Principled Technologies®

TEST REPORT
SEPTEMBER 2008

vConsolidate performance and power on quad-processor Intel processor-based servers

Executive summary

Intel® Corporation (Intel) commissioned Principled Technologies® (PT) to measure power and performance with Intel's vConsolidate version 2.0 (Profile 2) workload using Microsoft Windows Server 2008 Hyper-V on quad-processor servers using the following processors:

- Intel Xeon® processor X7460
- Intel Xeon processor X7350

KEY FINDINGS

- The Intel Xeon processor X7460-based server produced 52.1 percent better performance per watt than the Intel Xeon processor X7350-based server with redundant power supplies active at the optimal number of CSUs (see Figure 1).
- The Intel Xeon processor X7460-based server delivered 39.8 percent more performance running vConsolidate with the optimum number of CSUs than the Intel Xeon processor X7350-based server (see Figure 2).

The servers were similarly configured with four Intel Xeon processors, 16 4GB FBDIMMs, and identical PCI-e NICs and HBAs. Figure 1 provides a normalized comparison for the test servers with the optimal number of vConsolidate work units, which it calls consolidation stack units (CSUs). The Intel Xeon processor X7460-based server achieved optimal performance with six CSUs while the Intel Xeon processor X7350-based server achieved optimal performance with five CSUs. (See the Workload section and later sections for more on CSUs.) This chart normalizes the results to the lower-performing server, the Intel Xeon processor X7350-based server. That system's score is thus 1.00. Normalizing makes each data point in the chart a comparative number, with higher numbers indicating better performance.

In this section, we discuss the best results for all servers. For complete details of the performance of each server at its optimum number of CSUs, see the Test results section.

As Figure 1 illustrates, the Intel Xeon processor X7460-based server delivered 52.1 percent greater vConsolidate performance per watt at the optimal number of CSUs than the Intel Xeon processor X7350-based server.

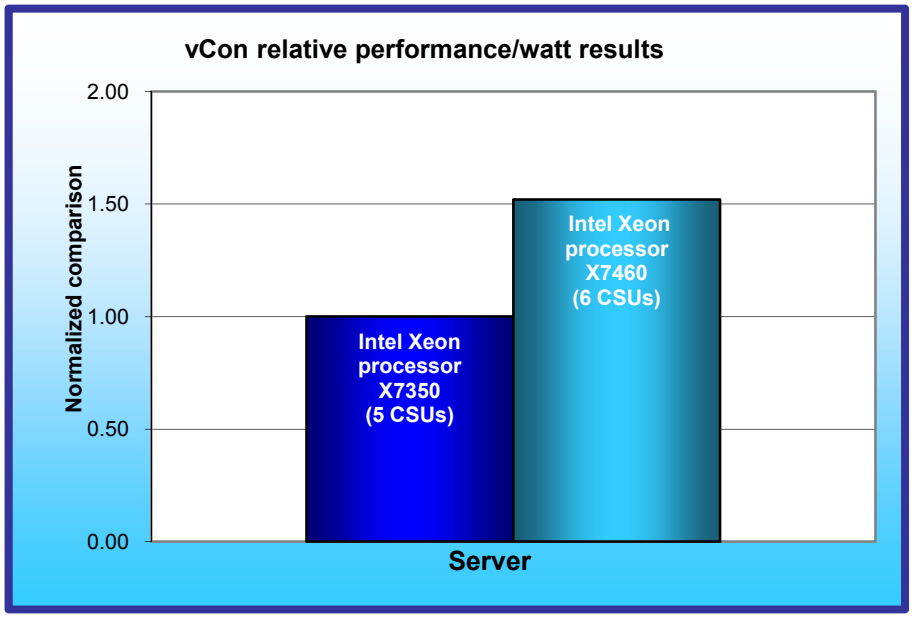

Figure 1: Relative vConsolidate performance/watt results at the optimal number of CSUs for the two servers we tested.

We calculated performance per watt by dividing the vConsolidate score for each server at the optimal number of CSUs by the measured power when running the optimal number of CSUs for a minimum 30-minute interval. We measured power at 208 V on both servers.

Figure 2 shows the Intel Xeon processor X7460-based server delivered 39.8 percent better overall performance at the optimal number of CSUs than did the Intel Xeon processor X7350-based server.

