Windows Media Server Unicast Streaming Test

ZDLABS

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Origin of report

ZD Labs prepared this report under contract from Microsoft Corporation.

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1.0 Executive Summary

Microsoft Corporation commissioned ZD Labs to independently verify the scalability of the Windows Media Services feature of the Windows 2000 server platform using Microsoft's Windows Media Load Simulator tool. Microsoft identified two target results:

- **Narrowband:** confirm over 9000 concurrent 22kbps video streams[1] on a single server running Windows 2000 Advanced Server
- **Broadband:** confirm over 2400 concurrent 100kbps video streams[2] on a single server running Windows 2000 Advanced Server for a 14 day endurance test run

All tests were conducted using Microsoft's Windows Media Load Simulator tool (WMLoad). WMLoad is a test tool publicly available for download on Microsoft's Web site from http://www.microsoft.com/windowsmedia that reads data streams based on Microsoft's MMS data streaming protocol. The tool reads the data stream sent from the Windows Media Server, but it doesn't display any video or audio output.

ZD Labs set up Windows Media Server on an 8-way Compaq Proliant 8500 server (supplied by Compaq) running Windows 2000 Advanced Server. We installed a copy of WMLoad 4.0 on test clients running NT 4.0 Workstation/SP6 and configured each client to read MMS unicast UDP video streams from the server. We used Windows Media Encoder 4.1 to encode Advanced Streaming Format (ASF) video streams and created 6 Broadcast Publishing Points on Windows Media Server to distribute the streams. To verify that the server streamed the data correctly, we ran 6 Windows Media Player 6.4 sessions and connected an instance of the player to each of the 6 Broadcast Publishing Points. Refer to Section 2.0 for a complete description of the test configuration and test methodology.

Narrowband Test Findings
For the narrowband test, ZD Labs configured Windows Media Server to distribute a 50-minute 22kbps-video stream. Each WMLoad client read 450 individual MMS unicast UDP streams from the server. We manually increased the load on the Windows Media server by incrementally adding one client at a time to the test, which increased the load by 450 streams per client. With 20 clients participating in the test, we successfully reached the 9000-stream goal (actually 9006 streams counting the 6 Windows Media Player streams). Once the load reached 9006 streams, we let the test run for 10 minutes. We saw no dropped streams or stream errors during the 10-minute run. After successfully running for 10 minutes, we added additional client streams in smaller increments until the server started dropping streams and reporting stream errors. The maximum repeatable stream count we reached was 9506 streams. We ran the test twice to verify results consistency.

During the test, we noticed that with up to 8100 streams the six Windows Media Players displayed fairly smooth consistent motion. At higher stream counts, one to three of the players displayed jerky, inconsistent motion while the remaining players seemed unaffected. We were unable to determine the cause of this, as we detected no packet loss from the server.

Broadband Test Findings
For the broadband test, ZD Labs configured Windows Media Server to distribute a 60-minute 100kbps-video stream in an endless loop. Each WMLoad client read 50 individual MMS unicast UDP streams from the server. We manually increased the load on the Windows Media server by incrementally adding one client at a time to the test, which increased the load by 50 streams per client. With 48 clients participating in the test, we successfully reached the 2400-stream goal (actually 2406 streams counting the 6 Windows Media Player streams). Once the load reached 2406 streams, we let the test run for 14 days. After 12 days and 16 hours the test stopped unexpectedly due to an UPS hardware failure. At the point where the test ended, Windows Media Server was still successfully streaming all 2406 100kbps-video streams to the test clients with a

[1] MMS Unicast via UDP
[2] MMS Unicast via UDP

99.9999999% accuracy rate in its delivery of over 26 billion packets of data. After reviewing the logs, we determined that the test failure was not related to Windows Media Server.

