

Force10 Networks, Inc. TeraScale E-Series E1200 Resilient Switch/Router



Test
 Summary

Evaluation of Non-Stop Networks, Advanced QoS and Scalability

Premise: Enterprises and service providers are faced with supporting network infrastructures in which core network or aggregation devices must act as workhorses and cannot become a bottleneck to network performance. It is imperative that such devices exhibit line-rate throughput, along with ample non-stop networking resiliency and redundancy. Such key devices should withstand Denial of Service attacks, and offer advanced Quality of Service, as well as scale to operate in large-scale networks.

Force10 Networks, Inc. commissioned The Tolly Group to evaluate its TeraScale E-Series E1200 Resilient Switch/Router, a chassis-based system with 14 line-card slots, plus built-in redundancy and resiliency features.

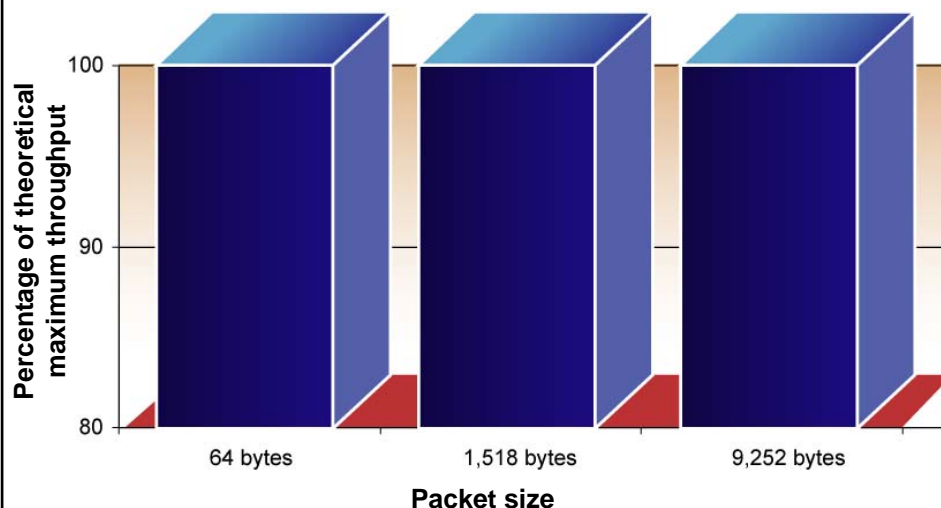
Engineers measured the failover resiliency of the E1200's Switch Fabric Modules (SFM) and Route Processor Modules (RPM). The Tolly Group also examined the E1200's response to a multiheaded Denial of Service (DoS) attack, and its capability to rebound from link outages. Engineers also examined the E1200's Quality of Service (QoS) facility to understand how latency-sensitive voice, video and data traffic are treated during link oversubscription scenarios, and engineers examined the E1200's scalability for BGP and OSPF networks. Tests were conducted in August 2004.

Tests demonstrate that the E-Series E1200 is capable of offering zero-loss line-rate throughput even during a SFM or RPM failover. Tests also demonstrate the device's resiliency to DoS attacks, to various failover scenarios and to delivering a QoS facility designed to serve enterprise and service provider networks.

Test Highlights

- Supports 100% of line-rate zero-loss throughput when tested across 56 10-Gigabit Ethernet ports during a Switch Fabric Module failover, while passing over 1 Terabits per second of traffic
- Recovers from link outages in less than 2 milliseconds with a single Layer 2 flow, and less than 1 millisecond with 16 million Layer 3 flows, both well below the failover time usually reserved for SONET/SDH links
- Maintains all BGP, OSPF and Telnet sessions even when hammered by a multiheaded Denial of Service attack
- Relies upon QoS facilities to ensure voice, video and data traffic types are handled according to policy parameters and with respect to latency sensitivity
- Scales to support service provider-class peers, handling more than 1,500 BGP peers and 6 million paths

