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## Virtualized Exchange comparison: Dell PowerEdge R710 vs. HP ProLiant DL380 G6

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### Executive summary

We compared the virtualized Microsoft Exchange performance of a Dell™ PowerEdge™ R710 server to an HP ProLiant DL380 G6 server using Microsoft Exchange Load Generator (LoadGen). While the two servers delivered comparable performance, the Dell PowerEdge R710 server did so at a price per virtual machine (VM) advantage of 19.2 percent. (See Figure 1.)



**Figure 1: The Dell PowerEdge R710 server delivers a 19.2 percent better price per VM over the HP ProLiant DL380 G6 server.**

We used similarly configured Dell PowerEdge R710 and HP ProLiant DL380 G6 servers. We attached external storage to contain the VMs. We connected four Dell EqualLogic PS5000XV arrays to the Dell PowerEdge R710 server and an HP StorageWorks EVA4400 with five shelves to the HP ProLiant DL380 G6 server. Each storage solution used a total of 60 drives. The focus of this comparison was the server's performance and price, so we do not include the storage prices in this report. See Appendix A and Appendix B for detailed specifications on the servers and storage.

We used Microsoft Windows Server® 2008 R2 Hyper-V™ hypervisor to implement eight VMs in each solution, and assigned two vCPUs to each VM, since both systems under tests had 16 logical processors. We configured each VM with Microsoft Windows Server 2008 and Microsoft® Exchange Server 2007 SP2.

We used LoadGen, a simulation tool that measures the impact that various clients (MAPI, OWA, IMAP, POP, and SMTP) have on Exchange servers. The simulator sends multiple message requests to the server running Exchange, resulting in a mail load. For more details about LoadGen, see <http://www.microsoft.com/downloads/details.aspx?familyid=ddec1642-f6e3-4d66-a82f-8d3062c6fa98&displaylang=en>.

We created a custom workload of 5,000 users distributed across five storage groups with one mailbox database of 1,000 users per storage group. Each mailbox database LoadGen created was approximately 20 GB in size. We assigned each VM a separate client machine running LoadGen.

During the tests, LoadGen performs tasks to simulate a standard user generating mail activity. When the workload finishes, LoadGen reports the response time, which is the number of seconds necessary to complete the task. We used a weighted task system we based on the MMB3 workload, the forerunner to LoadGen. We modified the weight system to reflect the Online 2007 custom LoadGen profile. Appendix C shows the weight system we used for this test.

To verify acceptable performance, we ran LoadGen for 30 minutes, and verified that the average latency over all VMs for the different classes of Exchange operations was below the 500ms threshold for each solution.

## What we found

Figure 2 illustrates the median average latency for each VM of the Dell PowerEdge R710 and the HP ProLiant DL380 G6 servers. Both servers exhibit overall average latency under 500 milliseconds:

Median average latency results (milliseconds)		
VM	Dell PowerEdge R710	HP ProLiant DL380 G6
VM 1 latency	536.8	476.6
VM 2 latency	490.5	459.6
VM 3 latency	470.7	458.0
VM 4 latency	479.8	415.5
VM 5 latency	475.8	444.6
VM 6 latency	476.1	480.6
VM 7 latency	492.2	456.5
VM 8 latency	493.3	455.8
<b>Average latency over all VMs</b>	<b>489.4</b>	<b>455.9</b>

Figure 2: Average latency, in milliseconds, from the median run for all virtual machines of the Dell PowerEdge R710 server and the HP ProLiant DL380 G6 server. Lower numbers are better.

Figure 3 shows the price/VM results of the two servers. To calculate the price/VM, we divided the server price by the total number of VMs it supported. The Dell PowerEdge R710 server delivered 19.2 percent better price/VM than the HP ProLiant DL380 G6 server.

Price/VM results	
	Dollars/VM
Dell PowerEdge R710	\$1,267.63
HP ProLiant DL380 G6	\$1,568.75

Figure 3: Price/VM results for the Dell PowerEdge R710 server and the HP ProLiant DL380 G6 server while running the LoadGen workload. Lower price/VM numbers are better.

## How we tested

### Adjusting BIOS settings

We used the default BIOS settings on both the Dell PowerEdge R710 server and HP ProLiant DL380 G6 server, except that we disabled hardware prefetch and node interleaving.

### Setting up and configuring the servers and storage

We installed two internal drives in the Dell PowerEdge R710 and HP ProLiant DL380 G6 servers. We configured these drives as a RAID 10 array for the Microsoft Server 2008 R2 installation on both systems. We connected four Dell EqualLogic PS5000XV arrays to the Dell PowerEdge R710 to store the VMs. We attached the HP ProLiant DL380 G6 server to a HP StorageWorks EVA4400 with five shelves to store the VMs.

