

# Torrent Networking Technologies Corp. IP9000 Gigabit Router Fast Ethernet IP Routing Performance

## Test Summary

**W**ith the ever accelerating growth of the Internet, more traffic is being forwarded across the Internet than ever before. Hundreds of new hosts are being installed everyday and the applications running across the Internet are increasing steadily. All of this growth has created a need for Internet-class IP routers that are capable of handling the IP address scaling concerns of the Internet, as well as providing wire-speed performance for both traditional traffic and for newer applications.

Torrent Networking Technologies Corp. commissioned The Tolly Group to evaluate the Fast Ethernet, IP-routing performance of its IP9000 Gigabit Router. The IP9000 is a member of this new class of routers that are designed to handle Internet traffic and are specifically architected for extremely large IP networks.

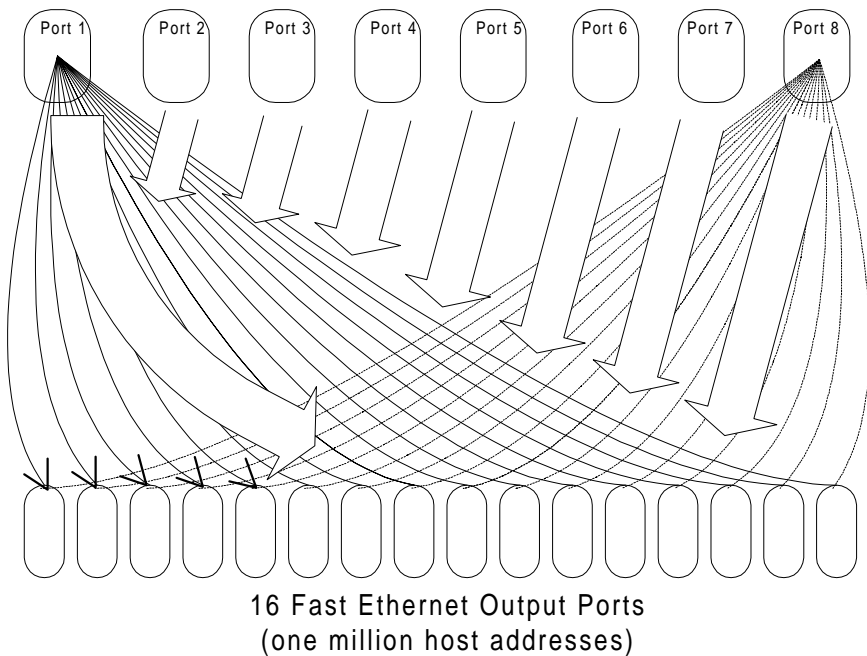
Unlike traditional IP routers, the IP9000 has the capability to maintain and quickly search huge route tables, enabling it to forward packets at wire speed to millions of hosts on thousands of networks. It also has the capability to transmit multicast IP packets to more than 65,000 multicast groups without penalizing performance. This scalable solution will help facilitate deployment of multicast applications such as video over the Internet.

The Tolly Group ran a series of Smart-Bits tests to benchmark the IP9000's capabilities in a variety of network environments including both unicast and

### Test Highlights

- Delivers wire-speed performance for all tests with "zero packet loss"
- Routes IP packets at wire speed to more than one million IP host addresses from eight Fast Ethernet streams on a single card
- Routes IP multicast traffic at wire speed over Fast Ethernet links to 65,536 multicast groups on 31 output ports
- Offers wire-speed IP routing throughput at low latency for up to 16 Fast Ethernet unicast streams
- Achieves wire-speed performance for 56 simultaneous multicast Fast Ethernet streams in mesh multicast testing

### Internet-Scale Routing Test Up to Eight Fast Ethernet Input Streams



All eight inport ports transmitted streams to each output port.

Source: The Tolly Group, May 1998

Figure 1

multicast configurations. In the configurations tested, the IP9000 forwarded traffic streams across Fast Ethernet connections at wire speed while providing routing services to the network. Initially, The Tolly Group subjected the IP9000 to multistream layer 3 IP routing throughput and latency tests for both unicast and multicast traffic. In addition, engineers ran a series of tests that explored the performance of the router when forwarding traffic in large network address spaces and in Internet-scale multicast environments. Testing was performed in March 1998.