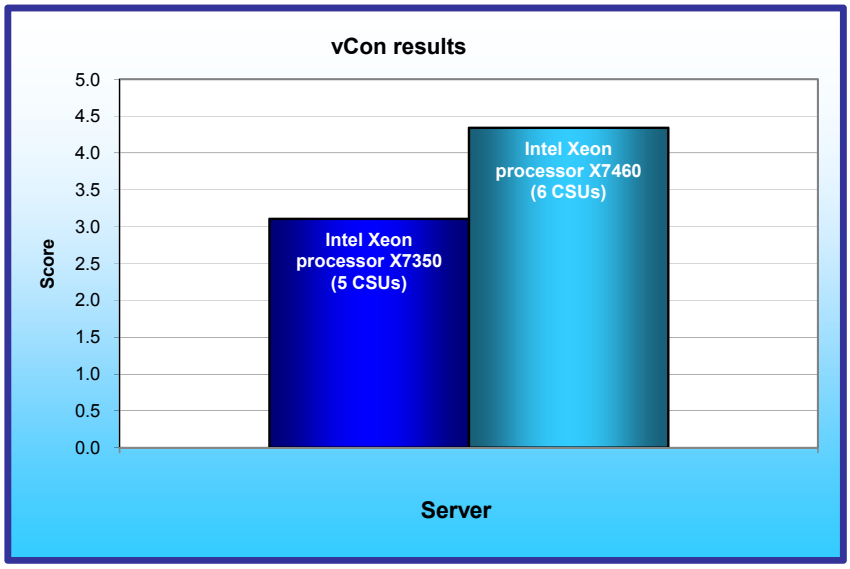

Figure 2: vConsolidate results at the optimal number of CSUs for the two servers we tested.

Workload

Intel defined, implemented, and supplied the vConsolidate version 2.0 workload. vConsolidate includes four different performance tests—database, Java, mail, and Web—that run simultaneously in different virtual machines (VMs) on a server. A fifth, idle VM is also present during the test. vConsolidate refers to a single collection of these five virtual machines as a consolidate stack unit (CSU). Depending on the type of server and its available resources, testers can choose to run one or more CSUs. The typical goal is to run enough CSUs to push the server under test to its maximum capacity by consuming close to 100 percent of the CPU capacity.

vConsolidate sums the throughput results of each type of work across all CSUs in a test. Then it amalgamates the combined throughputs of all CSUs to create an overall score for the server under test. See the Test results section for more information on this process.

vConsolidate uses the following four performance tests:

LoadSim

Microsoft Exchange Server 2003 Load Simulator (LoadSim) is a benchmark that measures a server's performance handling email. LoadSim uses the MAPI Messaging Benchmark 3 (MMB-3) to simulate MAPI email clients. The simulated clients issue requests to an Exchange server to generate an email load. LoadSim measures both the server's response time and the number of messages it delivers. LoadSim is available for free download from www.microsoft.com/downloads/details.aspx?FamilyId=92EB2EDC-3433-47CA-A5F8-0483C7DDEA85&displaylang=en.

SPECjbb2005®

SPECjbb2005 is an industry-standard benchmark from the Standard Performance Evaluation Corp. (SPEC) that measures a server's Java performance. (Note: SPEC and SPECjbb2005 are trademarks of the Standard Performance Evaluation Corporation.) SPEC modeled SPECjbb2005 on the three-tier client/server architecture, with the middle layer as the primary focus. According to SPEC, "Random input selection represents the first (user) tier. SPECjbb2005 fully implements the middle tier business logic. The third tier is represented by tables of objects, implemented by Java Collections, rather than a separate database." For more information about SPECjbb2005, see www.spec.org/jbb2005/docs/UserGuide.html.

The results we quote here for this workload are not official SPECjbb2005 results because the vConsolidate workload uses a slightly modified version of the benchmark. These results are not comparable to SPECjbb2005 results on SPEC's Web site.

SysBench

The developers at SourceForge (www.sourceforge.net) created SysBench to test various aspects of the performance of servers running database systems. The benchmark's original target was the MySQL database system (see www.mysql.com). Intel created a version of SysBench 0.4.0 that would work with Microsoft SQL

Server 2005 Enterprise Edition (www.microsoft.com/sql/editions/enterprise/default.mspx). We ran that version in our test. In the vConsolidate workload, SysBench created a 100,000-row SQL database and executed a batch of online transaction processing (OLTP) transactions against that data.

WebBench

WebBench 5.0 (128-bit US version) is an industry-standard benchmark for Web server software and hardware. It uses PC clients to send Web requests to the server under test. It generates performance results by incrementally increasing the number of clients making HTTP 1.0 GET requests to the Web server; the result is a curve showing the server's performance under increasing load. The peak of that curve represents the peak throughput of the server. WebBench reports both the total number of requests per second the server handled and the server's total throughput in bytes per second. To be certain that we found the true peak performance in our testing, we verified that the server's processor utilization reached or was extremely close to 100 percent during the test.

vConsolidate profiles

The vConsolidate workload comes with four sets of VM specifications, which it calls profiles. These profiles define five key factors for each workload VM:

- number of virtual CPUs (vCPUs) the workload should receive
- amount of virtual RAM (vMemory) the workload should receive
- the operating system (OS) the workload should run
- the key application the workload should run
- the workload itself

As we noted earlier, vConsolidate refers to a single collection of these five virtual machines as a consolidate stack unit (CSU). Depending on the type of server and its available resources, you may choose to run one or more CSUs. The typical goal is to run enough CSUs to push the server under test to its maximum capacity by consuming close to 100 percent of the CPU capacity.

vConsolidate offers four profiles; we tested with Profile 2, which we detail in Figure 3.

