Multiprotocol Label Switching (MPLS) performance forwarding

Agilent Technologies RouterTester Application Note

Multiprotocol Label Switching is an emerging set of protocols and technologies. Recently, there has been a tremendous amount of interest among Internet Service Providers (ISPs) in these technologies. Their customers are looking for ways to support the rapid and growing demands for bandwidth; they also need reliability and security for their mission critical applications. Service providers, on the other hand, not only have to support these customer demands but also need to have the ability to support a wide range of services and to unify offering these service offerings.

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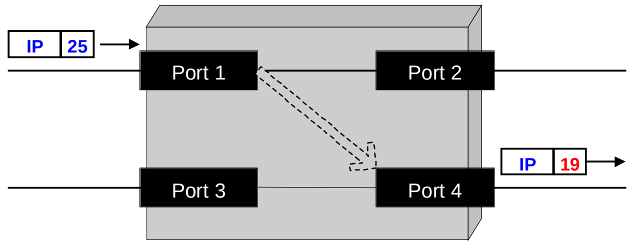
Multiprotocol Label Switching basics

A detailed description of MPLS is beyond the scope of this paper and there are many documents on this topic (see references). It is important, however, to understand that one of the key features of MPLS technology is that it has two distinct functional components - a control component and a forwarding component. The control component uses standard routing protocols (i.e. RSVP-TE, CR-LDP) to exchange routing data with other routers to build and maintain a forwarding table. The forwarding component, on the other hand, searches the forwarding table for a match of the arriving packets and directs them from the input interface to the output interface across the router's switch fabric. This paper focuses on the forwarding capabilities of MPLS technologies.

The forwarding component is based on label-swapping forwarding algorithm. Labels consist of a short, fixed length (20 bit) packet identifier carried in a shim header prefixed to IP packets and only have local link significance. Routers that support MPLS technologies are called Label Switch Routers - LSRs or Label Edge Routers LERs. Figure 1 depicts a sample of the label swapping process.

The label-swapping forwarding algorithm requires packet classification at the ingress of the network to assign each packet to a label switch path (LSP). An LSP is a concatenation of one or more LSRs and it is analogous to an ATM or Frame Relay PVC. An LSP is often referred to as an LSP tunnel because the traffic flowing through it is opaque to each of the intermediate LSRs along the LSP.

Ingress LERs are required to push labels onto the packets; intermediate LSRs swap the labels, and the egress LERs pop out the labels. Figure 2 illustrates the different roles for these LSRs.



In (port, label)	Out (port, label)	Label operation
(1,122)	(2,217)	Swap
(1,25)	**(4,19)**	**Swap**
(2,223)	(3,122)	Swap

Figure 1: LSR forwarding components

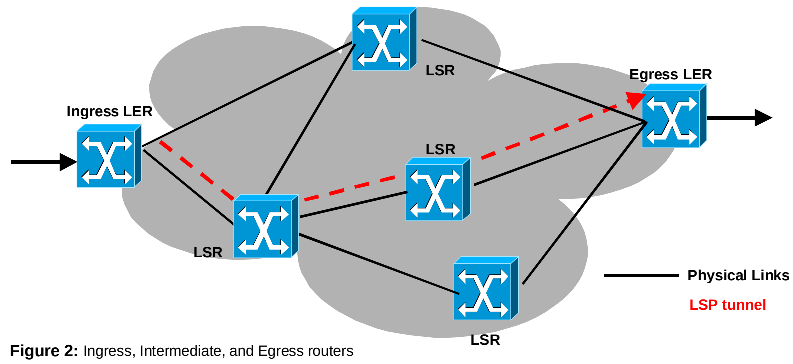


Figure 2: Ingress, Intermediate, and Egress routers

Test Challenges

Based on the above description of the new emerging MPLS technologies, a number of test challenges come to light. To effectively verify the functionality of LSRs, it is necessary to test the reliability of setting up label switched paths, and the label-swapping process has to be examined. We need to make sure that the system under test (SUT) - when deployed as an ingress, intermediate, or egress router - actually pushes, swaps, or pops out labels respectively. Also, in many cases, a single LSR can be part of multiple LSPs. It can be the ingress or egress LSR for one or more LSPs, and it also can be an intermediate LSR in one or more LSPs. The network design dictates the function that each LSR. LSRs perform more than one process (push, swap, or pop) at the same time based on their location in perspective to different LSP tunnels. Also, the effect of MPLS data traffic -if any- on the 'native' IP data traffic should be examined.