### Configuring the Dell Storage

Each of the four Dell EqualLogic arrays has 16 drives, for a total of 64 drives. Each of the five HP StorageWorks EVA4400 storage trays has 12 drives, for a total of 60 drives. To match the drive count of the two storage configurations, we configured two Dell EqualLogic arrays in RAID 10 no-spare mode (16 active drives each) and two Dell EqualLogic arrays in regular RAID 10 mode (14 active drives each), for a total of 60 active drives.

We connected the Dell PowerEdge R710 server to the Dell EqualLogic storage via three 1 GB/s Ethernet cables and three 1 GB/s iSCSI ports on each of the Dell EqualLogic PS5000XV arrays. We connected both to a Dell PowerConnect™ 6248 switch. We configured the Dell EqualLogic storage into two storage pools. The VM

operating system and log storage pool contained one Dell EqualLogic PS5000XV array with 14 active drives. The Exchange database storage pool contained three Dell EqualLogic PS5000XV arrays, of which two had 16 active drives and one had 14 active drives. We created one 900GB volume in the VM operating system and log storage pool, and one 1.99TB volume in the database storage pool. We used the following steps to configure the storage:

1. Using the command line, set up a storage group with the following RAID policies:
  - PS5000XV-1: RAID-10
  - PS5000XV-2: RAID-10 (no spares)
  - PS5000XV-3: RAID-10
  - PS5000XV-4: RAID-10 (no spares)
2. Create a storage pool you name `OS-Log` with the following member:
  - PS5000XV-1
3. Create a storage pool you name `database` with the following members:
  - PS5000XV-2
  - PS5000XV-3
  - PS5000XV-4
4. Enable all network connections on each Dell EqualLogic PS5000XV using the following IP address scheme:
  - IP Address: `192.168.1.##` (## being any number between 10 and 60)
  - Subnet Mask: `255.255.255.0`
5. Create one 900GB volume in the OS-Log storage pool with no snapshot reserve, and name it `OS-Log`
6. Create one 1.99TB volume in the database storage pool with no snapshot reserve, and name it `database`
7. Enable shared access to the iSCSI target from multiple initiators on every volume.
8. Create an access control record for every volume without specifying any limitations.

### Configuring the HP storage

We connected the HP ProLiant DL380 G6 server to the HP StorageWorks storage via two 4 GB/s Fibre Channel cables into a Brocade 200E 4 GB Fibre Channel switch. We connected the HP StorageWorks storage into the Brocade 200E Fibre Channel switch using four 4 GB/s Fibre Channel Cables. We configured the HP StorageWorks into two disk groups using RAID 10: a mailbox database disk group containing 46 disks and a VM operating system and log disk group containing 14 disks. We created one 955GB volume in the operating system and log disk group, and one 2,047 GB volume in the database disk group. We used the following steps to configure the storage:

1. Create a disk group with the following parameters:
  - Name: `Database`
  - Disks: 1-46
  - Disk drive failure protection: None
  - Alarm Level: 100%
2. Create a disk group with the following parameters:
  - Name: `OS-Log`
  - Disks: 47-60
  - Disk drive failure protection: None
  - Alarm Level: 100%
3. Create a new vDisk with the following parameters:
  - Name: `Database1`
  - Size: 2,047 GB
  - Disk Group: `Database`
  - Redundancy: `Vraid 1`
4. Create a new vDisk with the following parameters:
  - Name: `OS-Log`
  - Size: 955 GB

- Disk Group: OS-Log
  - Redundancy: Vraid 1
5. Create a Host, and add the world wide name for both Fibre Channel adapters on the server for each vDisk.

## Setting up and configuring the OS and VMs

We performed the following steps on both the Dell PowerEdge R710 server and HP ProLiant DL380 G6 server to install the OS and VMs for testing.

### Installing Windows Server 2008 R2

1. Insert the installation DVD for Windows Server 2008 R2 into the DVD drive.
2. Choose the language, time and currency, and keyboard input. Click Next.
3. Click Install Now.
4. Choose Windows Server Enterprise (Full Installation), and click Next.
5. Accept the license terms, and click Next.
6. Click Custom.
7. Click the Disk, and click Drive options (advanced).
8. Click New, Apply, Format, and click Next.
9. After the installation completes, click OK to set the Administrator password.
10. Enter the administrator password twice, and click OK.
11. Click Start, type `change power-saving settings` and press Enter.
12. Click Change plan settings.
13. Change the Turn off the display drop-down menu to Never.
14. Click Save changes, and close the Power Options, Screen Saver Settings, and Personalization windows.

