Agilent Technologies
RouterTester
Gigabit/Terabit Router Performance Test System

**Premise:** Today’s Internet traffic doubles every six months or less. Network equipment manufacturers must design and develop high performance routers capable of forwarding millions of packets per second within an inherently unstable Internet environment. These equipment manufacturers require test tools capable of simulating realistic, complex traffic to verify the true performance of their routers.

Agilent Technologies commissioned The Tolly Group to evaluate its RouterTester, a network simulation system specifically designed for testing the performance of gigabit and terabit routers. The system tested

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**Forwarding Performance and Scalability During Route Updates**

Carrier-class gigabit router

Full-mesh configuration*

Agilent RouterTester System

OC-12c Test module

OC-12c Test module

OC-48c Test module

System controller

Hub

100 Mbit/s Ethernet

* Full-mesh configuration means each port is sending traffic to every other port and each port is receiving traffic from every other port.

Source: The Tolly Group, December 2000

Figure 1
was equipped with OC-12c (622 Mbit/s) and OC-48c (2.488 Gbit/s) Packet over SONET/SDH interfaces. The RouterTester modules under test were configured to generate from 1% to 100% of both OC-12c and OC-48c rates. The Tolly Group verified that the RouterTester could advertise hundreds of thousands of routes to the router under test, and then send many streams of variable length packets over these routes. Engineers also evaluated the RouterTester to perform router stability tests, wherein the ability of a router to forward packets during periods of route flapping is measured. Finally, engineers demonstrated that the RouterTester could generate traffic marked with different levels of QoS and could measure the router's response to processing these streams under high-stress congestion. Testing was performed in August and September 2000.

Test results show that the Agilent RouterTester network simulation system is fully capable of simulating network conditions that one would expect to find in the Internet today, and is capable of simulating conditions that will come about in tomorrow's Internet as well.

Results

Forwarding Performance and Stability During Route Updates

The Tolly Group first verified that the RouterTester was capable of measuring the forwarding performance of a router in a stressful environment. Engineers validated that the Agilent RouterTester could create traffic conditions that stress a high-end router in an Internet environment and could measure the forwarding performance of a router with a mix of OC-12c and OC-48c POS interfaces. The RouterTester was capable of simulating neighbor routers on each interface and advertising routes to simulated networks via the Border Gateway Protocol version 4 (BGP-4) routing protocol emulation. The high-end router forwarded fully-meshed streams of traffic (IP packets routed from every port to every other port) over 10,000, 120,000 and 327,680 routes. See figure 1.

In addition, engineers evaluated whether RouterTester could measure the stability of a router during route updates. RouterTester simulated route updates by first advertising known routes and then withdrawing those routes over the same interfaces as the traffic, and at the same time as traffic generation. The routes were updated at rates up to 500 times per second and the RouterTester measured the impact, if any, that processing the updates had on the router's throughput.

1 BGP provides mechanisms by which a BGP speaker can inform its peer that a previously advertised route is no longer available for use. There are three methods by which a given BGP speaker can indicate that a route has been withdrawn from service: the IP prefix that expresses destinations for a previously advertised route can be advertised in the withdrawn routes field in the update message thus marking the associated route as being no longer available for use; a replacement route with the same Network Layer Reachability Information can be advertised; or, the BGP speaker connection can be closed, which implicitly removes from service all routes that the pair of speakers had advertised to each other. RouterTester can withdraw routes using all three methods.
Convergence After A Route Update

The Tolly Group tested the RouterTester's capability to simulate convergence, a routing scenario in which the RouterTester modifies active routes and thus forces the router to send data over a different route path. RouterTester could measure the time, within a one-second interval, that a router takes to update its routing table and forward traffic to the updated route after convergence. The RouterTester first timestamps when a preferred route is removed and the router must forward traffic at the same rate to an alternate, longer path on a different RouterTester interface. A RouterTester can simulate multiple Autonomous Systems and their route paths, including the preferred route. Tolly engineers verified that the RouterTester is capable of the following actions: logging the test start; logging the time the new route starts receiving packets; and logging the time the withdrawn preferred route stops receiving packets. Results show that RouterTester is capable of dynamically providing a "snapshot" of the router's behavior after it receives a route update. Specifically, RouterTester determines the length of time it takes a router to redirect traffic (at up to full wire speed) along the path (interface) required to complete the new route. See figures 2 and 3.

