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Enhanced Network Performance with Microsoft Windows Vista and Windows Server 2008

Hands-on testing reveals incentives to upgrade client and server OSes

THE TOLLY GROUP

A white paper commissioned by Microsoft Corp.

White Paper

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THE TOLLY GROUP

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Executive Summary

With the release of the Windows Vista client operating system, and the upcoming release of Windows Server 2008 network managers face the prospect of integrating these next-generation operating systems into their current networks alongside computers running Windows XP and Windows Server 2003. Ultimately, customers will migrate their clients and servers to these new operating systems. Understanding, however, the dramatic network performance benefits that Windows Vista and Windows Server 2008 deliver to clients with the specific issues of low bandwidth and/or high latency will enable network managers to prioritize their deployments to address their most critical problems first.

With the introduction of Windows Vista and Windows Server 2008, Microsoft delivers an update to its TCP/IP networking support that improves the network performance and, ultimately, the end-user experience and productivity of users who require access to resources across wide area and/or local area networks with limited bandwidth (i.e., speed), and/or high delay (latency). Additionally, it could include Fast Ethernet or Gigabit Ethernet (GbE) LAN users in a large campus environment. In this case, while bandwidth is plentiful, the need to traverse many switches, routers, firewalls, etc. can induce delay in the network thus degrading client network performance.

Just upgrading client PCs to Microsoft's Windows Vista can yield throughput and time-to-completion improvements of up to 2.5X over Windows XP. Complete migration of servers to Windows Server 2008 can yield throughput and time-to-completion improvements of up to 3.5X over Windows XP/Windows Server 2003.

To verify the benefits of the improved networking implementation, Microsoft Corporation commissioned The Tolly Group to quantify the improvements in network throughput and task completion time when executing common tasks in a variety of scenarios. Importantly, tests were run using key combinations of legacy and new client and server operating systems to determine benefits available to customers. Windows XP and Windows Vista client environments were combined with both Windows Server 2003 R2 and Windows Server 2008 Beta build 6001.

Test results show that there are significant benefits for both Phase 1

organizations that simply migrate to Windows Vista clients in networks with Windows Server 2003 back-end hosts, and further benefits to Phase 2 organizations that deploy both Windows Vista clients and Windows Server 2008. Tests show that for Phase 1, when users deploy Windows Vista clients, throughput improvements range from 2X to almost 3X and time-to-completion of tasks is reduced by up to 60% over traditional Windows XP installations, when copying or opening Microsoft Office files across a simulated 10-Mbps WAN over traditional Windows XP installations. The Phase 2 users, those who deploy both Windows Vista clients and Windows Server 2008, experience even greater gains. The tandem of Windows Vista and Windows Server 2008 was able to yield up to a 3.3X improvement in throughput and a 3.5X improvement in time to completion.

In many test scenarios, the tandem of Windows Vista and Windows Server 2008 delivered the greatest performance gains of any client/server operating system combination, and yielded the most impressive time-to-completion of tasks performed.

Microsoft Corp.

Windows Vista and Windows Server 2008

Performance over LAN/WAN Links

The Art of Progress

It was the English mathematician and philosopher, Alfred North Whitehead who stated that, “The art of progress is to preserve order amid change.”

Although Whitehead wasn’t speaking about client and server operating systems, his comment applies aptly to the current evolution of client and server operating systems. Microsoft’s Windows XP and Windows Server 2003 have been the de facto standards for client and server operating systems for many years.

Now, though, amidst significant change in enterprise networks, Microsoft is bringing Whitehead’s statement center stage. With the introduction of its Windows Vista client operating system and its upcoming Windows Server 2008 server operating system, Microsoft has raised the bar, again, in terms of the performance users can gain from utilizing the operating system products in enterprise networks.

Both operating systems have been architected to support Microsoft’s enhanced, next-generation TCP/IP stack. Among the improvements to Microsoft’s updated networking functionality is a focus on increasing throughput and maximizing efficiency on high-bandwidth links and being optimized for high-latency conditions and high-loss environments.

Networking Improvements

Although The Tolly Group’s testing goal was to examine the TCP/IP stack as a whole, rather than isolating the benefits of specific stack improvements, it is important to note the upgrades Microsoft has made and the role they play in improving performance.

One of the chief enhancements in the TCP/IP stack in Windows Vista and Microsoft’s Windows Server 2008 Beta is the TCP Receive Window Auto-Tuning capability. This feature continually determines the optimal “receive” window used by the TCP/IP protocol by measuring the bandwidth delay product and the application retrieve rate and adjusts the receive window based upon fluctuations in those network conditions. The idea behind the Receive Window Auto-Tuning is that with better throughput

between TCP peer nodes, there is an increase in network utilization during data transfer. This tuning occurs automatically and dynamically to ensure that the network is not saturated.

In addition to Receive Window Auto-Tuning, the new TCP/IP stack supports Compound TCP (CTCP), a feature that quickly increases the TCP send window for connections with large TCP receive windows and with large bandwidth delay. CTCP attempts to maximize throughput on these types of connections by monitoring delay variations and losses. This feature is enabled by default on Windows Server 2008 and disabled by default in Windows Vista.

With Explicit Congestion Notification (ECN) support, routers experiencing congestion can relay this information downstream by marking packets during the forwarding process. TCP peers receiving marked packets lower their transmission rate to ease congestion and prevent segment losses. Detecting congestion before packet losses are incurred increases the overall throughput between TCP peers.

Microsoft's new TCP/IP stack also boasts a number of upgrades designed to address high-loss environments. Further, the next-generation TCP/IP stack addresses routing path detection and recovery through Neighbor Unreachability Detection for IPv4 and fail-back support for an automatically changed default gateway configuration. IPv4 Neighbor Unreachability Detection determines the reachability of neighboring nodes through an exchange of unicast Address Resolution Protocol (ARP) messages. IPv4-based sessions benefit by identifying when routers are not reachable. These features were already part of IPv6 support.

The Windows Vista and Windows Server 2008 TCP/IP stack also supports fail-back for default gateway. If the primary gateway changes, the stack continues, periodically, to attempt to send TCP traffic through the previous gateway. If the TCP traffic sent through the previous gateway is successful, the TCP/IP stack switches the default gateway to the original default gateway. This is designed to provide faster throughput by sending traffic through the primary router on the subnet.

For a full understanding of all the TCP/IP networking enhancements Microsoft has built into Windows Vista and Windows Server 2008, refer to Microsoft's TechNet at:

http:www.microsoft.com/technet/network/evaluate/new_network.mspx#

It is important to note that TCP/IP improvements, alone, do not account for all of the performance benefits noted in this white paper. Microsoft has also enhanced Server Message Block (SMB) 2.0. which it uses between Windows Vista clients and back-end Windows Server 2008.

SMB, also known as the Common Internet File System (CIFS), is the file sharing protocol used by default on Windows-based computers. SMB in versions of Windows prior to Windows Server 2008 and Windows Vista, known as SMB 1.0, originally was designed 15 years ago for early Windows-based network operating systems such as Microsoft LAN Manager and Windows for Workgroups and carries with it the limitations of its initial design.

Windows Server 2008 and Windows Vista support SMB 2.0, a new version of SMB that has been redesigned for today's networking environments and the needs of the next generation of file servers. According to Microsoft, SMB 2.0 has the following enhancements:

- Supports sending multiple SMB commands within the same packet. This reduces the number of packets sent between an SMB client and server, a common complaint against SMB 1.0.
- Supports much larger buffer sizes compared to SMB 1.0.
- Increases the restrictive constants within the protocol design to allow for scalability. Examples include an increase in the number of concurrent open file handles on the server and the number of file shares that a server can have.
- Supports durable handles that can withstand short interruptions in network availability.
- Supports symbolic links.

