THE TOLLY GROUP

No. 200208 April 2000

Alcatel
OmniCore 5022, OmniPCX 4400, OmniStack 6024
IP Quality-of-Service Evaluation

Test Summary

Premise: *Network shops looking to consolidate voice and data services through packet telephony, especially Voice over IP (VoIP), have legacy, circuit-based analog systems that must be integrated successfully with IP infrastructures. Any such packet-based voice solutions must transcend simple connectivity and must instead, deliver Quality-of-Service (QoS) guarantees that ensure acceptable data transaction rates and voice quality even in severely congested networks.*

Alcatel commissioned The Tolly Group to evaluate the capabilities of its OmniCore 5022 Routing Switch, OmniPCX 4400 (a multi-application VoIP server with integrated H.323 and VoIP gateway functionality), and the OmniStack 6024 (a Layer 2 10/100 Mbit/s Fast Ethernet switch) in VoIP quality-of-service tests. Engineers tested the devices for QoS effectiveness for VoIP in several scenarios, including "severe traffic congestion." Testing also demonstrated that with the benefit of the OmniCore 5022s, the network can allocate adequate bandwidth to voice with high-transaction and moderate-transaction volumes of mission-critical application traffic even during severe congestion.

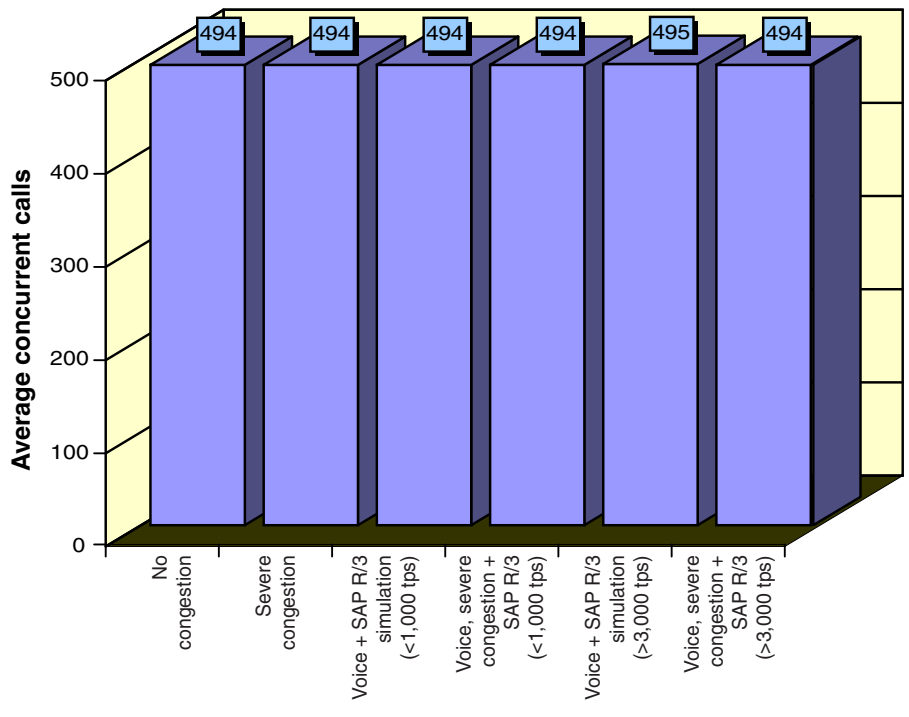
Note: The voice streams used in the aforementioned tests were compressed using A-law. The devices under test were evaluated in A-law and μ-law compression[1] configurations for voice quality. Testing was performed in March 2000.

