

INCREASE DENSITY AND PERFORMANCE WITH UPGRADES FROM INTEL AND DELL

Step up your server game with upgrades from Intel® and Dell™

Intel® Xeon® processor E5-2697 v2 & Microsoft® Windows Server® 2012 R2 operating system

Intel SSD DC S3700 series drive

Intel Ethernet CNA X520 series adapter

Get up to **4.5X** as many VMs versus an older server solution

intel DELL

Dell PowerEdge™ R720 server

Upgrading datacenter infrastructure is a necessary step for a growing business that has exhausted its current hardware resources. Usually, an upgrade will include replacing a server with a newer model to take advantage of technological advances. In addition to the generational advantages of newer hardware, you may opt to upgrade certain hardware components to stretch the effectiveness of the upgrade in your specific environment. Typically, these upgradeable components include the processor, operating system, drive type, and network card, but how do you know which components to choose?

In the Principled Technologies labs, we first measured the performance of an older Dell PowerEdge R710 with a Dell PowerEdge R710 storage server, and then upgraded both to Dell PowerEdge R720 servers in multiple component upgrade configurations to show the performance increases that come with upgrading these various components. We found in our tests that the Dell PowerEdge R720 servers upgraded with the Intel® Xeon® processor E5-2697 v2, Microsoft® Windows Server® 2012 R2 operating system, Intel SSD DC S3700 series drive, and Intel Ethernet CNA X520 series adapters supported 4.5 times as many VMs as the previous-generation Dell PowerEdge R710 servers did. While upgrading all four components maximized performance, we also found that each individual component upgrade significantly increased the number of users, database orders, and VMs that the server could support.



UPGRADES MATTER FOR PERFORMANCE

New servers typically mean updated technology, so even the newer base model will likely outperform the servers you currently use. Investing in component upgrades can further boost performance and support additional users, but knowing which components to upgrade can be tricky when trying to bypass bottlenecks and get additional performance. For example, if a server has upgraded processors but its workload is I/O intensive and limited on storage IOPs, then the upgraded processors may be underutilized due to the storage bottleneck. If the processor and storage are upgraded but the workload doesn't have sufficient network bandwidth, then again, the system may run sub-optimally. Figure 1 shows the results of our upgrade tests, first demonstrating the value of upgrading from the Dell PowerEdge R710s to the Dell PowerEdge R720 servers, and then showing the performance benefits of the component upgrades. The fully upgraded configuration increased VM density—up to 4.5 times the number of VMs—compared to the Dell PowerEdge R710 solution.

