Intel® Core™ vPro™ processor-based PC delivered the best multimedia user experience*

*compared to representative systems from other client classes when connected to an Intel Xeon® processor X5570-powered server running a single virtual desktop session with multimedia redirection enabled

OUR FINDINGS

Organizations deploying virtual desktops must weigh the benefits of different classes of clients. As computing needs grow over time, an investment in PCs can meet the needs of increasing categories of workers. In Principled Technologies' tests in our labs, an Intel® Core™ vPro™ processor-based PC delivered an excellent user experience while playing advanced multimedia workloads within a virtual desktop infrastructure (VDI) session. Such clients would serve a company well today and for years to come.

OUR PROCESS

To evaluate the user experience when running VDI sessions from three different clients, we rated the video and audio quality of various workloads, including multimedia and printing, in the VDI virtual machines. For testing, we played a video inside the virtual desktop and monitored the video and audio quality. In addition, we recorded the frames per second while the video played.

PROJECT OVERVIEW

The goal of this report is to communicate the multimedia performance benefits of using PCs rather than thin clients to run Microsoft® Windows Server® 2008 R2 Remote Desktop Services (RDS) virtual desktops. PCs can utilize their own processors and graphics processing units to offload multimedia workloads in a virtual desktop environment when multimedia redirection (MMR) is enabled. Multimedia redirection lets physical clients use their local hardware to format and play media content. This greatly reduces server CPU usage and demonstrates one of the benefits of intelligent PC clients as VDI end-points.

We tested the VDI performance of three classes of clients by selecting a leading representative system from each:

- **Mainstream business laptop:** HP EliteBook 8440p Intel Core i5-520M vPro processor (2.40 GHz)
- **Netbook:** HP Mini 5102 with Intel Atom™ N450 processor (1.66 GHz)
- **Thin client:** Wyse C90LEW with VIA Eden™ 1.00 GHz processor (1.00 GHz)

We ran three advanced multimedia workloads on each system. As Figure 1 shows, the Intel Core vPro processor-based PC delivered better multimedia experiences than other client classes. We present detailed results and explain our ratings in the What We Found section below.
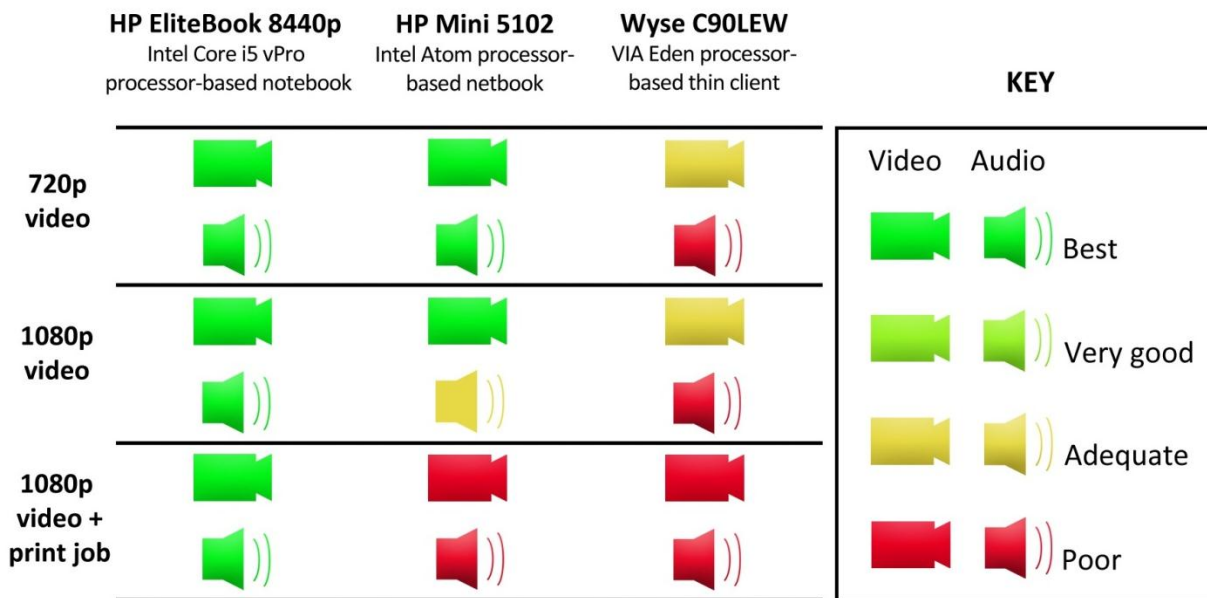

Figure 1: User-experience results for the three classes of clients we tested.