Computers running Windows Server 2008 or Windows Vista support both SMB 1.0 and SMB 2.0. The version of SMB that is used for file sharing operations is determined during the SMB session negotiation. The following table shows which version of SMB that is used for various combinations of client and server computers.

Taken together, the enhancements to TCP/IP and SMB 2.0 help users achieve sizable performance gains, Microsoft says.

The following sections summarize the detailed results of tests that Tolly Group engineers performed on Windows Vista and Windows XP clients, and Windows Server 2003 R2 and Windows Server 2008 back-end servers.

Window onto the Test Environment

Tolly Group testing of Microsoft's Windows client and server operating system products involved a variety of network scenarios. Since each of those tests share common methodology and setup elements, they will be described once, as they apply to each of the test scenarios.

For all tests, Tolly Group engineers benchmarked the performance of two Microsoft client operating systems and two server operating systems. On the client side, tests focused on Windows XP SP2 and Windows Vista RTM (Release to Manufacturing). On the server side, tests focused on Windows Server 2003 R2 and Windows Server 2008 (Build 6001).

Tolly Group engineers employed a variety of test tools to conduct tests. Spirent Communications' Converged Network Impairment Emulator (ConNIE) was used to emulate WAN links of 10 Mbps (50 ms delay), representative of a high-speed aggregated link, and 2 Mbps (150 ms delay), modeling E1/T1 circuit speeds. Spirent ConNIE also was used to introduce latency into the Gigabit Ethernet (GbE) and Fast Ethernet LAN tests.

Engineers also used Wireshark (previously known as Ethereal), an Open Source network protocol analyzer, to capture traffic between clients and servers to quantify task time and calculate throughput.

For the WAN test scenarios, engineers configured two servers to share folders with a 10-MB Microsoft Office file over simulated network links. First, engineers logged into the servers from the clients using Windows Explorer and located the share folders. Then they copied the 10-MB file from the server to the client by dragging the file onto the client's desktop. While the file was copying from the servers to the clients, Ethereal was used to capture the transfer traffic. Engineers ran the test three times and the results were averaged. For some test scenarios, rather than copy files

across the simulated links, the files were opened on the client from across the connections.

For the LAN test scenarios, engineers examined the impact on performance of sending a 10-MB Microsoft Office file via the Server Message Block (SMB) protocol across simulated GbE and Fast Ethernet links between Windows XP/Windows Vista clients and back-end Windows Server 2003 R2/Windows Server 2008 servers.

In order to demonstrate Microsoft's next-generation TCP/IP stack's ability to handle latency, engineers introduced LAN delay ranging from 1 millisecond to 5 ms. in the various test scenarios. While such delay may not typically be present in most enterprise LANs, it represents an arbitrary delay variable imposed to illustrate the next-generation TCP/IP capabilities of the Windows Vista client and Windows Server 2008 products.

For the roaming profile test, engineers copied 10-MB user profiles (such profiles include all elements on a user's desktop. including all folders the user may have stored on the desktop. The actual size of a user profile can vary dramatically across users.) from a server (Windows Server 2003 R2 and Windows Server 2008 Build 6001) to a client (Windows XP SP2 and Windows Vista RTM) across simulated WAN links. For this test, engineers configured two servers as Active Directory Domain Controllers with two remote user profiles.

For the Web portal test, engineers configured two servers with Windows SharePoint Services 3.0 to allow users to open a 10-MB Microsoft Office file across simulated WAN connections. For Microsoft Windows Server 2003 RC 2, engineers added the registry key, "MaxBytesPerSend" (DWORD) and set its value to "1-0xFFFFF" under the following registry location: "HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services \HTTP\Parameters".

This registry entry overrides the default data buffer size that is used by HTTP.sys and enables higher download speeds in network environments that have high bandwidth and is documented in a Microsoft Knowledgebase article at: http://support.microsoft.com/kb/820129/en-us.

Engineers copied the 10-MB file to the SharePoint portal and gave appropriate permissions to users to view the file on the client machines. Engineers used Internet Explorer 7 browser (for Windows XP and Windows

Vista clients) to connect the SharePoint portal site and clicked on a URL linked to the 10 MB file. Engineers configured Spirent ConNIE to emulate WAN connections for 10 Mbps (50 ms delay) and 2 Mbps (150 ms delay). Ethereal was used to capture traffic between clients and servers when the clients were opening a 10-MB Microsoft Office file from the server via Microsoft SharePoint portal.

Remote Resource Access in the Enterprise

Branch-office workers who need to access company servers across the WAN often experience relatively longer download times than users who are local to resources and, in turn, experience higher levels of frustration due to long wait times. A reduction in download times enables remote workers to eliminate this classic time waster and improve their productivity.

Tolly Group engineers examined the impact on performance of sending a 10-MB Microsoft Office file via the Server Message Block (SMB) protocol across simulated WAN links between Windows XP SP2 and Windows Vista clients and back-end Windows Server 2003 R2 and Windows Server 2008 (Build 6001) servers.

Copying Microsoft Office Files over a WAN

In this test scenario, engineers mapped a drive on the remote server using Microsoft's native SMB protocol. Then, they copied a 10-MB Office file from server to client.