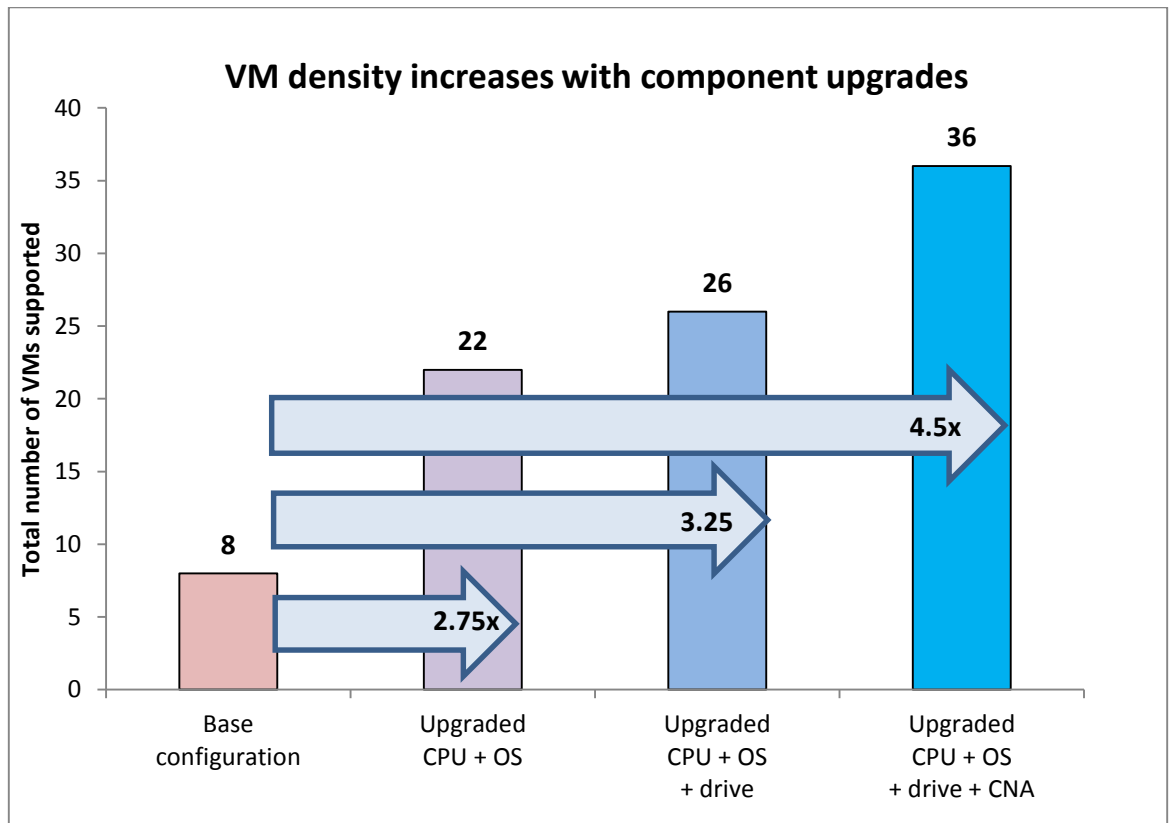


Figure 1: Upgrading servers, operating system, drives, and CNAs increased VM density up to 4.5x.

OUR TEST SPECIFICS

We set up a Dell PowerEdge R710 base server with older Intel Xeon processors E5540 as our previous-generation server under test to run both Microsoft SQL Server 2012 database VMs and Microsoft Exchange Server 2010 VMs. Our previous-generation

storage solution consisted of a Dell PowerEdge R710 with a Dell PERC H800 connected to an external JBOD via SAS. The storage volumes were presented from the storage server to the server under test via software iSCSI. We ran our VMs on the server under test, and stored the virtual hard drives from the VMs on the storage server. Each of our database VMs needed to deliver 25,000 OPM on average and each Exchange VM had to support 500 mail users with latency under 20ms. Note: because our study aimed to show the linear scaling advantages of these upgrades, it may not reflect the maximum users each VM can support. In all cases, the goal was to show how many VMs could sustain acceptable Microsoft SQL Server and Microsoft Exchange workload performance.

Using these parameters, this baseline configuration could host eight Microsoft Hyper-V VMs running Microsoft Windows Server 2008 R2, four running database workloads and four hosting Exchange mailboxes.

Next, we configured two Dell PowerEdge R720 servers to be our upgraded server under test and storage server. After testing the baseline configuration, we added incremental upgrades to the Dell PowerEdge R720 servers. Each configuration included the upgrades in the previous configuration. Figure 2 presents an overview of the components we upgraded along with their performance results.

Configuration	PowerEdge R710 configuration	PowerEdge R720 configuration	PowerEdge R720 configuration + SSD upgrade	PowerEdge R720 configuration + SSD + 10GbE CNA upgrade
Processor	Intel Xeon processor E5540	Intel Xeon processor E5-2697 v2	Intel Xeon processor E5-2697 v2	Intel Xeon processor E5-2697 v2
Host operating system	Windows Server 2008 R2	Windows Server 2012 R2	Windows Server 2012 R2	Windows Server 2012 R2
Drive type	HDD	HDD	SSD	SSD
Network connection	1GbE	1GbE	1GbE	10GbE
Results				
Total VMs supported	8	22	26	36
CPU utilization	45.4%	35.3%	42.0%	71.3%
iSCSI network utilization (Mb/s)	330.1	851.6	956.8	1,395.7
Database VMs	4	11	13	18
Total orders per minute (OPM)	114,028	319,685	351,477	467,660
OPMs/VM	28,507	29,062	27,037	25,981
Exchange VMs	4	11	13	18
Exchange users	2,000	5,500	6,500	9,000
Exchange latency (ms—lower numbers are better)	7.9	14.1	14.8	2.9

Figure 2: Overall results of our upgrade testing.

