from its forwarding tables.

3.2 Setup
This test requires two ports at a minimum – one to simulate a PE router and another to simulate a CE router. Multiple pseudowires are established between a single CE and one or more emulated PEs. Ixia’s IxExplorer with routing protocol emulations can be used to construct the topology and fulfill the control and data plane requirements for this test.

![Figure 9. L2 VPN label withdrawal test topology](image)

3.3 Input Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer Address</td>
<td>Target IP address on the DUT for the Martini LDP session – usually the device’s loopback address</td>
</tr>
<tr>
<td>MTU</td>
<td>The maximum frame size allowed over the established pseudowires; must be identical at both sides of the pseudowire</td>
</tr>
<tr>
<td>VC ID</td>
<td>Virtual Circuit ID providing a unique identifier for the L2 VPN</td>
</tr>
<tr>
<td>VLAN ID</td>
<td>Unique traffic identifier for CE traffic at the entry point to the MPLS domain</td>
</tr>
</tbody>
</table>

Table 3. L2 VPN label withdrawal test input parameters
3.4 Methodology

1. Tester port 2 establishes IGP (OSPF or ISIS), LDP Basic, and LDP Extended Martini sessions with the DUT. At least two PW must be established to execute this test. A VC type of VLAN should be used if Ethernet is the physical interface type.

2. Tester port 1 builds traffic flows to destinations represented by tester port 2, and proper forwarding of traffic is verified.

3. Take down of one of the PWs by inducing a withdrawal of the Martini label. With the Ixia test tool, this can be done by simply deselecting the VC Range checkbox in the GUI as shown in Figure 10. Alternatively, this can be automated via Tcl with a timer.

4. Pseudowires can be withdrawn and re-advertised dynamically to verify proper functionality.

![Figure 10. L2 VPN label withdrawal test pseudowire configuration](image)

3.5 Results

The expected result is that of decreased traffic throughput as result of PW flapping. By graphing the received traffic rate on tester port 2, the result of label withdrawal can be seen in terms of traffic loss. In Figure 11, it is seen that the received traffic rate decreases in half when a withdrawal occurs, then returns to full when the pseudowire is re-advertised. This test can be scaled to characterize the behavior of large numbers of pseudowires in a dynamic environment.
Figure 11. L2 VPN label withdrawal test results – frames received rate
4. L2 VPN Partially Meshed Performance Test

4.1 Objective

This test determines the throughput performance per VC for a router configured as a Layer 2 VPN provider edge (PE) node. The DUT can be tested as either an ingress or egress node.

4.2 Setup

This test requires at least two Ixia ports: one to simulate a PE router and another to simulate a CE router. Additional ports may be used to simulate additional PE and CE routers with the number of simulated PEs equaling the number of simulated CEs. The CE ports have a Layer 2 VLAN interface to the DUT. The traffic flow is configured as partially meshed. Ixia’s IxScriptMate application can be used to provide an automated framework to execute this test.

![Diagram of L2 VPN partially meshed performance test topology](image)

Figure 12. L2 VPN partially meshed performance test topology
4.3 Input Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of VCs Per PE</td>
<td>Number of VCs to configure per emulated PE</td>
</tr>
<tr>
<td>MTU Size</td>
<td>The maximum frame size allowed over the established pseudowires; must be</td>
</tr>
<tr>
<td></td>
<td>identical at both sides of the pseudowire</td>
</tr>
<tr>
<td>VC Distribution</td>
<td>Method for distributing configured VC IDs among PE – either consecutive or</td>
</tr>
<tr>
<td></td>
<td>round robin</td>
</tr>
<tr>
<td>L2 Interface Type</td>
<td>The L2 Virtual Circuit type</td>
</tr>
</tbody>
</table>

Table 4. L2 VPN partially meshed performance test input parameters

4.4 Methodology

1. PE ports establish OSPF, LDP Basic, and LDP Extended Martini sessions with the DUT.
2. PE ports advertise VCIDs based on the “Number of VCs Per PE” input parameter, and in the fashion specified by the “VC Distribution” parameter. At this point, the DUT should be queried to confirm an “Up” status for each VC advertised.
3. Traffic flows are built between every CE and PE port in a partially meshed fashion, with each CE transmitting to every PE, and vice versa. MPLS labels learned during the control plane signaling phase are used to construct the data plane flows to ensure traffic is being forwarded over the correct VCs.
4. Traffic flows are started and throughput measured.

Figure 13. L2 VPN partially meshed performance test configuration
4.5 Results

The primary results of this test are the frame loss on a per PE or VC ID basis. The bxScriptMate application measures and displays frame loss per PE or VC as well as min/max/average latency and data errors. Figures 14 and 15 show examples of bxScriptMate results for this test.

Figure 14. L2 VPN partially meshed performance test results – per PE

Figure 15. L2 VPN partially meshed performance test results – per VC