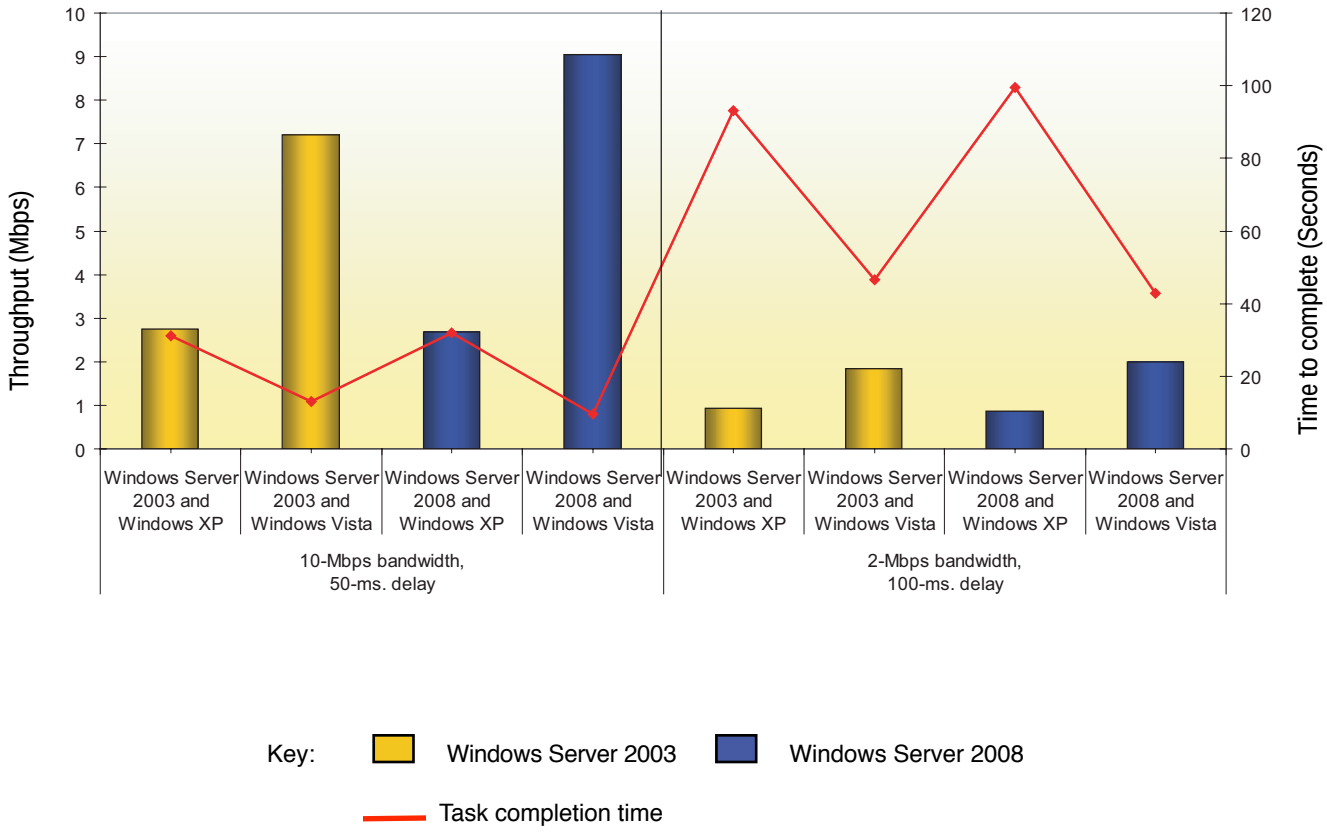
High-speed WAN Scenario

- Copying a 10-MB Microsoft Office file from Windows Server 2003 R2 to a Windows XP SP2 client consumed 31.2 seconds, at an average throughput rate of 2.7 Mbps over a simulated high-speed 10-Mbps link with 50-ms. of delay.

- When a Windows Vista client was paired with a Windows Server 2003 R2 server a 10-MB Microsoft Office file copied in 12.9 seconds, and data was copied at an average throughput rate of 7.2 Mbps.
- Tests with a Windows XP client and Windows Server 2008 server show that the 10-MB Microsoft Office file copied in 32

Throughput, Time to Completion of Copying a 10-MB Microsoft Office File Across a Simulated WAN

Impact of Microsoft Windows Server 2003 and Windows Server 2008 on Windows XP and Windows Vista Clients



Source: The Tolly Group, February 2007

Figure 1

seconds, at a rate of 2.7 Mbps — comparable to the Windows Server 2003 R2 results.

- When a Windows Vista client was paired with the Windows Server 2008 server, the Microsoft Office file transfer completed in 9.5 seconds, on average, and data was transferred at a rate of over 9 Mbps.

Analysis

The pairing of a Windows Vista client with a Windows Server 2003 R2 resulted in 2.5X faster task processing at a throughput rate more than 2.5X greater than with a Windows XP client. Thus, the tandem of Windows Vista clients and Windows Server 2008 servers delivers the maximum performance over the simulated WAN.

T1/E1 WAN Scenario

Tolly Group engineers re-ran the Office File Copy Test, this time in a WAN scenario simulating a 2-Mbps WAN link with 150 ms. of latency. This approximates the T1 circuits traditionally used in domestic U.S. networks and the E1 circuits used in EMEA and Pacific Rim countries.

- Windows Server 2003 R2 server was able to copy the 10-MB file to a Windows XP client at an average throughput rate of 0.9 Mbps, taking 93.07 seconds to complete the copy over the simulated WAN.
- Throughput doubled to 1.85 Mbps, with an average time to completion of 46.6 seconds when the same test was run with a Windows Vista client and Windows Server 2003 R2.
- With a Windows XP client and a Windows Server 2008 server, the same 10-MB Microsoft Office file transferred in 99.44 seconds at a throughput rate of 0.86 Mbps.

- When the Windows Server 2008 copied the file to a Windows Vista client, the throughput rate doubled to 2 Mbps, and the time to completion was less than half the Windows XP client test, at 42.85 seconds.

Analysis

The best performance for both the Windows Server 2003 R2 and the Windows Server 2008 was achieved with a Windows Vista client. Throughput doubled and response time was halved when the Windows Server 2008 replaced the Windows Server 2003 R2 during the WAN file transfer. Performance increased markedly when a Windows Vista client replaced a Windows XP client with the back-end Windows Server 2008 serving the file.

Opening Microsoft Office Files over a WAN

Many organizations choose to store critical corporate files on centralized file storage to enforce strict controls and maintain regular backups. When users at remote sites access these files, it is critical that the client and back-end server work cooperatively to serve the files.

One other point about opening files across a WAN: For many organizations this task will provide greater security than copying files, since the opened Microsoft Office file may be locked to other users and thus this basic locking can prevent multiple users from making updates.

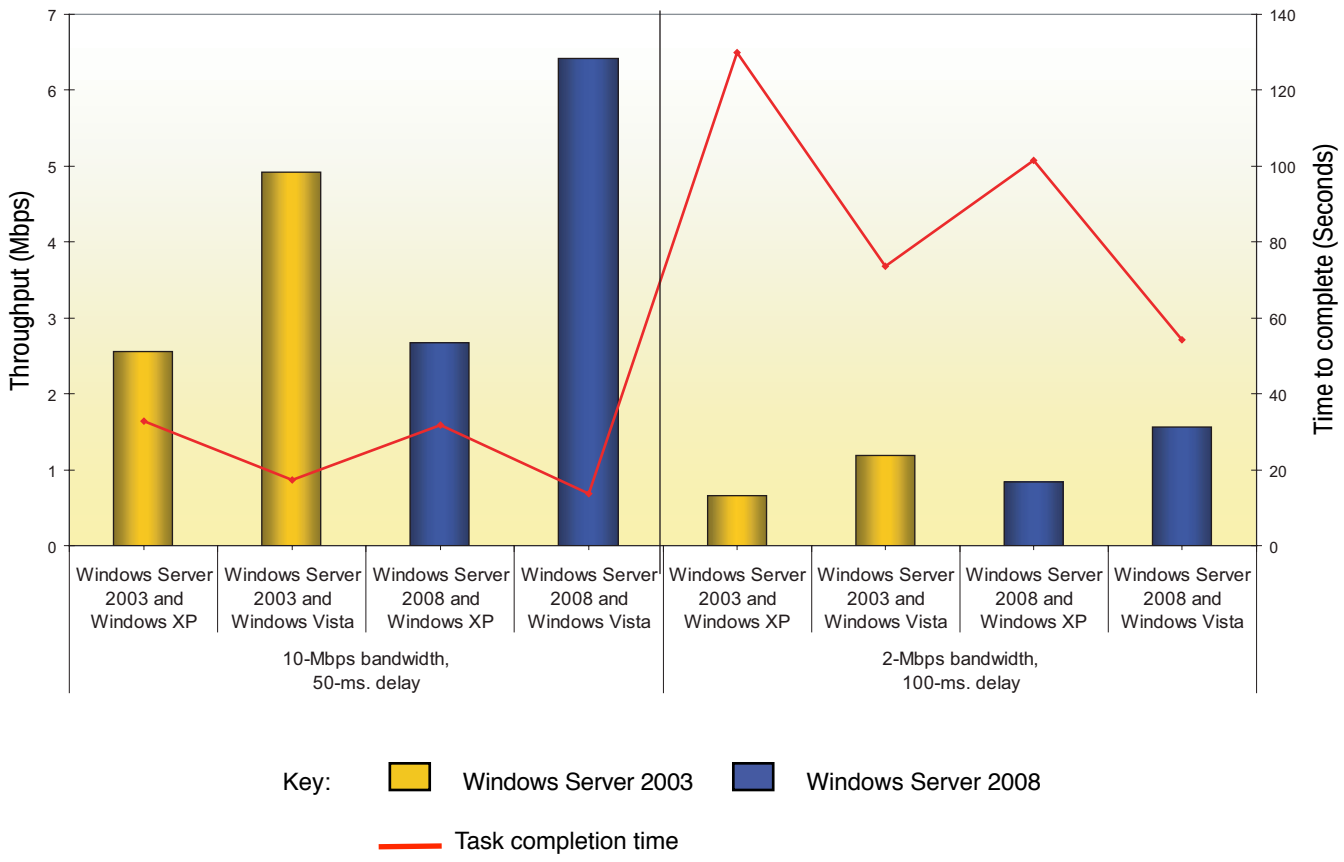
High-speed WAN Scenario

- A Microsoft Office file opened on a Windows Server 2003 server by a remote Windows XP client over a simulated 10-Mbps link (representing an aggregated connection) in 32.7 seconds on average and data throughput was 2.6 Mbps.