### Installing system updates in Windows Server 2008 R2

We installed the following updates on the system using the Microsoft Windows Update feature:

- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB974455)
- Security Update for ActiveX killbits for Windows Server 2008 R2 x64 Edition (KB973525)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)

### Installing the Hyper-V role in Windows Server 2008 R2

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

### Adding the additional drives for VHD usage in the parent partition via the iSCSI initiator (Dell server only)

1. Click Start, Control Panel, and double-click iSCSI Initiator.
2. Add the IP address of the Dell EqualLogic storage group in the Quick Connect box.
3. Find the relevant volume for VM OS VHDs, and select it. Click Log On...
4. Check the checkbox to allow automatic logon on reboot and to enable multipath.
5. Click OK.
6. Repeat steps 3 through 5 for the Exchange Server VHD data LUNs.

### Creating the Hyper-V virtual machine

1. Click Start→Administrative Tools→Hyper-V Manager.
2. From the Action menu, select New Virtual Hard Disk.
3. Choose Fixed Size, assign 30 GB for size, and place the VHD in the appropriate VM folder.
4. From the Action menu, select New→Virtual Hard Disk.
5. Choose Fixed Size, assign 200GB for size, and place the VHD in the appropriate VM folder on the database external volume.
6. From the Action menu, select New Virtual Machine.
7. On the Before You Begin page, click Next.
8. Enter a name for the virtual machine, and browse to the location where you want to store the VM files. (The New Virtual Machine Wizard will automatically create a subfolder with the name of the VM.)
9. On the Assign Memory page, enter 5,120 MB of RAM.
10. On the Configure Networking page, choose the network assigned to client/server traffic, and click Next.
11. Select Attach a virtual hard disk later, and click Next.
12. On the installation Options page, accept the default of Install an operating system later, and click Next.
13. On the Completing the New Virtual Machine Wizard page, click Finish.

### Modifying the virtual machine

1. Right-click the virtual machine, and choose Settings.
2. Click Processors, and choose 2 virtual processors.
3. Click the virtual IDE controller 0.
4. Click Add, and click Hard Drive.
5. Browse to the first VHD you created in Step 3, and choose that VHD for the guest OS VHD.
6. Click Apply.
7. Click the virtual SCSI controller.
8. Click Add, and click Hard Drive.
9. Browse to the first VHD you created in Step 5, and choose that VHD for the guest Database VHD.
10. Click Apply.
11. After you have cloned out your VMs, repeat steps 1 through 10 for all remaining VMs.

### Installing the guest operating system

1. Insert the installation DVD for Windows Server 2008 into the DVD drive.
2. In Hyper-V Manager, right-click the virtual machine, and choose Connect.
3. On the media menu, choose DVD DriveCapture D:
4. On the Action menu, choose Start.
5. Choose the language, time and currency, and keyboard input. Click Next.
6. Click Install Now.
7. Choose Windows Server Enterprise (Full Installation), and click Next.
8. Accept the license terms, and click Next.
9. Click Custom.
10. Click the Disk, and click Drive options (advanced).
11. Click New, Apply, Format, and click Next.
12. Let the installation process continue. The VM will reboot several times.
13. After the installation completes, click OK to set the Administrator password.
14. Enter the administrator password twice, and click OK.
15. When the Windows installation completes, select Action→Insert Integration Services Setup Disk from the menu. Installation should begin automatically.
16. At the prompt to restart, click Yes.
17. Once the system has restarted, log in, and verify that all configured devices (mouse, keyboard, video, network, etc.) are working.
18. Once you are sure all your devices are working, from the menu, select Media→DVD Drive→Eject vmguest.iso.

### Installing Windows updates on the VMs

1. Click Start→ Windows Update.
2. Click View Advanced Options.

3. Click Never Check for Updates.
4. Click OK.
5. Click Check for Updates.
6. Click Install Now when the application prompts you to install an update for Windows Update.
7. Click View available updates to ensure you install the necessary updates.
8. Click Install.
9. Agree to the license terms, and click Finish.
10. Reboot the VM when the application requests you do so.
11. After reboot, check Windows Update again for further updates. Click Start→Windows Update.
12. Click Check for updates.
13. If Windows lists no important updates, close the updates window.