Test results show that the OmniCore 5022 switch in conjunction with the OmniPCX 4400 and the OmniStack 6024, effectively

Test Highlights

- Preserves call processing throughput even during extended periods of severe network congestion
- Guarantees mission-critical application performance in a severely congested network
- Provides business-quality audio for circuit-based and VoIP calls as deemed by The Tolly Group

Effect of QoS on VoIP Volume Under Various Congestion Conditions



Source: The Tolly Group, April 2000 *Figure 1*

deliver QoS, thus guaranteeing the quality of voice traffic — even during periods of heavy congestion. Furthermore, the compressed voice streams used in the test were rated at an average mean opinion score (MOS) of 4.5 when converted from Hammer Technologies' Perceptual Speech Quality Measurement (PSQM) — a score that well exceeds The Tolly Group's business quality audio[2] recommendations which define "good voice quality" at a MOS of 4.0 or better.

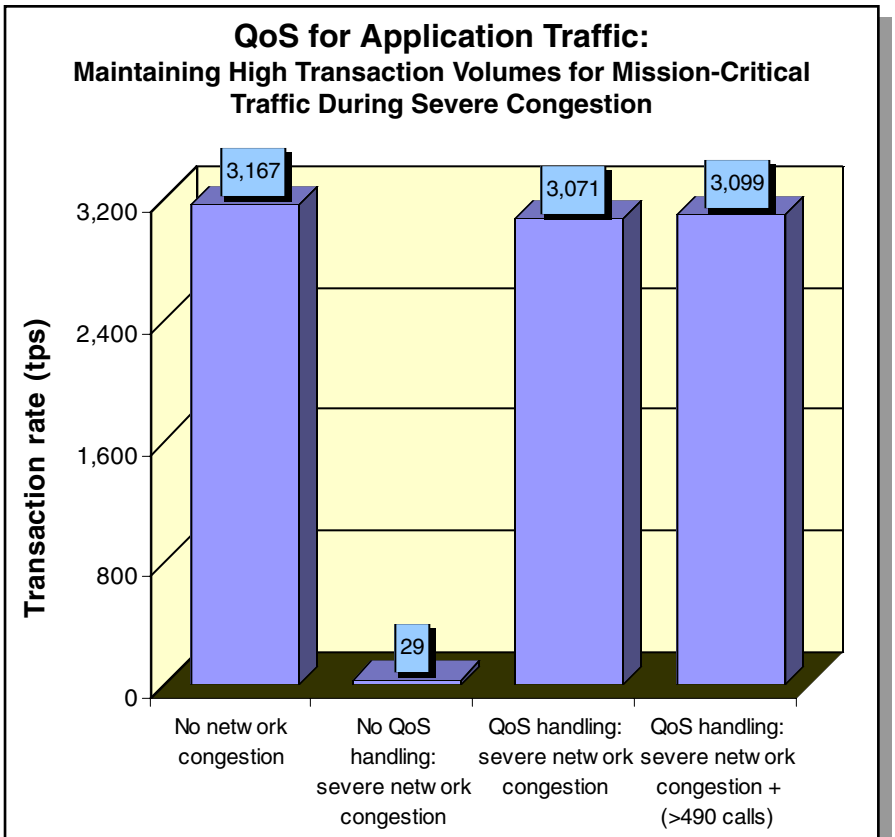
Results

QoS for Voice Over IP

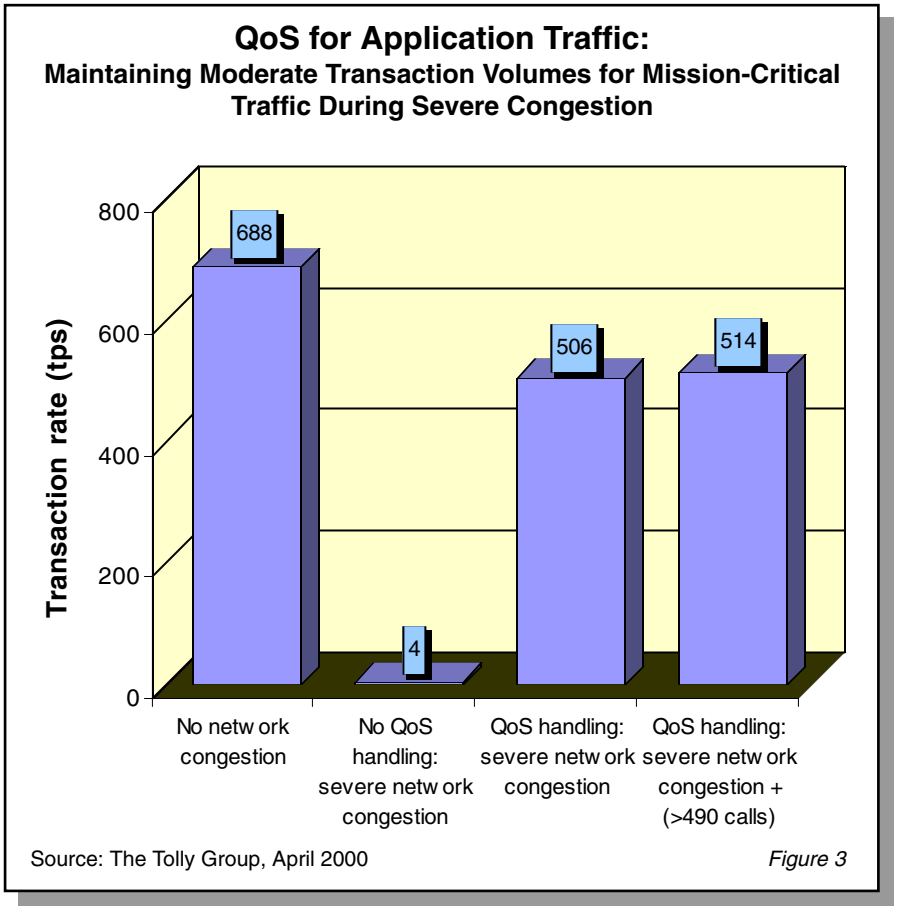
When engineers tested the QoS features of the OmniPCX 4400, the OmniCore 5022 and the OmniStack 6024 in VoIP tests, results demonstrated that the simulated network sustained 9,600 calls per hour. Furthermore, tests show that in tests of 500 concurrent calls, even with severe traffic congestion, in six different traffic scenarios, the network maintained the call volume. See figure 1.

QoS for Mission-Critical Applications