Hitless Switch Fabric Module Failover at Traffic Rates over 1 Tbps
 56 Ports 10-Gigabit Ethernet Bidirectional Traffic



Source: The Tolly Group, October 2004

Figure 1

Results

Hitless Switch Fabric Module Failover

Engineers measured the bidirectional zero-loss 10-Gigabit Ethernet throughput across 56 10-GbE ports (14 four-port 10-GbE line cards) with hitless Switch Fabric Module (SFM) failover. This test offers a baseline of failover capability so that an active module can be removed for service with confidence, with the knowledge that the remaining infrastructure will cope with the surge of failover load.

Throughput tests were recorded with various packet sizes transmitted across the device. Results show that the E1200 achieved full-line rate throughput — with zero frame loss at any frame.

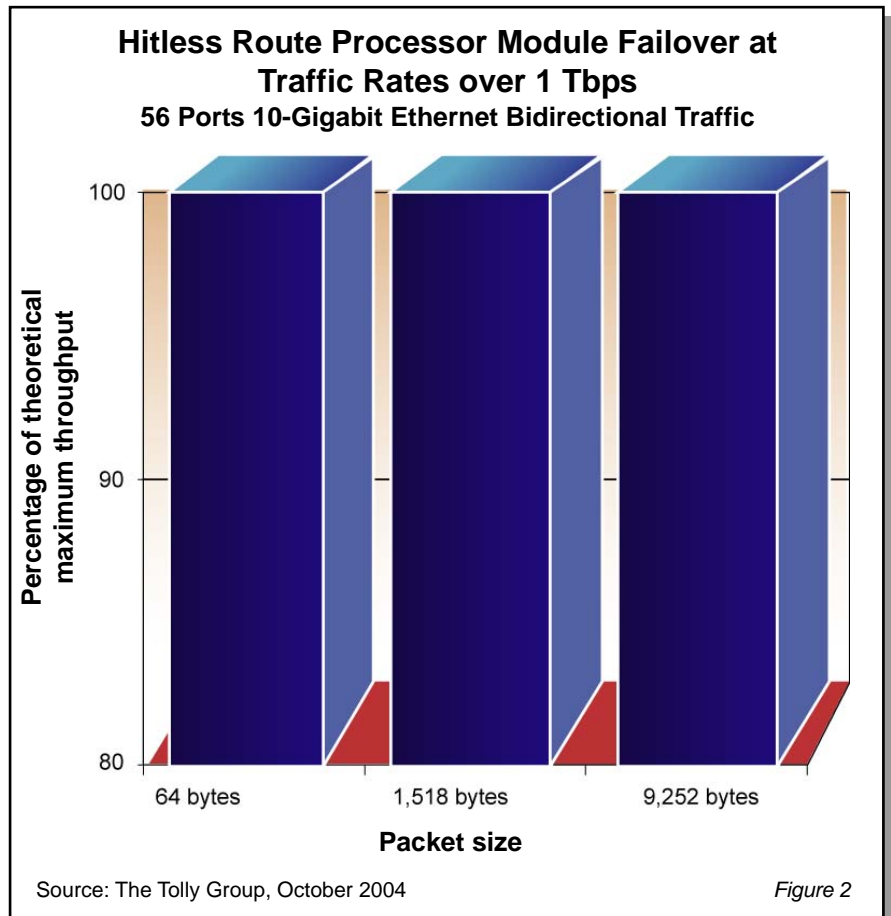


Figure 2

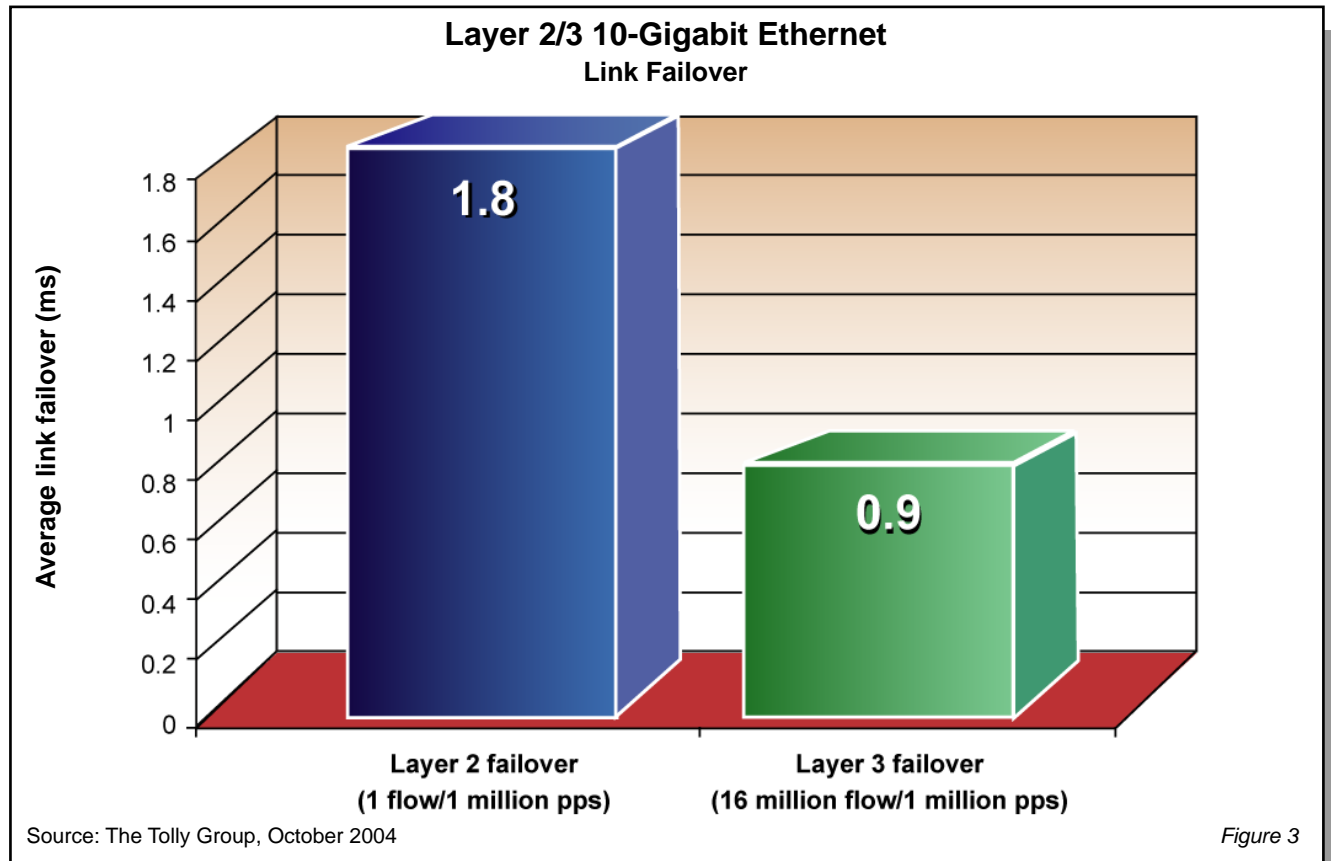


Figure 3

Hitless Route Processor Module Fail over

Engineers repeated the test again, this time failing the E1200's Route Processor Module (RPM) one minute into the test. Throughput tests were recorded with various frame sizes transmitted across the device. Results again show that the E1200 achieved full-line rate throughput with zero frame loss at any frame size.

Layer 2/3 Hitless SFM Fail over

Engineers measured the zero-loss bidirectional traffic of hitless Layer 2 and Layer 3 (OSPF and BGP) traffic with SFM failover. Throughput tests were recorded with various frame sizes transmitted across the device. Results show that the E1200 achieved full-line rate throughput with zero frame loss at any frame size.