	Profile 2			
	vCPUs	**vMemory**	**OS**	**Application**
WebBench (Web)	2	1.5 GB	Windows 32-bit	IIS
LoadSim (mail)	1	1.5 GB	Windows 32-bit	Exchange
SysBench (database)	2	1.5 GB	Windows 64-bit	SQL Server
SPECjbb2005 (Java)	2	2.0 GB	Windows 64-bit	BEA JVM
Idle	1	0.4 GB	Windows 32-bit	NA

Figure 3: The vConsolidate profile we used in our testing.

For further information on vConsolidate, please contact Intel.

Test results

The result for an execution of the vConsolidate workload amalgamates the results of all four of the workloads it includes. To calculate a final score for a vConsolidate run, we used the following four steps, as vConsolidate specifies:

1. Benchmark throughput = benchmark's raw results/benchmark duration (for each of the four benchmarks)
2. Total benchmark throughput = add benchmark throughput for all CSUs in test
3. Normalized throughput = total benchmark throughput/reference system's benchmark throughput
4. vConsolidate score = geomean (normalized throughput of all four benchmarks)

The first step in this process uses whatever raw results a benchmark produces, such as number of transactions or operations, and the benchmark's duration in seconds. We calculate a benchmark's duration by subtracting the start time of the vConsolidate test from its stop time and converting that time to seconds.
WebBench is an exception to this process because it automatically produces a score in requests per second. For this benchmark, we calculate the average requests per second for the three WebBench mixes that run while the other benchmarks are running and record this result as its throughput.

The second step is to sum the throughput for a given benchmark across all CSUs. In the one-CSU case, there is no need for this step. For the two-, three-, four-, five-, and six- CSU tests, we summed the throughput of each individual benchmark across all CSUs to obtain that benchmark's final score.

The third step is to normalize the throughput. We use the Profile 2 reference score defined in the vConsolidate installation guide and assign it a normalized score of 1.00. We then divide the summed throughput for a given type of work by the reference score for that benchmark. This produces the normalized score for that type of work in this test.

The last step is to take the geometric mean of the normalized throughput for all four benchmarks.

Figure 4 shows the final score (the median of three runs) and CPU utilization of the test servers by number of CSUs. The CPU utilization percentage is the average over the period the vConsolidate workload ran.

Server	Intel Xeon processor X7460		Intel Xeon processor X7350	
Number of CSUs	Score	CPU	Score	CPU
1	1.22	22%	1.17	33%
2	2.33	43%	2.23	65%
3	3.26	65%	2.85	89%
4	3.92	86%	3.03	96%
5	4.23	94%	3.10	98%
6	4.34	97%	3.10	99%
7	4.34	98%	3.03	100%
8	4.34	99%		

Figure 4: vConsolidate results for the test systems with varying numbers of CSUs with corresponding CPU utilizations. Higher scores are better.

Figure 5 details the power consumption, in watts, of the test servers while idle and during the median peak number of CSUs.

Server	Idle power (watts)	Average power (watts)
Intel Xeon processor X7460	534.77	757.91
Intel Xeon processor X7350	539.38	824.60

Figure 5: Average power usage (in watts) of the test servers while idle and during the median peak CSU runs. Lower numbers are better.

Figure 6 shows the optimum CSU test results, by benchmark and CSU, for the Intel Xeon processor X7460-based server.

Intel Xeon processor X7460-based server	Database	Java	Mail	Web	Final score
CSU 1	80.80	18,247.28	14.67	445.98	
CSU 2	80.99	18,186.89	14.86	444.86	
CSU 3	81.10	18,319.26	16.18	454.22	
CSU 4	82.69	18,249.15	15.51	448.64	
CSU 5	80.70	18,305.59	14.01	445.79	
CSU 6	81.58	18,343.71	15.35	451.73	4.34

Figure 6: vConsolidate optimum CSU median results, by benchmark and CSU, for the Intel Xeon processor X7460-based server. Higher scores are better.

Figure 7 shows the optimum CSU test results, by benchmark and CSU, for the Intel Xeon processor X7350-based server.

Intel Xeon processor X7350-based server	Database	Java	Mail	Web	Final score
CSU 1	60.61	15,208.48	15.29	383.43	
CSU 2	60.02	15,270.64	15.18	380.69	
CSU 3	59.99	15,209.45	15.14	388.93	
CSU 4	60.63	15,307.38	15.67	380.86	
CSU 5	61.38	15,346.50	15.56	389.91	3.10

Figure 7: vConsolidate optimum CSU median results, by benchmark and CSU, for the Intel Xeon processor X7350-based server. Higher scores are better.

We include complete results for all three runs on the two test systems in Appendix B.

Note: Due to the complexity and number of components the vConsolidate benchmark uses (e.g., network interfaces, client computers, storage sub-system, configuration of VMs and benchmark components), Intel does not recommend directly comparing test results from this report with results from other vConsolidate reports. Unless the benchmark and its components have identical configurations, results may vary, providing an inadequate basis for direct comparison.

