Network World Clear Choice Test: WAN Acceleration
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Test Methodology

A PDF version of this document is available here:
http://networktest.com/wa07/wa07meth.pdf

1 Executive Summary

This document describes benchmarking procedures for WAN acceleration devices. Test results are tentatively scheduled for publication in Network World in August 2007.

Given that Network World's readership is comprised largely of corporate network managers, a key focus of these tests will be suitability of WAN acceleration devices for use in enterprise settings. These tests will assess devices using the following metrics:

- Functionality (20% of total scoring)
- Manageability (20%)
- Performance (45%)
- Usability (15%)

This document is organized as follows. This section introduces the tests to be conducted. Section 2 describes the test bed. Section 3 describes the tests to be performed. Section 4 provides a change log.

2 The Test Bed

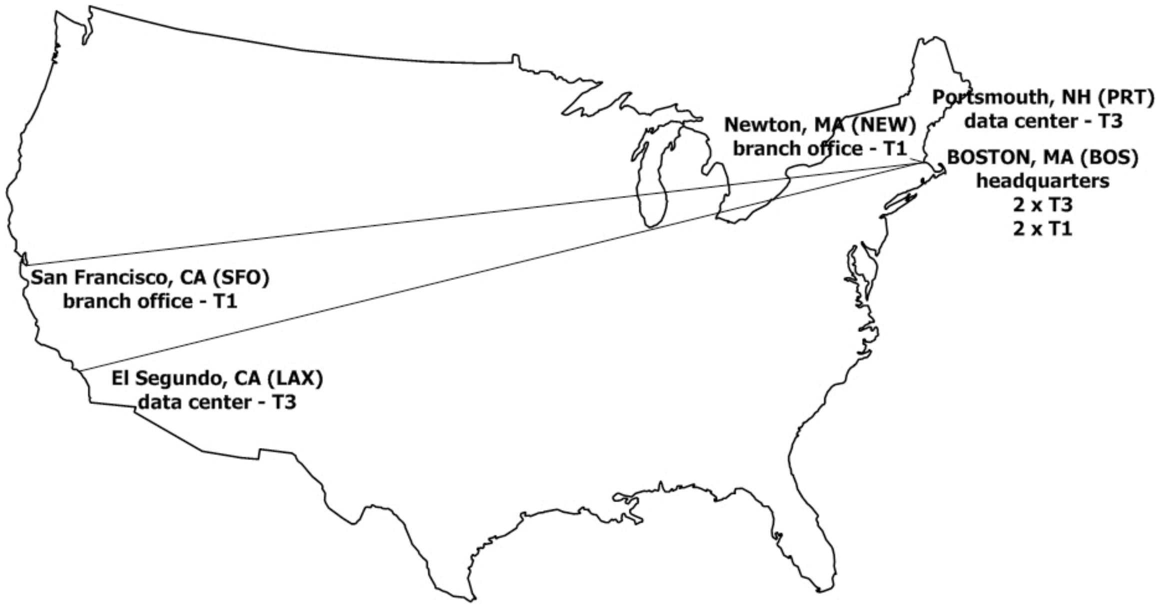
2.1 The Logical Test Bed

To assess the effectiveness of WAN acceleration in an enterprise context, we have constructed a test bed that carries enterprise traffic and simulates many aspects of enterprise WAN behavior.

The figure below illustrates the logical test bed. Bogus Corp. has a hub-and-spoke network connecting its Boston headquarters with data centers in Portsmouth, NH and El Segundo, CA, and branch offices in Newton, MA and San Francisco, CA.

This network covers all four permutations of low and high bandwidth and latency. Dedicated T3 (45-Mbit/s) circuits connect the Boston headquarters with the Portsmouth and El Segundo data centers.[1] The links between the Boston headquarters and the Newton and San Francisco branch offices use a VDSL service rate-controlled at 1.5 Mbit/s.

[1] Note, however, that WAN acceleration device interfaces may be copper gigabit or fast Ethernet, as appropriate.