### **Installing the Host Integration toolkit on the Hyper-V server (Dell server only)**

1. Download the host integration toolkit (Setup64.exe).
2. Double-click Setup64.exe.
3. Accept the security warnings, and choose to run the EXE.
4. Click Next.
5. Click Accept, then Next.
6. Click Typical, then Next.
7. Proceed through the installation, accepting the defaults.
8. Click Install.
9. Click Yes to install multipath software automatically.
10. Choose to restart the server when the application prompts you to do so.

### **Partitioning the database drive**

1. Click Start→Administrative Tools→Computer Management
2. Expand Storage in the right pane, and click Disk Management.
3. Right-click the offline disk, and click Online.
4. When the disk shows as Online, right-click the disk, and choose Initialize Disk.
5. Choose MBR and click Next.
6. When the disk initialization is complete, right-click the volume, and choose New Simple Volume.
7. Click Next.
8. Choose NTFS, check the Perform a quick format checkbox, and click Next.
9. Set the volume size to 102,400, keep the default drive letter assignment, and click Next.
10. Choose NTFS, check the Perform a quick format checkbox, and click Next.
11. Click Finish.
12. To make the database backup partition, right-click the remaining volume, and follow steps 6 through 11.
13. Create folders necessary for the datastores. We used E:\Mailstore for the database and F:\Mailstore for the database backup.

### **Installing the domain controller**

1. Set a static IP address using the following steps:
  - a. Right-click the network icon in the quick-launch bar, and choose Network and Sharing Center.
  - b. Click Manage network connections.
  - c. Right-click the local area connection, and choose Properties.
  - d. Select Internet Protocol Version (TCP/IPv4), and click Properties.
  - e. Select the Use the following IP address radio button and type 192.168.1.250 in the IP address field.
  - f. Press Tab to auto-fill 255.255.255.0 in the Subnet mask field.
  - g. In the Preferred DNS server field, type 127.0.0.1 and click OK to close the IPv4 properties window.
  - h. Click Close.
2. Give the computer a name using the following steps:
  - a. Click Start, right-click Computer, and select Properties.
  - b. Click Change Settings.

- c. Click Change.
- d. Type `mailserver` in the Computer name field, and click OK.
- e. In the Computer Name/Domain Changes pop-up window, click OK.
- f. Click OK.
- g. In the Microsoft pop-up window, click Restart Now.
3. Promote the mailserver to domain controller by following these steps:
  - a. Select Start→Command Prompt.
  - b. Type `dcpromo`
  - c. At the Welcome pop-up window, click Next.
  - d. At the Operating System Compatibility screen, click Next.
  - e. At the Choose a Deployment Configuration screen select the Create a new domain in a new forest radio button, and click Next.
  - f. At the Name the Forest Root Domain screen, type a domain name (`mailserver.com`), and click Next.
  - g. At the Set Forest Functional Level screen, choose Windows Server 2008 from the drop-down menu, and click Next.
  - h. At the Additional Domain Controller Options screen, accept the defaults, and click Next.
  - i. When the Static IP assignment window pops up, click Yes, the computer will use a dynamically assigned IP address.
  - j. When the Active Directory domain Services Installation Wizard window pops up, click Yes.
  - k. At the Location for Database, Log Files, and SYSVOL screen, leave defaults, and click Next.
  - l. At the Directory Services Restore Mode Administrator Password screen, enter a password, and click Next.
  - m. At the Summary screen review the selections, and click Next.
  - n. When the installation software prompts you to do so, insert the OS CD, and click OK.
  - o. At the Completing the Active Directory Installation Wizard screen, click Finish.
  - p. When the system prompts you to reboot the server, click Restart Now.
  - q. After the server reboots, log into the system.

### Installing Internet Information Services 6.0

1. Select Start→Administrative Tools→Server Manager.
2. Click Add Roles.
3. At the Select Server Roles screen, click Web Server (IIS).
4. In the pop up Add features required for Web Server (IIS) window, click Add Required Features.
5. Click Next.
6. At the Web Server (IIS) screen, click Next.
7. At the Select Role Services screen select the IIS 6 Metabase Compatibility, IIS 6 Management Console, Basic Authentication, Windows Authentication, Digest Authentication, and Dynamic content Compression checkboxes, and click Next.
8. At the Confirm Installation Selections screen, click Install.
9. At the Installation Results screen, click Close.