Along with increasing VM density, the upgraded components also improved database performance and the number of mailbox users in a predictable linear fashion. While each upgrade increased performance steadily, upgrading all components at once provided the best performance, most VMs, and most users. In our final configuration, we saw a 210 percent increase over the previous-generation configuration in the total OPM, and a 250 percent increase in the number of mailbox users supported.

In the sections that follow, we break down the performance that each configuration achieved and briefly discuss the components we upgraded. To look at the detailed specifications of our test hardware, see [Appendix A](#). For the detailed steps we followed for our testing, see [Appendix B](#).

UPGRADING TO THE DELL POWEREDGE R720

The Dell PowerEdge R720 servers included the upgraded OS - from Microsoft Windows Server 2008 R2 in the Dell PowerEdge R710 servers to Microsoft Windows Server 2012 R2. Additionally, it upgraded the processors from older Intel Xeon processors E5540 to two Intel Xeon processors E5-2697 v2. This would be a reasonable upgrade, as new hardware will include new processor technology and the latest operating system.

And the results of the upgrade are...

Simply having the Intel Xeon processor E5-2600 v2 product family and the Microsoft Windows Server 2012 R2 OS on the new system more than doubled the number of VMs the new server could support (from 8 to 22) over the previous-generation server and more than doubled database performance (from 114,028 OPM to 319,685 OPM). These upgrades also increased the number of mailbox users the server could support by 175 percent—from 2,000 Exchange users to 5,500. Figure 3 shows the impact that acquiring these components in a new system had on capacity and performance.