Layer 2/3 Hitless RPM Fail over

Engineers measured the zero-loss bidirectional traffic of hitless Layer 2 and Layer 3 (OSPF and BGP) traffic with RPM failover. Throughput tests were recorded with various frame sizes transmitted across the device. Results show that the E1200 achieved full-line rate throughput with zero frame loss at any frame size.

Link Fail over

Engineers measured the link failover time of a 10-GbE link aggregated connection (LAG) using two 10-Gigabit Ethernet and one Gigabit Ethernet line card. Two tests were conducted:

first, engineers measured the packet loss and failover time with a single Layer 2 flow. The link failover occurred in 1.8 ms. (See Figure 3).

Next, engineers measured the Layer 3 failover time of a 10-GbE LAG. In this test, engineers verified that 16 million Layer 3 flows were distributed between two 10-GbE links before one of the links was brought down. The link failover occurred in 0.9 ms (See Figure 3).

Denial-of-Service Attack Resiliency

Engineers attempted to validate that the E1200 can withstand DoS attacks without any adverse effect on Layer 2 or Layer 3 bidirectional data traffic. For the test, engineers launched multiple attacks (Ping, ARP, Ping of Death, LAND and SYN simultaneous attacks) against an E1200 supporting converged OSPF and BGP traffic. The E1200 remained operational with no packet loss for BGP and OSPF sessions and no loss of Telnet sessions (See Figure 5).

Advanced QoS

In this scenario, engineers benchmarked the Mean Opinion Score (MOS) quality of a high-priority triple-play — voice, data and video — traffic simulation along with best effort traffic. For this test, engineers classified voice traffic to a high-priority queue representing “Gold” class of service. Video traffic was classified to a slightly lower priority or “Silver” class and data traffic was left as best-effort queue or “Bronze” class of service.

Force10 Networks, Inc.

TeraScale E-Series E1200

Non-Stop Networking, Advanced QoS and Scalability



**Force10 Networks, Inc.
E-Series E1200
Product Specifications***

Resilient architecture

- Distributed control plane with separate processors and memory for Layer 2 switching, Layer 3 routing and system management
- Robust Force10 FTOS™ modular software delivers full functionality Layer 2 switching and Layer 3 routing while also supporting zero packet loss hitless restarts and software upgrades
- Redundant route processor modules (RPMs), switch fabric modules (SFM) and power supplies
- Zero packet loss hitless failover of all components for non-stop applications
- Live insertion/removal of interface cards
- Virtual Router Redundancy Protocol (VRRP)

Scalable performance and port density

- Up to 672 Gigabit Ethernet line rate ports or 56 10-Gigabit Ethernet line rate ports per chassis
- Innovative Force10 ASICs deliver non-blocking, line-rate forwarding throughput of 1 billion packets per second with access control lists (ACLs) and QoS enabled for all packet sizes from 64 byte to 9,252 byte frames
- Large packet buffers on ingress 10 GbE LAN and WAN ports capable of buffering from 55 to 200 milliseconds of line rate traffic
- Patented 5 Tbps fully passive copper backplane enables seamless migration to 100 Gigabit Ethernet without a forklift upgrade
- Dual-stack IPv4/IPv6 support with hardware-based forwarding

Embedded Security

- Denial-of-Service protection through filtering and rate limiting control traffic
- Up to 1.4 million ACLs per system with real time insertion capability without creating a security issue
- RADIUS/TACACS+ for strong authentication, authorization and accounting
- Authentication and encryption of data transfers to and from the switch/router

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**Vendor-supplied information not verified by The Tolly Group*