### Installing Exchange Server 2007 SP2

1. Insert the Microsoft Exchange Server 2007 CD.
2. In the pop-up AutoPlay window, click Run Setup.EXE.
3. Steps 1 and 2 should already be completed and grayed out.
4. Click Step 3: Install Microsoft Windows PowerShell.
5. Select Start→Command Prompt.
6. In the Command Prompt window type `ServerManagerCmd -I PowerShell` and press Enter.
7. When the installation completes, close the Command Prompt window.
8. Click the link to Step 4: Install Microsoft Exchange Server 2007 SP1.
9. Click Next to go past the introduction screen.
10. Accept the license agreement, and click Next.
11. Select No for error reporting, and click Next.
12. Select Typical Exchange Server Installation, and click Next.

13. Leave the organization name at default (First Organization), and click Next.
14. Select No to the question about client computers running Outlook 2003 and earlier, and click Next.
15. If a warning about a lack of SMTP appears after the check finishes, ignore it.
16. Click Install to start the installation process.
17. Once installation is complete, click Finish. Exchange should automatically open the Exchange Management Console.

### Configuring Exchange Server 2007 SP2

1. If Exchange does not automatically open the Exchange Management Console, select Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console.
2. In the left pane, expand Organization Configuration, and select Hub Transport.
3. In the action pane on the far right, select New Send Connector.
4. Name the send connector SMTP, select the intended use as Internet, and click Next.
5. In the Address space window, click Add.
6. In the SMTP Address Space window, type \* as the address, make sure Include all subdomains is checked, and click OK.
7. Click Next.
8. Accept defaults for the next two pages by clicking Next.
9. At the New Connector page, click New to create the connector.
10. Click Finish to close the New SMTP Send Connector wizard.
11. In the left pane of the Exchange Management Console window, expand Server Configuration, and select Mailbox.
12. In the Database Management tab, right-click First Storage Group, and select New Public Folder Database.
13. Name the new public folder database Public Folder Database, and click New.
14. In the Completion page, click Finish to close the New Public Folder Database window.
15. Close the Exchange Management Console, and reboot the server.
16. Once the server successfully reboots, log in, and select Start→All Programs→Administrative Tools→Active Directory Users and Computers.
17. In the Active Directory Users and Computers window, select mailserver.com in the left pane, and open Users in the right pane.
18. Right-click a blank area in the Users folder, and select New→User.
19. In the New Object - User window, complete the name fields as you wish (we used first name: test, last name: tester, logon name: tester), and select Next.
20. Enter a secure password (we used Password1), and check Password never expires.
21. In the pop-up information window, click Accept.
22. Select Next to close the New Object – User window.
23. Double-click the new user to bring up the Properties window.
24. Under the Member Of tab, click Add.
25. In the Enter the object names to select dialog box, type Domain Admins; Exchange Organization Administrators, select Check Names to verify, and click OK.
26. Click OK to close the user Properties window and close Active Directory Users and Computers window.
27. Select Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console.
28. In the left pane of the Exchange Management Console window, select Recipient Configuration; and in the right pane, select New Mailbox.
29. In the New Mailbox window, select User Mailbox, and click Next.
30. In the User Type page, select Existing users, and click Add.
31. Select the new account you created earlier, and click OK to add it to selection box.
32. Click Next.
33. In the Mailbox Settings page, leave the Alias textbox with default settings, and select Browse in the Mailbox database selection spot.
34. In the Select Mailbox database window, select Mailbox Database, and click OK.
35. Click through the next screens to create the new mailbox, and close when you have done so.
36. Close the Exchange Management Console.
37. Select Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console.