### TEST RESULTS

Delivering wire-speed throughput of basic IP routing functions is expected of any new IP router entering the marketplace. To distinguish itself, a product must also deliver high performance combined with such advanced features as multicasting, speedy route table lookups, and scalability of multicast groups. The Tolly Group examined the IP9000's ability to deliver such advanced features by running a series of performance tests designed to stress each of the advanced functionality areas.

At the highest level, the test results show that the IP9000 offers wire-speed throughput for every test that was run during the evaluation. The router delivers wire-speed performance even for tests that go beyond simple throughput or latency measurements.

### INTERNET-SCALE ROUTING

In a large-scale network like the Internet, where thousands of IP networks exist, route tables used by IP routers grow very large. When routing IP, the lookup process is a potential bottleneck and exacerbated as the routing table grows. Every time an IP router receives a packet to forward, it must first

Number of Ports Used (input x output)	Number of Traffic Streams	Packet Size	Number of Packets Transmitted (per port)	Number of Packets Received (per port)	Packets Lost or Dropped
1x16	16	64	1,048,576	65,536	0
2x16	32	64	1,048,576	131,072	0
4x16	64	64	1,048,576	262,144	0
8x16	128	64	1,048,576	524,288	0

Source: The Tolly Group, May 1998 Figure 2

Number of Ports Used (input x output)	Number of Traffic Streams	Packet Size	Number of Packets Transmitted	Number of Packets Received (per port)	Packets Lost or Dropped
1x31	31	64	65,536	65,536	0
1x31	31	1,518	65,536	65,536	0

Source: The Tolly Group, May 1998 Figure 3

Number of Ports Used (input x output)	Number of Traffic Streams	Packet Size	Number of Packets Sent (per port)	Number of Packets Received (per port)	Packets Lost or Dropped
8x7	56	64	100,000	700,000	0
8x7	56	128	100,000	700,000	0
8x7	56	512	100,000	700,000	0
8x7	56	1,518	100,000	700,000	0

Source: The Tolly Group, May 1998 Figure 4

search its routing table to determine which output port should receive the packet. Even a small delay in searching the routing table can result in a significant performance hit when high rates of traffic are being forwarded.

The Tolly Group measured the IP9000's packet forwarding capability within a large address space (over a million host addresses) to determine how well the router

will operate in large, routed IP environments, such as the Internet. The IP9000 delivered wire-speed throughput even when performing route lookups and forwarding unicast packets to 1,048,576 different host addresses spread evenly across 16 Fast Ethernet output ports.

Tests revealed that the IP9000 did not drop a single packet for any of the test iterations (see figure 2). This Internet-Scale Routing Test

sent a stream of one million 64-byte packets from the input port(s) to 16 output ports (see figure 1). Each of the 16 output ports was configured to forward traffic to 65,536 host IP addresses. This creates a "worst case" situation in which the router must determine where to forward traffic based on searching a route table that contains literally more than a million entries. A stream of 1,048,576 packets was sent at wire speed (with a minimum interframe gap) and the number of packets received at each of the 16 output ports was determined.

#### LARGE-SCALE MULTICAST

Multicast applications are becoming more prevalent both inside corporate networks and on the Internet. Multicast is commonly used to broadcast video streams simultaneously across a network to multiple stations that all belong to the same Multicast Source Group. A Multicast Source Group is simply a group of IP addresses that all receive the same multicast packets, from the same source. The IP router must decide where to forward multicast packets based on the group membership of each IP address.

Any network used to deliver multicast applications must scale beyond a few thousand multicast source groups without performance degradation. With multicast applications, dropped packets can quickly degrade application performance, so it is critical for the networking hardware to perform without frame loss.

By definition, multicast consists of one source and many recipients. For this test, one Fast Ethernet port was used as a source and the 31 remaining ports as destination ports. The Tolly Group set up a large-scale multicast test with 65,536 multicast groups defined across 31 Fast Ethernet ports on the

router. The IP9000 router consequently had to determine which of the 65,536 multicast source groups would receive each packet. The SmartBits generated a stream of 65,536 packets from one input port to 31 output ports. The router then had to determine the proper multicast source group for each packet and forward packets accordingly. It did so without dropping a single packet (see figure 3).

This test demonstrates that the IP9000 can handle multicast applications in demanding environments where tens of thousands of users may need to use an application simultaneously and where packet loss is not acceptable.

#### MULTICAST MESH

A mesh configuration is potentially one of the most taxing configurations on a piece of networking hardware. The mesh implies that every port will be sending and receiving traffic from every other port. Therefore, in a mesh configuration, the maximum number of data streams possible for a given set of ports will be handled by the device being tested. Since the device is handling the maximum number of data streams, it is also handling the maximum amount of traffic that it would ever need to forward.