- With a Windows Vista client in favor of a Windows XP client, the same task completed in 17.4 seconds, with an average throughput of 4.9 Mbps, or 88% greater.
- When a Windows XP client was paired with a Windows Server 2008 server, the Microsoft Office file transferred in 31.7

Throughput, Time to Completion of Opening a 10-MB Microsoft Office File Across a Simulated WAN

Impact of Microsoft Windows Server 2003 and Windows Server 2008 on Windows XP and Windows Vista Clients



Source: The Tolly Group, February 2007

Figure 2

seconds at a throughput rate of 2.67 Mbps.

- The best performance was realized when a Windows Vista client was paired with a Windows Server 2008 server, with the file transferring in 13.8 seconds at a data rate of 6.4 Mbps.

Analysis

The Windows 2003 Server R2/Windows Vista tandem handled the file open task in almost half the time (47% less) when compared to a Windows XP client and recorded almost double the throughput.

The Windows Vista pairing with the Windows Server 2008 server yielded 31% greater data throughput and accomplished the file transfer in 21% less time than when the Windows Vista client was paired with a Windows Server 2003 server.

T1/E1 WAN Scenario

Tolly Group engineers re-ran the File Open Test, this time in a WAN scenario simulating a 2-Mbps WAN link with 150 ms. of latency.

- With Microsoft Windows Server 2003 R2 and a Windows XP client, the task was completed in 130 seconds, with throughput of 0.66 Mbps.
- With the same server but with a Windows Vista client in place, the file open task completed in 73.7 seconds and throughput doubled to 1.2 Mbps.
- A Windows XP client coupled with the Windows Server 2008 server yielded a file open completion time of 101.5 seconds, with throughput of 0.85 Mbps.
- The best performance was observed between a Windows Vista client and a Windows Server 2008 server, with the file open

completing in 54.3 seconds and throughput of 1.6 Mbps.

Analysis

The Windows Vista client halved the time to completion when paired with a Windows Server 2003 R2 server and throughput doubled. Clearly, there is a performance benefit to replacing Windows XP clients in deployments where Windows Server 2003 R2 back-end devices exist.

For those users who opt to deploy both Windows Vista clients and Windows Server 2008 back-ends, the payoff comes in the form of improved response time over WAN circuits and greater, more efficient usage of WAN pipes.

Supporting Mobility in the Workplace

In traditional enterprise networks, user profiles reside on local PCs, so a single PC may be bound to a specific user. However, as enterprises evolve, users constantly move through the enterprise and their user profile should move with them, independent of the hardware host on which it resides.

Roaming profiles are used to preserve users' configurations (desktops, backgrounds, files, folders and their contents, etc.) and present users with an identical environment on any computer onto which a roaming user logs on. By storing all of the user profile information centrally, this allows network administrators to easily rebuild and recover the machines should a problem arise.

Branch offices with limited or nonexistent local IT support realize the benefits of centrally stored profiles. The real issue for branch offices, though, is that they could be hampered by the relatively low bandwidth of WAN connections that link them back to user profiles stored on central servers and by the performance penalty they likely face due to the low-speed connections. Ultimately, the user faces a longer log-on time.

Tolly Group testing shows, however, that with Windows Vista clients and

Windows Server 2008 servers, remote users can download the profile twice as fast as Windows XP/Windows Server 2003 R2. This improvement by Windows Vista will reduce the booting time and certainly result in an enhanced experience for branch office users or traveling workers who receive their profiles from the central server.

High-speed WAN Scenario

- Windows Server 2003 R2 was able to deliver a 10-MB user profile over a simulated 10-Mbps aggregated WAN connection (50 ms. delay) to a Windows XP client at a rate of 2.97 Mbps, with an average time to completion of 29.9 seconds.
- With Windows Server 2003 R2 transferring the 10-MB profile to a Windows Vista client, the task completed in 16.6 seconds, on average, with a throughput rate of 4.9 Mbps.
- When a Windows Server 2008 server transferred the user profile to a Windows XP client, the task consumed 27 seconds and the data transfer rate was 2.94 Mbps.
- The best performance observed was when the Windows Server 2008 server transferred the user profile to a Windows Vista client in just 11.3 seconds, at an average data throughput of 7.6 Mbps.

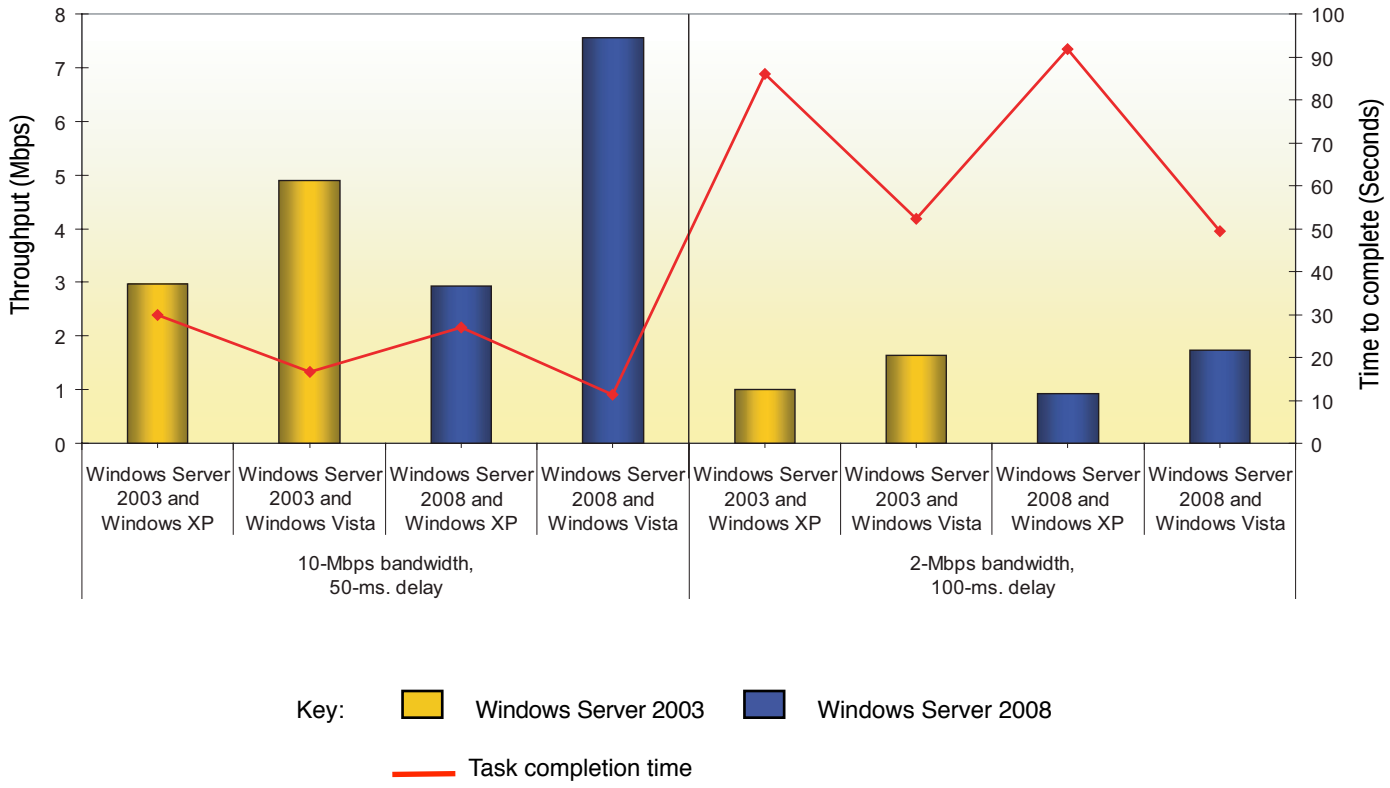
Analysis

Users deploying Windows Vista-based clients with Windows Server 2003 servers will benefit from almost 45% faster downloads with almost 65% greater throughput over a 10-Mbps high-speed simulated WAN . (See Figure 3.)

