Premise: As 10-Gigabit Ethernet switching equipment comes to market, users need independent third-party validation of device performance claims to separate fact from fiction. Several benchmarks are critical: zero-loss device throughput and latency, as well as the capacity of the device’s route table. However, performance needs to be tested in a full-mesh configuration and with advanced functions such as Extended Access Control Lists (ACLs) enabled to understand the true device performance under real-world operating conditions.

Force10 Networks commissioned The Tolly Group to evaluate its Force10 E1200, a high-performance Ethernet switch/router that supports 28 ports of 10-Gigabit Ethernet. Engineers evaluated the E1200’s bidirectional zero-loss (≤0.001%) throughput when handling data at Layer 2, Layer 3 or a combination of traffic types. Moreover, engineers tested the E1200 in a full-mesh configuration with ACLs enabled for Layer 2 and Layer 3, creating a common representation of real-world operating conditions. Tests were conducted in July 2002.

Results

Zero-Loss Layer 2/ Layer 3 Throughput

The zero-loss throughput tolerance that is accepted by the networking community for tests performed on Layer 2 switches and Layer 3 routers has been 0.001%. The five nines of reliability (99.999%) is a deviation from the RFC definition of zero loss, though generally accepted. This means

Test Highlights

- Achieves 100% line-rate forwarding with ACLs enabled in tests of packet sizes above 512 bytes, and 95% to 99% line rate at frame sizes ranging from 64 bytes to 256 bytes
- Delivers 98% to 99% of line-rate throughput on 28 10-Gigabit Ethernet ports fully meshed with all packet sizes tested
- Maintains packet forwarding rates regardless of operating in Layer 2 switching or Layer 3 routing mode
- Demonstrates a routing table capacity of 262,000 BGP-4 routes, 65,000 OSPF routes and 50,000 IS-IS routes
- Achieves a predictable latency of just under 40 µsec at Layer 2 and just over 40 µsec at Layer 3 using a packet size 64 bytes in a 28 port-pair configuration

Source: The Tolly Group, July 2002
that out of every 100,000 frames transmitted, it is permissible for the device to drop a single frame. The Tolly Group endorses the zero-loss metric of \( \leq 0.001\% \) throughput to equate to zero loss.

Engineers measured the zero-loss \( \leq (0.001\%) \) throughput of the E1200 configured to forward data in a dual-port bidirectional configuration with ACLs enabled.

In the port-pairing tests, one designated port transmitted data bidirectionally to another designated port. The E1200 delivered 100% of zero-loss throughput at Layer 3 when tested with packet sizes greater than 512 bytes (see Figure 1). The E1200 delivered Layer 3 zero-loss throughput ranging from 95% to 99% when tested with packet sizes of 64 bytes to 512 bytes in the port-pairing test.

When handling Layer 2 traffic in port-pairing tests, the E1200 delivered 99% of zero-loss throughput when tested with frame sizes of 256 bytes or greater (see Figure 2). The E1200 achieved 95% to 97% of zero-loss throughput when handling frame sizes of 64 bytes and 128 bytes in the port-pairing tests.

Engineers also assessed the bidirectional zero-loss throughput in a 28-port full-mesh configuration that fully exercised the E1200 backplane. Full-mesh testing is where one port transmits to all other ports. For instance with the 28-port full mesh test, port 1 was transmitting to ports 2 to 28, port 2 was transmitting to 1 and 3 to 28, etc. The E1200 yielded Layer 3 zero-loss throughput of 99% when tested with packets sizes greater than 256 bytes. When tested with packet sizes of 64 bytes and 128 bytes, the E1200 yielded Layer 3 zero-loss throughput of 98%.

When handling Layer 2 traffic in the full-mesh tests, the E1200 delivered 99% of zero-loss throughput when tested with frame sizes of 256 bytes or greater. The E1200 achieved zero-loss throughput of 98% when tested with frame sizes of 64 bytes and 128 bytes in the full-mesh tests.