In summary, our tests of the Windows Media Services feature in the Windows 2000 Advanced Server platform found that it is possible to distribute over 9000 concurrent narrowband (22kbps) video streams on a single physical server to clients running WMLoad. In separate testing, ZD Labs found that it is also possible to distribute over 2400 broadband (100kbps) streams reliably for an extended period of time to clients running WMLoad from a single physical server utilizing the Windows Media Services feature in Windows 2000 Advanced Server.

2.0 Testing Methodology

We setup Windows Media Server on an 8-way Compaq Proliant 8500 server running Windows 2000 Advanced Server along with 48 test clients running Microsoft's Windows Media Load Simulator tool and performed the following tests:

- **Narrowband:** confirm over 9000 concurrent 22kbps video streams[3] on a single server running Windows 2000 Advanced Server
- **Broadband:** confirm over 2400 concurrent 100kbps video streams[4] on a single server running Windows 2000 Advanced Server for a 14 day endurance test run

The following sections describe the steps we performed to configure the testbed, encode the source streams, verify proper test operation, and run the tests.

2.1 Test Configuration and Setup

We performed the test at ZD Labs in Morrisville, NC. Our test bed contained a Compaq Proliant 8500 server and 60 client machines connected via two Extreme Summit48 Fast Ethernet switches. Figure 1 shows the basic components and network configuration used for our test.

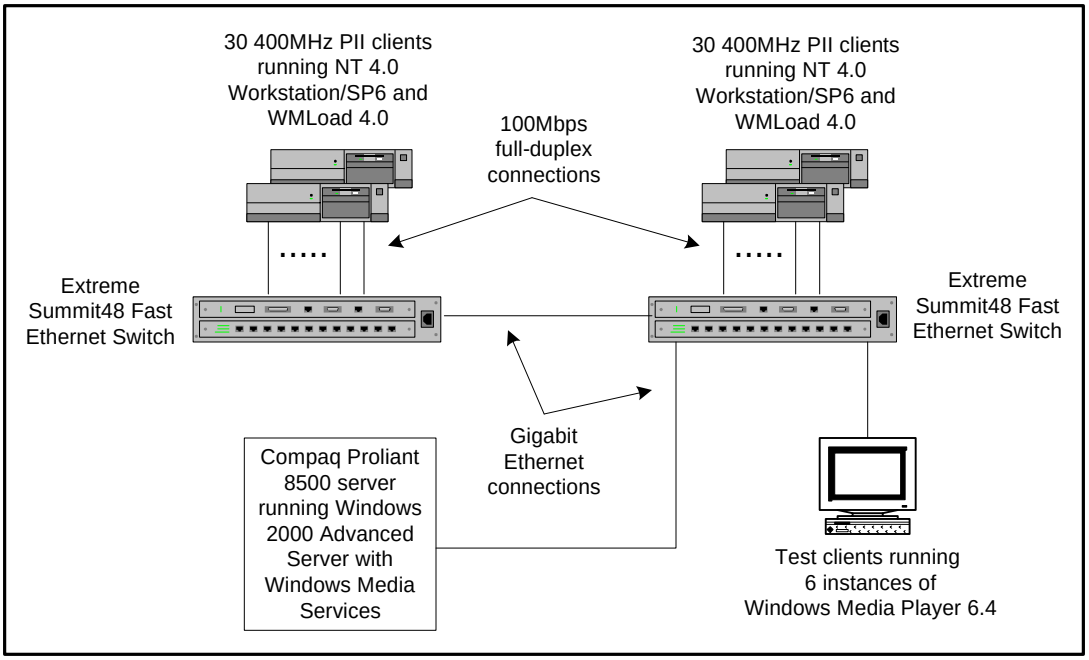

Figure 1.

Compaq supplied the Proliant 8500 server used for this test. The server contained 8 550MHz Pentium III Xeon processors with 2MB of L2 cache per processor, 1 GB of RAM, a Smart Array 4200 RAID controller, 2 9.1 GB drives, and a Gigabit NIC. Refer to Appendix A for a complete description of the hardware and software used for the test.