WHAT WE TESTED

About multimedia redirection

Multimedia redirection is a technology that lets physical clients use their local CPUs and graphics cards to format and play media content. Without MMR, this processing demand is on the hosting server, thus causing the server to utilize more resources per virtual desktop. For testing, we ran with MMR enabled on all clients but the Wyse C90LEW, because it does not support MMR. For information about the benefits MMR provides for virtual desktop deployments, including the reduction of server utilization, please see our corresponding report at

http://www.principledtechnologies.com/clients/reports/Intel/MMR_effect_VDI_RDS_1010.pdf.

About Remote Desktop Services

RDS is one of the core virtualization technologies available in Windows Server 2008 R2. According to the Microsoft Web site, RDS represents the company's progress toward providing the best virtualization platform for accelerating and extending desktop and application deployments from the data center to any device. In addition to the traditional session virtualization scenario (formerly known as "Terminal Services"), Remote Desktop Services is expanding its role to provide an extensible platform for a Virtual Desktop Infrastructure. For more information on RDS, see http://www.microsoft.com/windowsserver2008/en/us/rds-product-home.aspx.

How we tested Remote Desktop Services

To test the performance of the three clients running Remote Desktop Services, we used two video workloads:

- Microsoft Robotica video, available for download at http://www.highdefforum.com/high-definition-movies-video-clips/6537-official-hd-video-clip-list.html
- Robotica video while running a print job

We rated the video and audio quality of the video workloads on each client. We installed Beepa® Fraps® on the clients to record the average frames per second (FPS) rate that each client achieved, and assigned overall quality scores based on the quality of the video and audio on each client. Note that we were unable to record average FPS rates for the Wyse C90LEW because its operating system was incapable of running the Fraps program.

We chose advanced multimedia workloads at 720p and 1080p to measure the user experience capabilities of the various client classes because a company looking to deploy a VDI solution needs to ensure

that their virtual desktop clients will be able to handle the computing needs of their workers not only today, but into the future as well. While the typical virtual desktop user may not regularly play 720p or 1080p videos, ensuring that clients can meet these more advanced needs will ensure that most user demands can be met today while preparing for future computing needs.

To determine the performance of each client while each completed multiple tasks, we played the Robotica video at 1080p while simultaneously running a print job. We opened a target PDF file, selected Print, started the video, returned to the Print PDF screen, and clicked OK to ensure that the print job executed while the video was running.

Finally, we configured a dual-socket server and gigabit LAN environment in such a way that it did not interfere with client performance. To ensure further that our testing focused on client performance, we ran only one virtual desktop for each test. For detailed server configuration information, see Appendix A. For detailed client configuration information, see Appendix B. For our detailed test methodology, see Appendix C.

WHAT WE FOUND

Figure 2 lists the ratings we use to describe the audio, video, and overall quality of the workloads, and the criteria we used to determine each rating.

Rating	Meaning
Best	Essentially flawless audio and video quality
Very good	Near-perfect quality, with some minor syncing or skipping issues
Adequate	Moderate syncing or skipping issues
Poor	Severe syncing or skipping issues; practically unwatchable

Figure 2: Ratings we used for our workload testing and their meanings.

In addition to rating the video and audio quality of the advanced multimedia workloads, we also recorded the average FPS as we note earlier. An average FPS rate of around 30 FPS indicates the best video quality, while anything less than 30 FPS indicates that the video performance likely suffered. Please note that we were unable to record average FPS rates from the Wyse C90LEW because its embedded operating system is incapable of running the Fraps program.

Figure 3 shows the video playback results for the clients at 720p. The HP EliteBook8440p and HP Mini5102 played the video with perfect audio and video quality, while the Wyse C90LEW displayed video that skipped occasionally with the audio skipping throughout.