Engineers also tested the transaction rates of the simulated network with all three Alcatel products for mission-critical traffic during severe congestion. With high transaction volumes from 32 simulated sessions of mission-critical traffic, the network maintained 3,099 tps while QoS was active across all Alcatel products. See figure 2.



Source: The Tolly Group, April 2000 *Figure 2*



Source: The Tolly Group, April 2000 *Figure 3*

1 A-law (Europe) and μ-law (North America) are compression techniques based upon a technique called companding. Companding is the process of compressing the amplitude range of a signal for economical transmission and then expanding it back to its original form at the receiving end.

2 The Tolly Group has coined the term "business-quality audio" to refer to telephony audio quality that is appropriate for business telephone communications. The Tolly Group proposes that good business-quality audio is equivalent to a MOS score of approximately 4.0 or better. MOS scores are assigned as follows: 5.0 = "Excellent," 4.0 = "Good," 3.0 = "Fair," 2.0 = "Poor," 1.0 = "Bad."

Engineers also tested the QoS transaction volumes for mission-critical application traffic during severe congestion with moderate transaction volumes (four simulated sessions of mission-critical traffic) and found that the network delivered 514 tps. See figure 3.

Voice Quality

When measuring the quality of voice connections across an inter-switch backbone during network congestion — using A-law and µ-law compression techniques — with the OmniCore 5022, OmniPCX 4400 and the OmniStack 6024, results show a MOS of nearly 4.5, which demonstrates that the audio clarity is excellent as measured on the MOS scale. See figure 4.