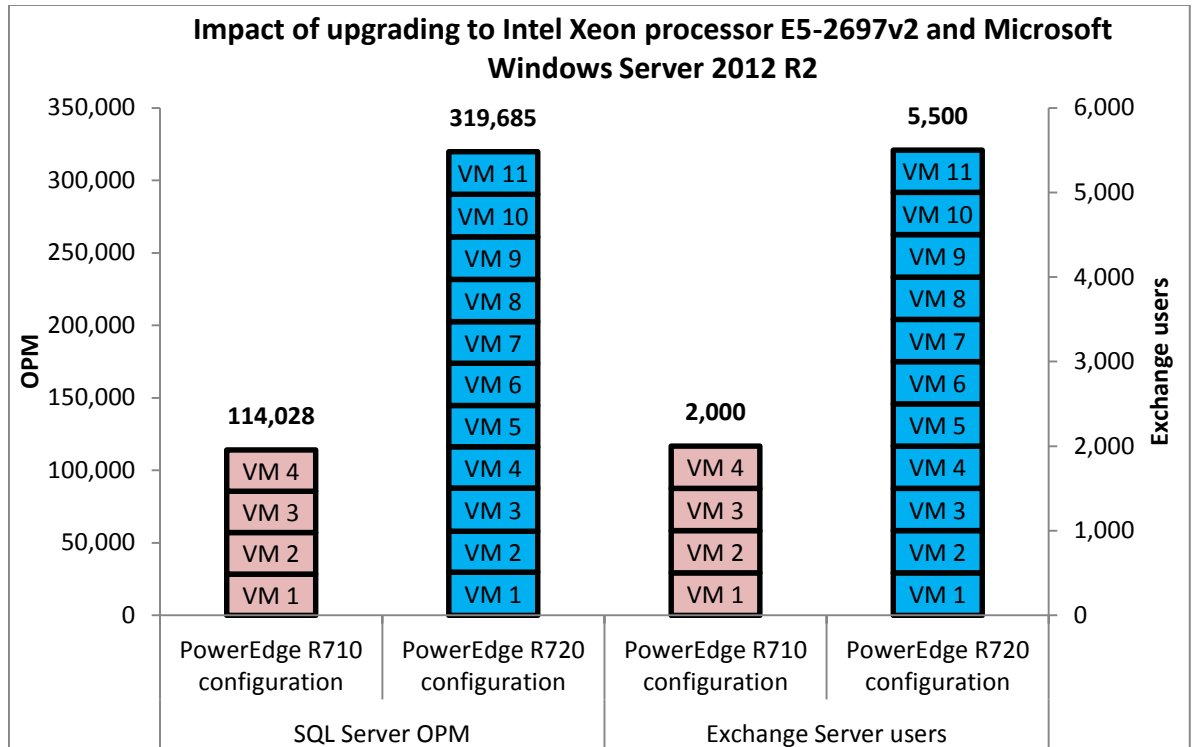


Figure 3: Upgrading to the Dell PowerEdge R720 increased database performance, mail users, and VM density.

REPLACING TRADITIONAL SAS HARD DISK DRIVES WITH SOLID-STATE DRIVES

After we upgraded the configuration to a server with a new processor and operating system, we upgraded the SAS hard disk drives (HDDs) on our external storage array to Intel SSD DC S3700 series SSDs to remove the performance bottleneck and show the potential improvement in performance.

And the results of the upgrade are...

Replacing the HDDs with Intel SSDs increased performance even more. Upgrading to Intel SSDs in the storage array (in addition to processors and OS) more than tripled the number of VMs the previous-generation server and storage could support (from 8 to 26) and delivered more than three times the database performance (from 114,028 OPM to 351,477 OPM). These upgrades also more than tripled the number of mailbox users the server could support—from 2,000 Exchange users to 6,500. Figure 4 shows the impact that upgrading these components had on capacity and performance.