720p video playback results			
Client	Video quality	Audio quality	Avg. FPS
HP EliteBook 8440p	Best	Best	24
HP Mini 5102	Best	Best	24
Wyse C90LEW	Adequate	Poor	N/A

Figure 3: Video playback test results at 720p.

Figure 4 shows the video playback results for the clients at 1080p. The HP EliteBook8440p played the video with perfect audio and video quality, the HP Mini 5102 displayed perfect video quality with audio that was out-of-sync at times, and the Wyse C90LEW displayed somewhat choppy video with the audio out-of-sync throughout the test.

1080p video playback results			
Client	Video quality	Audio quality	Avg. FPS
HP EliteBook 8440p	Best	Best	24
HP Mini 5102	Best	Adequate	24
Wyse C90LEW	Adequate	Poor	N/A

Figure 4: Video playback test results at 1080p.

Figure 5 shows the video playback and print job test results for the clients at 1080p. The HP EliteBook 8440p played the video with perfect audio and video quality, and both the HP Mini 5102 and the Wyse C90LEW displayed extremely choppy video with out-of-sync audio throughout the video.

1080p video playback + print job results			
Client	Video quality	Audio quality	Avg. FPS
HP EliteBook 8440p	Best	Best	24
HP Mini 5102	Poor	Poor	17
Wyse C90LEW	Poor	Poor	N/A

Figure 5: Video playback and print job test results at 1080p.

For CPU utilization and throughput data we recorded during our tests, please see Appendix D.

SUMMARY

Of the three client systems we tested for Remote Desktop Services (RDS) virtual desktops, the HP EliteBook 8440p with Intel Core i5-520M vPro processor provided the best user experience. Not only did this system achieve the highest quality audio and video across the three advanced multimedia workloads we tested, it did so using its own local hardware to format and play media content. A large-scale deployment of these notebook PC systems would provide workers with excellent multimedia experiences while greatly reducing server CPU usage.

APPENDIX A – SERVER CONFIGURATION INFORMATION

Figure 6 provides detailed configuration information about the host server.

System	Super Micro 6026T-NTR+
Power supplies	
Total number	2
Vendor and model number	SuperMicro PWS-721P-R1
Wattage of each (W)	720
Cooling fans	
Total number	3
Vendor and model number	Sanyo Denki San Ace 80 9G0812P1G09
Dimensions (h x w) of each (inches)	3-1/4 x 3-1/4
Volts	12
Amps	1.1
General	
Number of processor packages	2
Number of cores per processor	4
Number of hardware threads per core	2
System power management policy	Balanced
CPU	
Vendor	Intel
Name	Xeon
Model number	X5570
Stepping	D0
Socket type	LGA 1366
Core frequency (GHz)	2.93
Bus frequency	6.4 GT/s
L1 cache	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)
L3 cache	8 MB (shared)
Platform	
Vendor and model number	SuperMicro 6026T-NTR+
Motherboard model number	SuperMicro X8DTN+
Motherboard chipset	Intel 5520
BIOS name and version	American Megatrends Inc. (03/08/2010)
BIOS settings	Default
Memory module(s)	
Total RAM in system (GB)	24
Vendor and model number	Crucial CT51272BB1339.36SF D1
Type	PC3-10600
Speed (MHz)	1,333

System	Super Micro 6026T-NTR+
Speed running in the system (MHz)	1,333
Timing/latency (tCL-tRCD-tRP-tRASmin)	9-9-9-24
Size (GB)	8
Number of RAM module(s)	6 x 8 GB
Chip organization	Double-sided
Rank	Dual
Hard disk	
Vendor and model number	Western Digital WD1601ABYS
Number of disks in system	2
Size (GB)	160
Buffer size (MB)	16
RPM	7,200
Type	SATA
Disk controller	
Vendor and model	Intel Corporation ICH10R/DO SATA
Controller cache	N/A
Controller driver	Intel 9.6.4.1002 (6/8/2010)
Controller firmware	1.2.5
RAID configuration	RAID 0
Operating system	
Name	Windows Server 2008 R2
Build number	7600
Service pack	NA
File system	NTFS
Kernel	ACPI x64 based PC
Language	English
Graphics	
Vendor and model number	ATI ES1000
Graphics memory	32 MB
Driver	ATI technologies Inc. 8.240.50.3000 (1/21/2008)
Ethernet	
Vendor and model number	Intel 82576 Gigabit Dual Port Connection
Type	Integrated
Driver	11.0.5.22 (4/6/2009)
Optical drive(s)	
Vendor and model number	TEAC DV28S-V
Type	DVD/CD-ROM

System	Super Micro 6026T-NTR+
USB ports	
Number	4
Type	2.0

Figure 6: Test server configuration details.