Application traffic between all offices consists of:

CIFS
MAPI (Exchange servers and Outlook clients)
HTTP
SIP/RTP (for QoS tests)
UDP/IP background traffic (for QoS tests)
HTTPS (optional, see "Optional SSL Handling" below)

2.2 The Physical Test Bed

This section discusses the devices to be used on the test bed.

2.2.1 Device under test/System under test

Each participating vendor is required to supply the following:

- "Headquarters" WAN acceleration device(s) capable of supporting two connections at T3 (45-Mbit/s) rates and two connections at T1 (1.5-Mbit/s) rates. All interfaces should be copper Ethernet

- Two "data center" WAN acceleration devices each capable of supporting one connection at T3 (45-Mbit/s) rates; all interfaces should be copper Ethernet

- Two "branch office" WAN acceleration devices each capable of supporting one connection at T1 (1.5-Mbit/s) rates; all interfaces should be copper Ethernet

- A management system capable of remote configuration and monitoring of all WAN acceleration devices from the headquarters office. Unless you don't care whether we run your management software on a 1989 Compaq 386/25, the management platform should include both hardware and software.

- All relevant documentation for the WAN acceleration and management systems

2.2.2 Network Impairment

WAN links introduce reduced bandwidth and delay. Our test bed recreates these conditions using the Spirent Converged Network Impairment Emulator (SCNIE) between all locations. In addition to standard impairment functions, SCNIE is the first emulator to implement the TIA-921 standard for measured impairments over time. The TIA-921 impairment model is based on actual network conditions measured by service providers.

The following table describes the bandwidth and delay characteristics of each link.

From BOS to...	Bandwidth	Round-trip delay (0.5n applied equally in each direction)	FIFO buffer size (bytes)[2]
POR	45 Mbit/s	15 ms	1,400,000
NEW	1.5 Mbit/s	15 ms	48,000
LAX	45 Mbit/s	100 ms	1,400,000
SFO	1.5 Mbit/s	100 ms	48,000

Note that we introduce bandwidth and delay restrictions only, not packet loss and/or jitter. While these latter two conditions exist on many WAN circuits, developing a meaningful multi-variable model that factors for these conditions would greatly increase the number of test permutations. We hope to model all these factors in future tests, but for now bandwidth and delay will be the factors used in WAN emulation.

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[2] Core routers typically offer at least 250 ms of buffering capacity to deal with transient network congestion. (See, for example, the series of articles on router buffer sizes in the July 2005 issue of ACM SIGCOMM Computer Communications Review.) The FIFO queue sizes here represent 250 ms for each link speed. Failure to define FIFO queuing in the WAN impairment tool may introduce significant and unintended packet loss.

2.2.3 Traffic Generators

We use real Windows servers and clients to offer CIFS, MAPI, and HTTP traffic. The standard server platform is Windows Advanced Server 2003 R2 running IIS6 and Exchange Server 2003. The standard client platform is Windows XP Professional SP2 and Office 2007.

To automate the execution of data transfers, we use Visual Basic scripts custom-developed for this project. Each client runs Microsoft .Net 2.0 and Office 2007 Primary Interop Assemblies (PIA) to support the scripts.

To test TCP connection scalability and generate HTTPS traffic, we plan to use the Spirent Avalanche and Reflector traffic generator/analyzers. Our Avalanche and Reflector appliances can generate up to 4 million concurrent TCP connections. ***Please advise if your system has a higher rated capacity.***

To assess audio quality for VoIP traffic in the QoS tests, we use the GL Communications Voice Quality Testing (VQT) tool suite.

To generate background traffic in the QoS tests, we use the Spirent SmartBits traffic generator/analyzer and Spirent's SmartWindow application.

2.2.4 Optional SSL Handling

A growing number of WAN acceleration devices support optimization of SSL traffic. We plan to conduct performance tests with HTTPS traffic on those devices that support SSL. Not all devices yet support SSL optimization. In the interest of ensuring apples-to-apples comparisons, the main test article will discuss only those features supported by all products. We plan to discuss SSL results in a sidebar article accompanying the main test.

2.2.5 IPv4 Addressing

Vendors MAY, at their option, configure their devices to serve as routers at each location. If not, we will provide line-rate devices to route traffic between sites.