Once again, the benefits of Microsoft's next-generation TCP/IP stack were apparent when testers paired the Windows Vista client with the Windows Server 2008 server. The new operating systems deliver almost a 2.5X boost in throughput when transferring the user

Throughput, Time to Completion of Downloading a User Profile Across a Simulated WAN

Impact of Microsoft Windows Server 2003 and Windows Server 2008 on Windows XP and Windows Vista Clients



Source: The Tolly Group, February 2007

Figure 3

profile in nearly one-thirds the time of a Windows XP client paired with a Windows Server 2003 R2 server.

T1/E1 WAN Scenario

- Windows Server 2003 R2 server was able to transfer the 10-MB user profile over a simulated 2-Mbps link (150 ms. delay) to a Windows XP client at a rate slightly less than 1 Mbps, with an average time to completion of 86 seconds.
- Data was sent at a rate of 1.6 Mbps, with an average time to completion of 52.4 seconds between a Windows Server 2003 R2 and a Windows Vista client.
- Between a Windows Server 2008 server to a Windows XP client, the 10-MB user profile copied to a Windows XP client at a rate of 0.9 Mbps, with an average time to completion of 91.9 seconds.
- Windows Server 2008 copied the file to a Windows Vista client, in 49.4 seconds at an average throughput of 1.7 Mbps

Analysis

Copying user profiles between the Windows 2003 Server R2 and the Windows Vista client data achieves a 61% faster throughput rate than with the Windows XP client, and the time to completion is about 40% faster.

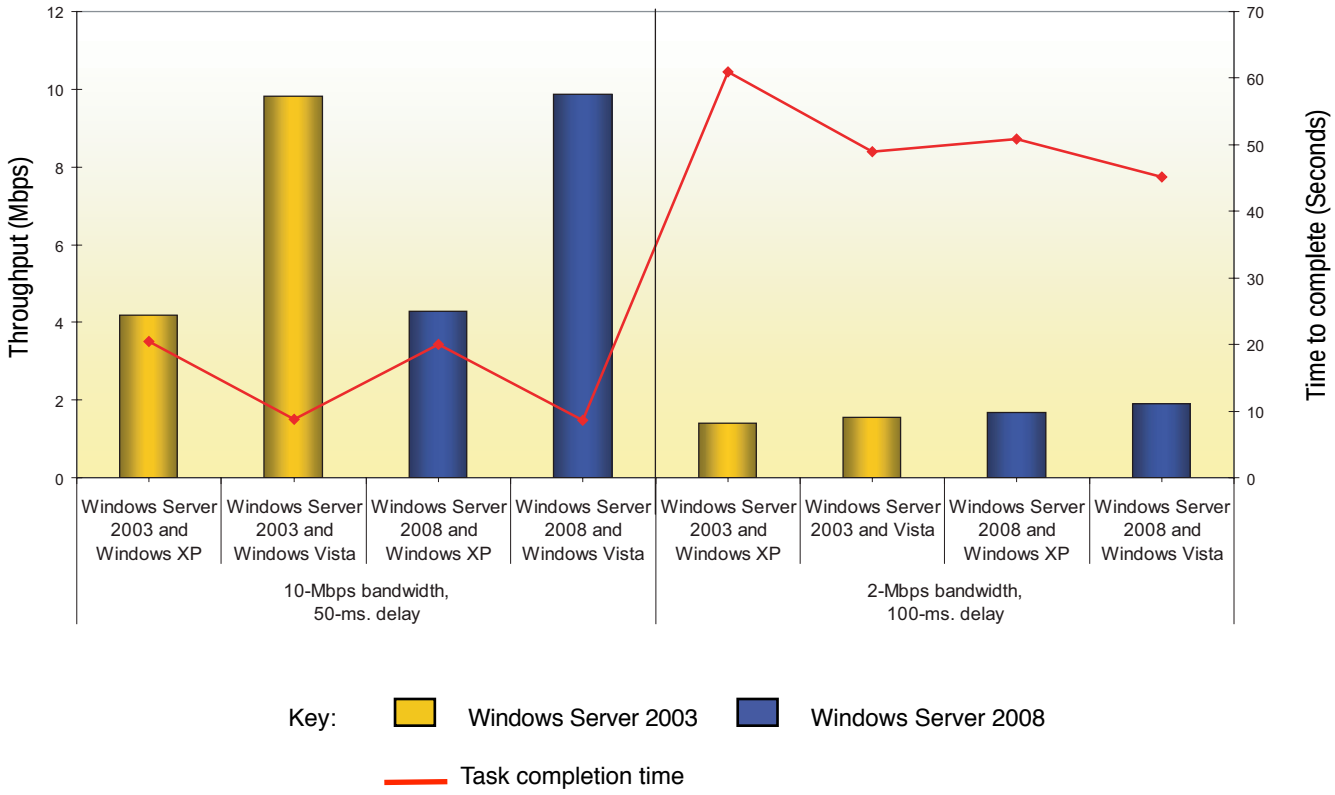
The optimal performance is achieved when pairing a Windows Vista client with a Windows Server 2008 server. The Windows Vista pairing with a Windows Server 2008 server yields 70% greater throughput and completes the task in almost half the time of the Windows XP client paired with the Windows Server 2003 R2 server.

Performance with Portals

Traditional file and resource access to back-end servers is undergoing a metamorphosis within many enterprise networks. The traditional remote client access to back-end servers is yielding to a new paradigm in which users log into Web-based portals on the Internet or intranets to gain wide access to a vast array of files, databases and applications. Such portals provide users with collaboration tools and access to Web-enabled applications from anywhere.

Throughput, Time to Completion of Opening a 10-MB Office File via SharePoint Services Across a Simulated WAN

Impact of Microsoft Windows Server 2003 and Windows Server 2008 on Windows XP and Vista Clients



Source: The Tolly Group, February 2007

Figure 4

Microsoft offers one such collaborative Web environment through its Windows SharePoint Services built into Windows Server 2003 R2 and in Windows Server 2008. Windows SharePoint Services provides a scalable, manageable platform for collaboration and the development of Web-based business applications.

The Tolly Group set out to examine the impact on performance of opening a 10-MB Microsoft Office file across a simulated WAN (10-Mbps aggregated link, 50 ms. delay) using SharePoint Services. Key findings show:

- With Windows SharePoint Services running on a Windows Server 2003 R2 server, and a Windows XP client, the file open task completed in 20.5 seconds, with average throughput of 4.2 Mbps.
- The pairing of a Windows Vista client with a Windows Server 2003 R2 yielded throughput of 9.8 Mbps and the file open task completed in 8.7 seconds.
- With the Windows XP client and a Windows Server 2008 server, the file open task completed in 20 seconds with throughput of 4.3 Mbps.
- The file open task completed in 8.7 seconds (almost 57% faster than with the Windows XP client) and throughput was 9.9 Mbps with a Windows Vista client paired with a Windows Server 2008 server.