Setting up static LSP tunnels is obviously a hard process, error prone, and in some cases it is not a possible option. Hence, network operators prefer to use signaling protocol (i.e. RSVP-TE or CR-LDP) to dynamically establish LSPs.

The operation of MPLS signaling protocols such as RSVP-TE and CR-LDP relies on the internal gateway routing protocol (IGP). Hence, support for at least one of the IGP protocols (such as Open Shortest Path First (OSPF), or intermediate-system-to-intermediate-system (IS-IS)) and the ability to accurately simulate IGP topology is necessary in order to effectively test the MPLS capabilities and features of high performance gigabit/terabit routers.LSRs performance forwarding tests

The Agilent Technologies RouterTester generates RSVP-TE signaling messages that support the establishment of LSP tunnels; RouterTester also supports OSPF-TE IGP protocol. In the following section we examine how effectively RouterTester measures the ability of LSRs to push, swap, and pop out labels.

Ingress router scenario: This scenario shows how to test the router when deployed at the edge of the network, i.e. Ingress LER. Figure 3 illustrates the establishment of an LSP scenario, which checks the SUT's ability to push labels onto the IP packet.

As per its configuration, the SUT is prompted to establish an LSP tunnel to a simulated router behind RouterTester port 1B by sending an RSVP-TE PATH message. Port 1B sends an RSVP-TE RESV message with the label that SUT should use. A simulated router (RouterTester port 1A) sends IP data packets (without labels) to the SUT. Upon receiving the IP packets, the SUT pushes labels to the IP packet and forwards them to the next hop in the LSP (port 1B). Port 1B examines the received packets and verifies whether they have the proper label value.

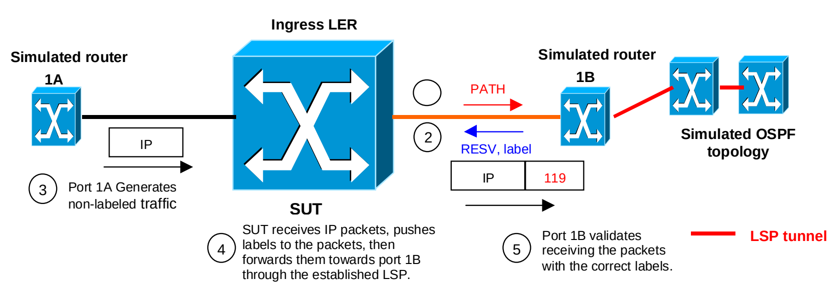


Figure 3: Ingress router test scenario

Note that the SUT should be configured to accommodate the test. Figure 5 shows a sample configuration of Juniper and Cisco routers.

5 easy steps to achieve ingress router scenario

1. To establish a multi-hop LSP tunnel, an OSPF network topology is emulated behind port 1B (Figure 6 and 7 show how to enable OSPF on port 1B and establish emulated OSPF network topology behind RouterTester ports). As shown in figure 3, based on the SUT's configuration, it is prompted to send an RSVP-TE PATH message to the simulated router. (Port 1B is configured to be an egress router, refer to figure 4).

2. Port 1B sends an RSVP-TE RESV message to the SUT in response to the PATH message; the RESV message includes the label (119) the SUT must use for packets destined to port 1B. The SUT then adds this label mapping to its label-forwarding table, and an LSP tunnel between the SUT and port 1B is established.

3. After the LSP tunnel is established, port 1A generates wire speed non-labeled data traffic to the SUT to exercise the LSP tunnel operation.

4. Upon receiving the packets, the SUT learns (from searching its label forwarding table) that it is to be forwarded across the newly established LSP, and should 'push' a label value of '119' to the packets, and forward the traffic to port 1B.