As an additional stress test of multicast performance, The Tolly Group benchmarked the bi-directional forwarding performance of an eight port by eight port (a single Fast Ethernet module), multicast mesh configuration. Each input port handled a stream of 100,000 packets generated by the SmartBits, which the router then multicasted to the other seven output ports. That operation delivered 700,000 packets to each output port. The IP9000 for-

**Torrent  
Networking  
Technologies  
Corporation**

**IP9000 Gigabit  
Router**

**Fast Ethernet  
IP Routing  
Performance  
and Scalability**



#### **Torrent Networking Technologies Corporation IP9000 Gigabit Router Product Specifications\***

IP9000 Gigabit Router (Eight-slot system)

#### **Performance Specifications:**

- Forwarding: 10 million packets/second (unicast/multicast)
- Throughput: 10 Gbit/s (unicast/multicast)
- Latency: 25 microseconds

#### **Routing table:**

- Unicast prefixes: 100,000 to 400,000
- Multicast groups: 64,000
- User-defined flows: 50,000 per port

#### **Routing Protocols Supported:**

IP RIP-1 RIP-2, OSPF, BGP-3, BGP-4, DVMRP, IRDP, IGMP, ICMP  
Integrated IS-IS, PIM Sparse Mode, PIM Dense Mode planned

#### **Interfaces Supported:**

10/100 Ethernet, Gigabit Ethernet, ATM OC-3, ATM OC-12, IP over SONET OC-3, IP over SONET OC-12

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

warded packets from each of the eight input ports to each of the output ports at wire speed without dropping any packets. The tested mesh configuration indicates that each port is forwarding traffic to every other port (the input port is not sending packets to itself though) and receiving traffic from all seven other ports, meaning the IP9000 handled 56 simultaneous streams (see figure 3).

#### BASE MULTICAST PERFORMANCE

The multicast performance test determined the IP9000's throughput and latency when the router forwarded packets to a single multicast source group. This test is a measure of base multicast performance and was not as stressful as the other multicast tests.

The IP9000 offered wire-speed performance here as well. The test showed that multicast latency remained low and consistent throughout each packet size regardless of traffic load; the IP9000 delivered a consistent latency of 26 microseconds for 64-byte packets and 220 microseconds for 1518-byte packets.

The test results show that 100,000 packets were generated at wire speed on a single input port and 100,000 packets were multicasted to every output port. The IP9000 didn't drop a packet even when forwarding traffic to 31 output ports and demonstrated dependable response times that didn't vary as the load on the router was increased from seven to 31 output ports. This low, consistent latency is important for time variation sensitive multicast applications such as video.

The multicast performance test consisted of four main test iterations and two packet sizes for each. All multicast performance test traffic was generated through a single input port. The number of output ports varied through the four main itera-

tions of the test, ramping up from 7 to 15, then 23 and finally 31 ports (see figure 6).

#### BASE UNICAST PERFORMANCE

Currently, the most common type of IP traffic in use is unicast. While it is expected that today's routers deliver near flawless unicast forwarding performance, it is nonetheless important to verify this basic functionality. The unicast performance tests were run using the Netcom Systems SmartApps application. The unicast performance tests consisted of 16 traffic streams (32 Fast Ethernet ports) and measured zero packet loss, steady state throughput and latency of layer 3 routed unicast packets.

The IP9000 forwarded unicast traffic at wire speed: 148,810 packets per second per traffic stream with 64-byte packets and 8,127 packets per second per traffic stream with 1,518-byte packets.

Latency tests show that the router provides a low, consistent response time ranging from 26.4 microseconds at 64-byte packets to 219.2 microseconds at 1,518-byte packets (see figure 5). Taken together, these results indicate that the router will have little difficulty in providing consistent, scalable unicast packet forwarding performance.

### Unicast Performance (Throughput and Latency)

Packet Size (in bytes)	Average PPS per Stream	Aggregate PPS	Average Latency (microseconds)
64	148,810	2,380,960	26.4
128	84,459	1,351,344	32.5
256	45,290	724,640	50.0
512	23,496	375,936	83.1
1,024	11,973	191,568	154.0
1,280	9,615	153,840	187.4
1,518	8,127	130,032	219.2

Source: The Tolly Group, May 1998

Figure 5

#### TEST CONFIGURATION AND METHODOLOGY

For all of the tests, The Tolly Group used the same hardware and physical configuration. However, both the test scripts used and router configuration varied widely for each test.

