Introduction

Test automation has significant competitive advantages throughout the development and deployment of network devices. It not only provides unrivaled benefits when test scenarios are complex, time-consuming to configure, or frequently repeated, but also becomes crucial when tests must compare devices from different vendors or provide critical ‘pass/fail’ results. One of the key features of a good test automation system is its ability to provide tests that are fast, repeatable, and simple to customize. In addition, test results should be clearly graphed and consistently presented so they are easy to compare. The discussion below highlights the advantages of using automated test systems and lists the tests you should consider automating when testing the functionality and performance of next-generation routing devices.

Benefits of Automation

Automation has many benefits to end users in a complex environment where critically important benchmarking and validation tests are conducted under extreme time pressure. These benefits are summarized as follows:

Time savings

In a fully automated scenario, a configured test system is a ready-to-use collection of related test cases. All test cases are set to execute one after another in a fully automated mode that requires no operator intervention, thereby saving hundreds of hours of work each month.

Consistency

Results obtained from running automated tests should be saved for future retrieval, along with important logging information and configuration parameters. This saved data can be used as a reference for future runs to check the effect of environmental or operational variations caused by changes in the hardware or software of the system under test (SUT).

When testing multiple devices, automation assures that the results identify true performance differences since tests are carried out under identical conditions. Similarly, testing a single device with incremental configuration changes in an automated way provides full confidence that the test procedure has remained constant, allowing you to isolate and analyze the effect of the changes.
Customization

A good automated test system allows you to access and edit individual test cases so you can duplicate, combine, or delete elements of the test scripts. This ability to add new scripts to your automated library is an important return on a company’s test resource investment, and also provides the necessary flexibility to meet day-to-day testing demands.

Avoidance of human error

Perhaps the most important benefit of all that test automation provides is the removal of human error from the test procedure. Testing today’s routers is a complex and difficult task, with each step introducing a new opportunity for human error. Automation effectively removes operator intervention during the running of a test, thus providing the highest possible degree of reliability.

Comprehensive text and graph results

Automated tests store complete sets of results in textual and graphical formats that are designed to integrate with commercially available analysis tools. This standardized reporting provides an easy way to compare and communicate results.

Industry-accepted test methodologies

Each test case in a test automation system should implement either an entire RFC (e.g., RFC 2544, RFC 3222), as published by the Internet Engineering Task Force (IETF), or a comprehensive draft proposal. In addition, any specific test scenarios should be based on industry standards and well-accepted test methodologies (e.g., “The Journal of Internet Test Methodologies”).

Testing the Functionality and Performance of Routing Devices

Automated test systems designed to verify the functionality and performance of network routing devices provide a valuable time-and-cost advantage to network equipment manufacturers and service providers throughout development and pre-deployment tests.

Automating any test takes time. For maximum return, the time you invest in test automation should deliver the most useful results. When evaluating the functionality and performance of today’s core, metro/edge, and optical routing devices, the most commonly requested information can be categorized into the following broad categories.

RFC 2544—Benchmarking

Forwarding performance tests should be based on RFC 2544, “Benchmarking Methodology for Network Interconnect Devices”. This standard describes how to measure and report performance characteristics so that network devices from different vendors can be compared and evaluated. It defines the following tests:

- throughput and latency
- frame loss rate
- back-to-back frame handling
- system recovery speed
- reset recovery speed

An automated test system should deliver all these basic performance measurements. Ideally, you should also be able to build on these simple tests to investigate a device’s performance under more stressful and realistic Internet conditions. Sample outputs of an RFC 2544 benchmarking test are shown in Figures 1 through 4.

IP Services

With service providers racing to provide revenue-generating services over network infrastructure, testing a device’s ability to handle these services becomes increasingly important. For example, any automated system for today’s network routing devices should verify the functionality and performance of both layer-2 and layer-3 VPNs, such as:

- MPLS VPNs (RFC 2547bis and L2 over MPLS), and
- IP VPNs (IPsec and L2TP).
Forwarding table performance

Routers in today’s networks exchange millions of routing prefixes each day. This large demand has a direct impact on a router’s performance, since exchanges fluctuate constantly and are further stressed by route flapping (routes that are withdrawn then re-advertised). Testing the ability of a router to increase its routing tables provides valuable information about scalability and the router’s ability to handle realistic network conditions.

An automated test system should execute tests that verify performance under real-world conditions. Any automated test case should therefore provide insight into the following critical performance characteristics:

- the router’s stability and performance under normal and extreme conditions, such as route flapping
- the scalability of routing tables
- the router’s ability to handle interactions between multiple routing protocols

Protocol conformance

The interoperability of multiple independent devices relies on the correct implementation of existing and emerging protocols. Conformance of protocol implementations can be guaranteed only if the automated tests are derived directly from the protocol standards—standards that may still be evolving.

Some key protocols to be included in the testing of today’s network routing devices are as follows:

- BGP-4
- OSPF
- IS-IS
- LDP/CR-LDP
- RSVP-TE
- L2TP
- PIM-SM
- GMPLS RSVP & LMP
- OIF UNI RSVP & LMP

At first glance, this appears to be a daunting task. However, with the assistance of an automated test system, conformance testing is relatively simple and straightforward.
**Specific Test Cases**

The following list summarizes specific test cases that should be automated for best results when testing today’s next-generation routers.