Analysis

With packet telephony becoming more prevalent in the networking industry today, customers are investigating how they can migrate from legacy, circuit-based voice systems onto IP infrastructures and maintain acceptable voice quality traditionally offered through PBXs. When voice is packetized and made to share a transport with other unknown, unpredictable data traffic, top notch QoS is required to "protect" the voice traffic. Needless to say, the dual requirement to deliver business-quality voice and acceptable response times across potentially congested networks poses a considerable technical challenge. It is, therefore, not surprising that customers are reluctant to exchange the reliability and scalability of their current legacy systems for the uncertainty of newly-emerging packet-based voice solutions. Rather, the decision to initiate such a migration is often predicated upon successful proof-of-concept testing and benchmarking. Only after such integrated solutions have survived rigorous "worst-case" evaluations can customers be asked to trust the reliability and scalability of packet-based voice solutions.

Alcatel

OmniCore 5022, OmniPCX 4400 and OmniStack 6024

VoIP Quality-of-Service Evaluation

Alcatel
OmniCore 5022, OmniPCX 4400 and OmniStack 6024
Product Specifications*

OmniCore 5022
Description
- Backbone switch that supports converged voice, video, and data networks

Features
- Switching performance of 52 Gbit/s
- IP/IPX routing up to 37 Mpps
- Wirespeed QoS and access list filtering
- True Layer 2, 3, 4, and 7 packet classification, can probe 256 bytes at wire speed
- Embedded QoS mapping techniques between Layer 2 and 3 signaling for multi-vendor environments
- Parallel access shared memory to distribute buffers where and when needed

OmniPCX 4400
Description
- World's most advanced IP-based PBX

Features
- 50 to 50,000 users
- 99.999% reliability
- One-number mobility
- Unified messaging
- Voice over IP with quality of service management
- Web-based customer contact center

OmniStack 6024
Description
- Low-cost wire-speed switch for networks supporting voice/data/video traffic

Features
- 24-port 10/100 Ethernet switch with uplink options; can be stacked four high
- Optional slots for stacking modules, and fiber-optic Fast and Gigabit Ethernet uplink modules
- Four Gbit/s stacking connections ensuring high performance for the entire stack

Advanced Reflexes
Description
- Digital telephones designed to make communications more efficient

Features
- Intuitive user interface and voice prompts guide you through features
- Embedded keyboard allows dial-by-name
- Plugware allows easy upgrade to IP phone

For more information contact:

Vendor: Alcatel
Address 26801 West Agoura Rd.
Calabasas, CA 91301
Phone: (818) 878-3500
Fax: (818) 880-3505
URL: http://www.alcatel.com

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

The OmniCore 5022, in conjunction with the OmniPCX 4400 and the OmniStack 6024, successfully demonstrated their capabilities to handle QoS effectively and ensure delivery of mission-critical applications during congestion. Transaction rates remained virtually unchanged during high transaction volumes and during congestion.

Customers also need to expect superior call quality and call volumes regardless of whether connections are made with traditional, PBX or IP telephones. Furthermore, customers should have the same quality whether the backbone is lightly or heavily congested and regardless of compression technique (A-law or µ-law).

During voice quality tests, the Alcatel OmniCore 5022, OmniPCX 4400 and OmniStack 6024 demonstrated a MOS of nearly 4.5; this exceeds The Tolly Group's business-quality audio recommendations of a MOS of 4.0 or better for acceptable quality audio.