APPENDIX B – CLIENT CONFIGURATION INFORMATION

Figures 7 and 8 present detailed system configuration information for the three test clients.

System	HP EliteBook 8440p (Intel Core i5 vPro processor-based notebook)	HP Mini 5102 (Intel Atom processor-based netbook)
General		
Number of processor packages	1	1
Number of cores per processor	2	1
Number of hardware threads per core	2	2
System power management policy	Balanced	Balanced
Processor power-saving option	Enhanced Intel SpeedStep® Technology	Enhanced Intel SpeedStep Technology
System dimensions (length x width x height)	13-3/16" x 9-1/8" x 1-3/8"	10-5/16" x 7-1/16" x 1-1/16"
System weight	5 lbs. 2.5 oz.	2 lbs. 7.5 oz.
CPU		
Vendor	Intel	Intel
Name	Core i5	Atom
Model number	520M	N450
Stepping	C2	B0
Socket type and number of pins	BGA1288	FCBGA559
Core frequency (GHz)	2.40	1.66
Bus frequency	2.5 GT/s	667 MHz
L1 cache	64 KB + 64 KB (per core)	24 KB + 32 KB
L2 cache	512 KB (shared)	512 KB
L3 cache (MB)	3	N/A
Platform		
Vendor	HP	HP
Motherboard model number	172A	3653
Motherboard chipset	Intel QM57	Intel NM10
BIOS name and version	HP 68CCU Ver. F.06 (03/22/2010)	HP 68PGU Ver. F.03 (01/27/2010)
Memory module(s)		
Vendor and model number	Samsung M471B5673EH1-CH9	Hynix HYMP112S64CP6-S6
Type	PC3-10600S	PC2-6400S
Speed (MHz)	1,333	800

System	HP EliteBook 8440p (Intel Core i5 vPro processor-based notebook)	HP Mini 5102 (Intel Atom processor-based netbook)
Speed running in the system (MHz)	1,066	800
Timing/Latency (tCL-tRCD-tRP-tRASmin)	7-7-7-20	5-5-5-15
Size (MB)	2,048	1,024
Number of memory module(s)	1	1
Chip organization (single-sided/double-sided)	Double-sided	Double-sided
Channel (single/dual)	Single	Single
Hard disk		
Vendor and model number	Seagate ST9250410AS	Hitachi HTS725016A9A364
Number of disks in system	1	1
Size (GB)	250	160
Buffer size (MB)	16	16
RPM	7,200	7,200
Type	SATA	SATA
Controller	Intel PCHM SATA AHCI Controller 6 Port	Standard AHCI 1.0 Serial ATA Controller
Driver	Intel 8.9.2.1002 (08/07/2009)	Microsoft 6.1.7600.16593 (06/21/2006)
Operating system		
Name	Windows 7 Professional 32-bit	Windows 7 Professional 32-bit
Build number	7600	7600
Service Pack	N/A	N/A
File system	NTFS	NTFS
Kernel	ACPI x86-based PC	ACPI x86-based PC
Language	English	English
Microsoft DirectX version	11	11
Graphics		
Vendor and model number	Intel Graphics Media Accelerator HD	Intel Graphics Media Accelerator 3150
Type	Integrated	Integrated
Chipset	Intel GMA HD	Intel GMA 3150
BIOS version	1994.0	1921.0
Total available graphics memory (MB)	762	248
Dedicated video memory (MB)	64	0