Test methodology

Intel configured and provided both servers.

With the following exception, we used the default BIOS settings on each server: we enabled Intel Virtualization Technology on all servers.

To be sure we could push the processors of each of the two system configurations to their maximum capacities, we tested each server with as many vConsolidate CSUs as the server could handle, starting with one CSU, up to or extremely close to 100 percent processor utilization. The rest of this section details how we set up the servers and the vConsolidate workload.

Hardware and software the test involved

Software

We used the following software to configure and run the vConsolidate workload:

- Windows Server 2008 Hyper-V
- Microsoft Windows Server 2003 R2, Enterprise Edition
- Microsoft Windows Server 2003 R2, Enterprise x64 Edition
- Microsoft Exchange Server 2003
- Microsoft SQL Server 2005

- BEA JRockit 1.6.0_02-b05
- WebBench 5.0
- Microsoft Exchange Server Load Simulator (LoadSim) 06.05.7775
- SPECjbb2005 v1.07
- SysBench v0.4.0
- Intel vConsolidate framework version 2.0

Hardware

Our test bed consisted of the following hardware:

- The server under test
- Eleven custom-built Intel Desktop Board D915GMH with Intel Pentium® 4 3.0GHz w/HT systems, which we used for all WebBench clients, LoadSim clients, and WebBench controllers (CSU 2 and CSU 3).
- One custom-built Intel Server Board D945GTP system, which we used as both the main vConsolidate controller and the CSU 1 WebBench controller
- NETGEAR GS724T, which we set up into two VLANs (one for external network and one for internal network)
- Network Appliance NetApp FAS960 filer
- Two Network Appliance DS14 Disk Shelves, with 14 x Seagate Cheetah ST373307FC 73.4 GB disk drives each
- QLogic SANblade QLE2462 Dual Port 4-Gbps Fibre Channel Host Bus Adapter (HBA) installed in the server under test

Figure 8 illustrates the test bed.

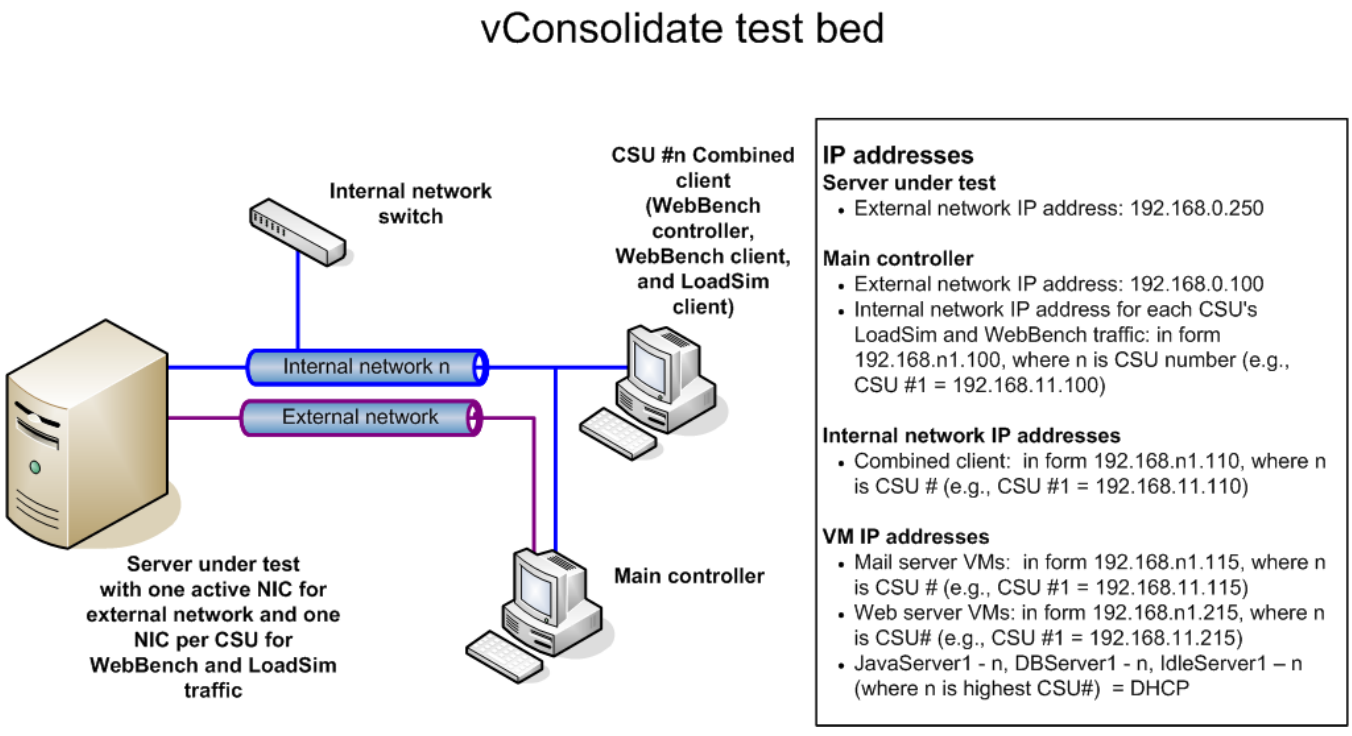

Figure 8: Our vConsolidate test bed.

