THE TOLLY GROUP

No. 7306 November 1997

Ascend Communications

GRF 1600 and GRF 400

ATM OC-12 Forwarding Performance

Test Summary

Ascend Communications commissioned The Tolly Group to test the ATM OC-12 (622 Mbit/s) forwarding performance of its GRF™ 1600 and GRF 400. The Tolly Group determined aggregate throughput by sending streams of traffic through the device under test. Additional streams were added until each of the 16 modules in the chassis operated at maximum throughput. Additionally, to approximate a real-world scenario, The Tolly Group determined how the router performed while forwarding packets to varying Class C IP destination addresses. Testing was performed during September 1997.

The Ascend GRF 1600 delivered aggregate forwarding throughput of more than 4.7 million pps while forwarding 64-byte IP packets through 16 ATM OC-12 modules. With this packet size, each module forwarded an average of 295,000 pps. When forwarding 1,518-byte packets, the GRF 1600 routed 100 percent of the usable OC-12 bandwidth for all modules, or over 8.3 Gbit/s. Identical tests on the GRF 400 demonstrated that the GRF 400 exhibits similar throughput with up to four modules, the slot capacity of its chassis.

Further, The Tolly Group found no significant degradation in performance of the GRF 1600 or GRF 400 when forwarding packets to varying destination address.

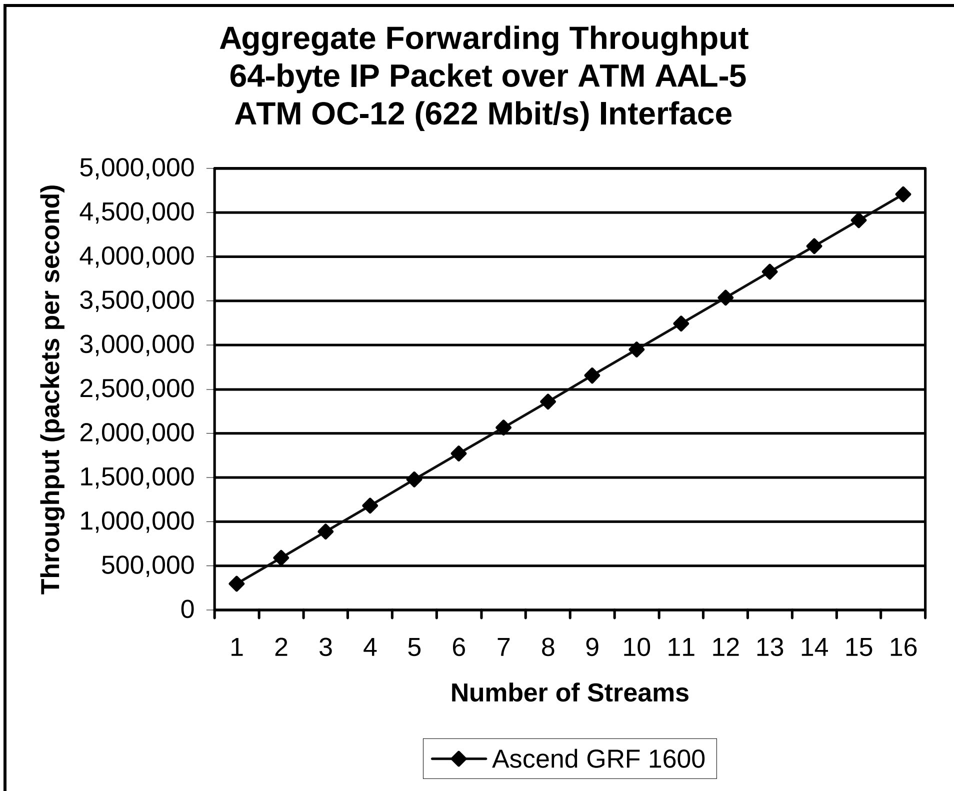
Results

Small Packet Performance

Since data is forwarded on a per-packet basis, the number of packets per second

Test Highlights

- The GRF 1600's aggregate ATM OC-12 throughput forwarding 64-byte IP packets is more than 4.7 million packets per second (pps), with each of 16 modules processing approximately 295,000 pps.
- The GRF 1600 backplane forwards data from 16 simultaneous ATM OC-12 modules, each offering 100% of usable OC-12 bandwidth, for an aggregate of 8.3 Gbit/s with 1,518-byte IP packets.
- The GRF backplane scales linearly to handle full output from all 16 operating OC-12 modules.
- The GRF 400, with up to four modules, the capacity of its chassis, achieves per module throughput similar to the GRF 1600.
- Forwarding to varying IP destination addresses does not significantly degrade throughput.