Business-Quality Audio:
Greater Than or Equal to Four

	A-law compression	µ-law compression
Qos	✓ Pass	✓ Pass
No Qos	✓ Pass	✓ Pass

Source: The Tolly Group, April 2000

Figure 4

Test Configuration and Methodology

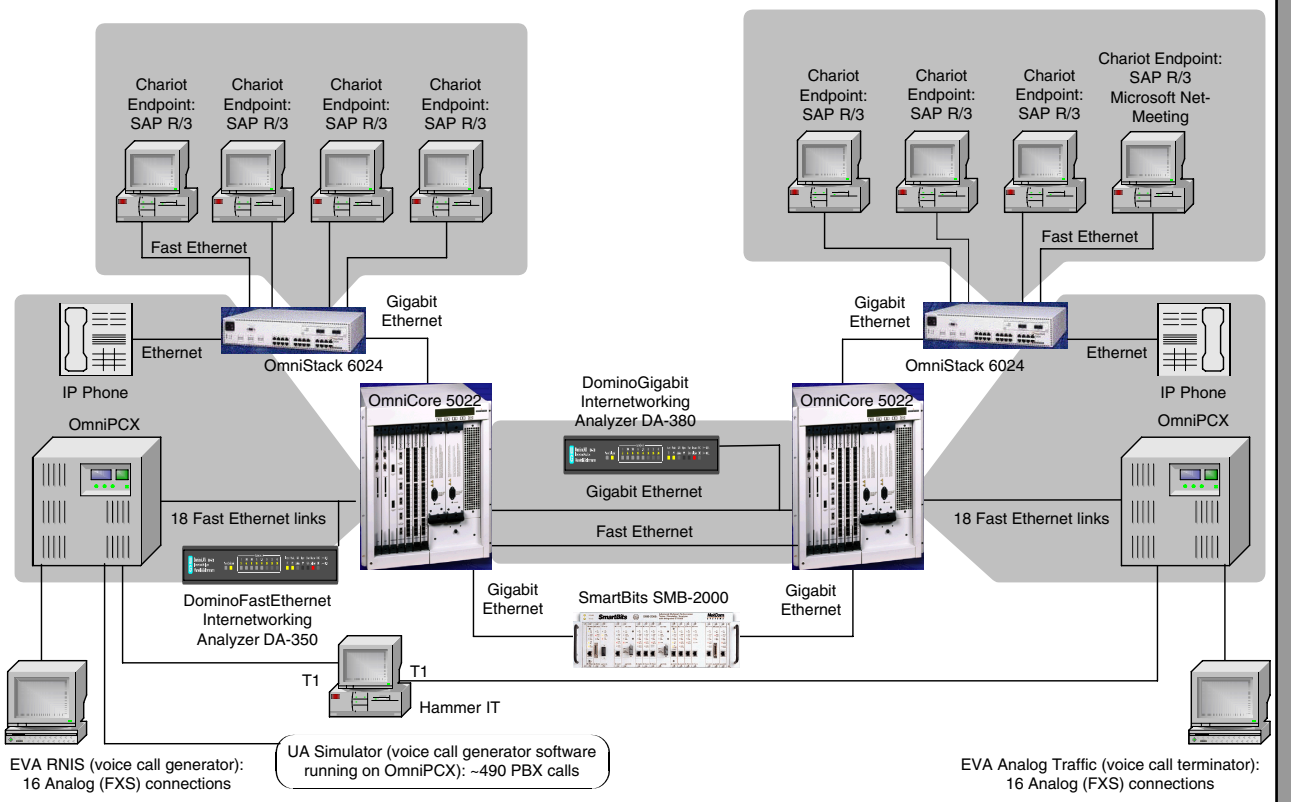
The test bed consisted of the following systems under test: two Alcatel OmniCore 5022 Routing Switches with Fast Ethernet and Gigabit Ethernet interfaces, both model PE-301 version 2.7.0r16 equipped with 64 Mbytes of RAM; two Alcatel OmniPCX 4400 VoIP and H.323 gateways; and two OmniStack 6024 switches. Each OmniPCX 4400 housed 18 VoIP gateways but for the purposes of these tests, only 17 were utilized. All models were LioE and each supported 30 connections over a single Fast Ethernet connection. Alcatel's UA Simulator version 4.0, a proprietary call generation tool, was running on the UA 32 modules.