Server installation

We configured all servers with the same disk setup using the NetApp FAS960 filer. We split the storage into four volumes, one with 10 GB and five with 130 GB. For each server, we installed Windows Server 2008 Hyper-V on the 10GB volume and installed a CSU on each of the five 130GB volumes. We installed the boot loader on the hard drive installed in the server's drive chassis on the server under test.

Adding the Hyper-V role to Windows Server 2008

Note: Make sure you have installed all the latest critical and recommended updates for Windows Server 2008 from Windows Update. Specifically, you must install the update that upgrades Hyper-V from beta to release software. (As of 07/21/2008, this update is KB950050 on 64-bit Windows.)

1. Click Server Manager→Roles→Add Roles.
2. Check the box beside the Hyper-V role, and click Next.
3. Click Next.
4. Check the box beside the Ethernet card you wish to use, and click Next.
5. Click Install. Installation begins.
6. When installation finishes, click Close.
7. When the system prompts you to restart, click Yes.
8. Once the system finishes rebooting (this might happen twice), log in.
   The Resume Configuration Wizard should start automatically.
9. Once the Resume Configuration Wizard completes, the installation results should appear with a message that the installation succeeded.
10. Click Close.
11. Restart the server.

Adding logical unit numbers (LUNs)

Note: Make sure the Fibre Channel/iSCSI LUN is mapped to the card in your system.

1. Click Server Manager→Storage→Disk Management.
2. When the wizard prompts you to initialize new disks, click OK. Note: If you must select a partition table, select MBR.
3. Right-click the first unallocated disk partition, and select New Simple Volume…
4. Click Next.
5. Use the entire LUN storage space (this should be the default), and click Next.
6. Select the drive letter to assign to the new partition, and click Next.
7. Label the volume appropriately (i.e., LUN0, LUN1, etc.), make sure Perform a quick format is checked, and click Next.
8. Click Finish.

Configure Hyper-V default options

1. Click Start→Administrative Tools→Hyper-V Manager.
2. From the Actions menu, select Hyper-V Settings…
3. From the left menu of the Settings screen, select Virtual Hard Disks, and enter the default folder to store virtual hard disk files (e.g., E:\Hyper-V\Virtual Hard Disks).
4. From the left menu of the Settings screen, select Virtual Machines, and enter the default folder to store virtual hard disk files (e.g., E:\Hyper-V).
5. Click OK.
6. You may also want to configure any VM network switch settings at this time.

Creating a virtual machine

1. Click Start→Administrative Tools→Hyper-V Manager.
2. From the Actions menu, select New→Virtual Machine...
3. Click Next.
4. 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).
5. Click Next.

6. Specify the amount of memory to allocate to the virtual machine, and click Next.
7. Select the network connection for the virtual machine to use, and click Next.
8. Select Attach a virtual hard disk later, and click Next.
9. Click Finish.

Modifying the Virtual Machine (Creating the virtual HDD)

1. Click Start→Administrative Tools→Hyper-V Manager.
2. Right-click the Virtual Machine on which you want to install Windows, and click "Settings…"
3. From the menu on the left, select IDE Controller 0, and click Add to add a new hard drive to the IDE Controller.
4. Click New to create a new virtual hard disk file.
5. Click Next.
6. Select Fixed size, and click Next.
7. Specify the name and location of the virtual hard disk file.
8. Specify the size of the new blank virtual hard disk (in GB).
9. Click Finish. The server begins creating the new virtual hard disk.
10. Once it finishes creating the new virtual hard disk, click OK.

Modifying the Virtual Machine (adding an additional hard disk)

Note: Do not use this method to configure the VM primary hard disk; for that you must use a virtual IDE hard disk. However, we recommend that you perform high-usage I/O tasks (i.e., database server, file server, mail server, etc.) on a secondary disk whenever feasible.

1. Click Start→Administrative Tools→Hyper-V Manager.
2. Right-click the Virtual Machine on which you want to install Windows, and click Settings…
3. From the menu on the left, select Add Hardware.
4. Choose the "SCSI Controller" device and click Add.
5. Click "Add" to add a new hard drive to the virtual SCSI Controller.
6. Click New to create a new virtual hard disk file.
7. Click Next.
8. Select "Fixed size" and click Next.
9. Specify the name and location of the virtual hard disk file.
10. Specify the size of the new blank virtual hard disk (in GB).
11. Click Finish. The server will then begin creating the new virtual hard disk.
12. Once it finishes creating the new virtual hard disk, click OK.

Installing Windows on the VM

Note: We have tested this using Windows Server 2003 R2 Enterprise x64 Edition with SP2.