Source: The Tolly Group, November 1997 *Figure 1* that can be processed is of critical importance to forwarding performance. The Tolly Group measured the packet-per-second performance of the GRF 1600 by using a 64-byte IP packet. As figure 1 illustrates, the aggregate throughput of the GRF 1600 reaches 4.7 million pps forwarding 16 streams of single destination IP addresses.

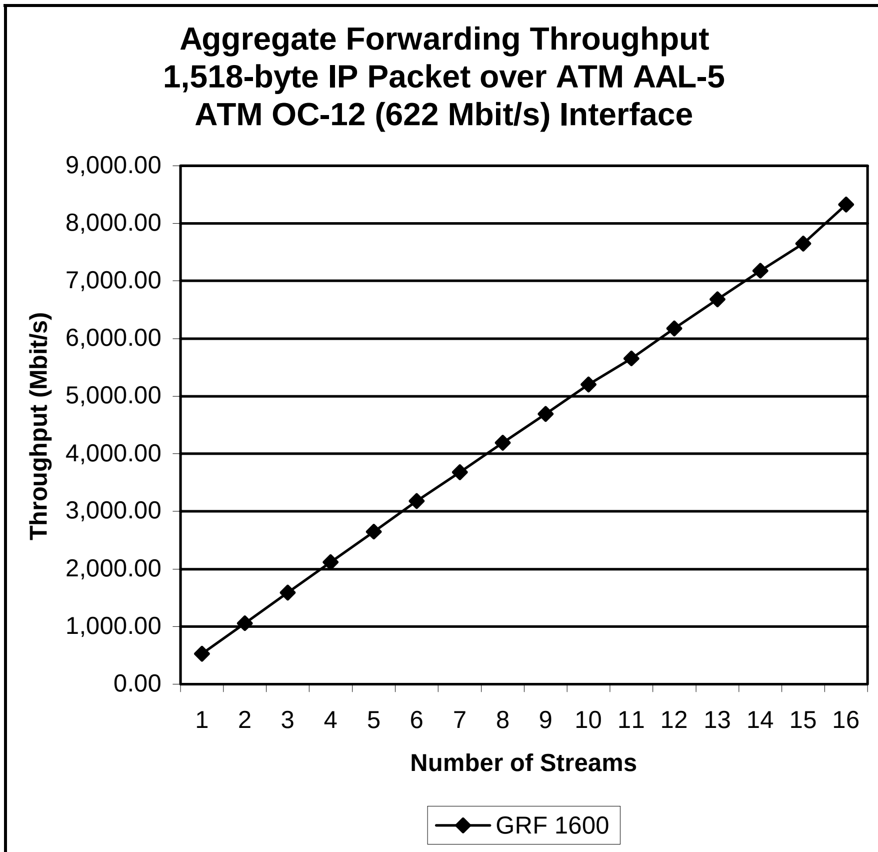
Each ATM OC-12 GRF module delivers up to 296,453 pps per module with 80 address entries in the forwarding table. The aggregate throughput of the chassis scales linearly from 295,604 pps at 1 stream, up to 4,707,451 pps at sixteen streams. All streams passed through the backplane.