[3] MMS Unicast via UDP
[4] MMS Unicast via UDP

We used the Compaq SmartStart 4.60 CD to erase the existing configuration on the server so we could set up all of the software from scratch. We configured the two drives as individual logical drives with the Array Management Utility and installed Windows 2000 Advanced Server in a 4GB NTFS partition on the C: drive. During the Windows 2000 Advanced Server installation process, we chose to install Windows Media Services and Network Monitor, and we removed the Index Service.

Based on recommendations from Microsoft, we made the following changes to the server's registry:

HKLM\System\CurrentControlSet\Services\Nsunicast\Parameters\MaxConnectionsPerSecond=100
HKLM\System\CurrentControlSet\Services\Tcpip\Parameters\MaxUserPort=0xfffe
HKLM\System\CurrentControlSet\Services\AFD\Parameters\FastSendDatagramThreshold=30000

Our testbed clients consisted of 60 Dell Optiplex G1 machines configured with a 400MHz Pentium II processor, 128 MB of RAM, and Windows NT 4.0 Workstation with Service Pack 6. We downloaded a copy of Windows Media Player 6.4 (version 6.4.07.1112) and Windows Media Load Simulator 4.0 from Microsoft's Web site at http://www.microsoft.com/windows/windowsmedia/en/download/default.asp and installed them on each of the testbed clients.

We cascaded the Extreme switches together via a single Gigabit Ethernet connection and configured all of the clients and the server on a single IP subnet. Each client had a 100Mbps full duplex connection to the switch, and the Proliant 8500 server connected to the switch via a Gigabit Ethernet connection.

2.2 Stream Encoding

We setup a dual processor 450MHz Pentium II system running Windows NT 4.0 Workstation with Service Pack 4 as our encoding station. As an input source for the encoder, we installed a ViewCast.com Osprey-100 video capture card in the system and connected it to a JVC Super VHS VCR via an S-Video connection. We downloaded the Windows Media Tools 4.1 package from Microsoft's Web site at http://www.microsoft.com/windows/windowsmedia/en/download/default.asp and installed the Windows Media Encoder 4.1 (version 4.1.0.3920) component.

For the narrowband test, based on input from Microsoft, we chose the "28.8 Video for Web Server" template to encode an ASF (Advanced Streaming Format) file using input from the VCR passed through the Osprey-100. The template created a 22kbps stream with a 15-fps stream rate. We encoded 50 minutes of video, which resulted in an output file of roughly 8MB. During the encoding process, the encoding rate varied from 20kbps to 22kbps. The table in Figure 2 shows the information displayed by the encoder during the encoding process:

Windows Media Encoder Output	
Video Codec – MS-MPEG4 V3	Audio Codec – Windows Media Audio V2
Video Source – o100vc.dll	Audio Source – AudioPCI Record
Output File – 22kbps_stream.asf	Audio Input – Mixed Output
Configuration – 28.8 Video for Web Server	

Figure 2.

For the broadband test, we used the same hardware configuration, but used the "100 Video" template to create a 60-minute 100kbps stream. Figure 3 shows the information displayed by the encoder.

Windows Media Encoder Output	
Video Codec – MS-MPEG4 V3	Audio Codec – Windows Media Audio V2
Video Source – o100vc.dll	Audio Source – AudioPCI Record
Output File – 100kbps_stream.asf	Audio Input – Mixed Output
Configuration – 100 Video	

Figure 3.

2.3 Verification Checks

Before running the tests, we performed several basic verification checks on the Windows Media Load Simulator tool (WMLoad) to ensure that it interacted properly with Windows Media Server. First we compared network traces of Windows Media Player and WMLoad reading a single MMS unicast UDP stream. Both traces showed similar interaction between the client and server.