1. Click Start→Administrative Tools→Hyper-V Manager.
2. Right-click the Virtual Machine on which you want to install Windows, and click Connect…
3. From the menu, select Media→DVD Drive→Insert Disk…
4. Select the ISO image file for the version of Windows you are installing, and click Open.
5. To start the virtual machine, select Start from the Action menu.
6. Click the screen, and begin installing Windows as you normally would.
7. Once installation is complete, select action →Ctrl-Alt-Delete.
8. Enter your password, and press Enter.
9. Select Media→Eject CD.
10. Select Media→Insert CD and choose the second installation disk.
11. When the Windows installation completes select Action→Insert Integration Services Setup Disk from the menu. Installation should begin automatically.
12. At the prompt to restart, click Yes.
13. Once the system has restarted, log in, and verify that all configured devices (mouse, keyboard, video, network, etc.) are working.
14. Once you are sure all your devices are working, from the menu select Media→DVD Drive→Eject vmguest.iso.

Installing vmbus.sys patch

Note: We installed an updated version of vmbus.sys on both systems to provide optimum performance. The version we installed was 6.0.6001.18018.

1. On both 64-bit and 32-bit virtual machines, copy the vmbus.sys file to C:\WINDOWS\system32\drivers.
2. On all virtual machines, copy the vmbus.sys file to c:\WINDOWS\Virtualizationi\6.0.6001.18016.
3. On the Hyper-V server, open a command prompt and type `bcdedit /set testsigning on`.
4. Copy the 64-bit vmbus.sys file to c:\WINDOWS\system32\drivers.

To create one vConsolidate CSU, we had to create the five virtual machines that CSU describes:

- mail server
- Web server
- Java application server
- database server
- idle server

The following subsections detail how we created and configured each of these VMs.

Copying the VMs

Use the following steps to create VMs with the same base OS:

1. Navigate to the Virtual Hard Disk folder on the server where the Virtual Hard Disks are stored.
2. Highlight your base VM, and use the copy/paste method to create the appropriate number of copies for your VMs.
3. Right click each Hard Disk and rename them according to the VM for which they are to be used.
4. Select Start→Administrative Tools→Hyper-V Manager…
5. Choose New→Virtual Machine.
6. Click Next.
7. Enter a name for the virtual machine, and select the location to store the VM files The New Virtual Machine Wizard will automatically create a subfolder with the name of the VM).
8. Click Next.
9. Specify the amount of memory to allocate to the virtual machine, and click Next.
10. Select the network connection for the virtual machine to use, and click Next.
11. Select Attach a virtual hard disk later, and click Next.
12. Click Finish.
13. Select the newly created VM and choose Settings→IDE Controller 0.
14. Choose Add to add a Hard Disk to the VM.
15. Choose Browse.
16. Select the appropriate Hard Disk and click Okay.
17. Click OK.

Installing and configuring the mail server VM

1. Follow the steps in the earlier Copying the VMs section using the following VM specifications:
   - Base VM: Base32
   - Name: MailServer1
   - Virtual processors: 1
   - Virtual memory: 1.5 GB
   - Virtual disk size: 10 GB
   - Virtual network: Internal Network (set the IP address to 192.168.11.115 in Windows within the VM)

To finish setting up this VM for vConsolidate, we had to install several additional software components. The following subsections detail the necessary installation processes.

Installing the domain controller

1. Select Start→Administrative Tools→Manage Your Server.
2. Click Add or remove a role.

3. At the Configure Your Server window, click Next.
4. At the Configuration and Options screen, select Custom Configuration, and click Next.
5. At the Server Role screen, select Domain Controller, and click Next.
6. At the Summary of Selections screen, click Next.
7. At the Welcome pop-up window, click Next.
8. At the Operating System Compatibility screen, click Next.
9. For the Domain Controller Type, leave the default option (Domain controller for a new domain), and click Next.
10. At the Create New Domain screen, leave the default (Domain in a new forest), and click Next.
11. At the Install or Configure DNS window, select No, and click Next.
12. At the New Domain Name screen, type a domain name (`vcon.com`), and click Next.
13. At the NetBIOS Domain Name screen, enter a NETBIOS domain name (vcon), and click Next.
14. Click Next through the following screens: Database and Log Folders, Shared System Volume, and Permissions. Doing so accepts the default options for each of those screens.
15. At the Directory Services Restore Mode Administrative Password screen, enter a password (`password`), and click Next.
16. When the installation software prompts you to do so, insert the OS CD, and click OK.
17. At the Completing the Active Directory Installation Wizard screen, click Finish.
18. When the system prompts you to reboot the VM, click Restart Now.
19. After the VM reboots, log in to the system.
20. At the This Server is Now a Domain Controller window, click Finish.

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 NNTP Services and SMTP Services, make sure a check appears in both check boxes, and click OK.
7. Click OK to close the Application Server window.
8. At the Windows Components Wizard, click Next to begin the installation.
9. When the system prompts you to do so, insert the OS CD, and click OK.
10. At the Completing the Windows Components Wizard window, click Finish.
11. Close the Add or Remove Programs window.