Some WAN acceleration devices function as proxies and require IP addresses; others are passive and do not. In either cases, each device also requires an IP address for device management. We provide addressing guidelines in the following table. ***Please let us know if your device does not meet these addressing requirements.***

Site	Inline interface (if needed)	Management address	Management console	Default gateway
Headquarters (BOS)	10.0.0.2/24	10.0.0.3/24	10.0.0.10/24	10.0.0.1/24
Data center (PRT)	10.1.0.2/24	10.1.0.3/24	10.0.0.10/24	10.1.0.1/24

Branch office (NEW)	10.2.0.2/24	10.2.0.3/24	10.0.0.10/24	10.2.0.1/24
Data center (LAX)	10.3.0.2/24	10.3.0.3/24	10.0.0.10/24	10.3.0.1/24
Branch office (SFO)	10.4.0.2/24	10.4.0.3/24	10.0.0.10/24	10.4.0.1/24

3 Test procedures

This section describes procedures used to assess devices in terms of functionality, manageability, performance, and usability.

3.1 Functionality

Given that not all WAN acceleration devices work the same way, our assessment of WAN acceleration functionality will attempt to provide a taxonomy of device features. The questions we plan to answer in assessing functionality include the following:

- Does the DUT sit inline or out of the traffic path?
- Does the DUT compress traffic in flight?
- What layer-7 traffic types can the DUT identify?
- What QoS methods does the DUT support for traffic classification and prioritization?
- Can the DUT automatically learn and classify different application types?
- Can the DUT automatically learn and classify application types that dynamically negotiate port numbers, such as H.323 and SIP? If so, how does any compression performed by the device affect this ability to detect application-layer headers?
- What authentication and encryption methods, if any, does the DUT use to prevent man-in-the-middle attacks and/or alteration of data in flight?
- Does the device accelerate UDP as well as TCP traffic?
- Does the device accelerate SSL traffic? (See "Optional SSL Handling" above; this will be covered in a sidebar article.)
- Does the device support incremental updates, where only changes to a large file or directory structure are transferred? (This is verified in performance testing as well)
- Does the device support redundant connections between sites? If so, are the connections active-active or active-passive? Can the device dynamically allocate traffic onto one link or another depending on link utilization?
- What features does the device offer for scalability, both on a per-device basis and across multiple devices?
- What other high-availability features, if any, does the device offer?

3.2 Manageability

While increased performance is the nominal reason for deploying WAN acceleration devices, the addition of any new platform to the network inevitably raises questions about manageability. While network management is a huge topic, we plan to focus on configuration and monitoring tasks specific to WAN acceleration. Among the management criteria to be evaluated:

- What are the supported device management methods (CLI via ssh, CLI via telnet, Web UI, proprietary UI)?
- What are the supported centralized management methods (element manager, integration into SNMP-based NMS, integration into OSS)?
- How well does the product support centralized configuration management?
- How well does the product support centralized management of multiple devices?
- How well does the management platform support aggregated logging and reporting from multiple remote acceleration devices?
- Can a single policy configuration change be applied to multiple devices in one operation?
- What traffic reporting tools does the management system offer?
- Does the management system support partitioned and delegated management, where different classes of managers have different privilege levels?
- Does the management system provide "if-then" capability, where it can dynamically configure devices to assign higher or lower priority to a given traffic class in response to some administrative or network event (i.e., prioritize a given video stream during a companywide address by the CEO)?

3.3 Performance

While functionality, manageability, and usability are all important criteria in selecting a WAN acceleration device, improving performance is *the* key attraction. We assess device performance in several ways, measuring latency and bandwidth reduction, QoS handling, and concurrent connection scalability.

Traffic types are:
CIFS (File transfers and directory listings)
MAPI (Outlook and Exchange)
HTTP (Home pages of amazon.com, boston.com, caltech.edu, cnn.com, and news.bbc.co.uk)
SIP/RTP voice over IP traffic (used only in QoS tests)
UDP/IP background traffic (used only in QoS tests)
HTTPS (optional, if supported)

3.3.1 Delay and bandwidth reduction

For each of the traffic types above except VoIP, we will measure the effective reduction in delay and bandwidth.