System	HP EliteBook 8440p (Intel Core i5 vPro processor-based notebook)	HP Mini 5102 (Intel Atom processor-based netbook)
System video memory (MB)	0	64
Shared system memory (MB)	698	184
Resolution	1,366 x 768 x 32-bit	1,024 x 600 x 32-bit
Driver	Intel 8.15.10.1995 (11/06/2009)	Intel 8.14.10.1972 (10/15/2009)
Sound card/subsystem		
Vendor and model number	IDT High Definition Audio CODEC	IDT High Definition Audio CODEC
Driver	IDT 6.10.6257.0 (11/18/2009)	IDT 6.10.6257.0 (11/18/2009)
Ethernet		
Vendor and model number	Intel 82577LM Gigabit Network Connection	Marvell Yukon 88E8059 PCI-E Gigabit Ethernet Controller
Driver	Intel 11.5.4.0 (11/05/2009)	Marvell 11.25.3.3 (04/26/2010)
Wireless		
Vendor and model number	Intel Centrino® Advanced-N 6200 AGN	Broadcom® 43224AG 802.11a/b/g/draft-n Wi-Fi Adapter
Driver	Intel 13.0.0.107 (09/15/2009)	Broadcom 5.60.350.11 (05/07/2010)
USB ports		
Number	3	3
Type	2.0	2.0
Other	eSATA, dual-mode DisplayPort, SD-MMC Card Reader	SD-MMC Card Reader
IEEE 1394 ports		
Number	1	N/A
Monitor		
LCD type	LED-backlit HD anti-glare	LED-backlit WSVGA widescreen
Screen size (inches)	14.0	10.1
Refresh rate (Hz)	60	60
Battery		
Type	HP TD06	HP GC04
Size (length x width x height)	8" x 1-9/16" x 3/4"	8-1/8" x 1-5/8" x 1/2"
Rated capacity	4600 mAh / 10.8 V (55 Wh)	8600 mAh / 14.8 V (128 Wh)
Weight (ounces)	11.2	7.0

Figure 7: Configuration details for two of the test clients.

System	Wyse C90LEW (VIA Eden processor-based thin client)
General	
Number of processor packages	1
CPU	
Vendor	VIA
Name	Eden
Stepping	C5R
Socket type	nanoBGA2
Core frequency (GHz)	1.00
Bus frequency	400 MHz
Platform	
Vendor	Wyse
Motherboard model number	Inventec C Class
Motherboard chipset	VIA VX855/VX875
BIOS name and version	Phoenix Technologies 1.0B 10/07/2010
Memory module(s)	
Vendor and model number	Apacer 8Y.4D014.7254B
Type	Flash
Size (MB)	2,048
Memory module(s) 2	
Vendor and model number	Apacer 75.073AM.G06
Type	PC2-6400
Speed (MHz)	800
Speed running in the system (MHz)	800
Size (MB)	1,024
Number of memory module(s)	1
Chip organization	Double-sided
Channel	Single
Operating System	
Name	Microsoft Windows® XP Embedded
Build number	2600
Service Pack	3
File System	NTFS
Kernel	ACPI Uniprocessor PC
Language	English
Microsoft DirectX version	9.0c
Graphics	
Vendor and model number	VIA Technologies VIA Chrome9 HCM IGP

System	Wyse C90LEW (VIA Eden processor-based thin client)
Type	Integrated
Chipset	VIA Chrome9 HCM IGP
Sound card/subsystem	
Vendor and model number	VIA Technologies High Definition Audio v 1.0
Ethernet	
Vendor and model number	VIA Velocity Family Gigabit
USB ports	
Number	4
Type	2.0

Figure 8: Configuration details for the Wyse C90LEW.

APPENDIX C – TEST METHODOLOGY

Setting up DC1 (infrastructure server)

Installing Windows Server 2008 R2 Enterprise Edition

1. Boot the infrastructure server, and insert the Windows Server 2008 R2 installation DVD in the DVD-ROM drive.
2. At the Language Selection Screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 Enterprise Edition R2 (Full Installation), and click Next.
5. Click the I accept the license terms check box, and click Next.
6. Click Custom.
7. Click Drive options (advanced).
8. Ensure you select the proper drive, and click New.
9. Click Apply.
10. Click Next.
11. When the installation completes, open Server Manager→Configuration→Local Users and Computers→Users, select Administrator, and right click the Administrator. Set Password to `Password1`
12. Log out, and log in as Administrator.
13. Open Server Manager.
14. Select Change System Properties.
15. In the systems properties dialog box, rename the computer name to `DC1`
16. Reboot the system.
17. Set the password to `Password1`
18. At the Your password has been changed screen, click OK.