Installing Exchange Server 2003

1. Insert the Microsoft Exchange Server 2003 CD. The CD should automatically launch the installation software.
2. Choose Exchange Server Enterprise Edition.
3. Run the Setup application.
4. Click the Exchange Deployment Tools link.
5. Click the Deploy the first Exchange 2003 Server link.
6. Click the New Exchange 2003 Installation link.
7. Click the Run ForestPrep now link.
   a. When the compatibility issue notice appears, click Continue, and check the Don't display this message again box.
   b. At the Welcome screen, click Next.
   c. Accept the End User License Agreement, and click Next.
   d. At Component Selection Screen, keep the defaults, and click Next.
   e. Leave the default account information, and click Next.
   f. Installation should start. (This process may take a while to complete.)
   g. When the installation completes, click Finish.
8. Return to the Exchange Server Deployment Tools screen, and click the Run DomainPrep now link.
   a. At the Welcome screen, click Next.
   b. Accept the End User License Agreement, and click Next.

c. At Component Selection Screen, keep the defaults, and click Next.
d. At the insecure domain notice, click OK.
e. When the installation completes, click Finish.

9. Return to the Exchange Server Deployment Tools screen, and click Run Setup Now.
   a. At the Welcome screen, click Next.
   b. Accept the End User License Agreement, and click Next.
   c. At the Component Selection screen, the action for Microsoft Exchange should by default be Typical. (If it is not, use the drop-down box to set it to Typical.)
   d. Click Next.
   e. For the Installation Type, select Create new Exchange Organization, and click Next.
   f. Enter `vcon` as the Organization Name, and click Next.
   g. Accept the Microsoft Exchange Server Licensing Agreement, and click Next.
   h. Review the installation summary, and click Next.
   i. The installation should start. (This process may take a while to complete.)
   j. When the installation completes, click Finish.
10. Close the Exchange Server Deployment Tools window.
11. Install Microsoft Exchange Server 2003 Service Pack 2.
    a. Insert the SP2 CD, and double-click update exe.
    b. Accept the default location to extract the file, and click OK.
    c. After the extraction finishes, open Windows Explorer, and browse to the update.exe executable.
    d. At the Welcome screen, click Next.
    e. Select I agree to accept the License Agreement, and click Next.
    f. At the Component Selection window, leave the default option (Update), and click Next.
    g. Verify the installation Summary, and click Next.
    h. When the installation completes, click Finish.
12. In the Virtual Infrastructure Client console, add a new 40GB virtual hard disk to this VM by doing the following:
    a. Right-click the MailServer1 VM, and select Settings from the menu.
    b. On the Hardware Tab, click Add Hardware.
    c. Choose the “SCSI Controller” device and click Add.
    d. Click “Add” to add a new hard drive to the virtual SCSI Controller.
    e. Click New to create a new virtual hard disk file.
    f. Click Next.
    g. Select “Fixed size” and click Next.
    h. Specify the name and location of the virtual hard disk file.
    i. Specify the size of the new blank virtual hard disk (in GB).
    j. Click Finish. The server will then begin creating the new virtual hard disk.
    k. Once it finishes creating the new virtual hard disk, click OK.
13. Restart the VM by selecting Start→Shut down→Restart inside the MailServer VM.
14. In the MailServer VM, right-click My Computer, and select Manage.
15. In the Computer Management Console, select Disk Management.
16. When a Welcome to Initialize and Convert Disk Wizard window appears, click Next.
17. Select Disk 1 to initialize.
18. At the Select Disk to Convert screen, leave the disk unchecked.
19. At the Completing the Initialize and Convert Disk Wizard screen, click Finish.
20. Right-click the Disk 1 unallocated box, and select New Partition.
21. At the Welcome screen, click Next.
22. Leave the partition type as Primary, and click Next.
23. Accept the default Partition Size, which should be the same as the Maximum disk space, and click Next.
24. Assign the drive letter E, and click Next.
25. Format the partition with the NTFS File system, enter `Mail Store` for the volume label, and click Next.
26. At the Completing the New Partition Wizard screen, click Finish.
    The partition should begin formatting.
27. When the formatting completes, close the Computer Management console.
28. Select Start→All Programs→Microsoft Exchange→System Manager.

29. In the left window pane, expand Servers and MailServer so the First Storage Group is visible.
30. Right-click First Storage Group, and select Properties.
31. Click Browse, and change the Transaction log and System path location to E:\.
32. Check the Enable circular logging box, and click Apply.
33. When the pop-up message appears asking if you want to perform this task, click Yes.
34. When the message appears saying that all mounted stores are back online, click OK.
35. Right-click Mailbox Store under First Storage Group, and select Properties.
36. Select the Database tab.
37. Click Browse, and move the Exchange database and Exchange streaming database to E:\.
38. Check the This database can be overwritten by a restore box.
39. Click Customize next to Maintenance interval.
40. Remove all blue from the boxes so the system will not perform maintenance, and click OK.
41. At the Mailbox Store Properties window, click Apply.
42. When a warning message appears, click Yes.
43. When the message that the database files have been moved appears, click OK.
44. Click OK to close the Mailbox Store Properties window.
45. Right-click Public Store 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:\.
48. Check the This database can be overwritten by a restore box.
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 Public 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 Public Store Properties window.
55. Reboot the virtual machine.