5. Port 1B monitors and validates the receiving packets with the correct label value.

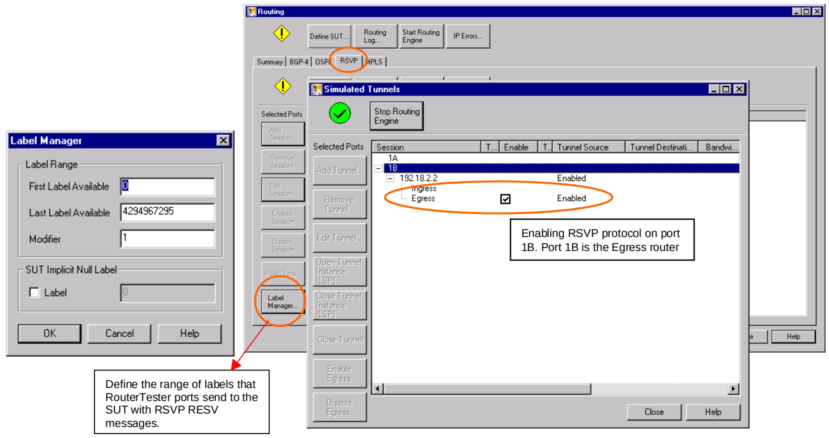


Figure 4: Configuring RouterTester 1B as an Egress.

```
Interfaces{
      so-0/0/0{
            unit 0{
                  family mpls;
            }
      }
}
protocols{
   rsvp{
      interface so-0/0/0;
      }
   mpls{
      label-switched-path to_port_1B{
         to 100.200.1.2;
         primary use_1B;
         }
      path use_1B{
         100.200.1.2 loose;
         }
   interface so-0/0/0
```

```
interface POS0/1
 ip address 192.18.6.1 255.255.255.0
 mpls traffic-eng tunnels
 ip rsvp bandwidth 466500 466500
!
interface Tunnel1000
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 100.201.2.2
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng path-option 1 explicit name my_ERO
!
ip explicit-path name my_ERO
 next-address 192.18.2.2
 next-address 100.2.2.1
 next-address 201.1.1.2
 next-address 100.2.1.2
!
```

Sample configuration for Juniper and Cisco routers

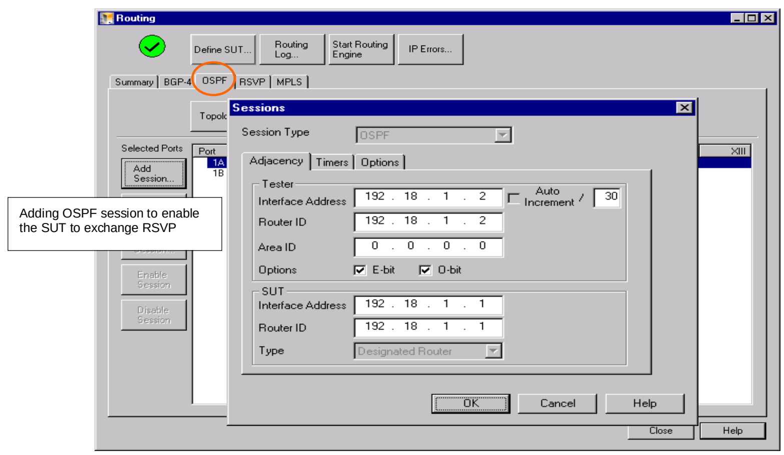


Figure 6: Adding OSPF session between the SUT and RouterTester port 1B

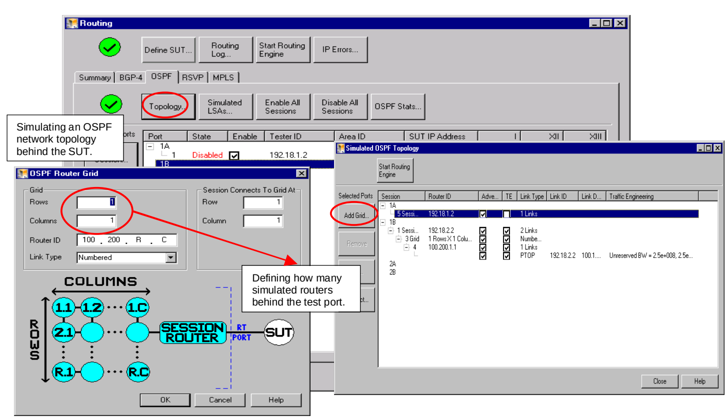


Figure 7: Adding a simulated OSPF network topology.