Analysis

File-open performance using Windows SharePoint Services was improved with the tandem of Windows Vista/Windows Server 2008. Both the time to completion and the average throughput benefitted from a 2.5X improvement over Windows Server 2003 R2 and Windows XP, when the newer OS offerings were tested.

T1/E1 WAN Scenario

- With Windows Server 2003 R2 and a Windows XP client communicating over a simulated 2-Mbps WAN link, the file open task completed in 60.5 seconds, with throughput of 1.4 Mbps.

- The task completed in 49 seconds, with average throughput of 1.6 Mbps when a Windows Vista client was tested with the Windows Server 2003 R2 server.
- The file open task completed in 50.8 seconds over the simulated T-1/E1 links when a Windows XP client was paired with a Windows Server 2008 server. Average throughput was 1.7 Mbps.
- The pairing of Windows Vista client with the Windows Server 2008 server yielded the best performance yet again. Throughput for the file open test using SharePoint Services was 1.9 Mbps and the task completed in 45.1 seconds.

Analysis

The real boon to performance came when engineers paired the Windows Server 2008 server with the Windows Vista client. Average throughput was 19% greater for a task that completed in about 8% less time than with Vista running on a Windows Server 2003 R2 host.

Even the Windows Vista client paired with the Windows Server 2003 R2 server produced performance improvements of 19% faster time to completion and 14% greater average throughput than when the Windows Server 2003 R2 was paired with a Windows XP client.

Local Access to Resources

Copying Microsoft Office Files over a LAN

Test results show that Windows Vista/Windows Server 2008 improves the performance not only in the WAN environment but also in the LAN environment all the way up to 1 Gbps tested by delivering as much as 2X the performance as Windows XP and Windows Server 2003 R2. Tests

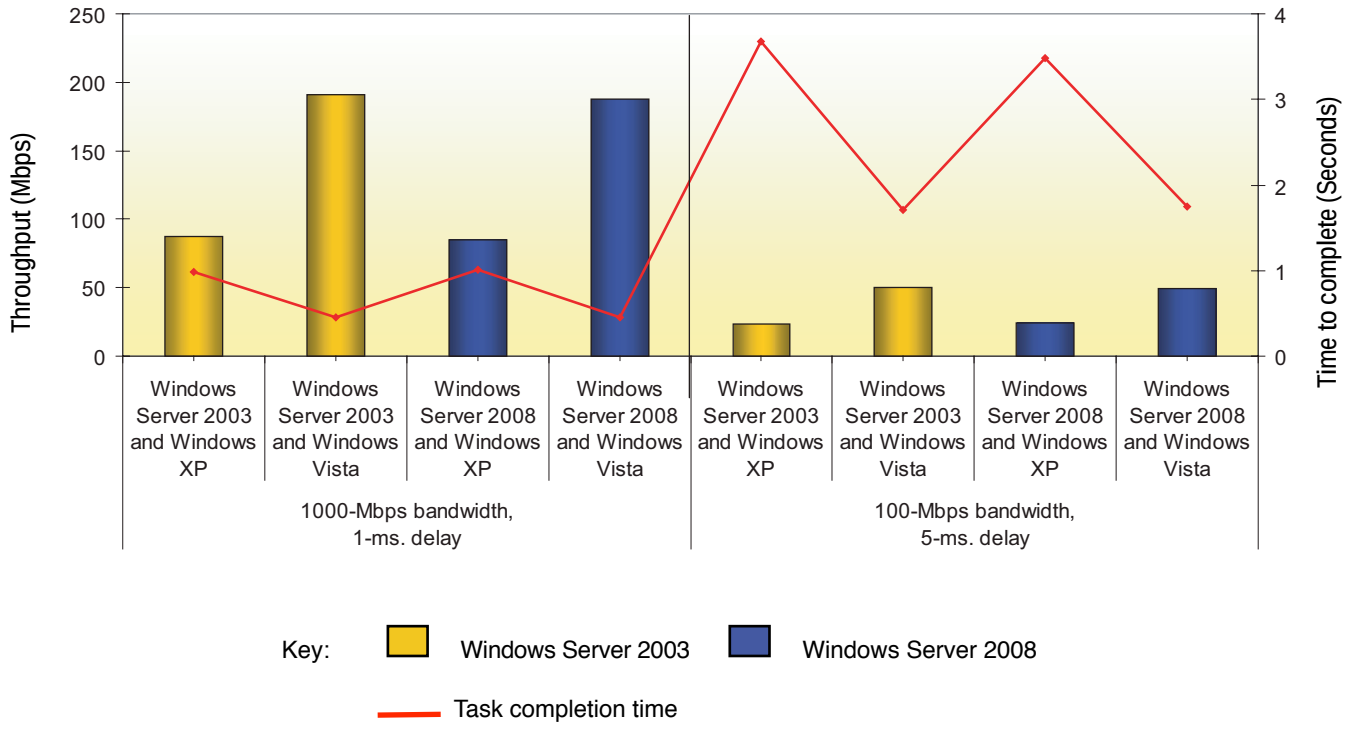
show that LAN users can improve performance when copying files from the server to local machines over a high-speed network.

Gigabit Ethernet LAN Scenario

- The file copy between the Windows Server 2003 R2 server and the Windows XP client over a simulated 1-Gbps link (1 ms. delay) resulted in average throughput of 87.4 Mbps and the task was completed in 0.98 seconds.

Throughput, Time to Completion of Copying a 10-MB Microsoft Office File Across a Simulated LAN

Impact of Microsoft Windows Server 2003 and Windows Server 2008 Build 6001 on Windows XP and Windows Vista Clients



Source: The Tolly Group, February 2007

Figure 5

- Throughput more than doubled to 190.9 Mbps and the time to completion was less than half at 0.45 seconds between a Windows Server 2003 R2 server and a Windows Vista client.
- With a Windows XP client communicating with a Windows Server 2008 server, throughput was 85.3 Mbps and the time to completion was just over one second.
- Throughput more than doubled to 187.7 Mbps and the time to completion was 0.46 seconds — or less than half with the Windows XP client — when data flowed between a Windows Server 2008 server and a Windows Vista client.

Fast Ethernet Scenario

Engineers re-ran the test, this time in a Fast Ethernet (100 Mbps, 5 ms. delay) simulated LAN scenario

- With a Windows Server 2003 R2 server and Windows XP client, the throughput to copy a file was 23.3 Mbps and the task completed in 3.7 seconds.
- Between a Windows Server 2003 R2 server and a Windows Vista client, throughput more than doubled, to 50 Mbps, and time to completion was halved to 1.7 seconds.
- With a Windows XP client communicating with a Windows Server 2008 server, the average throughput was 24.6 Mbps and the time to completion was 3.5 seconds.
- The best result was between the Windows Server 2008 server and a Windows Vista when throughput more than doubled to 49.2 Mbps on average, and time to completion again was halved to 1.75 seconds.

Analysis

In both LAN scenarios, the tandem of Windows Server 2008 and Windows Vista yielded the highest throughput and the shortest time to completion. The message is that even over LAN links, where bandwidth is abundant, that the efficiency of the next-generation TCP/IP stack results in performance benefits to LAN users.

Opening Microsoft Office Files Over a LAN

Expectations for throughput and time to completion of a user opening a file across a LAN should vary markedly from WAN results. Engineers set out to record the average throughput and time to completion for opening a 10-MB Microsoft Office file across a LAN.