We also verified that the following properties correlated correctly as we varied the number of client streams handled by WMLoad:

- The number of distinct UDP ports used to communicate between the client and server (should be one port per unicast stream)
- The client machine's CPU and network utilization (should increase as streams are added)
- The Active UDP Stream Count displayed by Perfmon on the server (should match the WMLoad stream count)

Finally, we configured WMLoad to stream 450 22kbps MMS unicast UDP streams from the Windows Media Server. The total network bandwidth required for all of the streams should be approximately 9.9 Mbps (22,000 * 450). Using the port utilization counters of the Extreme switch, we verified that the network bandwidth on the client varied between 9.8 and 10.5 Mbps.

We did not attempt to verify any functions of the WMLoad tool beyond those above, because doing so was beyond the scope of this commission.

2.4 Narrowband Test Procedure

Before running the test, we created 6 Multicast Stations (Station1 – Station6) and their accompanying Broadcast Publishing Points on Windows Media Server. We set each Broadcast Publishing Point to endlessly stream the 22kbps ASF file created during the narrowband encoding process.

Microsoft requested that we use the following configuration parameters for the WMLoad tool on each test client:

- 450 UDP unicast streams per test client
- Client streams established at 50 connections/second
- mmsu protocol
- No authentication
- Indefinite duration
- No logging

We also setup an additional test client running 6 instances of Windows Media Player 6.4. Each player connected to one of the six stations on the server. This allowed us to view and verify the video stream sent by each station during the test.

We ran two test runs to verify reproducibility of results. For each test run, we followed the steps listed below:

1. Reboot the server and all of the test clients
2. Start the video stream for each station. Stagger the start of each stream by 7 seconds
3. Start 6 instances of Windows Media Player and connect to each station. Verify that the video stream is displaying properly on each player
4. Start WMLoad on a test client connected to the first Extreme switch. Start 450 MMS unicast UDP streams connected to Station 1 at a rate of 50 connections/second.
5. Verify that the network bandwidth used by the test client is approximately 10Mbps based on the switch port utilization counters.

6. Verify via Perfmon that the Active UDP Stream Count increased by 450
7. Verify that all 6 Windows Media Players are still playing the 6 stations
8. Repeat steps 4 – 7 alternating between the two Extreme switches and the 6 stations until the stream count reaches 8106.
9. Repeat steps 4 – 7 using a connection rate of 25 connections/second until the stream count reaches 9006.
10. Run the test with 9006 streams for 10 minutes to test server stability
11. Add 250 additional streams at a rate of 25 connections/second until Windows Media Server starts dropping streams.

In both test runs, Windows Media Server successfully delivered 9006 MMS unicast UDP streams for 10 minutes. We were able to increase the stream count to 9506 streams before we started seeing stream errors and dropped streams.

We did notice that the video playback on some of the Windows Media Players became jerky and inconsistent once the stream count passed 8100 streams. Typically 1 or 2 of the six players showed this behavior while the remaining players showed normal playback. We were unable to determine the cause of this, as we detected no packet loss originating from the server. The playback on all of the players slowed considerably right before Windows Media Server started to exhibit stream errors and dropped streams.

2.5 Broadband Test Procedure

Before running the test, we created 6 Multicast Stations (Station1 – Station6) and their accompanying Broadcast Publishing Points on Windows Media Server. We set each Broadcast Publishing Point to endlessly stream the 100kbps ASF file created during the broadband encoding process.

Microsoft requested that we use the following configuration parameters for the WMLoad tool on each test client:

- 50 UDP unicast streams per test client
- Client streams established at 50 connections/second
- mmsu protocol
- No authentication
- Indefinite duration
- No logging

We also setup six additional test clients each running an instance of Windows Media Player 6.4. Each player connected to one of the six stations on the server. This allowed us to view and verify the video stream sent by each station during the test.