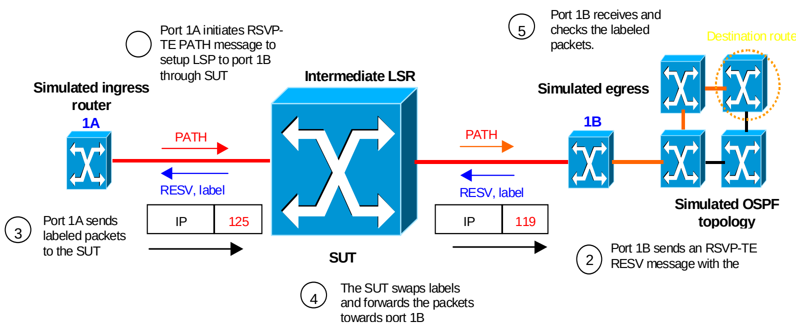


Figure 8: Intermediate router test scenario

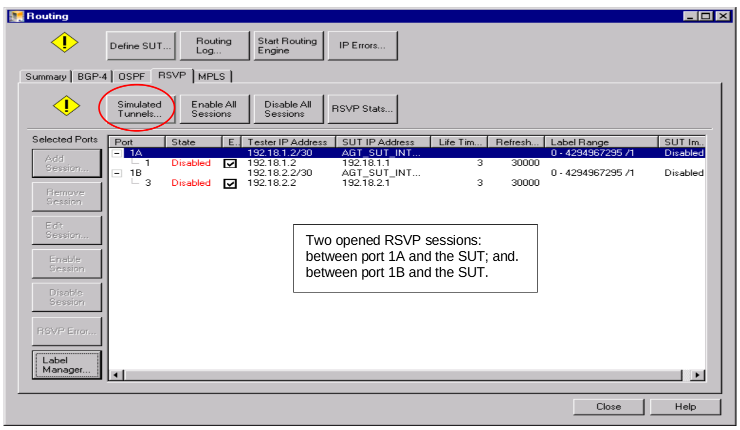


Figure 9: Setup LSP tunnel between Port 1A and Prot 1B through SUT

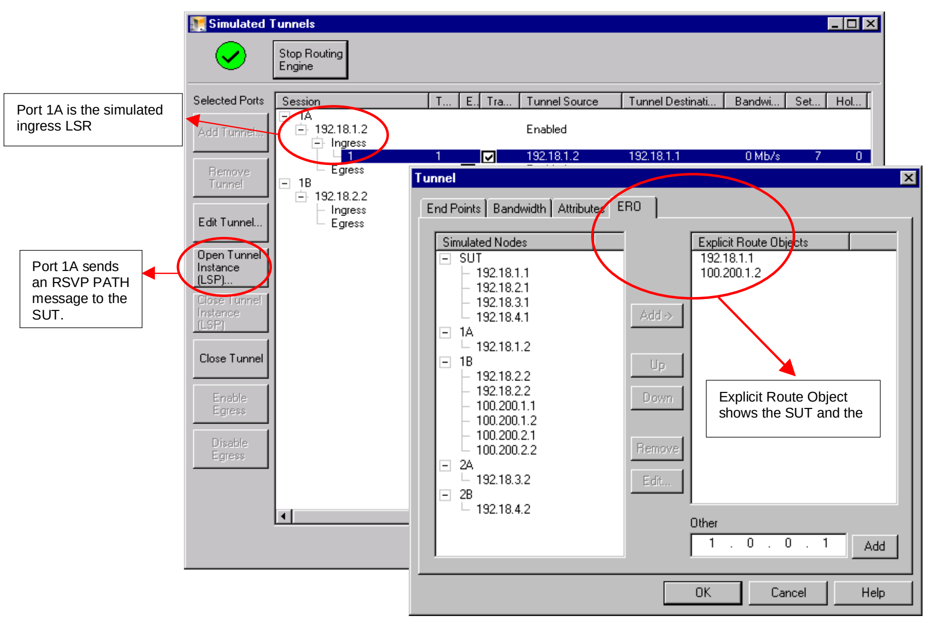


Figure 10: How to specify Explicit Route Object in the PATH message

Intermediate router scenario: This scenario shows how to test the SUT when deployed as an intermediate LSR in the network. As shown in figure 8, RouterTester port 1A simulates an Ingress router; it sends an RSVP-TE PATH message to establish an LSP tunnel (through the SUT) to a simulated router behind port 1B. RouterTester port 1B sends an RSVP-TE RESV message with the label binding to the SUT in response to the PATH message, the SUT in turn sends RESV message to port 1A. The LSP tunnel is now established between port 1A, the SUT, and the simulated router behind port 1B.

5 easy steps to achieve the intermediate router scenario:

1. As shown in figure 8, Port 1A sends an RSVP-TE PATH message to the SUT to setup LSP tunnel to a simulated router behind port 1B. The PATH message includes an explicit route (ERO) to the egress router. The SUT then sends an RSVP-TE PATH message to RouterTester port 1B.

2. In response to the PATH message, the egress router (port 1B) sends an RSVP-TE RESV message with the label to the SUT. In turn, the SUT sends an RSVP-TE RESV message to the ingress router (port 1A) completing the establishment of the LSP between port 1A and port 1B.

3. To exercise the LSP operation, port 1A sends MPLS labeled traffic to the SUT.

4. After searching its label-forwarding table, the SUT swaps the label value and forwards the packets to port 1B.

5. Port 1B monitors and verifies the SUT's ability to successfully swap label values.

Figure 9 and 10 show how to open RSVP sessions and how to specify the Explicit Route of the LSP tunnel.