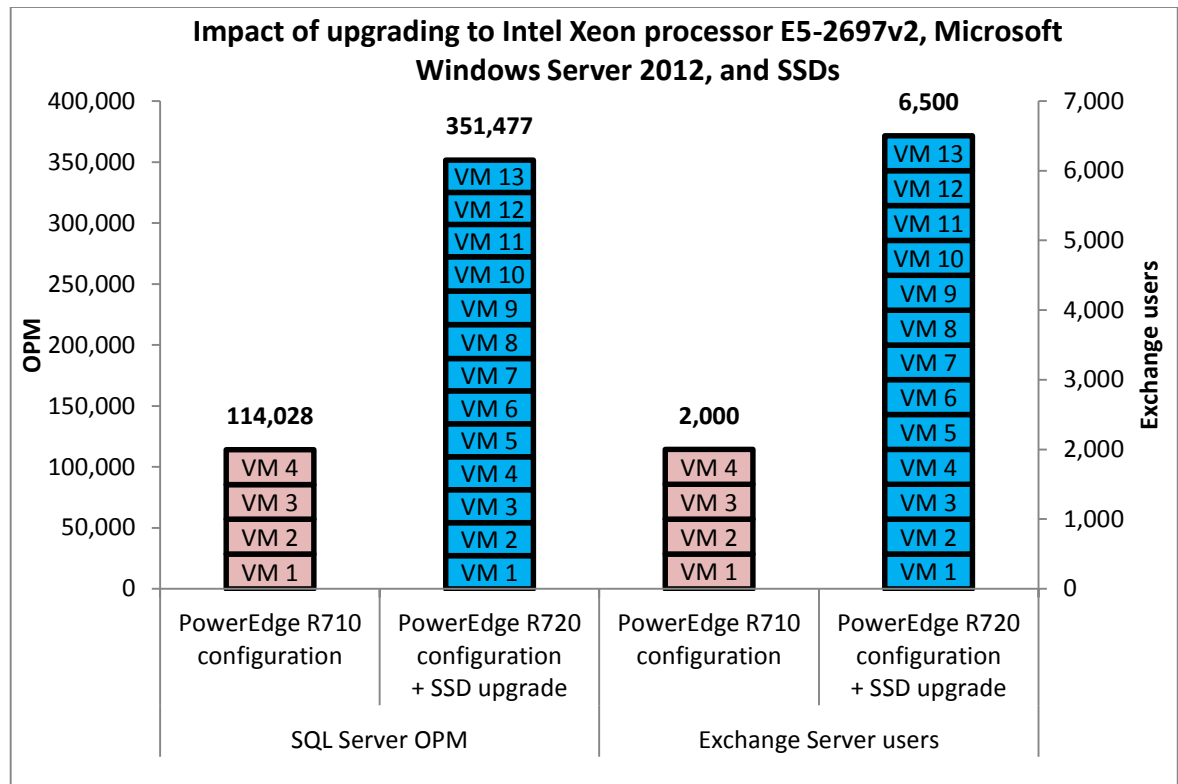


Figure 4: Upgrading to Intel SSDs along with the Intel Xeon processor E5-2600 v2 product family and Microsoft Windows Server 2012 R2 increased database performance, mail users, and VM density.

UPGRADING TO A 10GBE NETWORK CONNECTION

After upgrading processors, operating system, and disk drives, another potential obstacle to even greater performance is your network connection, in our case the storage network connection. We upgraded the servers' iSCSI connection from a 1GbE network connection to a 10GbE network connection using the Intel Ethernet CNA X520 series on both the hypervisor server and storage server, and found that doing so, in addition to the other upgrades, maximized performance, users, and VM density.

And the results of the upgrade are...

Upgrading to a 10GbE iSCSI network connection with the Intel Ethernet CNA X520 increased performance even more. In fact, we hit a memory ceiling before falling below acceptable performance per VM. To find the maximum VM count, we added enough memory to fit one more SQL VM and one more Exchange VM. This final upgrade (in addition to processors, OS, and SSDs) more than quadrupled the number of VMs the baseline server could support (from 8 to 36) and delivered 310.1 percent more database performance (from 114,028 OPM to 467,660 OPM). Together, these four upgrades also more than quadrupled the number of mailbox users the server could support—from 2,000 Exchange users to 9,000.

Figure 5 shows the impact that upgrading all of the components had on capacity and performance. This configuration, with upgraded processor, operating system, disk drives, and network connection, provided the greatest performance and capacity.