LARGE PACKET PERFORMANCE

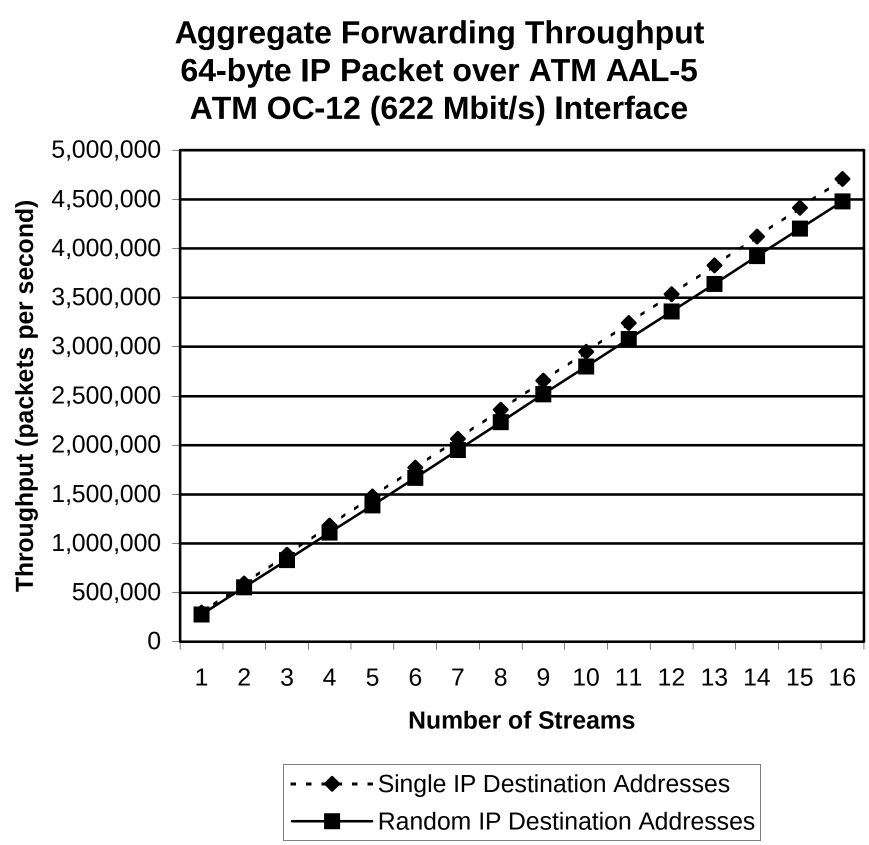
Once packets are processed, they must be successfully transported to the output module for transmission. As such, each packet must traverse the backplane, where sufficient bandwidth must be available. The Tolly Group tested the throughput of the GRF with 1,518-byte frames, and converted the packet per second throughput to Mbit/s by multiplying pps by bits per packet.

Figure 2 illustrates that the GRF 1600 forwards the combined output of each of 16 ATM OC-12 modules at line-rate. The throughput reached 8.324 Gigabit/s (Gbit/s) or 8,324.86 Mbit/s. Each module forwards an average 530 Mbit/s. With one module, the GRF 1600 forwards 529.54 Mbit/s (98.84% of ATM OC-12 usable bandwidth), and with 16 modules, 8,324.86 Mbit/s (97.04% ATM OC-12 usable bandwidth).

The Tolly Group also tested the GRF 400 with up to 4 modules, the maximum capacity of its chassis. The GRF 400 uses the same modules and CPU as the GRF 1600, and similar results were found for the GRF 400.



Source: The Tolly Group, November 1997 *Figure 2*



Source: The Tolly Group, November 1997 *Figure 3*

Varying Destination Addresses

Since actual network environments contain traffic to be forwarded to a variety of destinations, The Tolly Group ran a subset of the aggregate throughput test, modifying the packet content. The packets contained varying destination addresses more closely reflecting an actual network than packets to a single destination. Figure 3 illustrates the performance of the GRF 1600 under these conditions with up to 16 streams.

The GRF 1600 maintains aggregate throughput that scales linearly as in single IP destination packet tests. Throughput degraded only 4.8 percent compared to the single IP packet tests. For one stream, throughput of the GRF was 295,604 pps, for two, 553,771 pps. At five streams the throughput was 1,387,515 pps, and with the full sixteen the throughput was 4,480,309 (95.17 percent of the single IP throughput).

Figure 3 also includes single IP throughput of the GRF 1600 for reference (dashed lines).

Test Configuration and Methodology

The Tolly Group tested throughput of a single IP packet up to sixteen streams with both 64-byte IP packets and 1,518-byte IP packets. The Tolly Group repeated the throughput test using varying destination addresses.

Device Under Test

Both the GRF 1600 and 400 were tested with code revision 1.4.1. The GRF 1600 had sixteen ATM OC-12 modules in its chassis and the GRF 400 had four. Both routers were configured with static routes and dynamic routing protocols were disabled.