The backbone of the testing network consisted of a full-duplex Fast Ethernet and a full-duplex Gigabit Ethernet connection between a pair of OmniCore 5022s. For any given test, only one of the links was active. The first connection, Gigabit Ethernet LAN, was connected to a Wavetek Wandel Goltermann DominoGigabit DA-380 version 2.5 to capture network traces. The second, Fast Ethernet LAN, was connected to a Wavetek Wandel Goltermann DominoFastEthernet Internetworking Analyzer DA-350 version 2.5 to capture network traces. The Tolly Group also connected a Netcom Systems, Inc. SmartBits 2000 Advanced Multiport Performance Tester/Analyzer/Simulator version SmartWindows 6.52, firmware 6.22 0012, and Gigabit Ethernet (GX-1405b) firmware 2.23.001 to a Gigabit Ethernet interface on each of the two OmniCore 5022s to introduce backbone congestion. The SmartBits console was running on a 550-MHz Compaq Computer Corp. Professional Workstation AP400 running Microsoft Windows NT Workstation 4.0 Service Pack 5 and equipped with 128 Mbytes of RAM and a Compaq NC3161 Fast Ethernet network interface controller in a PCI bus configuration.

Two Alcatel OmniStack 6024s 10/100/1,000 Mbit/s hybrid Ethernet switches provided Layer 2 connectivity between LAN-attached devices and the two OmniCore 5022s. The LAN-attached devices included two Alcatel Advanced Reflexes IP telephones (equipped with Ethernet interfaces) and eight 550-MHz Compaq Professional Workstation AP400 Intel Pentium IIs running Ganymede Software, Inc. Chariot Endpoint version 3.4 application traffic generators configured for SAP R/3 and equipped with Compaq NC3161 Fast Ethernet NICs. Additionally, engineers configured Microsoft NetMeeting videoconferencing application version 2.11 running on a 550-MHz Compaq Professional Workstation AP400 Intel Pentium II equipped with 128 Mbytes of RAM and a Compaq NC3161 Fast Ethernet NIC, running Microsoft Windows NT Workstation 4.0 Service Pack 5; this NetMeeting station initiated calls to, and accepted calls from, a Reflexes IP telephone.

The Tolly Group controlled Chariot sessions with a Chariot Console running Chariot 3.1 on a 450-MHz Modulux SuperPower Intel Pentium II with 256 Mbytes of RAM and a PCI bus with a 3Com Corp. 3C90x Fast Ethernet Network Interface Card and Microsoft Windows NT Workstation 4.0 Service Pack 4.

An NMG Telecom (formerly Clemessey) Analog Call Generator EVA RNIS equipped with two four-port analog interface modules running version 2.0 connected to one of the OmniPCX 4400s through a Z24 24-port analog card. The analog call generator platform ran Microsoft Windows NT 4.0 Workstation SP 5 and was equipped with 128 Mbytes of RAM. A Wavetek Wandel Goltermann DominoFastEthernet



Source: The Tolly Group, April 2000

Figure 5

Internetworking Analyzer DA-350 collected network traces between this OmniPCX 4400 and one of the OmniCore 5022s across one of 18 Fast Ethernet links. The Domino console ran on a 300-MHz Dell Computer Corp. Intel Pentium II equipped with 64 Mbytes of RAM and a 3Com Corp. 3Com Megahertz CardBus PC 10/100 Mbit/s Ethernet NIC, running Microsoft Windows NT Workstation 4.0 SP5.

The other OmniPCX 4400 was connected on one end to a NGM Telecom Analog Call Receiver model Eva Analogique Traffic version 1.02 running Microsoft Windows 3.11 Workstation with 16 Mbytes of RAM. The OmniPCX 4400 connected to the other OmniCore 5022 via 18 Fast Ethernet links.