Router Response to Priority Traffic during Congestion

Results verified that the RouterTester was capable of encoding IP Precedence Type of Service (ToS) bits and IP Differentiated Services Code Point bits within its traffic stream profiles and measuring the packet loss, latency and throughput on each stream, therefore testing a router's QoS-based queue-management performance. RouterTester measured the forwarding performance on each stream delivered through an oversubscribed router without QoS-based queue-management and then measured the performance of the router with QoS-based queue-management to discover how accurately the router was able to control bandwidth. See figure 4.

Analysis

When envisioning the future of carrier-class routers, the vision includes routers that have the capabilities to keep up with the growing routing table sizes of the Internet, have gigabit and terabit switching capacities, and have Class of Service features. Routers must provide high-speed transport of data with superior traffic management capabilities.

In order to keep ahead, Internet Service Providers (ISPs) and router manufacturers must be able to deploy carrier-class networks with high-speed and high reliability. When ISPs integrate these routers into their networks they need to know that these devices can handle their future needs. To determine the traffic of the future, managers need scalable and comprehensive test tools that can simulate this load of data.
A router test tool has to be able to offer complex, high-speed traffic streams – and measurement facilities – that allow the user to gauge the behavior of gigabit/terabit routers under controlled conditions and not expose a network to infrastructure failure when these conditions occur on an actual network with real customer traffic. Not only must the test device generate traffic and simulate hundreds of thousands of routes, it must be capable of simulating other realistic Internet activity, such as multiple route updates, and measure the impact those updates have on the router under test. Router test systems must generate many traffic streams with different traffic priority levels and measure the QoS-based queue-management capabilities of a carrier-class router.

Internet routers today must deal with constant route updates to their routing tables. If a router fails in a network, a storm of routing messages will propagate throughout the network to indicate this failure and to disseminate new routes. Routers must quickly adjust their routing tables with these new routes in order to minimize loss of IP packets. As the Internet grows, so do the number of routes within a routing table – as well as the number of route updates that can occur. A router must be able to update its routing table as quickly as possible when it receives an update, with minimal impact upon packet forwarding performance. A router tester should be able to simulate these effects to stress a router beyond current demands.

Though ISPs and router manufacturers look at lists of functions as an indication of a router's performance before they purchase it, a better approach is to investigate the functionality of the router during performance testing. A router tester must provide a superior method of testing by simulating wire-speed traffic in order to stress a router. The RouterTester demonstrates its capability to simulate high-stress network conditions.

**Test Configuration and Methodology**

For these tests, engineers used an Agilent Technologies RouterTester system. The test system was comprised of an E7901A RouterTester P48/2 module with two OC-48c Packet over SONET/SDH interfaces and two E7902A RouterTester P12/2 modules, each with two OC-12c
Packet over SONET/SDH interfaces. The RouterTester modules were connected together via a synchronization line which ensures the accuracy of time measurements between the modules, and with an event line, which ensures that traffic transmission and packet capture across all modules is synchronized.

The system controller PC was equipped with the following two network adapters. One adapter was used to access the RouterTesters and the additional adapter was used for corporate network and Internet access.

As its carrier-class routing device, The Tolly Group used a Juniper Networks M20 Router software suite 4.1R2.1. All three RouterTester modules were connected to the corresponding interfaces on a Juniper Networks M20 Router. The RouterTester modules connected to a Hewlett-Packard Co. ProCurve 10/100 Mbit/s hub model J3295A via Fast Ethernet. The hub was attached to the RouterTester system controller, a dual 733-MHz Intel Corp. Pentium III Hewlett-Packard Co. Kayak XU800 with 128 Mbytes of RAM running Microsoft Corp. Windows NT version 4.0 Service Pack 5 and RouterTester software v. 1.5 Build 0.17. The Tolly Group is not reporting the results of the performance of this router because the evaluation was to determine the capabilities of the Agilent RouterTester.