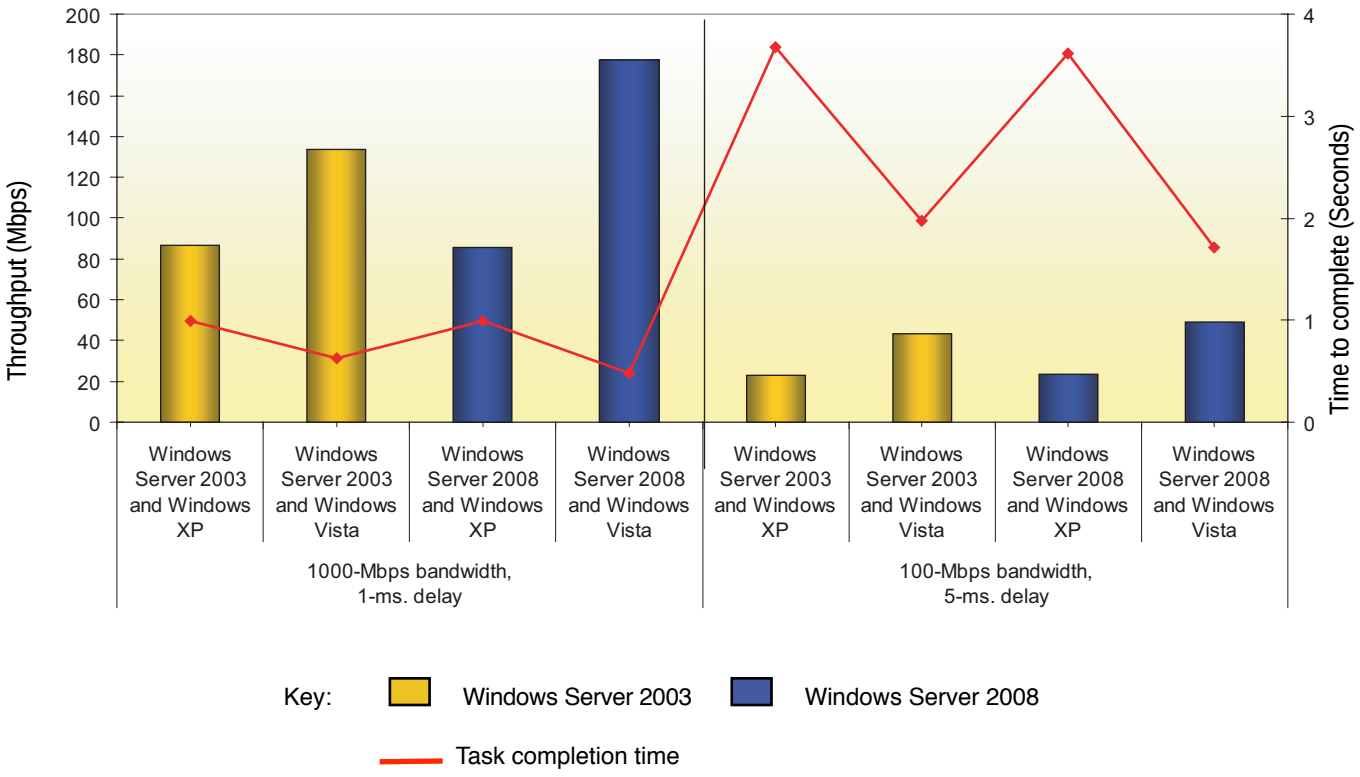
- The file open task completed in 0.99 seconds between a Windows Server 2003 R2 server and Windows XP client over a simulated GbE link and average data throughput was 86.5 Mbps.
- The same task completed in 0.6 seconds, and throughput was 133.5 Mbps with a Windows Vista client in place of the Windows XP client.
- The file open task completed in one second, and throughput was 85.8 Mbps between a Windows XP client and a Windows Server 2008 server.
- When a Windows Vista client was used with the Windows Server 2008 server the task completed in 0.48 seconds and throughput was 177.7 Mbps.

Analysis

The substitution of a Windows Vista client in place of a Windows XP

Throughput, Time to Completion of Opening a 10-MB Office File Across a LAN

Impact of Microsoft Windows Server 2003 and Windows Server 2008 on Windows XP and Vista Clients



Source: The Tolly Group, February 2007

Figure 6

client communicating with a back-end Windows Server 2003 R2 server resulted in a 54% jump in throughput.

When engineers upgraded both the client OS and the server OS to Windows Vista and Windows Server 2008, respectively, the time to completion was halved and throughput more than doubled.

Fast Ethernet Scenario

- With the Windows 2003 Server R2 server and an Windows XP client, the file open task completed in 3.7 seconds over a simulated Fast Ethernet connection (100 Mbps, 5 ms. delay), with throughput of 23 Mbps.
- The file open task completed in 1.98 seconds and throughput was 43.4 Mbps between a Windows Server 2003 R2 server and a Windows Vista client.
- With a Windows XP client and a Windows Server 2008, the file open task completed in 3.6 seconds with average throughput of 23.7 Mbps.
- When the Windows Vista client was used with the Windows Server 2008 server, the task completed in 1.7 seconds and throughput more than doubled to 49.1 Mbps.

Analysis

The Fast Ethernet scenario for the file open procedure echoed other tests by demonstrating that throughput can be improved in a situation using Windows Server 2003 R2 servers by migrating to Windows Vista clients. Tests show that throughput almost doubled and time to completion was nearly half with the Windows Vista client compared to the Windows XP client.

The best performance increase comes when users replace both the Windows XP client (by upgrading to Windows Vista) and the Windows Server 2003 R2 (by upgrading to Windows Server 2008). Tests show that throughput more than doubled and time to completion was less than half compared to the Windows XP client with a

Windows Server 2003 R2 server.

Maximizing Performance

It's important for enterprise IT managers to maximize the performance of common business tasks over expensive WAN circuits. As IT centralizes key applications, those remote and branch locations will increase their reliance on remote sessions running over TCP/IP and over WAN circuits. It becomes critical for IT to guarantee an acceptable level of performance to remote office workers.

All testing evidence points to the fact that organizations should seriously examine upgrading Windows clients and server operating systems to Windows Vista and Windows Server 2008, respectively, to extract the maximum performance out of WAN and LAN connections.

Testing validates the benefits provided by Microsoft in the updated TCP/IP stack for Windows Vista and Windows Server 2008. By relying on the improvements in the TCP/IP stack, users will realize performance gains and time to completion improvements that make more efficient usage of WAN and LAN connections and keep end users satisfied.

Moreover, the ability to copy user profiles from central site servers rapidly to remote and branch offices means central IT staffs can rebuild/recover remote PCs more quickly.

And, Microsoft's support for efficient processing over SharePoint Services shows that both Windows Vista and Windows Server 2008 are positioned well to support Web-based applications and collaboration services.

In the end, the bottom line is that Windows Vista and Windows Server 2008 help to bolster improved performance and a better quality of experience for end users. And in the end, that's what it's all about.

Appendices

Appendix A: Test Equipment

Hardware configuration

The Microsoft Windows Server 2003 R2 (32-bit) and Windows Server 2008 Build 6001 (32-bit) were run on a server based on an AMD Athlon 64 3500+ 2.2 GHz/ HT, 1000 MHz, 512K L2 Cache, 2 GB DDR PC3200, 74.3 GB SATA 10,000 RPM, and Broadcom BCM5700 PCI-X 10/100/1000Base-T NIC.

The client PCs used to support Microsoft Windows XP Service Pack 2 (32-bit) and Windows Vista Release to Manufacturing (RTM) build 6000 (32-bit), were based upon an HP-Compaq d530 SFF Base Model (Pentium 4 2.66 GHz/533 MHz FSB, 512 KB L2 Cache, 1 GB DDR/333MHz, 40 GB Ultra ATA/100 7,200 RPM, and 10/100/1000Base-T on-board NIC).

