THE TOLLY GROUP

No. 7263 JANUARY 1997

Ascend Communications, Inc.
MAX 4000
Remote Access Concentrator Performance

Test Summary

Ascend Communications commissioned The Tolly Group to benchmark the performance of three remote access concentrators. The Tolly Group evaluated the Ascend MAX 4000 (version 4.6b and 4.6ci22), the Shiva LanRover AccessSwitch (version 4.5) and the U.S. Robotics Total Control Enterprise Network Hub (version 4.1.3). The Tolly Group measured UDP (Universal Datagram Protocol) performance across an ISDN primary rate interface (PRI) connection for all three devices. Additionally, The Tolly Group measured the UDP performance of the Ascend MAX 4000 across a channelized T1 connection.

The Results

In the test of analog clients, concentrated onto ISDN, testing showed that the aggregate throughput of the MAX 4000 was the closest to the theoretical maximum performance limit of the three remote access concentrators evaluated. Testing also showed that the performance of the Ascend MAX 4000 across an ISDN PRI connection and a channelized T1 connection was virtually the same. Furthermore, the performance recorded for the Ascend MAX 4000 running version 4.6ci22 and version 4.6b was virtually identical.

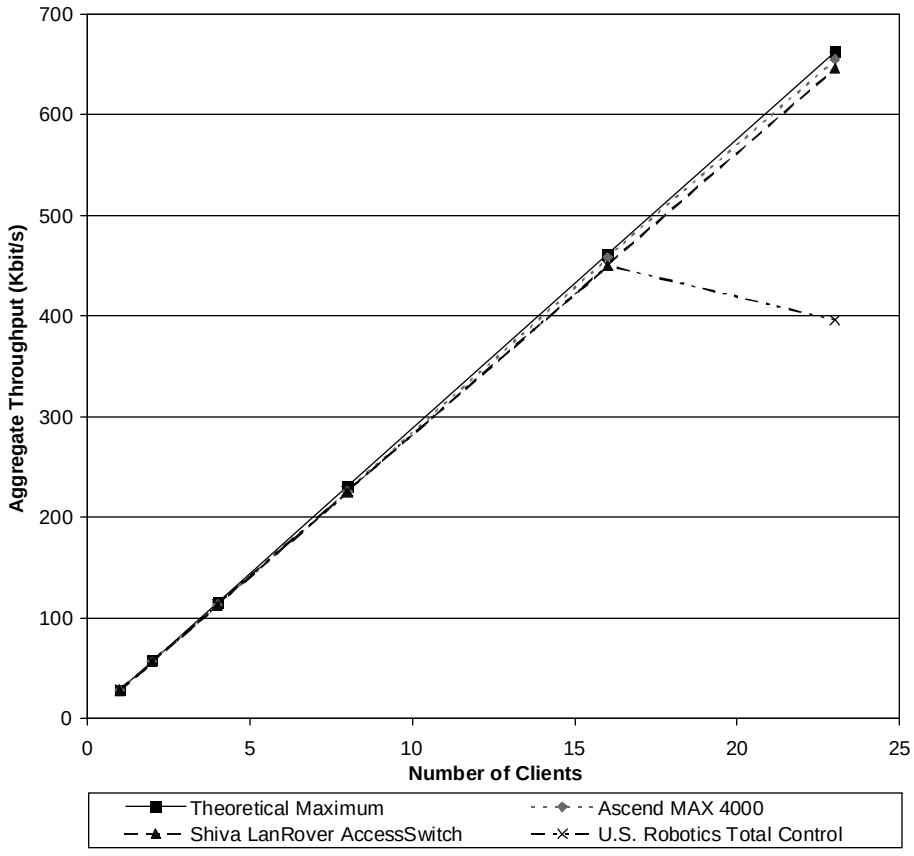
Throughput Across the Primary Rate Interface

Figure 1 shows the results of the PRI performance testing where up to 23 clients (outfitted with 28.8 Kbit/s modems) accessed the device under test via a PBX. The PBX was linked to the device under test (remote access concentrator) by a single ISDN PRI connection. The aggregate performance of the Ascend MAX 4000 ranged from 28.4

Test Highlights

- The Ascend MAX 4000's aggregate throughput is closer to the theoretical maximum than the Shiva LanRover AccessSwitch or the U.S. Robotics Total Control Enterprise Network Hub.
- The Ascend MAX 4000 exhibits consistent performance across both ISDN PRI and channelized T1 links.