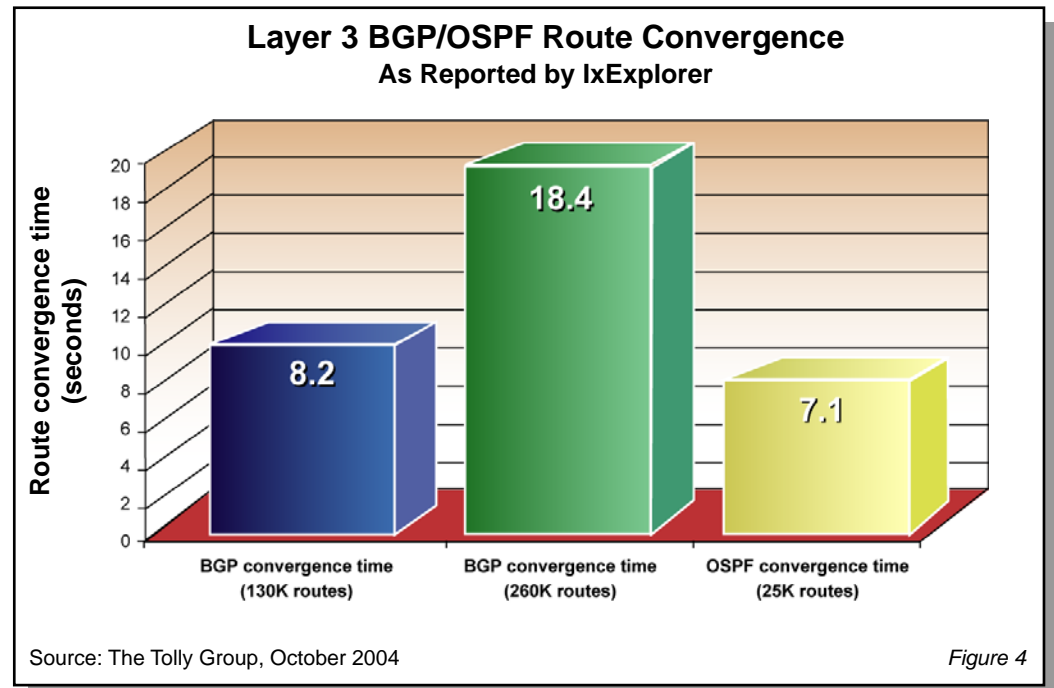
In this test, the quality of voice traffic was measured at 4.38 out of a possible 5 rating on the MOS scale, with anything over 4 considered toll-quality. Video traffic, represented in the Silver class, experienced no packet loss.

Routing Performance & Scalability

Engineers measured the E1200's BGP performance for route convergence and found minimal delay introduced when switching from primary routes to converging route tables and re-advertising backup routes. In fact, during a test of 130,000-route convergence, the E1200 consumed 8.2 seconds to withdraw routes and reissue new routes (See Figure 4). When the route table was increased to 260,000 routes, the E1200 consumed 18 seconds to withdraw and re-advertise routes.

Engineers re-ran the test with 25,000 OSPF routes, the E1200 consumed 7 seconds to withdraw and reconverge routes.

Tests also determined that the E1200 can scale to support communication with over 1,500 peers and 6 million paths with background traffic using the BGP protocol. With OSPF as the protocol supported, the E1200 can scale to support communication with over 500 peers.



Analysis

Network architects of service provider and large-scale enterprise networks realize that scalability, line-rate performance, and full Layer 2 switching and Layer 3 routing functionality are essential for today's most demanding network applications.

This report offers proof that the E1200 delivers the type of non-stop networking, advanced QoS and scalability capabilities required to support very large enterprise and service provider-class networks.

Failover tests conducted on the E1200 verify redundancy mechanisms for large-scale enterprise/service provider network managers to provide fail-safe service in the network while a system is under load. Such tests (hitless SFM and hitless RPM failover) provide a baseline of redundancy capability so that in-service healing of a

'sick' device can be performed with confidence, in the knowledge that the remaining infrastructure will cope with the surge of failover load. Likewise, tests of link failover underscore that when the network links fail, and not the E1200 line cards, the device also is capable of extremely rapid failover to alternate paths, often times in a fraction of the time required to revive SONET/SDH links.