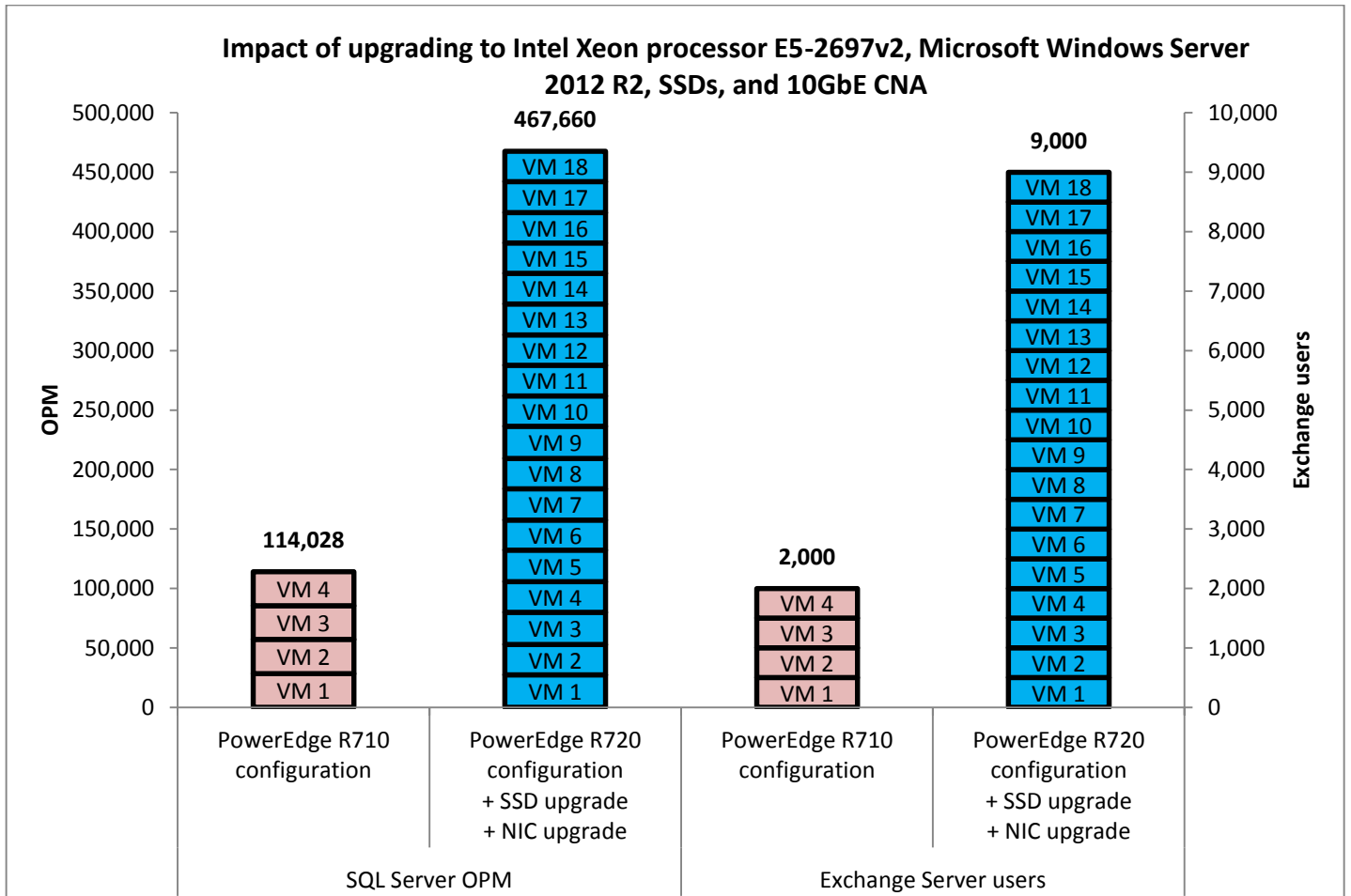


Figure 5: Upgrading to a 10GbE iSCSI network connection with Intel Ethernet CNAs along with Intel SSDs, the Intel Xeon processor E5-2600 v2 product family, and Microsoft Windows Server 2012 R2, had the maximum impact on database performance, number of mail users, and VM density.

RETURN ON INVESTMENT

In our new configuration, we were able to run 4.5 times as many VMs on a single physical server than the previous-generation configuration, which shows potential for consolidating your workloads into fewer servers. Although the new server and accessories would result in an initial CAPEX outlay, the resulting OPEX savings potentially could be significant. Each physical server in your infrastructure represents another management endpoint, another hardware maintenance target, additional required software licensing, and another source of consumed power, all of which cost OPEX dollars. If you upgrade components for optimal system utilization, and thereby increase VM counts on your new servers, you reduce the number of physical servers

required, which contributes to a reduction in OPEX dollars and could provide a quicker ROI.

SUMMARY

As the needs of your business grow, so must the power of your server infrastructure. Rather than purchasing replacement servers with base configurations, consider upgrading key components to ensure you get the performance you need.

We found that upgrading to the Dell PowerEdge R720 with the Intel Xeon processor E5-2697 v2, Microsoft Windows Server 2012 R2 operating system, Intel SSD DC S3700 series drive, and Intel Ethernet CNA X520 series adapters supported 4.5 times as many VMs as the previous-generation Dell PowerEdge R710 solution.

When you purchase a server, wisely selecting these components offered by Dell and Intel can allow your business to hit the sweet spot of supporting all your users without breaking the bank. Incremental upgrades also leave room to grow and help your infrastructure handle growth for years to come.

Finally, these select upgrades could translate to savings for your business—fewer servers you need to purchase now to meet performance demands, and a longer lifespan for these servers as your business continues to grow.