Installing and configuring the Web server VM

1. Follow the steps in the earlier Cloning the base VMs section using the following VM specifications:
   - Source VM: Base32
   - Name: WebServer1 (use WebServer for the Host Name in the VM)
   - Virtual processors: 2
   - Virtual memory: 1.5 GB
   - Virtual Disk Size: 10GB
   - Virtual Network: Internal Network (set the IP address to 192.168.11.215 in Windows within the VM)

To finish setting up this VM for vConsolidate, we had to install several additional software components. The following subsections detail the necessary installation processes.

Installing Microsoft Internet Information Server

1. Select Start→Administrative Tools→Manage Your Server.
2. Select Add or remove a role.
3. At the Configure Your Server window, click Next.
4. At the Configuration Options screen, select Custom configuration, and click Next.
5. At the Server Role screen, select Application Server, and click Next.
6. At the Application Server Options screen, select Enable ASP.NET, and click Next.
7. At the Summary of Selections screen, click Next.
8. When the installation software prompts you to do so, insert the Operating System CD, and click OK.
9. When the installation completes, click Finish.
10. Close the Manage Your Server window.

Installing WebBench 5.0

1. Insert the WebBench 5.0 CD into the Virtual Client, and connect with the Virtual CDROM.
2. Copy wbtree.exe from the \wb50\workload directory on the CD to C:\inetpub\wwwroot.

3. Double-click wbtree.exe to expand the workload. (This step will create a wbtree folder with all the test data WebBench required.)
4. Create a cgi-bin folder in c:\inetpub\wwwroot.
5. After installing the WebBench controller, copy simcgi.exe from the controller machine in C:\WebBench\Controller\Suites\WebBench\Examples directory to the Web server VM's C:\Inetpub\wwwroot\cgi-bin\ directory.
6. Right-click My Computer, and select Manage.
7. Expand Services and Applications, Internet Information Services, and Web Sites in the left window pane.
8. Click Default Web Sites.
9. Right-click the cgi-bin directory in the right pane, and select Properties from the drop-down menu.
10. In the Execute permissions field, select Scripts and Executables, and click OK.
11. Using Windows Explorer, browse to C:\Inetpub\wwwroot\cgi-bin, right-click simcgi.exe, and select Properties from the drop-down menu.
12. Select the Security tab, and grant Read/Read & Execute permissions to the user, Internet Guest Account.
13. Click OK to close simcgi.exe properties.
14. Close Windows Explorer.
15. In the Computer Management window, right-click the Default Web Server, and select properties from the drop-down menu.
16. Select the HTTP Headers tab, and click MIME Types.
17. In the MIME Types window, click New.
18. In the Extension text box, enter `.ex`.
19. In the MIME type text box, enter `application/octet-stream`, and click OK.
20. Click OK again to close the MIME Types window and the Default Web Site Properties window.
21. If a notification window about a child node pops up, click OK.
22. In the Computer Management console, select Web Service Extension.
23. Select All unknown CGI Extensions in the right pane, and click Allow.
24. Click Yes, you do want to allow All Unknown CGI Extensions in the pop-up window.
25. Open a Web browser, and type the URL http://localhost/cgi-bin/simcgi.exe to verify you correctly installed the WebBench files. Text about the system should appear in the browser window.
26. Close the Web browser.

Installing Certificate Server

1. Select Start→Control Panel→Add or Remove Programs.
2. Click Add/Remove Windows Components.
3. Select Certificate Servers, and accept the CA Service warning.
4. Click Next.
5. Select Standalone root CA in the CA Type Windows, and click Next.
6. Enter `WEBBENCH` in the common name field, and click Next.
7. At the Certificate Database Settings screen, leave the default options, and click Next.
8. When the warning about stopping IIS appears, click Yes.
9. When the installation software prompts you to do so, insert the OS CD, and click OK.
10. Click Yes to enable Active Server Pages.
11. When the installation completes, click Finish.

Creating a certificate request

1. In the Computer Management Console, right-click the Default Web site, and select Properties.
2. Select the Directory Security tab, and then click Server Certificate under Secure Communications to start the Web Server Certificate Wizard.
3. At the Welcome screen, click Next.
4. Select Create a new certificate, and click Next.
5. Select Prepare the request now, but send it later, and click Next.
6. Type `Default Web Site` for the certificate name.
7. Use the default bit length (1024), and click Next.
8. Type `MyWeb` for the organization name and `Development Dept` for the organizational unit, and click Next.