Aggregate Client-to-Server Throughput
28.8-Kbit/s Analog Modems via an ISDN PRI



Source: The Tolly Group, January 1997

Figure 1

Kbit/s for one session to 654.9 Kbit/s for 23 sessions, the highest for all the products tested. The theoretical maximum throughput across the PRI connection is 662.4 Kbit/s. (The theoretical maximum throughput for this PRI test is limited by the fact that only 23 connections can be made simultaneously. In the testing, each of those connections was limited to 28.8 Kbit/s since all compression was disabled. Twenty three simultaneous 28.8 connections set a theoretical throughput limit of 662.4 Kbit/s.)

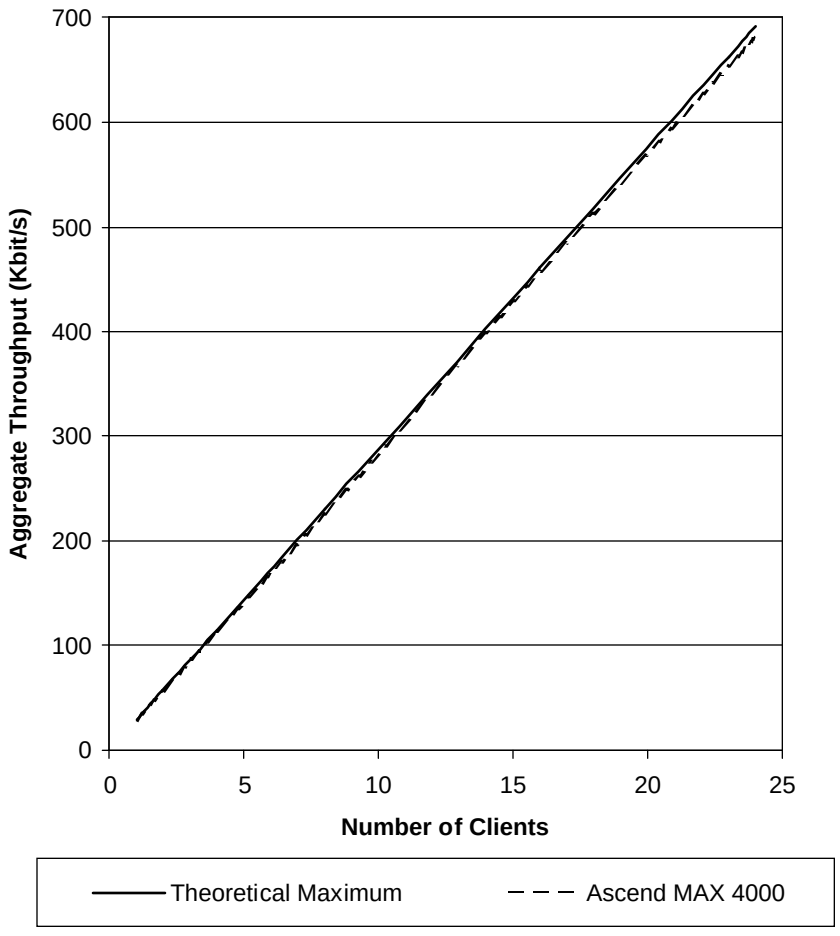
Shiva's LanRover AccessSwitch ranked next delivering 646.3 Kbit/s across the PRI connection. The U.S. Robotics Total Control Hub achieved an aggregate throughput of only 395.7 Kbit/s with 23 client sessions running. Examination of individual client station throughput results revealed that throughput was distributed unevenly. Sixteen clients continued to send traffic at speeds in excess of 20 Kbit/s each, while the remaining 7 clients appeared to stall. Traffic rates for those clients averaged less than 11 Kbit/s each. To determine whether physical memory of the U.S. Robotics Total Control Hub might be the bottleneck, the RAM of that unit was increased to 16 MB. The performance remained the same. Figure 2 shows all the PRI performance results in tabular format.