38. In the left window pane, expand Server Configuration and Mailbox so the First Storage Group is visible.
39. Right-click First Storage Group, and select Properties.
40. Click Browse, and change the Transaction log and System path location to C:\First Storage Group.
41. Check the Enable circular logging box.
42. Click Apply.
43. When the pop-up message appears asking if you want to perform this task, click Yes.
44. When the message appears saying that all mounted stores are back online, click OK.
45. Right-click Mailbox Database under First Storage Group, and select Properties.
46. Select the Database tab.
47. Click Browse, and move the Exchange database and Exchange streaming database to E:\Mailstore. If there is not a directory called Mailstore, create it.
48. Check the box beside This database can be overwritten by a restore.
49. Click Customize next to Maintenance interval.
50. Remove all blue from the boxes so the system will not perform maintenance, and click OK.
51. At the Mailbox Store Properties window, click Apply.
52. When a warning message appears, click Yes.
53. When the message that the database files have been moved appears, click OK.
54. Click OK to close the Mailbox Store Properties window.
55. On the right side of the screen, click New Storage Group.
56. Under Storage Group name, write Second Storage Group.
57. Click the New button to create the Storage Group.
58. Click Finish when Exchange finishes creating the second storage group.
59. Right-click First Storage Group, and select Properties.
60. Click Browse, and change the Transaction log and System path location to C:\Second Storage Group.
61. Check the Enable circular logging box.
62. Click Apply.
63. Right-click Second Storage Group, and select New Mailbox Database.
64. Under Mailbox database name, type Mailbox Database 2
65. Click the Browse button, and select E:\Mailstore.
66. Click the New button to create the database.
67. Right-click Mailbox Database 2 under First Storage Group, and select Properties.
68. Select the Database tab.
69. Click Browse, and move the Exchange database and Exchange streaming database to E:\.
70. Check the box beside This database can be overwritten by a restore.
71. Click Customize next to Maintenance interval.
72. Remove all blue from the boxes so the system will not perform maintenance, and click OK.
73. At the Mailbox Database 2 Properties window, click Apply.
74. When a warning message appears, click Yes.
75. When the message that the database files have been moved appears, click OK.
76. Click OK to close the Mailbox Database 2 Properties window.
77. Repeat steps 55 through 76 three more times to create three more storage groups and mailbox databases.
78. Right-click Public Mailbox Database under First Storage Group, and select Properties.
79. Select the Database tab.
80. Click Browse, and move the Exchange database and Exchange streaming database to E:\.
81. Check the box beside This database can be overwritten by a restore.
82. Click Customize next to Maintenance interval.
83. Remove all blue from the boxes so the system will not perform maintenance, and click OK.
84. At the Public Store Properties window, click Apply.
85. When a warning message appears, click Yes.
86. When the message that the database files have been moved appears, click OK.
87. Click OK to close the Public Mailbox Database Properties window.

### **Installing and configuring the mail client**

Note: You must repeat the following process for each mail VM client.

To create a mail client, you must install several software components. Before following these instructions, make sure to statically assign an IP address for the client, and then plug that port into the system under test. This allows the client to join the Active Directory domain. We followed this process for each installation:

1. Install Microsoft Windows Server 2003 R2 Enterprise x64 Edition Service Pack 2.
2. Assign a computer name of `ClientX` for the mail client, where `x` is the client number.
3. For the licensing mode, use the default setting of five concurrent connections.
4. Enter a password for the administrator log on.
5. Select Eastern Time Zone.
6. Use typical settings for the Network installation.
7. Type `Testbed` for the workgroup.

The following subsections detail the necessary installation processes we had to follow for each client.

### Joining the domain

1. Select Start→Control Panel→Network Connections→Local Area Connection.
2. Click Properties.
3. Highlight Internet Protocol (TCP/IP), and click Properties.
4. Select the Use the following DNS server addresses radio button, and enter the IP of the DNS server in the Preferred DNS server field. Click OK.
5. Right-click My Computer, and select Properties.
6. Under the Computer Name tab, click Change.
7. In the Computer Name Changes window, under the Member of section, select the Domain radial box, and type `mailserver.com`.
8. Select OK to start joining the domain.
9. When the window appears asking for a person qualified on the domain, type `Tester` as the username and `Password1` as the password.
10. Click OK at the welcome pop-up window and the window warning that you must reset the computer for the changes to take effect.
11. Click OK in the System Properties window.
12. When a pop-up appears asking if you want to restart now, click Yes to restart your computer.

### Installing Internet Information Services 6.0

1. Select Start→Control Panel→Add or Remove Programs.
2. Click Add/Remove Windows Components.
3. Select Application Servers, and click Details.
4. Click ASP.NET, and make sure a check appears in the check box.
5. Select Internet Information Services (IIS), and click Details.
6. Click OK to close the Application Server window.
7. At the Windows Components Wizard, click Next to begin the installation.
8. When the system prompts you to do so, insert the OS CD, and click OK.
9. At the Completing the Windows Components Wizard window, click Finish.
10. Close the Add or Remove Programs window.

### Installing Exchange Server 2007 and Load Generator

1. Insert the Microsoft Exchange Server 2007 CD. The CD should automatically launch the installation software.
2. Click the link to Step 1: Install .NET Framework 2.0.
3. When you arrive at the download link, download the x64 version of the .NET Framework, and install.
4. Click the link to Step 3: Install Microsoft Windows PowerShell; this takes you to the download link.
5. When you arrive at the download link, download Microsoft Windows PowerShell, and install with defaults.
6. Search for and download SP1 for .NET Framework 2.0.
7. Install SP1 with all defaults.
8. Click the link to Step 4: Install Microsoft Exchange Server 2007 SP1.