All tests run concurrently between the Boston headquarters and the four branch sites.

3.3.1.1 CIFS-Pull and CIFS-Push

The CIFS tests involve the transfer of 750 Word 2003 (not Word 2007) files per each of two clients at each T3 site and 25 Word 2003 files per each of two clients at each T1 site. The Word files range in size from roughly 25 kbytes to 1 Mbyte. The file contents are "words" comprising random characters, with a random word length averaging approximately five characters.

Clients concurrently run a "CIFS-Pull" and "CIFS-Push" test in which they download and upload files, respectively, from a server in Boston.

In the CIFS-Pull case, clients perform the following operations:

1. Map a drive to a server directory
2. Delete all files from a local "PullTest" directory
3. Delete the local "PullTest" directory
4. Create a new local "PullTest" directory
5. Copy Word files from the mapped server drive to the new PullTest directory (750 files for clients on T3 links, 25 files for clients on T1 links)

In the CIFS-Push case, clients perform the following operations:

6. Map a drive to a server directory (this is a different drive letter than in the CIFS-Pull case)
7. Delete all files from a given server directory
8. Delete the server directory
9. Create a new directory on the server
10. Copy Word files to the new server directory (750 files for clients on T3 links, 25 files for clients on T1 links)

We run the CIFS tests a total of four times:

1. Baseline test with no acceleration enabled and no DUT inline
2. Acceleration enabled, a "cold" run to allow the DUT to learn the traffic pattern and possibly cache data
3. Acceleration enabled, a "warm" run after the DUT has learned the traffic pattern and cached data
4. A "10 percent" run in which 10 percent of the files to be transferred have been changed

3.3.1.2 MAPI

In the MAPI tests, Outlook 2007 clients on T3 links create 240 messages of random length and with a random number of Word 2003 file attachments; for clients on T1 links, each creates 10 messages. All messages are destined to all other clients at all sites.

At test startup, all Outlook clients are in offline mode. A Visual Basic script running on each client causes it to go online, sending all messages to the Exchange server in Boston and then on to their destinations.

3.3.1.3 HTTP

In the HTTP tests, Spirent Reflector emulates Web servers and Spirent Avalanche emulates Internet Explorer Web clients. In all tests, clients retrieve an 11-kbyte object from one of eight Web servers configured at the headquarters site.

We conduct the test twice: once with 248 total users and again with 2,480 total users. The following table lists the distribution of users:

Test	LAX clients	NEW clients	PRT clients	SFO clients
248 total users	120 users	4 users	120 users	4 users
2,480 total users	1,200 users	40 users	1,200 users	4 users

3.3.1.4 HTTPS

The HTTP tests are identical to the HTTP tests except that clients retrieve objects over SSL connections.

Not all devices under test support SSL proxying. Thus, results from this test will appear in a sidebar and will not be used in scoring results.

3.3.2 QoS Handling

In this test we deliberately oversubscribe a link with low-priority UDP/IP traffic while simultaneously attempting to place high-priority VoIP calls. Vendors should *not* use static bandwidth allocation (aka strict priority) to reserve bandwidth for VoIP traffic; the final step of our procedure is a check against TDM-like approaches.

The background traffic consists of UDP/IP packets with a destination port of 111, generated by Spirent's SmartBits traffic generator/analyzer. Note that the packets do not have an NFS header; they are simply correctly formed UDP/IP packets.

Devices *should* use diff-serv code points for prioritization (if supported). Further, devices *should* re-mark all incoming packets with new DSCPs; for this test, assume that the DSCP markings applied by hosts cannot be trusted.

In this test, the WAN acceleration device should re-mark VoIP packets with a DSCP value of 40. The device should re-mark UDP/IP background packets with a DSCP value of 20. We will verify these settings using a protocol analyzer to capture and decode traffic.