Lastly, engineers tested the E1200’s throughput with a combination test of Layer 2 and Layer 3 traffic. Twenty-two ports were configured to carry the throughput portion of the test while the remaining six ports were configured for BGP and OSPF traffic to populate the routing tables and forward traffic based on defined routes. The 22 ports were split into two separate virtual LANs, each consisting of Layer 2 and Layer 3 ports. Each VLAN was configured for an 11-port full mesh. The E1200 demonstrated 99% zero-loss throughput for frame sizes above 256-bytes, 95% zero-loss throughput for 64-byte frames and 97% for 128-byte frames.

<table>
<thead>
<tr>
<th>Packet size</th>
<th>Layer 2 ((\mu)sec)</th>
<th>Layer 3 ((\mu)sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-port</td>
<td>28-port</td>
</tr>
<tr>
<td>64</td>
<td>47.1</td>
<td>39.6</td>
</tr>
<tr>
<td>128</td>
<td>47.2</td>
<td>33.9</td>
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<td>256</td>
<td>46.4</td>
<td>33.8</td>
</tr>
<tr>
<td>512</td>
<td>45.7</td>
<td>46.0</td>
</tr>
<tr>
<td>1,024</td>
<td>46.7</td>
<td>34.6</td>
</tr>
<tr>
<td>1,280</td>
<td>49.3</td>
<td>40.3</td>
</tr>
<tr>
<td>1,518</td>
<td>46.9</td>
<td>48.2</td>
</tr>
</tbody>
</table>

Source: The Tolly Group, July 2002

Figure 2

E1200 Latency Measurements
**Latency Results**

In tests, the E1200 exhibited very little latency fluctuation. Since the latency increments we are reporting are in microseconds (µsec) the fluctuation we did see usually will result in little to no effect on latency-sensitive applications. In a two port-pair configuration across a variety of frame sizes (64-, 128-, 256-, 512-, 1,024-, 1,280 and 1,518-byte frames), the E1200 latency ranged from 45.7 µsec and 49.3 µsec. This compared with the same frame sizes at Layer 3 where the E1200’s latency ranged from 27.5 µsec to 40.5 µsec. When tested with the same frame sizes in a 28 port-pair configuration, Layer 2 latency ranged from 33.8 µsec to 48.2 µsec and Layer 3 latency ranged from 39 µsec to 47.7 µsec.

**Route Table Capacity**

The Tolly group measured the E1200’s route table capacity. Tests show the E1200 can support 262,000 BGP-4 routes, 65,000 OSPF routes and 50,000 IS-IS routes.

**Analysis**

As users embrace 10-Gigabit Ethernet technology in their network backbone and out to server farms, they will come to expect consistency in performance, regardless of whether data travels at Layer 2, Layer 3, or with access control lists enabled or disabled.

Force10 Networks has demonstrated with its E1200 switch/router that the product delivers line-rate performance in tests of 512-byte frames and higher in full-mesh tests on all 28 10-Gigabit Ethernet ports. But the E1200 is not simply a packet blaster. The device surely delivers high performance, whether configured as a Layer 2 switch, or as a Layer 3 router, or whether it juggles both data types simultaneously. Regardless of its operational mode, the E1200 delivered uniform performance in both the bidirectional port-pairing and the full-mesh tests.

Additionally, the E1200 shows the same high data forwarding rates while it also performs complex IP filtering or ACL processing. In bidirectional testing with ACLs enabled unidirectionally on all 28 ports, the E1200 achieved between 99% and 100% line rate for all packet sizes above 256 bytes. At packet sizes below 256 bytes, performance dropped slightly to between 95% and 97% of line rate, even though no such performance drop was recorded in full-mesh testing. The idea here was to ‘mix it up’ since the ACLs might be viewed as a firewall function – prohibiting untrusted traffic to the trusted environment. So, tests focused solely on unidirectional ACLs since that represents typically how they are deployed.