Aggregate Client-to-Server Throughput
28.8-Kbit/s Analog Modems via an ISDN PRI (Kbit/s)

Number of Clients	Theoretical Maximum	Ascend MAX 4000	Shiva LanRover AccessSwitch	U.S. Robotics Total Control
1	28.8	28.37	28.15	28.44
2	57.6	56.74	56.26	56.38
4	115.2	113.00	112.53	113.12
8	230.4	225.64	225.05	225.77
16	460.8	457.96	450.10	450.46
23	662.4	654.86	646.30	395.74

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

Aggregate Client-to-Server Throughput
28.8-Kbit/s Analog Modems via a T1



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

Throughput across the T1 Connection

Only the Ascend MAX 4000 was evaluated across the channelized T1 connection. Figure 3 shows the performance of the MAX 4000 compared to the theoretical limit for the T1 connection. Since it is possible, when connecting over a single T1, to have only 24 simultaneous 28.8 Kbit/s connections, and compression was not utilized, the theoretical maximum for aggregate throughput is 691.2 Kbit/s. The MAX 4000 achieved 653.5 Kbit/s at 23 client sessions and 681.0 Kbit/s at 24 client sessions (only 10.2 Kbit/s below the theoretical maximum). Figure 4 shows the tabular results of the T1 performance test for the MAX 4000.

Test Methodology

The tests measured the client/server throughput of remote node PC clients performing IP UDP transfers to a central server.

The tests showed the aggregate throughput of PCs communicating

Aggregate Client-to-Server Throughput
28.8-Kbit/s Analog Modems via a T1 (Kbit/s)

Number of Clients	Theoretical Maximum	Ascend MAX 4000
1	28.8	28.37
2	57.6	56.62
4	115.2	113.12
8	230.4	225.65
16	460.8	457.02
23	662.4	653.46
24	691.2	680.99

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

Ascend Communications, Inc.

MAX 4000

Performance

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through a remote access concentration device to a central server over a 28.8 Kbit/s analog phone connection using UDP. Results were recorded in bytes/s and are presented as total uni-directional throughput (to the server) in Kbit/s.

For each data point, (tests were run using 1, 2, 4, 8, 16, & 23 PCs) each client logged into the central server via Dial-up Networking. One application was used throughout the testing, a UDP traffic generator that runs in a DOS window under Microsoft Windows 95™ and Microsoft Windows NT™. A Network General Expert Sniffer reported that the application generated 298 byte UDP frames with a 60 msec delay between frames.

Once the client logged in, the UDP traffic generator was initiated. When all clients were running the application and steady state throughput was determined, a network trace using a Network General Expert Sniffer located on the central Ethernet LAN was recorded. The trace provided cumulative bytes captured, relative time, average frames per second and the total time of the trace. The analyzer was also used to verify the number of active connections during the test. (If one or more of the clients stopped generating traffic, the client was restarted and the test was rerun.) The time of the trace was limited by the buffer size of the analyzer, and was approximately 30 seconds under medium network load. The shortest sample time used to analyze the data captured by the Sniffer was 10 seconds.

Aggregate throughput was measured as the total uni-directional bytes transferred to the server over the sample time (in seconds). There was no bi-directional traffic created by the UDP traffic generator. Aggregate Kbit/s per second was calculated by dividing the cumulative bytes recorded by the length of the frame capture (in seconds), multiplying by 8 bits/byte and dividing by 1,000.

The test was repeated using the next greater number of clients, until the maximum number of clients to be tested were used or until any Dial-up networking sessions timed out. Throughput measurements were taken with all compression disabled on the concentrator under test, the remote clients, and the modems.