We used the following procedure to start the test:

1. Reboot the server and all of the test clients
2. Start the video stream for each station. Stagger the start of each stream by 7 seconds
3. Start 6 instances of Windows Media Player and connect one to each station. Verify that the video stream is displaying properly on each player
4. Start WMLoad on a test client connected to the first Extreme switch. Start 50 MMS unicast UDP streams connected to Station 1 at a rate of 50 connections/second.
5. Verify that the network bandwidth used by the test client is approximately 5Mbps based on the switch port utilization counters.
6. Verify via Perfmon that the Active UDP Stream Count increased by 50
7. Verify that all 6 Windows Media Players are still playing the 6 stations
8. Repeat steps 4 – 7 alternating between the two Extreme switches and the 6 stations until the stream count reaches 2406 (required 48 clients).

Once the load reached 2406 streams, we let the test run for 14 days. We checked the status of the test four times daily to verify that Windows Media Server was still distributing all 2406 streams. After 12 days and 16 hours the test stopped unexpectedly due to an UPS hardware failure. At the point where the test ended, Windows Media Server was still successfully streaming all 2406 100kbps-video streams to the test clients. The packet counters on the WMLoad clients reported a total of only 16 lost packets out of more than 26 billion packets transmitted over the entire life of the test. This resulted in an accurate delivery of 99.9999999% of the data. After reviewing the test logs, we determined that the test failure was not related to Windows Media Server.

Appendix

A. Test Bed Configuration Information

Windows Media Server	
Machine Type	Compaq Proliant 8500
BIOS	Compaq BIOS P42 (10/11/1999)
Processors	8 550 MHz Pentium III Xeon
L2 Cache	2MB
Expansion Bus	3 PCI buses PCI 1 – 6 64bit/33MHz slots PCI 2 – 3 64bit/33MHz slots PCI 3 – 2 64bit/66MHz slots
Memory	1GB
Disk(s)	2 9.1GB 10K RPM Ultra2 SCSI drives
Disk Controller	Compaq SmartArray 4200 RAID Controller w/56MB cache, 1.06 firmware, and Windows 2000 driver version 5.0.2183.1
Disk Configuration	1 drive for the OS, 1 drive for data
Network Adapter(s)	Compaq NC3131 Dual Port Fast Ethernet NIC with NC6132 Gigabit Ethernet module. We only used the Gigabit Adapter for our test. The Gigabit module ran Windows 2000 driver version 1.5.0.1020
OS	Windows 2000 Advanced Server
Additional Software	Windows Media Server

Windows Media Encoding System	
BIOS	Award Modular BIOS v4.51PG (10/21/99)
Processors	2 450 MHz Pentium II
L2 Cache	512KB
Expansion Bus	1 32-bit PCI bus
Memory	256MB
Disk(s)	1 11GB EIDE drive
Network Adapter(s)	Netgear FA310TX Fast Ethernet Adapter running NT driver version 4.30.
Video Capture Card	ViewCast.com Osprey-100 running NT driver version 1.31
Sound Card	Creative Ensoniq AudioPCI 197 running NT driver version 4.10.10
Video Adapter	Matrox Millennium G200 AGP running NT driver version 4.0
OS	Windows NT 4.0 Workstation
OS Updates	Service Pack 4
Additional Software	Windows Media Tools 4.1
Additional Hardware	JVC Super VHS VCR Model HR-S7200U

Network Test Bed Clients	
Machine Type	Dell OptiPlex G1
BIOS	Phoenix ROM BIOS PLUS Version 1
Processor(s)	400MHz PII
L2 Cache	512K
Expansion Bus	32-bit PCI
Memory	128 MB

Disk(s)	1 4GB IDE
Network Adapter(s)	1 3Com FastEthernet XL 3C905B running NT driver version 4.01A
OS	Windows NT Workstation 4.0
OS Updates	Service Pack 6
Additional Software	Windows Media Player 6.4 (version 6.4.07.1112) Windows Media Load Simulator 4.0

Network Configuration	
Media	All the clients were connected to the switches via 100Mbps full duplex. The server connection was Gigabit Ethernet
Switches	Two 48 port Extreme Summit48 switches configured in Layer 2 mode running ExtremeWare version 2.1.8

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