This test uses the following procedure:

1. Disable QoS features on the DUTs. Offer high-bandwidth UDP/IP at a rate of 200 Mbit/s and low-bandwidth VoIP traffic (SIP signaling and RTP media traffic). Measure forwarding rates and latency for both UDP/IP and VoIP.
2. Enable QoS features on the DUTs. Offer high-bandwidth UDP/IP and low-bandwidth VoIP traffic (SIP signaling and RTP media traffic). Measure forwarding rates and latency for both UDP/IP and VoIP.
3. Repeat the previous step using only UDP/IP traffic. This is a check against TDM-like bandwidth reservation for VoIP traffic.
4. Repeat the three previous steps for all four links (BOS-PRT, BOS-NEW, BOS-LAX, BOS-SFO).

3.3.3 Concurrent Connection Scalability

This test will determine the maximum number of TCP connections one pair of WAN acceleration devices can handle.

We using the Spirent Avalanche and Reflector test instruments to generate traffic and follow this procedure:

1. Using HTTP 1.1, each client emulated by Avalanche requests a 1-kbyte object from an IIS Web server emulated by Reflector.
2. After receiving the object, the client waits 60 seconds before requesting the next object. This large client-side latency allows the buildup of a large number of concurrent connections between clients and servers.
3. Using the procedure described in the previous step, we ramp up the number of connections made to the servers. Our two pairs of Avalanches and Reflectors can request up to 4 million concurrent connections.

The Avalanche load specification for this test is “connections.” This load profile uses a fairly coarse-grained stair-step pattern, setting up as many as 4 million connection attempts. We attempt to measure to the nearest 1,000 concurrent connections.

The following table lists sample load profile phases for a test with 4 million concurrent connections. Note that the actual counts we use depend on the DUT’s capability.

	Phase 0	**Phase 1**	**Phase 2**	**Phase 3**
Label	Delay	Stair Step	Steady State	Ramp Down
Pattern	Flat	Stair	Stair	Flat
Time Scale	Default	Default	Default	Default
Repetitions	NA	10	1	NA
Height	0	400,000	0	0

Ramp Time	0	300	0	0
Steady Time	8	28	64	16

The metric for this test is maximum concurrent TCP connection capacity, sustained over a 60-second steady-state period.

3.4 Usability

While usability assessments are inherently subjective, we also make an effort to make quantitative as well as qualitative judgments about each DUT's ease of deployment and maintenance. Among the usability criteria we plan to use:

- High-quality documentation in both quick-start and reference areas
- Appliance-style installation for devices, requiring little more than power-on and address assignment to bring up the system
- Autolearning of various application-layer traffic types during initial setup phase
- Multiple language support in device and element management UIs
- Easy classification and prioritization of different traffic types
- Intuitive and useful displays of enterprise-wide tasks, such as a global change in QoS or security settings
- Intuitive and useful displays of system status, including real-time and non-real-time reporting on traffic and acceleration status

Above and beyond these criteria are intrinsically subjective criteria. If it takes us nine steps on each of five menus to perform a task that should be available on one screen, we'll say so. At the same time, we bring no preconceived notions of "good" or "bad" UI designs to this project. In the subjective ratings, like all other tests, the ultimate goal is describing how well the DUT helps the network manager accelerate traffic across the WAN.

4 Change history

Version 2007081301
Test published; changed title to include publication date

Version 2007070301
Section 2.1: Added UDP/IP as background traffic

Section 2.2.2: Deleted jitter from description, noted that WAN impairment tool introduces rate control and delay only

Added FIFO queue values

Section 2.2.3: Deleted LoadSim reference; added reference to Outlook client; deleted Asterisk reference; added references to VB scripts, Office 2007, .Net 2.0, and Office 2007 PIA; added SmartBits reference

Section 2.2.4: Noted that SSL testing will be conducted on all products but not counted in scoring

Section 2.2.5: Changed IPv4 addressing from /24 to /16 at each site

Section 3.3: Added UDP/IP as background traffic

Section 3.3.1: Added detailed descriptions of CIFS-Pull, CIFS-Push, MAPI, HTTP, and HTTPS tests

Section 3.3.2: Changed background traffic from HTTP to UDP/IP from SmartBits

Section 3.3.3: Restated objective as test between single pair of devices; deleted concurrent connection testing between all sites

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