9. Click Next to go past the introduction screen.
10. Accept the license agreement, and click Next.
11. Select No for error reporting, and click Next.
12. Select Custom Exchange Server Installation, and click Next.
13. Check Management Tools, and click Next.
14. After the check finishes, click Install to start the installation process.
15. Once installation is complete, click Finish.
16. Download and install Load Generator using all defaults.

### Preparing Load Generator

1. Log into the MailClient using the tester account.
2. Select Start→All Programs→Microsoft Exchange→Exchange Load Generator.
3. When the Load Generator window appears, select Start a new test.
4. Select Create a new test configuration, and click Continue.
5. Type `tester` as the account name.
6. In the Specify test settings window, type `Password1` as the Directory Access Password and Mailbox Account Master Password, and click Continue with recipient management.
7. Make 1,000 users in each Mailbox Database, and click Continue.
8. To accept defaults for Advanced recipient settings, click Continue.
9. In the Specify test user groups window, select the plus sign to add a user group.
10. Change the Client Type to Outlook 2007 Online and the Action Profile to Custom, and click Continue.
11. Leave defaults in Remote configurations, and click Continue.
12. Click Save the configuration file as, and name it `Loadgen.cfg`
13. Click Start the initialization phase (recommended before running the test) to start initialization. The initialization process might take a few hours.

### Backing up the Exchange databases

1. Log into the VMs using the Administrator account.
2. Select Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console.
3. In the left window pane, expand Server Configuration and Mailbox so the First Storage Group is visible.
4. Right-click Mailbox Database 1, and select dismount.
5. Repeat Step 4 for the remaining four Mailbox Databases.
6. Once all of the VM's mailbox databases are dismounted, browse to `E:\Mailstore`.
7. Copy the contents of `E:\Mailstore` to `F:\Mailstore`.
8. Copy the log folders for all five of the storage groups to the F drive as well.
9. Browse back to the Exchange Management Console.
10. Right-click Mailbox Database 1, and select mount.
11. Repeat Step 10 for the remaining four Mailbox Databases.

### Conducting the test

To perform the test, we used a series of batch files. We stored batch files under the `C:\LoadGen_Scripts` folder on the controller machine. We installed a single listener batch file on each mail client that starts at boot time and sits idle waiting to receive a run batch file from the controller, at which point it executes the file and returns to the idle wait loop. First, we powered on all virtual machines. We started the scripts, which copied the LoadGen parameter files to the clients. Then, we started our monitoring programs. To start the test, we executed the start batch file on our controller, which copied a file to all clients to start LoadGen. After LoadGen finished, we used another batch file to copy the results from all clients. The batch files simply used the copy command and referred to all clients by their IP addresses. Once a run finished, we used a restore batch file, which restored the mail database store to the original state for each VM. This allowed us to start from the same point in testing.

We obtained performance test results by running the virtualized LoadGen workload three times, and by taking the median result as representative of the sample.

## Appendix A – Test server information

Figure 4 presents detailed information for the test servers we used in this report.

Servers	Dell PowerEdge R710	HP ProLiant DL380 G6
<b>General dimension information</b>		
Height (inches)	3.50	3.39
Width (inches)	17.50	17.53
Depth (inches)	27.00	25.81
U size in server rack (U)	2	2
<b>Power supplies</b>		
Total number	2	2
Brand and model	Dell A570P-00	HP HSTNS-PL14
Wattage (W)	570	460
<b>Cooling fans</b>		
Total number	5	6
Dimensions (h x w)	2.5" x 2.5"	2 3/8" x 2.5"
Voltage (V)	12	12
Amps (A)	1.60	2.45
<b>General processor setup</b>		
Number of processor packages	2	2
Number of cores per processor package	4	4
Number of hardware threads per core	2	2
System power management policy	Balanced	Balanced
<b>CPU</b>		
Vendor	Intel	Intel
Name	Xeon E5540	Xeon E5540
Stepping	D0	D0
Socket type	LGA1366	LGA1366
Core frequency (GHz)	2.53	2.53
L1 cache	4 x 32 KB + 32 KB	4 x 32 KB + 32 KB
L2 cache	4 x 256 KB	4 x 256 KB
L3 cache (MB)	8	8
<b>Platform</b>		
Vendor and model number	Dell PowerEdge R710	HP ProLiant DL380 G6
Motherboard model number	0N047H	PADAB0G9VXC1CQ
Motherboard revision number	13	13
BIOS name and version	Dell 1.2.6 (07/17/2009)	HP BIOS P62 (10/01/2009)
BIOS settings	Hardware Prefetch disabled, Node Interleaving disabled	Hardware Prefetch disabled, Node Interleaving disabled
<b>Memory modules</b>		
Total RAM in system (GB)	48	48
Vendor and model number	Samsung M393B1K70BH1	Samsung M393B1K70BH1