Installing system updates in Windows Server 2008 R2

Using the Windows Update feature, we installed the following updates:

- Security Update for Microsoft .NET Framework 3.5.1, Windows 7, and Windows Server 2008 R2 for x64-based Systems (KB2416471)
- Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2398632)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2347290)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981550)
- Security Update for .NET Framework 3.5.1 on Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB983590)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2160329)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2079403)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2183461)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978886)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981852)
- Windows Malicious Software Removal Tool x64 - September 2010 (KB890830)
- Update for Windows Server 2008 R2 x64 Edition (KB2158563)

- Security Update for Windows Server 2008 R2 x64 Edition (KB982799)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980436)
- Security Update for Windows Server 2008 R2 x64 Edition (KB982214)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2286198)
- Windows Malicious Software Removal Tool x64 - July 2010 (KB890830)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2032276)
- Rules Update for Active Directory Domain Services Best Practice Analyzer for Windows Server 2008 R2 x64 Editions (KB980360)
- Microsoft .NET Framework 3.5 SP1 Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB982526)
- Security Update for Windows Server 2008 R2 x64 Edition (KB977894)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB980195)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB982381)
- Update for Windows Server 2008 R2 x64 Edition (KB977074)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979309)
- Security Update for Windows Server 2008 R2 x64 Edition (KB972270)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980232)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979683)
- Update for Windows Server 2008 R2 x64 Edition (KB976662)
- Windows Malicious Software Removal Tool x64 - June 2010 (KB890830)
- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979482)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979559)
- Update for Best Practices Analyzer for Application Server for Windows Server 2008 R2 x64 Edition (KB981392)
- Update for Best Practices Analyzer for File Services for Windows Server 2008 R2 x64 Edition (KB981111)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975560)
- Microsoft .NET Framework 3.5 SP1 Security Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB979916)
- Update for Best Practices Analyzer for HYPER-V for Windows Server 2008 R2 x64 Edition (KB977238)
- Security Update for Windows Server 2008 R2 x64 Edition (KB971468)
- Microsoft .NET Framework 3.5 SP1 Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB982526)
- Update for Windows Server 2008 R2 x64 Edition (KB981793)
- Update for Best Practices Analyzer for DHCP Server for Windows Server 2008 R2 x64 Edition (KB977236)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980218)
- Update for Windows Server 2008 R2 x64 Edition (KB982519)
- Update for Best Practices Analyzer for Network Policy and Access Services for Windows Server 2008 R2 x64 Edition (NPAS) (KB977239)

- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Update for Windows Server 2008 R2 x64 Edition (KB980846)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978542)
- Update for Windows Server 2008 R2 x64 Edition (KB978637)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978601)
- Update for Best Practices Analyzer for Windows Server Update Services for Windows Server 2008 R2 x64 Edition (KB981390)
- Update for Rights Management Services Client for Windows Server 2008 R2 x64 Edition (KB979099)
- Update for Best Practices Analyzer for Active Directory Rights Management Services for Windows Server 2008 R2 x64 Edition (KB981391)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981332)
- Update for Windows Server 2008 R2 x64 Edition (KB980408)
- Update for Internet Explorer 8 Compatibility View List for Windows Server 2008 R2 x64 Edition (KB982632)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)

Setting up network configuration on DC1

1. Click Start→Run, and type `ncpa.cpl`
2. Right-click on the active adaptor, and click Properties.
3. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
4. At the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
5. Type `192.168.1.200` for the IP address, `255.255.255.0` for the default subnet mask, and `192.168.1.200` for the gateway.
6. Click OK, and click Close to exit.