#### SYSTEM UNDER TEST

The IP9000 Gigabit Router was outfitted with a route processor (Serial number 004, Hardware Revision B, and running IP Action 1.0), an eight-slot chassis (Hardware Revision C), four 8-port (RJ-45 ports with Category 5 cabling) Fast Ethernet modules (Hardware Revision D) and a power supply. Since the testing consisted of a maximum of 32 FE ports, four Fast Ethernet modules were used.

#### TEST BED DESCRIPTION

The test bed consisted of the Netcom SmartBits Advanced Multiport Performance Tester (version 6.23), the SmartBits console to load and start test scripts, a WinPharaoh Network Analyzer from GN Nettek (version 2.1), and the IP9000 (see figure 7). The SmartBits test tool was connected to the IP9000 by 32 RJ-45 Fast Ethernet connections over Category 5 cabling. The SmartBits console was connected to the SmartBits via a serial connection. The Win-

### Multicast Performance

Number of Ports Used (input x output)	Number of Traffic Streams	Packet Size	Number of Packets Transmitted (per port)	Number of Packets Received (per port)	Packets Lost or Dropped	Cut Through Latency (micro-seconds)	Store and Forward Latency (micro-seconds)
1x7	7	64	100,000	100,000	0	28.0	22.2
1x7	7	1,518	100,000	100,000	0	220.2	98.1
1x15	15	64	100,000	100,000	0	28.1	22.3
1x15	15	1,518	100,000	100,000	0	220.4	98.3
1x23	23	64	100,000	100,000	0	28.4	22.6
1x23	23	1,518	100,000	100,000	0	220.5	98.4
1x31	31	64	100,000	100,000	0	28.6	22.8
1x31	31	1,518	100,000	100,000	0	220.8	98.7

Source: The Tolly Group, May 1998

Figure 6

Pharaoh Network Analyzer was connected to a router port, the test scripts run again and the traffic was captured and saved for later analysis of traffic flow and packet composition.

The SmartBits test system generated traffic for testing the performance of the IP9000 and recorded the results. The SmartBits utilized 32 100Base-TX Modules (SX-7410s) for Fast Ethernet connectivity. The SMB-2000 is the main chassis, and the SMB-1000 (see below) is the slave to the SMB-2000. Both chassis are running software version 6.23, FW6/07. The console is a Windows 95 PC (OEM release) with a 233 MHz MMX processor and 64 MB of RAM.

#### METHODOLOGY

The unicast throughput and latency tests are standard layer 3 routing tests that are run from Netcom System's SmartApps application that determine the maximum packet forwarding rate without packet loss (zero loss performance). The multicast performance tests show packet loss when forwarding traffic, as well as the per packet latency.

The other three IP router tests utilized three different custom Smart-

Bits scripts (written by Torrent Networking Technology's engineers) that generate test traffic (unicast or multicast) and forward the traffic to specific destination addresses. Each of these three tests measure the number of packets generated to an input port and the number of packets received on each output port, albeit in different configurations of input/output ports. Any difference between the number of generated packets and the number of received packets indicates that the router being tested dropped packets when the script was run.

The script files and router configuration files are available on The Tolly Group's Web site at <http://www.tolly.com> and on Torrent Networking Technology's Web site at <http://www.torrentnet.com>.