Test Tools:

- Spirent Converged Network Impairment Emulator (ConNIE); Software version 2.10
- WireShark Network Protocol Analyzer version 0.99/ (formerly known as Ethereal)

Appendix B: Detailed Test Results

SMB Copy File Across a Simulated WAN

SMB Copy File Across a WAN (10-MB Microsoft Word File)			
Simulated WAN Type	Sender	Receiver Performance Measurement: Average time to completion (seconds)	Receiver Performance Measurement: Throughput (Mbps)
10 Mbps, 50-ms delay	Windows Server 2003	Windows XP	
		31.24	2.74
		Windows Vista	
		12.91	7.21
	Windows Server 2008	Windows XP	
		32.18	2.66
		Windows Vista	
		9.47	9.05
5 Mbps, 100-ms delay	Windows Server 2003	Windows XP	
		61.96	1.38
		Windows Vista	
		18.47	4.69
	Windows Server 2008	Windows XP	
		65.57	1.31
		Windows Vista	
		18.27	4.68
2 Mbps, 150-ms delay	Windows Server 2003	Windows XP	
		93.07	0.92
		Windows Vista	
		46.56	1.85
	Windows Server 2008	Windows XP	
		99.44	0.86
		Windows Vista	
		42.85	2.00
1 Mbps, 200-ms delay	Windows Server 2003	Windows XP	
		135.33	0.63
		Windows Vista	
		87.12	0.99
	Windows Server 2008	Windows XP	
		128.51	0.67
		Windows Vista	
		89.51	0.96
512 Kbps, 300-ms delay	Windows Server 2003	Windows XP	
		232.03	0.37
		Windows Vista	
		171.65	0.50
	Windows Server 2008	Windows XP	
		192.03	0.45
		Windows Vista	
		171.31	0.51

SMB Open File Across a Simulated WAN

SMB Open File Across WAN (10-MB Microsoft Word File)			
WAN Type	Sender	Receiver Performance Measurement	
		Average time to completion (seconds)	Throughput (Mbps)
10 Mbps, 50-ms delay	Windows Server 2003	**Windows XP**	
		32.72	2.56
		Windows Vista	
		17.41	4.92
	Windows Server 2008	**Windows XP**	
		31.74	2.67
		Windows Vista	
		13.81	6.42
5 Mbps, 100-ms delay	Windows Server 2003	**Windows XP**	
		68.70	1.25
		Windows Vista	
		34.51	2.48
	Windows Server 2008	**Windows XP**	
		62.98	1.37
		Windows Vista	
		28.71	3.08
2 Mbps, 150-ms delay	Windows Server 2003	**Windows XP**	
		130.03	0.66
		Windows Vista	
		73.72	1.18
	Windows Server 2008	**Windows XP**	
		101.50	0.84
		Windows Vista	
		54.26	1.56
1 Mbps, 200-ms delay	Windows Server 2003	**Windows XP**	
		240.13	0.36
		Windows Vista	
		157.36	0.55
	Windows Server 2008	**Windows XP**	
		209.96	0.41
		Windows Vista	
		96.18	0.85
512 Kbps, 300-ms delay	Windows Server 2003	**Windows XP**	
		346.13	0.25
		Windows Vista	
		277.36	0.31
	Windows Server 2008	**Windows XP**	
		345.78	0.25
		Windows Vista	
		178.01	0.48

Roaming File Across a Simulated WAN

Roaming Profile Across WAN (10-MB User Profile Transferred for Each Login)			
Simulated WAN Type	Sender	Receiver Performance Measurement	
		Average time to completion (seconds)	Throughput (Mbps)
10 Mbps, 50-ms delay	Windows Server 2003	Windows XP	
		29.39	2.97
		Windows Vista	
		16.59	4.90
	Windows Server 2008	Windows XP	
		26.98	2.93
		Windows Vista	
		11.28	7.56
5 Mbps, 100-ms delay	Windows Server 2003	Windows XP	
		57.31	1.49
		Windows Vista	
		34.56	2.48
	Windows Server 2008	Windows XP	
		57.42	1.49
		Windows Vista	
		28.90	2.95
2 Mbps, 150-ms delay	Windows Server 2003	Windows XP	
		86.10	1.00
		Windows Vista	
		52.41	1.63
	Windows Server 2008	Windows XP	
		91.88	0.93
		Windows Vista	
		49.50	1.73
1 Mbps, 200-ms delay	Windows Server 2003	Windows XP	
		115.53	0.74
		Windows Vista	
		85.48	1.00
	Windows Server 2008	Windows XP	
		121.26	0.71
		Windows Vista	
		90.19	0.95
512 Kbps, 300-ms delay	Windows Server 2003	Windows XP	
		188.34	0.43
		Windows Vista	
		179.99	0.48
	Windows Server 2008	Windows XP	
		238.25	0.36
		Windows Vista	
		168.38	0.51

Microsoft SharePoint Open File Across a WAN

Microsoft SharePoint Open File Across WAN (10-MB Microsoft Word File)			
WAN Type	Sender	Receiver Performance Measurement	
		Average time to completion (seconds)	Throughput (Mbps)
10 Mbps, 50 ms Delay	Windows Server 2003	Windows XP	
		20.54	4.18
		Windows Vista	
		8.72	9.82
	Windows Server 2008	Windows XP	
		20.02	4.29
		Windows Vista	
		8.68	9.88
5 Mbps, 100 ms Delay	Windows Server 2003	Windows XP	
		40.54	2.12
		Windows Vista	
		17.53	4.88
	Windows Server 2008	Windows XP	
		40.03	2.15
		Windows Vista	
		17.85	4.80
2 Mbps, 150 ms Delay	Windows Server 2003	Windows XP	
		60.55	1.41
		Windows Vista	
		48.94	1.56
	Windows Server 2008	Windows XP	
		50.84	1.68
		Windows Vista	
		45.11	1.90
1 Mbps, 200 ms Delay	Windows Server 2003	Windows XP	
		100.71	0.85
		Windows Vista	
		86.15	0.99
	Windows Server 2008	Windows XP	
		86.72	0.99
		Windows Vista	
		85.73	1.00
512 Kbps, 300 ms Delay	Windows Server 2003	Windows XP	
		189.46	0.45
		Windows Vista	
		168.23	0.51
	Windows Server 2008	Windows XP	
		168.70	0.51
		Windows Vista	
		167.93	0.51

Microsoft Copy File Across a LAN

SMB Copy File Across LAN (10-MB Microsoft Word File)			
Simulated LAN Type	Sender	Receiver Performance Measurement	
		Average time to completion (seconds)	Throughput (Mbps)
1000 Mbps, 1-ms delay	Windows Server 2003	Windows XP	
		0.99	86.53
		Windows Vista	
		0.63	133.50
	Windows Server 2008	Windows XP	
		1.00	85.84
		Windows Vista	
		0.48	177.72
100 Mbps, 5-ms delay	Windows Server 2003	Windows XP	
		3.68	23.15
		Windows Vista	
		1.97	43.36
	Windows Server 2008	Windows XP	
		3.61	23.70
		Windows Vista	
		1.71	49.13

Microsoft Open File Across a LAN

SMB Open File Across LAN (10-MB Microsoft Word File)			
LAN Type	Sender	Receiver Performance Measurement	
		Average time to completion (seconds)	Throughput (Mbps)
1000 Mbps, 1-ms delay	Windows Server 2003	**Windows XP**	
		0.99	86.53
		Windows Vista	
		0.63	133.50
	Windows Server 2008	**Windows XP**	
		1.00	85.84
		Windows Vista	
		0.48	177.72
100 Mbps, 5-ms delay	Windows Server 2003	**Windows XP**	
		3.68	23.15
		Windows Vista	
		1.97	43.36
	Windows Server 2008	**Windows XP**	
		3.61	23.70
		Windows Vista	
		1.71	49.13

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