Enterprise network managers and service providers also are sensitive these days to DoS attacks. Tests show that despite getting hammered by a volley of attacks simultaneously, the E1200 never lost a Telnet, BGP or OSPF session, delivering service provider-class resiliency.

Beyond non-stop networking, tests demonstrate that the E1200 provides the type of QoS facilities service providers and enterprise users need to support large-scale voice, video and data

activity, apportioning bandwidth with respect to the latency-sensitive nature of each application type.

Finally, the E1200 proved it is capable of delivering service in large-scale networks, where it demonstrated route convergence and peering scalability on a level normally associated with service-provider-class gear.

Test Configuration and Methodology

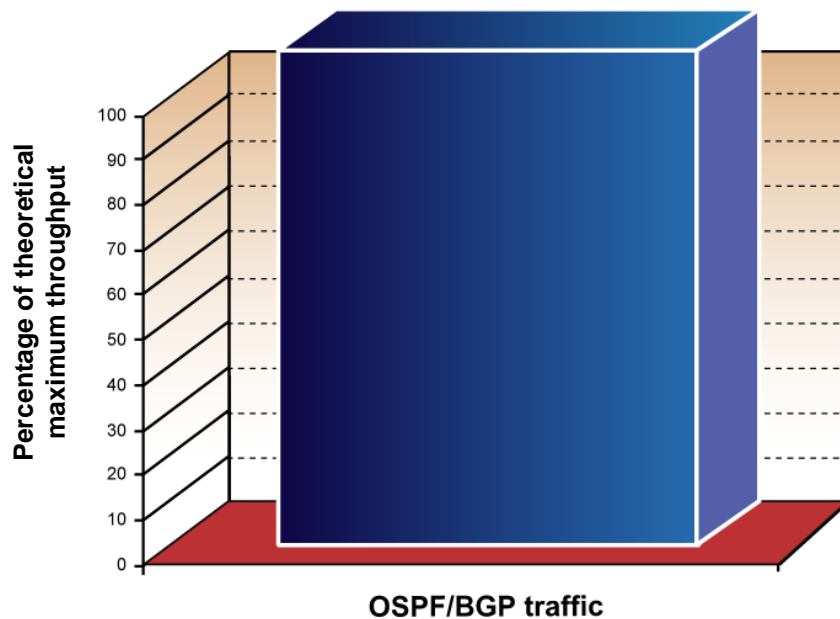
For performance tests, The Tolly Group tested a Force10 Networks Inc. E-Series E1200 Resilient Switch/Router Software Version 4.4.2.107.

According to Force10 Networks, this Beta release was replaced by Version 6.1.1.0.

For redundancy at terabits per second tests, engineers configured a pair of 10-GbE ports for the IXIA 1600T chassis and configured 14 four-port 10-GbE cards for the E1200. Engineers configured the test suite for “snake” traffic. Engineers also configured the test suite to transmit traffic from 64 bytes to 9,252 bytes. Engineers ran the test for 60 seconds and recorded the throughput; tests were run three times and the results averaged. After the first 60 seconds, the SFM or RPM card was failed.

For the Layer 2/3 hitless failover tests for SFM and RPM,

Layer 2/Layer 3 Percent of Throughput Delivered During Denial-of-Service Attack (DoS) As Reported by IxExplorer



Note: OSPF and BGP throughput experienced zero loss even during simultaneous Ping attacks, Ping of Death attacks, ARP attacks, Sync attacks and Land attacks.