Test Bed

The test bed consisted of a Windows NT 4.0 server connected to a central Ethernet LAN. 24 Windows 95 Client PCs connected to Practical Peripheral 28.8 modems (one per PC) simulated remote clients dialing into the central LAN. The 24 Client PCs, dialed the system under test through a Lucent Definity PBX. The remote access concentrator device under test was connected to the server on the central LAN via

Ascend Communications, Inc.
MAX 4000
Product Specifications*

The MAX 4000 series of WAN access switches is designed for remote networking applications. Supports ISDN BRI (up to 32), ISDN PRI (up to four), T1/E1 (up to four) and one Ethernet on the base unit. Allows simultaneous calls (up to 96 domestic, 120 international) from ISDN BRI, Frame Relay and/or analog modem users over ISDN PRI, channelized T1/E1 or ISDN BRI lines.

LAN protocol support: TCP/IP, IPX

Routing protocol support:
AppleTalk, BCP bridging, RIP, RIP2, OSPF (IP only), IGMP multicast forwarding

Bandwidth management support:
Multilink PPP, Multilink Protocol Plus, TCP header compression, Data compression, AppleTalk Remote Access

Security support:
Secure Access ™ Firewall (dynamic, fully-integrated), Ascend Access Control ™ (RADIUS), TACACS+, PAP, CHAP, CLID, Packet filtering, SNMP, User authentication

Additional information/features:
The MAX 4000 series contains six expansion slots. It also supports a wide range of modem and WAN protocols as well as multimedia support.

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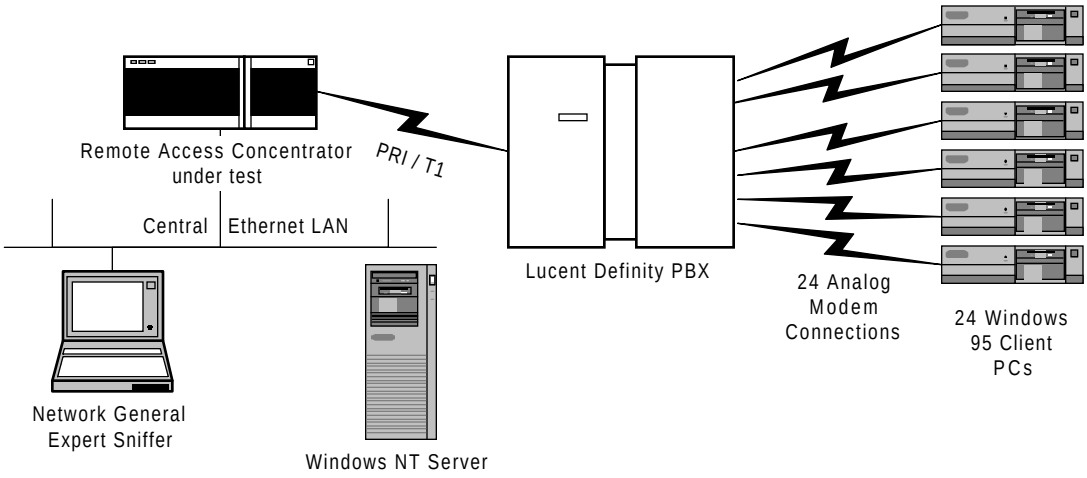
**Vendor-supplied information not verified by The Tolly Group*

Test Bed
UDP Performance Testing with up to 24 Remote Clients



Source: The Tolly Group, January 1997

Figure 5

an Ethernet switch. A network analyzer was connected to the Ethernet LAN between the system under test and the Windows NT Server™, using an Ethernet concentrator. The clients were set up for IP networking and all clients were configured identically.

For the purposes of determining raw packet throughput, compression must necessarily be disabled. The UDP frame generator being used to create the client to server traffic was sending highly compressible data and using it with compression enabled would have resulted in completely erroneous data. Each client had IP header compression (VJ Header Compression) as well as data compression disabled. The modems were configured with AT command string %C0 in their initialization string so as to totally disable all modem based compression.

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 including networking, multimedia, and messaging. 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 100 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 908-528-3300, or fax 908-528-1888.

Tolly Group doc. 7263 rev. 28Jan97