Forwarding Performance and Stability During Route Updates

The Tolly Group first verified that the RouterTester could generate the following IP packet sizes: 40-, 512- and 1,500-bytes at rates from 1% to 100% of the theoretical maximum line rate.

In order to verify the performance of the RouterTester against a router, Tolly engineers connected three OC-12c ports from two OC-12c RouterTester modules and two OC-48c ports from one OC-48c RouterTester module to the Juniper router and conducted full-mesh tests (each port is sending traffic to every other port and each port is receiving traffic from every other port) transmitting 40-byte packets from each RouterTester interface. The Tolly Group used 40-byte packets since this packet size is the most strenuous on a router. Engineers then offered traffic loads in 5% increments/decrements of the theoretical maximum number of packets per second until no loss of IP packets through the router occurred.

To verify the capabilities of the RouterTester and routing stability of the Juniper router, The Tolly Group conducted a full-mesh test of 40-byte packets with 20,000 routes at the maximum zero-loss packet-per-second rate and began sending route updates on each interface. While RouterTester was sending packets, engineers used the RouterTester to update 20 routes per port per second for a total of 100 routes per second. Engineers increased the updates by 20 up to a total of 100 routes per port — a total of 500 updates per second. This is more than the maximum number of route updates observed per second within the Internet.

Convergence After A Route Update

To test route convergence after a route has been withdrawn, engineers configured two OC-12c RouterTester interfaces and an OC-48c RouterTester interface to simulate neighboring Autonomous Systems (AS). An AS is a group of simulated routers administered collectively. By associating a distinct AS path with groups of network prefixes, RouterTester is able to advertise multiple AS paths to network prefixes advertised from a remote Autonomous System. RouterTester can advertise a short path (i.e., a route to a remote Autonomous System that passes through two intermediate Autonomous Systems) and a long path (i.e., a route to the same remote Autonomous System that passes through three Autonomous Systems) on separate interfaces. See figure 2.

Each interface was connected to a corresponding interface on the Juniper router. The stop time was set for the packets per second of the current transmitting rate. A trigger was set to start when a valid packet arrived on the new path. In the first iteration, 2,000 routes were advertised into RouterTester. 40-byte packets were sent over these routes, through the router at wire-speed. All 2,000 routes were then removed, and re-advertised on a second port. The time differential between when the first packet was received on the second port, and when the second port started receiving packets at full-line rate was measured. The test was repeated with 24,000 and 65,536 routes. Increasing the number of routes advertised and withdrawn adds additional stress to the router by forcing it to update large numbers of routes within its routing table.

Router Response to Priority Traffic during Congestion

For QoS tests, engineers configured each of two OC-12c
RouterTester interfaces and one OC-48c RouterTester interface to send three streams of traffic through the Juniper router to another OC-48c RouterTester interface. The Tolly Group engineers then tested the RouterTester’s capability of simulating QoS congestion and of measuring a routers QoS-based queue-management performance by sending three different priority streams classified as gold (high), silver (medium) and bronze (low) for the following three tests: zero-loss at 100% of the theoretical maximum; loss beyond 100% of the theoretical maximum; and loss with QoS.

Since its inception, The Tolly Group has produced high-quality tests that meet three overarching criteria: All tests are objective, fully documented and repeatable.

We endeavor to provide complete disclosure of information concerning individual product tests, and multiparty competitive product evaluations.

As an independent organization, The Tolly Group does not accept retainer contracts from vendors, nor does it endorse products or suppliers. This open and honest environment assures vendors they are treated fairly, and with the necessary care to guarantee all parties that the results of these tests are accurate and valid. The Tolly Group has codified this into the Fair Testing Charter, which may be viewed at http://www.tolly.com.

Project Profile

Sponsor: Agilent Technologies
Document number: 200234
Product class: Carrier-class router test tool
Products under test:
- Agilent Technologies RouterTester comprised of one E7901A RouterTester P48/2 OC-48c Packet over SONET/SDH module and two E7902A RouterTester P12/2 OC-12c Packet over SONET/SDH modules.

Testing window: August/September 2000

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