Installing Active Directory and DNS services on DC1

1. Click Start→Run, type `dcpromo` and click OK.
2. At the Active Directory Domain Services Installation Wizard welcome screen, check the Use advanced mode installation option, and click Next.
3. In the Choose a Deployment Configuration dialog box, select Create a new domain in a new forest, and click Next.
4. At the FQDN page, type `login-vsi.com` and click Next.
5. At the NetBIOS name prompt, leave the name LOGIN-VSI, and click Next.
6. At the Forest Functionality level, select Windows Server 2008 R2, click Next.
7. At the additional Domain Controller Options, leave DNS server selected, and click Next.
8. At the System Folder Location screen, leave the default options, and click Next.
9. Assign a Directory Services Restore Mode Administrator account password, and click Next.
10. At the Summary screen, review your selections, and click Next.
11. Once Active Directory Domain Services finishes installing, click Finish, and restart the system.

Setting up DHCP services on DC1

1. Click Start→Administrative Tools→Server Manager→Add Roles.
2. Select DHCP Server, and click Next.

3. At the Introduction to DHCP Server screen, click Next.
4. At the Specify IPv4 DNS Settings screen, type `loginvsi.com` for the parent domain.
5. Set the preferred DNS server IPv4 address to `192.168.1.200` and click Next.
6. At the Specify IPv4 WINS Server Settings screen, select WINS is not required for applications on the network, and click Next.
7. At the Add or Edit DHCP Scopes screen, click Add.
8. At the Add Scope screen, enter the Name DHCP Scope name.
9. In the next box, set the following values, and click OK.
   - Starting IP Address: `192.168.1.1`
   - Ending IP Address: `192.168.1.199`
   - Subnet mask: `255.255.255.0`
10. Check the Activate This Scope box.
11. At the Add or Edit DHCP Scopes screen, click Next.
12. Click the Enable DHCP v6 Stateless Mode radio button, and click Next.
13. Leave the default IPv6 DNS Settings, and click Next.
14. At the Authorize DHCP server dialog box, select Use current credentials.
15. At the Confirm Installation Selections screen, click Next. If the installation is set up correctly, a screen displays that DHCP Server Install Succeeded.
16. Click Close.

Setting up RDS-V (server under test)

Installing Windows Server 2008 R2 Enterprise Edition

1. Boot the server under test, and insert the Windows Server 2008 R2 installation DVD in the DVD-ROM drive.
2. At the Language Selection Screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 Enterprise Edition R2 (Full Installation), and click Next.
5. Click the I accept the license terms check box, and click Next.
6. Click Custom.
7. Click Drive options (advanced).
8. Ensure you select the proper drive, and click New.
9. Click Apply.
10. Click Next.
11. When the installation completes, open Server Manager→Configuration→Local Users and Computers→Users, select Administrator, and right click the Administrator. Set Password to `Password1`
12. Log out and log in as Administrator.
13. Open Server Manager.
14. Select Change System Properties.
15. In the systems properties dialog box rename the computer name to `RDS-V`
16. Reboot the system.
17. Set the password to `Password1`
18. At the Your password has been changed screen, click OK.

Installing system updates in Windows Server 2008 R2

We installed all available updates using the Windows Update feature, which we list above.

Setting up network configuration on RDS-V

1. Click Start→Run, and type `ncpa.cpl`
2. Right click on the active adaptor, and click Properties.
3. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
4. At the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
5. Type `192.168.1.111` for the IP address, `255.255.255.0` for the default subnet mask, and `192.168.1.200` for preferred DNS server.
6. Click OK, and click Close to exit.

Enabling the Hyper-V role on RDS-V

1. Click Start→Administrative Tools→Server Manager.
2. Click Roles.
3. Click Add Roles.
4. Click Next.
5. Select the Hyper-V role by checking the box beside it, and click Next.
6. Check the box beside the Ethernet Card you wish to use for client/server traffic, and click Next.
7. Click Install to begin the Hyper-V installation.
8. When the installation finishes, click Close.
9. When the installer prompts you to restart now, click Yes.
10. Follow the prompt to log onto the system.
11. Enter the password, and click the arrow to continue. The Resuming Configuration Wizard should start automatically.
12. Once the Resuming Configuration Wizard completes, the installation results appear with a message that the installation succeeded.
13. Click Close.