Source: The Tolly Group, October 2004

Figure 5

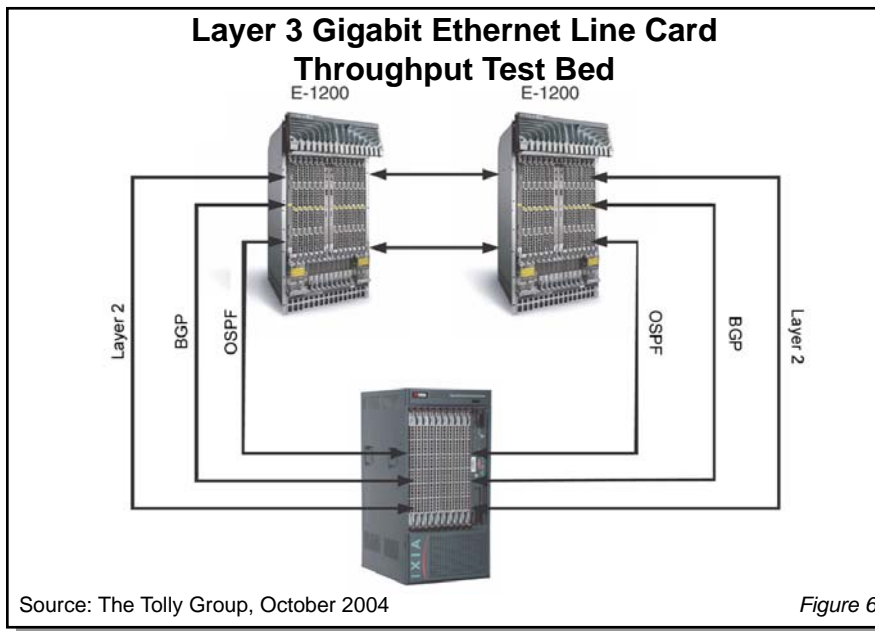
engineers sent bidirectional Layer 2 (1 million traffic flows) and Layer 3 (OSPF – 4 billion traffic flows) and (BGP — 4 billion traffic flows) using IxExplorer. Engineers configured the test suite to transmit traffic for random packet sizes and set the duration for 60 seconds. They issued an RPM or SFM failover command after 30 seconds of traffic.

In the link failover tests, engineers configured two 10-GbE ports and one GbE port for the Ixia chassis. They also configured two 10-GbE ports and one GbE line card for the DUT. Engineers also configured the test suite for unidirectional traffic and used IxExplorer to send traffic at

1 million pps (1 flow and also 16 million flows). Engineers then configured the test suite to transmit traffic for packet size of 64-bytes and used Ixia’s laser-off button to simulate a cable-cut. Testers then recorded the number of lost packets and divided by 1 million pps.

For the DoS attack test, engineers configured the Ixia chassis (using IxAttack software) to generate five different types of DoS attacks (Ping Attack, Ping of Death, Land Attack, ARP Attack, and Sync Attack); all of them attacking simultaneously five different GbE ports on the DUT.

In the QoS test, engineers oversubscribed a link by 40%.



The link carried 20,000+ VoIP calls using 3 Gbps bandwidth, 1,000 video streams (IPTV MPEG Video) using 1 Gbps bandwidth and 10 Gbps background data traffic. They also set assigned policy parameters to the voice, video and data types and then measured the mean opinion score for VoIP calls and measured packet loss for video traffic.

The Tolly Group gratefully acknowledges the providers of test equipment used in this project.

Vendor	Product	Web address
Ixia	IXIA 1600T	http://www.ixiacom.com
Ixia	IxChariot Console 5.1	http://www.ixiacom.com
Ixia	IxExplorer 3.70.24.46.SP3A	http://www.ixiacom.com
Ixia	IxAttack 1.25	http://www.ixiacom.com
Ixia	IxScriptMate 4.10.5.9	http://www.ixiacom.com
Ixia	Performance Endpoint 5.1	http://www.ixiacom.com
Ixia	Optixia	http://www.ixiacom.com



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Project Profile

Sponsor: Force10 Networks, Inc.

Document number: 204148

Product class: Carrier-class switch/router

Products under test:

- TeraScale E-Series E1200 Resilient Switch/Router

Testing window: August 2004

Software version tested:

- Version 4.4.2.107 (Version 6.1.1.0 now shipping)

Software status:

- Beta release

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