Test Bed Description

Up to sixteen packet generators/analyzers was used to generate traffic. All OC-12 generators/analyzers were connected directly to the device under test via multimode fiber cabling. A Wandel & Goltermann DA-30C was used to decode packet content on frames routed by a second GRF 1600 from ATM OC-12 on the device under test to FDDI (at FDDI packet rates). FDDI was only used to assist with packet decode and was not part of the test.

Methodology

Throughput was determined by finding the no-loss throughput of each module, by finding the output rate of each stream (one stream per module) that was no more than 2 percent less than the input of each stream. For the varying destination address test, the above methodology was repeated, except that instead of a single packet, The Tolly Group generated varying Class C destination addresses within a range of 192.0.0.0 to 223.255.255.254. For all tests every stream traversed the router's backplane (i.e. each stream was output on a module other than the stream's originating module).

Calculations

Aggregate router throughput was calculated by adding the throughput of all streams. Mbit/s was calculated by multiplying the packets per second value by the number of bits per frame (e.g. for 64-byte frames: pps result * 64 bytes per frame * 8 bits/byte).

Ascend Communications

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ATM OC-12 Forwarding Performance

The Tolly Group Up to Spec Certified

Ascend Communications
GRF 1600 and GRF 400
Product Specifications*

The GRF's architecture combines its Layer-3 switch with intelligent IP Forwarding Media cards to deliver scalable performance.

The GRF 1600 supports 16 Gbit/s of bandwidth and up to 16 media cards. The GRF 400 supports 4 Gbit/s bandwidth and up to four media cards.

Available IP Forwarding Media Cards:
- HSSI (2 ports per card),
- ATM OC-3c (2 ports per card)
- 10/100Base-T (4/8 ports per card)
- FDDI (4 ports per card)
- SONET OC-3c (PPP and Frame Relay; 1 port per card; supports APS 1 + 1 Architecture Switching),
- ATM OC-12c (1 port per card)
- HIPPI (1 port per card)

Routing Protocol Support:
- EGP, OSPF, BGP3 / 4
- BGP4 features (Route Reflection, MEDs, Communities, DPAs, Flat Route Dampening, Weighted Route Dampening, Confederations, NextHop Self, Static Routing as an IGP)
- OSPF Multicast, IP Multicast, Integrated IS-IS

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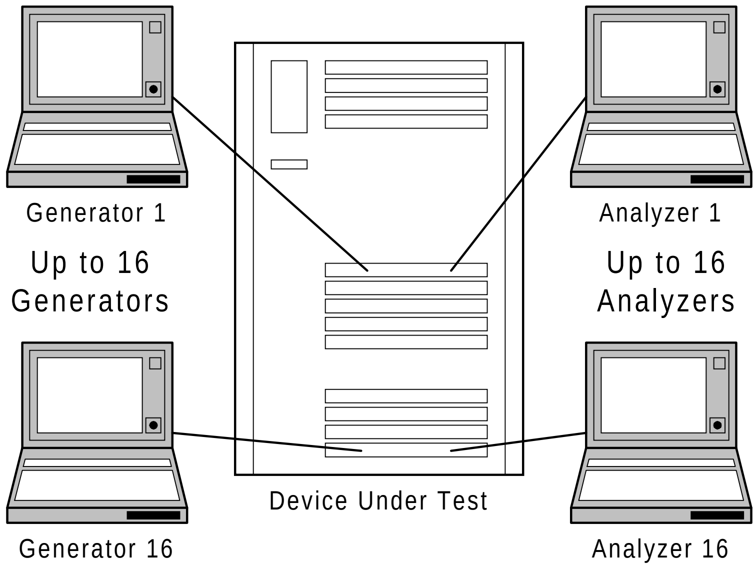
**Vendor-supplied information not verified by The Tolly Group*

Test Bed



Source: The Tolly Group, November 1997 *Figure 4*

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

Vendor	Product	Web address
Wandel and Goltermann	DA-30C	http://www.wg.com

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.

The Tolly Group is recognized worldwide for its expertise in assessing leading-edge technologies. By combining engineering-caliber test methodologies with informed interpretation, The Tolly Group consistently delivers meaningful analyses of technology solutions. The Tolly 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.

For more information on The Tolly Group's services, visit our World Wide Web site at ***http://www.tolly.com,*** email to info@tolly.com, call 800-933-1699 or 732-528-3300, or fax 732-528-1888.

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