#### PROCEDURE

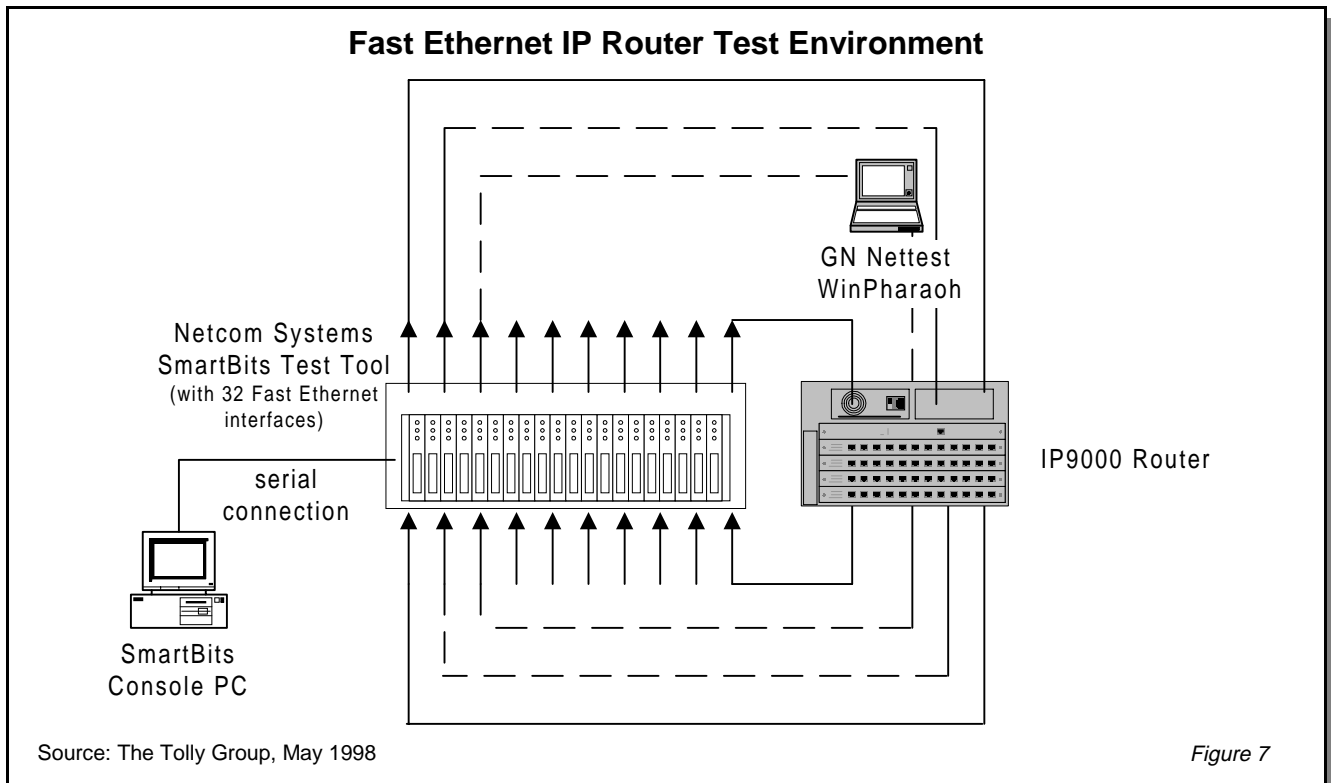
The overall procedure is generally similar for all of the performance tests. Prior to starting the SmartBits testing, the proper configuration must be loaded on the router under test. A SmartBits test script is then loaded via the SmartBits console.

The test definition includes: protocol (IP), number of streams, source and destination addresses, packet type, packet sizes, interframe gap, duration of the test and the number of test iterations to be run. Once the test is configured, the console is used to start the test. If necessary, the SmartBits initially sends out "learning packets" to load the proper source and destination MAC address on each port of the router.

Once the router has learned the proper addresses, the performance test begins. The performance of the device under test is determined by SmartBits and reported to the SmartApps (or SmartWindows) software. Three iterations of the test are run and the results are averaged. The resulting data is saved in text or bitmap format and imported into a spreadsheet for further calculations and analysis.

#### CALCULATIONS

The only calculations used in this test were averaging and summing the test results.



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

Vendor	Product	Web address
GN Nettest	WinPharaoh LAN Analyzer	<a href="http://www.gnnettest.com/">http://www.gnnettest.com/</a>
Netcom Systems	SmartBits SMB-2000	<a href="http://www.netcomsystems.com">http://www.netcomsystems.com</a>
Netcom Systems	SmartBits SMB-1000	<a href="http://www.netcomsystems.com">http://www.netcomsystems.com</a>

## ABOUT THE TOLLY GROUP

The Tolly Group provides strategic consulting, independent testing, and industry analysis. It offers a full range of services designed to furnish both vendor and end-user communities with authoritative, unbiased information. Fortune 1,000 companies look to The Tolly Group for vendor-independent assessments of critical corporate technologies. Leading manufacturers of computer and communications products engage The Tolly Group to test both pre-production and production equipment.

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Group has published more than 400 product evaluations, network design features and columns in the industry's most prestigious publications.

Kevin Tolly is President and CEO of The Tolly Group. He is a leading industry analyst and is responsible for guiding the technology decisions of major vendor and end-user organizations. In his consulting work, Tolly has designed enterprise-wide networks for government agencies, banks, retailers, and manufacturers.

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