<b>Servers</b>	<b>Dell PowerEdge R710</b>	<b>HP ProLiant DL380 G6</b>
Type	PC3-8500R DDR3	PC3-8500R DDR3
Speed (MHz)	1,066	1,066
Speed in the system currently running @ (MHz)	1,066	1,066
Timing/latency (tCL-tRCD-iRP-tRASmin)	7-7-7-20	7-7-7-20
Size (GB)	48	48
Number of RAM modules	6 x 8 GB	6 x 8 GB
Chip organization	Double-sided	Double-sided
<b>Hard disk</b>		
Vendor and model number	Seagate ST973451SS	Fujitsu DH072BAAKN
Number of disks in system	2	2
Size (GB)	73	73
Buffer size (MB)	16	16
RPM	15,000	15,000
Type	SAS	SAS
Controller	Dell PERC 6/i Integrated RAID Controller, 256MB cache and BBWC	HP 410i Integrated Smart Array Controller, 256MB cache and BBWC
<b>Operating system</b>		
Name	Windows Server 2008 R2 Enterprise	Windows Server 2008 R2 Enterprise
Build number	7600	7600
File system	NTFS	NTFS
Language	English	English
<b>Network card/subsystem</b>		
Vendor and model number	Broadcom NetXtreme II gigE 5709C Quad-Port Ethernet	Broadcom NetXtreme II gigE 5709C Quad-Port Ethernet
Type	Integrated	Integrated
<b>Fibre card</b>		
Vendor and model number	N/A	HP StorageWorks FC2242 Dual Channel 4Gb PCI-E HBA
Type	N/A	PCI Express
<b>Optical drive</b>		
Vendor and model number	TEAC DV28SV DVD-ROM	LG GDR-D20N DVD-ROM
<b>USB ports</b>		
Number	4	4
Type	2.0	2.0

Figure 4: Detailed system configuration information for the two test servers.

## Appendix B – Test storage information

Figure 5 presents detailed information for the test storage we used in this report.

	<b>Dell EqualLogic iSCSI SAN</b>	<b>HP StorageWorks Fibre Channel SAN</b>
Arrays	Three Dell EqualLogic PS5000XV arrays and one Dell EqualLogic PS6000 Array	One HP StorageWorks EVA 4400 Enterprise Virtual Array with five full disk shelves
Disks	60 active 15,000RPM SAS disks total for the four shelves	60 active 15,000RPM FC disks total for the five shelves
Active storage cache	4 GB (1 GB per Dell EqualLogic PS5000XV array)	4 GB
Number of active storage controllers	4 (1 per Dell EqualLogic PS5000XV array)	2
Number of passive storage controllers	4 (1 per Dell EqualLogic PS5000XV array)	0
Number of active storage ports	12 (3 per Dell EqualLogic PS5000XV array)	4
Switch type/ model/firmware revision	Dell PowerConnect 6248 v2.2.0.3	Brocade 200E Fabric OS v6.0.0b
Disk vendor and model number	48 x Seagate ST3146855SS 16x Maxtor ATLAS15K2_147SAS	36x HP BDF146DA47A 24x HP BF146DA47A
Disk size (GB)	146	146
Disk buffer size (MB)	16	16
Disk RPM	15,000	15,000
Disk type	SAS	Fibre Channel

Figure 5: Detailed configuration information for the storage arrays.

## Appendix C – LoadGen latency result weights

Figure 6 lists the weight values that we added to the relative tasks used in the Outlook 2007 custom profile in LoadGen.

Latency95	Weight
BrowseCalendar	1
Logon	0
Logoff	0
SendMail	1
ReadAndProcessMessages	50
MoveMail	0
DeleteMail	0
ExportMail	0
CreateFolder	0
PublicFolderPost	0
BrowsePublicFolder	0
PostFreeBusy	2
RequestMeeting	1
MakeAppointment	1
BrowseContacts	0
CreateContact	0
BrowseTasks	0
CreateTask	0
EditRules	2
DownloadOab	0
EditSmartFolders	2
SynchronizeFolders	0
Search	0
InitializeMailbox	0
UserInit	0
UserTerm	0
ModuleInit	0
ModuleTerm	0
Total	60

Figure 6: The weights we used to generate our latency response time.

## About Principled Technologies

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.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

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 you assess how it will fare against its competition, its performance, whether it's ready to go to market, 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.



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