Egress router scenario: This scenario shows how to test the SUT when deployed as an egress LER in the network. As shown in figure 11, RouterTester port 1A simulates an intermediate router and sends an RSVP-TE PATH message to establish an LSP to the SUT. On receiving the PATH message, the SUT sends an RSVP-TE RESV to port 1A.

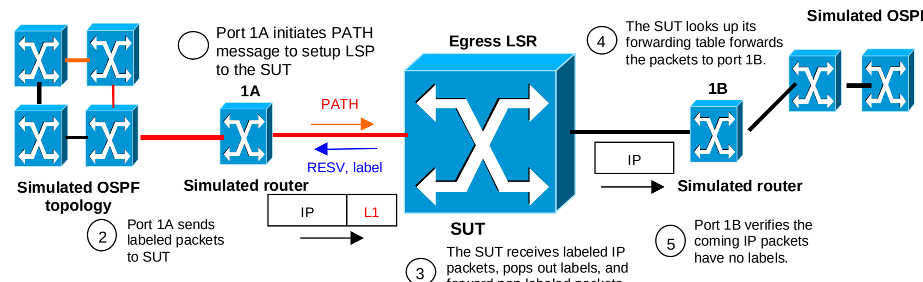


Figure 11: Egress router test scenario

5 easy steps to achieve egress router scenario

1. As shown in figure 11, Port 1A sends an RSVP-TE PATH message to the SUT, which sends an RSVP-TE RESV message to port 1A with the label binding. The LSP tunnel is now established. (Figure 12 shows how port 1A initiates an RSVP-TE PATH message to the SUT.)

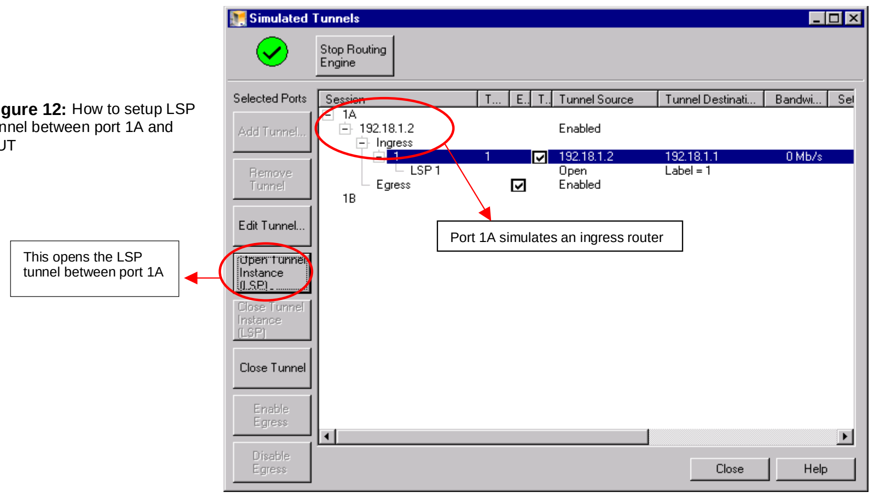
2. Port 1A sends labeled packets to the SUT destined to the networks reachable behind port 1B.

3. Upon receiving the packets, the SUT performs a search of its label-forwarding table, which identifies the SUT as the last-hop (egress LER) for this particular LSP. Therefore, the SUT pops out the labels from the packets and forwards them using the conventional IP routing protocols.

4. The router looks up its conventional IP forwarding table, and upon finding the destination address match, forwards the traffic to port 1B.

5. Port 1B verifies that the SUT has successfully popes out the labels from the packets..

Figure 12: How to setup LSP tunnel between port 1A and SUT



References

MPLS: technology and applications / Bruce Davie, Yakov Rekhter; September 2000.

"Multiprotocol Label Switching: Enhancing Routing in the New Public Network" white paper http://www.juniper.net/techcenter/techpapers/200001.html

"RSVP Signaling Extensions for MPLS Traffic Engineering" white paper;

http://www.juniper.net/techcenter/techpapers/200006.html

Multiprotocol Label Switching Architecture, RFC 3031

http://www.ietf.org/rfc/rfc3031.txt?number=3031

Agilent IP Routing Test Solution

Agilent's IP Routing Test Solution product family includes Agilent QA Robot and Agilent RouterTester and the test software that runs on these platforms. The QA Robot provides all basic IP routing test capabilities, plus conformance, stress and functional testing. The RouterTester is enhanced with wire-speed traffic generation that enables comprehensive performance metrics and integrated routing protocol support..

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