Configuring virtual networks

1. Open Hyper-V Manager.
2. From the Actions menu, click Virtual Network Manager.
3. Under Create virtual network, select External network. Use one physical NIC that is connected to the private 192.168.1.111 network. Click Add, and the New Virtual Network page appears.
4. Type `VSI-net` for the name of the new network. Review the other properties and modify them if necessary.
5. Click OK to create the virtual network and close Virtual Network Manager, or click Apply to create the virtual network and continue using Virtual Network Manager.

Installing the Windows 7 Enterprise (32 bit) Virtual Machine

1. Open the Hyper-V manager.
2. Right-click RDS-V, and select New Virtual Machine.
3. Name the virtual machine `WIN7EE1`.
4. Assign Memory to 1024 MB, and click Next.

5. Configure networking change connection to local area connection – Virtual network.
6. Click Create virtual hard disk.
7. Set size to 20 GB, and click Next.
8. From Install options, select Install media.
9. Click Finish.
10. Right click the Windows 7 VM, and select Settings.
11. Click on Processors, change the number of logical processors to 2, and click OK.
12. Start your VM with media ready.
13. When the installation prompts you, press any key to begin setup.
14. Enter your language preferences, and click Next.
15. Click Install.
16. Accept the license terms, and click Next.
17. Select Custom, and select the drive that will contain the OS.
18. Click Install. Setup begins.
19. Type `WIN7EE1` for the username, type `WIN7EE1-PC` for computer, and click Next.
20. Enter no password, and click Next.
21. For system protection, select Use recommended settings, and click Next.
22. Enter your time zone, and click Next.
23. Select the Work Network setting, and click Next.
24. Use Windows Update to patch the Windows 7 installation.
25. Click Start, right-click Computer, click Properties→Remote settings, and select Allow connections from any version of Remote Desktop. Click OK.
26. Click Start, right-click Computer, click Properties→Advanced system settings→System Protection→Configure →Turn off system protection, and click OK.
27. Click Start, right-click Computer, and click Properties→Advanced system settings→Advanced→Performance: Settings.
28. In Performance Settings, select the Advanced tab, and select Change for Virtual Memory.
29. De-select Automatically manage paging file size for all drives.
30. Select Custom size and for both values, enter `2048`, select Set, and click OK.

Joining the login-vsi domain

1. Click Start, right-click Computer, and click Properties→Advanced system settings→Computer Name tab.
2. Select Change.
3. Select Domain under Member of.
4. Enter the domain name as `login-vsi.com`, and click OK.
5. Enter the domain administrator account and password for the login-vsi domain.
6. Reboot the system.

APPENDIX D – CPU UTILIZATION AND THROUGHPUT DATA

While we tested the average FPS for the video workloads, we recorded CPU utilization and bandwidth for both the host server and the clients. Figures 9 through 11 present these results for the 720p video playback test, the 1080p video playback test, and the video playback and print job test we ran.

720p video playback	CPU %		Transfers/second	
	Server	Client	KB/s	KB/s peak
HP EliteBook 8440p	2.75	10.25	790.5	1,150.0
HP Mini 5102	2.38	57.99	641.9	1,180.4
Wyse C90LEW	2.60	98.57	734.5	940.1

Figure 9: CPU percent average and transfers/second for the server and clients during the 720p video playback test.

1080p video playback	CPU %		Transfers/second	
	Server	Client	KB/s	KB/s peak
HP EliteBook 8440p	3.49	12.06	1,001.3	1,557.2
HP Mini 5102	2.31	64.50	739.6	1,214.8
Wyse C90LEW	2.61	98.70	707.0	1,136.0

Figure 10: CPU percent average and transfers/second for the server and clients during the 1080p video playback test.

1080p video playback + print job	CPU %		Transfers/second	
	Server	Client	KB/s	KB/s peak
HP EliteBook 8440p	6.90	12.77	1,051.1	3,784.5
HP Mini 5102	6.54	57.05	823.0	1,239.6
Wyse C90LEW	3.18	99.95	699.8	1,076.7

Figure 11: CPU percent average and transfers/second for the server and clients during the 1080p video playback and print job test.

ABOUT PRINCIPLED TECHNOLOGIES

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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

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We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.