Finally, a Hammer Technologies, Inc. Hammer IT model HIT-30E-11 version 2.4 voice call generator and tester was connected to both OmniPCX 4400's DPT1 cards via a pair of T1s provided by the test equipment. The Hammer IT generated one call at a time. The Tolly Group captured the average reported PSQM results after at least 90 successful measurements had been completed. See figure 5.

For voice quality and prioritization of mission-critical data performance during congestion tests, The Tolly Group removed the Fast Ethernet backbone and replaced it with a Gigabit Ethernet backbone between the OmniCore 5022s.

Congestion traffic consisted of a stream of 1,518-byte IP packets (including CRC) generated at 100% of the theoretical maximum bandwidth (i.e., 81,274 packets per second) by a pair of Netcom Systems GX-1405b 1000Base-SX modules within the SmartBits SMB-2000 chassis. When the OmniCore added VLAN header information, the resulting packet size increased to 1,522 bytes.

The Tolly Group generated 490 to 500 concurrent calls generated by the UA Simulator from Alcatel, running on the UA 32 modules within one of the two OmniPCXs. Each of 17 LioE supported 30 connections, and the test tool maintained each connection for 220 seconds before disconnecting it. This resulted in 510 calls initiated every 220 seconds. This equates to a call rate of approximately 2.3 calls per second, 139 calls per minute, or 8,345 calls per hour.

Additionally, The Tolly Group used EVA RNIS from NMG Telecom, an analog call generator/simulator, to generate 16 analog calls at a rate of

1,182 calls per hour. The combination of calls from EVA RNIS and UA Simulator together generated a calling rate of 9,527 calls per hour.

The Tolly Group traced traffic (a) between the Chariot Endpoint 1 and the OmniStack 6024 to which it was directly attached via a full-duplex Fast Ethernet connection, and (b) between two OmniCore 5022 switches connected over a single full-duplex Gigabit Ethernet link.

The Tolly Group also verified that, when prioritization was disabled for voice traffic, (a) the rate of calls completed with µ-law dropped only slightly, but call quality was poor as observed by two observers communicating between UA telephones across the backbone, and (b) the quality of calls completed with A-law effectively remained unchanged but the number of concurrent calls connected dropped by as little as one.

The transaction volume (i.e., <1,000 transactions per second for a "moderate network load") is given as the maximum transaction rate of the test application across the test network in the absence of congestion. The Tolly Group simulated a medium transaction volume with four Chariot "pairs" consisting of four simulated servers (one "endpoint" on each of four servers) communicating with four simulated "clients" (one "endpoint" on each of four workstations). The Tolly Group simulated a large transaction volume with 32 Chariot "pairs" consisting of 32 simulated servers (eight "endpoints" on each of four servers) communicating with 32 simulated "clients" (eight "endpoints" on each of four workstations).

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

Vendor	Product	Web address
Alcatel	UA Simulator	http://www.alcatel.com
Ganymede Software, Inc.	Chariot Endpoint	http://www.ganymedesoftware.com
Hammer Technologies, Inc.	Hammer IT	http://www.hammer.com
Netcom Systems, Inc.	SmartBits 2000	http://www.netcomsystems.com
NMG Telecom	Analog Call Generator EVA RNIS	http://www.nmg.fr/
NMG Telecom	Analog Call Receiver	http://www.nmg.fr/
Wavetek Wandel Goltermann	DominoFastEthernet DA-350	http://www.wwg.com
Wavetek Wandel Goltermann	DominoGigabit DA-380	http://www.wwg.com

Since its inception, The Tolly Group has produced high-quality tests that meet three overarching criteria: All tests are objective, fully documented and repeatable.

We endeavor to provide complete disclosure of information concerning individual product tests, and multiparty competitive product evaluations.

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Project Profile

Sponsor: Alcatel
Document number: 200208
Product class: Voice over IP switches and gateways
Products under test:

- OmniCore 5022
- OmniPCX 4400
- OmniStack 6024

Testing window: March 2000
Software status:

- Generally available

Additional information available:

- Configuration files

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