Lastly, 10-Gigabit Ethernet switch performance testing often is conducted only with traffic running bidirectionally between pairs of ports. (The Tolly Group recommends ‘traditional’ Fast Ethernet and Gigabit Ethernet tests should be full mesh.) In order to test Force10’s scalability claims, as well as the backbone capacity, we ran traffic fully-meshed between all 28 10-Gigabit Ethernet ports. In this configuration the E1200 delivered exceptional performance between 98% and 99% of line rate for all packet sizes.

**Test Configuration and Methodology**

The Tolly Group tested a Force10 Networks E1200 switch/router with software version 3.1.2.1, in a 28-port 10-Gigabit Ethernet configuration. Tests were performed in fully loaded meshed configuration and also in a two port-pair configuration with active ACLs taxing the E1200’s ASIC-based forwarding plane. Both scenarios represent a more realistic test scenario than tests that simply forward traffic on a port-to-port basis across a switch interface card with no filters present.

The E1200 was connected, in the full-mesh configuration, via 28 10-Gigabit Ethernet ports. But the product delivers line-rate performance often is conducted only with traffic running bidirectionally between pairs of ports. (The Tolly Group recommends ‘traditional’ Fast Ethernet and Gigabit Ethernet tests should be full mesh.) In order to test Force10’s scalability claims, as well as the backbone capacity, we ran traffic fully-meshed between all 28 10-Gigabit Ethernet ports. In this configuration the E1200 delivered exceptional performance between 98% and 99% of line rate for all packet sizes.

**Force10 Networks, Inc.**

**E1200 Switch/Router**

**Functionality and Performance**

**System**
- 1.2 Tbit/s non-blocking switch fabric
- \( \frac{1}{2} \)-rack chassis (19” rack width)
- 500 million packets per second
- 9 line card slots
- 8+1 redundant RPMs; 8+1 redundant SFMs
- 1+1 redundant DC Power Entry Modules
- Hot-swap of all key components

**Layer 2 Switching**
- 4K VLANs and VLAN stacking
- Ethernet over MPLS
- Link Aggregation (16 links)
- Rapid Spanning Tree Protocol
- 802.1p prioritization

**Layer 3 Routing**
- Robust protocols: BGP4, IS-IS, OSPF, RIPv2, and MPLS
- Multicast with IGMP/PIM-SM
- Full Internet route table support up to 512K forwarding entries
- Equal Cost Multi-Path (16 links)
- VRRP

**Services**
- Congestion control with WRED and WFQ
- QoS interworking between MPLS, L2, and L3
- Egress rate-shaping, ingress rate policing
- Committed Access Rate support – two rate, three color model

**Management**
- Ping, Traceroute, Telnet
- RADIUS, TACACS+, SSH
- FTP, TFTP client
- DNS client, BootP/DHCP relay
- Accounting and statistics

**For more information contact:**
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Fax: (408) 571-3550

*Vendor-supplied information not verified by The Tolly Group*
In the steady-state zero-loss throughput tests for the two port-pair configuration, engineers first configured two 10-Gigabit Ethernet ports in a VLAN. The E1200 was configured to support 1,001 ACL rules on an ingress port. Engineers configured the Ixia ScriptMate tool to run the standard RFC 2544 test script for throughput. Engineers configured the test suite to transmit bidirectional packet sizes of 64, 128, 256, 512, 1,024 and 1,518 bytes. The zero-loss tolerance was set to 0.001% and the test duration per packet was set at 60 seconds. In the like test for the 28-port full-mesh configuration, the same procedure was used, except the test suite was configured to transmit at full-mesh on all ports.

In all tests, The Tolly Group performed three iterations of 60 seconds for each test at the maximum and averaged the three iterations. In order to obtain the zero-loss rate, the throughput test was configured to use a binary search algorithm until the zero-loss threshold was achieved.

For the latency tests, the same configurations used in the throughput tests were utilized except that the Ixia ScriptMate was configured to run the standard RFC 2544 test script for latency.