**Forwarding performance tests**

- **Sweep Packet Size**: Measure throughput and latency at constant bandwidth for a range of packet sizes.
- **Sweep TCP/UDP Ports**: Validate ACL behavior by testing the forwarding of packets with a range of source/destination port numbers.
- **Sustainable Throughput and Latency**: For a range of packet sizes, determine the maximum sustainable forwarding rate, then measure the latency at that rate.

**Hardware tests**

- **Stress SONET Alarms**: Test the response of the SUT to SONET/SDH alarms and errors.
- **Sweep Line Clock Offset**: Test the SUT’s performance as the line clock rate is varied.

**MPLS functional tests**

- **RSVP Egress LER**: Verify the SUT’s ability to pop labels at the exit of an LSP.
- **RSVP Ingress LER**: Verify the SUT’s ability to push labels at the entrance of an LSP.
- **RSVP Penultimate Hop LSR**: Verify the SUT’s ability to pop labels and forward IP packets as a Penultimate Hop router.
- **RSVP Transit LSR**: Verify the SUT’s ability to swap labels as an intermediate Label Switch Router (LSR).

**MPLS traffic engineering tests**

- **RSVP Fast Reroute Time**: Measure the SUT’s fast reroute performance under line failure.
- **RSVP Make Before Break**: Measure the time taken to redirect traffic from a sub-optimal primary LSP to a backup LSP.
- **RSVP Preemption**: Validate the SUT’s ability to preempt a low priority LSP for a high priority LSP.

**Multicast forwarding performance tests**

- **Aggregated Multicast Throughput**: Measure packet loss as additional ports add incremental multicast group joins.
- **Mixed-class Throughput**: Find the zero-loss rate to a fixed number of destinations for a mixture of unicast and multicast traffic.
- **Group Join Delay**: Measure the delay for the first N multicast group addresses joined.
- **Group Leave Delay**: Measure the delay for the first N multicast group addresses to leave the group.
- **Multicast Group Capacity**: Measure the maximum number of multicast groups the SUT can support without packet loss.
- **Multicast Latency**: Measure the latency of multicast traffic.
- **Scaled Group Forwarding Matrix**: Measure the packet loss as a function of the number of multicast groups joined on a fixed number of ports.

**RFC 2544 tests**

- **Back-to-back Burst Length Throughput**: For a range of packet sizes, determine the maximum zero-loss line-rate burst size, then measure the latency for that burst size.
- **Packet Loss Rate**: For a range of packet sizes, measure packet loss and latency at a number of transmit rates.
- **Throughput and Latency**: For a range of packet sizes, determine the zero-loss forwarding rate, then measure the latency at that rate.

**Routing scalability tests**

- **ARP Request Storm**: Verify the SUT’s ability to respond to ARP requests.
- **BGP-4 Route Learning Time**: Measure the time it takes a SUT to learn and propagate a number of BGP-4 routes.
- **Maximum BGP-4 Neighbors**: Measure the maximum number of BGP-4 sessions that the SUT can maintain while forwarding traffic to the advertised routes.
- **Maximum BGP-4 Routes Learned**: Find the maximum number of routing table entries before UPDATE messages are no longer learned or propagated.
• **Maximum FIB Size**: Find the maximum Forwarding Information Base (FIB) size before packets are lost or no longer forwarded.
• **Performance Impact of FIB Composition**: Determine the effect that FIB table composition has on packet forwarding performance.
• **Performance Impact of FIB Size**: Determine the effect that FIB table size has on packet forwarding performance.

**Routing stability tests**

• **BGP-4 Flap Convergence Time**: Measure the time for traffic to transfer to an alternate path when routes are withdrawn.
• **OSPF Flap Convergence Time**: Measure the time for traffic to transfer to an alternate path when routes are withdrawn.
• **Performance Impact During Route Flapping**: Measure the SUT’s forwarding performance when routes are withdrawn.
• **Performance Impact of Unstable Routes**: Measure the SUT’s forwarding performance while routes are flapped.

**Virtual Private Network tests**

• **BGP/MPLS VPN Functionality**: Measure the ability of a PE router to establish VPNs and forward packets correctly to and from CE routers.
• **BGP/MPLS VPN Overlapped Addresses**: Measure the ability of a PE router to correctly populate its VRF tables and forward packets to and from a BGP/MPLS network when customer sites contain overlapping addresses.

**Protocol conformance tests**

Common routing and signaling protocol implementations should be verified for conformance to recognized standards. In some cases hundreds of individual tests need to be performed for each protocol.

**Conclusion**

The complexity of testing next-generation routers can be greatly simplified by automating test cases. Automation tools can vary in complexity from simple algorithms or commands that run repeatedly to fully integrated test systems.

The key to success is to select a good automated test system which can provide a comprehensive testing schedule with speed and consistency. Scripts should be open so they can be easily customized to create new test cases. The list of specific test cases supplied in this article provides a powerful starting point for anyone looking to automate their router testing regime.

**More information**

For more information on how to use Agilent’s RouterTester to automate your testing, contact iptest@agilent.com or visit www.agilent.com/comms/RouterTester.