APPENDIX A – ABOUT THE HARDWARE & SOFTWARE

About the Dell PowerEdge R720

The new Intel® Xeon® processor E5-2600-v2-powered Dell PowerEdge R720 2U rack server incorporates many enhancements and features designed to improve performance, lower power consumption, and ease maintenance. Some of these features include the following:

- **Performance.** Dell engineered the PowerEdge R720 to handle complex workloads, with I/O and internal data management technologies (i.e., NSC, NPAR, CacheCade) to allow faster access to information and GPU accelerators for faster than ever computational performance.
- **Processors.** The Dell PowerEdge R720 is powered by two Intel Xeon E5-2600 v2 processors, which incorporate the very latest in technology from Intel. The powerful processors provide exceptional performance and make the PowerEdge R720 a solid virtualization platform.
- **Power efficiency.** Dell PowerEdge R720 servers implement leading industry power efficiency standards, and are designed to optimize performance while maintaining low power consumption. Automated tracking and regulation of thermal activity, intelligent design of right-sized power options, and high efficiency fans and airflow management work to save power, saving you money in the process.
- **Management.** The Dell PowerEdge R720, like all late-model Dell servers, comes with the Dell Lifecycle Controller. This tool simplifies server management by providing a single interface for management functions and by storing critical system information in the system itself. There are no CDs or USB keys to keep track of for drivers or firmware.
- **Storage.** With impressive storage capacity for small business servers, the Dell PowerEdge R720 is available in both an 8-bay and 16-bay chassis.
- **Memory.** The Dell PowerEdge R720 holds up to 768 GB of RAM, many times the memory capacity of older small business servers, allowing for powerful flexibility with virtualized database solutions.

About Microsoft Windows Server 2012 R2

Windows Server 2012 R2, the latest release of this server OS from Microsoft, includes many new features and enhancements. According to Microsoft, Windows Server 2012 R2 focuses on four core areas:

- **Beyond virtualization.** Windows Server 2012 R2 provides a robust and dynamic virtualization platform through Hyper-V, and includes new features that provide flexible options for delivering cloud services.
- **The power of many servers, the simplicity of one.** Windows Server 2012 R2 offers improvements in its features that allow for better-than-ever high availability and ease of management for multiple-server infrastructures.
- **Every app, any cloud.** Windows Server 2012 R2 delivers a scalable and flexible Web and application platform by providing a consistent and open set of tools and frameworks that apply to applications on-premises, in the cloud, or in a hybrid environment.
- **Modern work style, enabled.** Microsoft Windows Server 2012 R2 empowers users and IT staff with remote access to data, applications, and simpler management tools while strengthening security and compliance.

About the Intel Xeon processor E5-2600 v2 product family

The Intel Xeon processor E5-2600 v2 product family, previously code named “Ivy Bridge”, builds on the E5-2600 product family for even stronger processors. The new product family features increased core counts (up to 12 cores/24 threads) and up to 30M cache. Intel Xeon E5-2600 v2 processors support larger memory DIMMS, up to 64GB, and faster memory, up to 1,866 MHz.

This processor family also introduces new features to help protect your important data: Intel Secure Key, which provides faster and more secure encryption, and Intel OS Guard, which improves protection against malware. The Intel Xeon processor E5-2600 v2 product family also features Advance Programmable Interrupt Controller virtualization (APICv), which can help improve virtualization performance.

For more information on the Intel Xeon processor E5-2600 v2 product family, visit www.intel.com.

About the Intel SSD DC S3700 series

Solid-state drives from the Intel SSD DC S3700 series are designed for fast response times and lower power consumption. These SSDs provide 4KB random read performance and up to 75,000 IOPS. Intel SSDs also include error correction technologies to ensure that data stays safe. For more information about Intel SSD DC S3700 series, visit www.intel.com/content/www/us/en/solid-state-drives/solid-state-drives-dc-s3700-series.html.

About the Intel Ethernet CNA X520 series

According to Intel, “Intel’s new family of Intel Ethernet Converged Network Adapter X520 are the most flexible and scalable Ethernet adapters for today’s demanding data center and cloud environments.

The Intel Ethernet Converged Network Adapter X520 family addresses the demanding needs of the next-generation data center by providing unmatched features for virtualization, flexibility for LAN and storage area network (SAN) networking, and proven, reliable performance.”

For more information, visit www.intel.com/content/www/us/en/network-adapters/converged-network-adapters/ethernet-x520.html.

APPENDIX B – TEST HARDWARE CONFIGURATION

Figure 6 provides detailed configuration information about the baseline test servers. The hard disk and disk controller shown are for internal disk for the host operating system. The disks used for all VMs are shown in Figure 9.

System	Previous-generation server	Previous-generation storage server
Power supplies		
Total number	2	2
Maximum wattage of each (W)	870	870
Cooling fans		
Total number	5	5
Dimensions (h x w) of each	2.5" x 2.5"	2.5" x 2.5"
General		
Number of processor packages	2	2
Number of cores per processor	4	4
Number of hardware threads per core	2	2
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5540	E5540
Stepping	D0	D0
Socket type	FCLGA1366	FCLGA1366
Core frequency (GHz)	2.53	2.53
Bus frequency (GT/s)	6.4	6.4
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache (MB)	8	8
Platform		
Vendor and model number	Dell PowerEdge R710	Dell PowerEdge R710
Motherboard model number	0N0H4P	0N0H4P
BIOS name and version	Dell 6.3.0	Dell 6.3.0
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	96 GB	48 GB
Vendor and model number	Samsung® M393B1K70BH1-CH9	Samsung M393B1K70BH1-CH9
Type	PC3-10600R	PC3-10600R
Speed (MHz)	1,333	1,333
Speed running in the system (MHz)	1,333	1,333
Size (GB)	8	8
Number of RAM module(s)	12	6
Rank	Dual	Dual
Chip organization	Double-sided	Double-sided
Hard disk		
Vendor and model number	Dell WD3000BKHG-18A29V0	Dell WD3000BKHG-18A29V0
Number of disks in system	2	2

System	Previous-generation server	Previous-generation storage server
Size (GB)	300	300
Buffer size (MB)	32	32
RPM	10,000	10,000
Type	SAS	SAS
Controller	Dell PERC 6/i Integrated RAID Controller	Dell PERC 6/i Integrated RAID Controller
Network adapter		
Vendor and model number	Intel PRO/1000 PT Dual Port Server Adapter	Intel PRO/1000 PT Dual Port Server Adapter
Type	PCIe	PCIe

Figure 6: Detailed configuration information for the previous-generation servers.

Figure 7 provides detailed configuration information about the upgraded test servers. The hard disks and disk controller shown are for internal disks for the host operating system. The disks used for all VMs are shown in Figure 9.

System	Upgraded server	Upgraded storage server
Power supplies		
Total number	2	1
Maximum wattage of each (W)	750	110
Cooling fans		
Total number	5	5
Dimensions (h x w) of each	2.5" x 2.5"	2.5" x 2.5"
General		
Number of processor packages	2	2
Number of cores per processor	12	12
Number of hardware threads per core	2	2
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2697 v2	E5-2697 v2
Stepping	C1	C1
Socket type	FCLGA2011	FCLGA2011
Core frequency (GHz)	2.7	2.7
Bus frequency (GT/s)	8	8
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache (MB)	30	30
Platform		
Vendor and model number	Dell PowerEdge R720	Dell PowerEdge R720
Motherboard model number	00W9X3	00W9X3
BIOS name and version	Dell 2.2.3	Dell 2.2.3
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	256, +32 for CNA upgrade step	64
Vendor and model number	Hynix HMT42GR7MFR4C-PB	Samsung M393B1K70DH0-CMA
Type	PC3-12800R	PC3-12800R
Speed (MHz)	1,600	1,866
Speed running in the system (MHz)	1,600	1,866
Size (GB)	16	8
Number of RAM module(s)	16	8
Rank	Dual	Dual
Chip organization	Double-sided	Double-sided
Hard disk		
Vendor and model number	Dell ST9300605SS	Dell ST9300605SS
Number of disks in system	2	2
Size (GB)	300	300

System	Upgraded server	Upgraded storage server
Buffer size (MB)	64	64
RPM	10,000	10,000
Type	SAS	SAS
Controller	Dell PERC H710P Mini	Dell PERC H710P Mini
Network adapter		
1GbE network (1GbE scenarios)		
Vendor and model number	Intel Gigabit 4P I350-t rNDC	Intel Gigabit 4P I350-t rNDC
Type	Integrated	Integrated
10GbE network (10GbE scenarios)		
Vendor and model number	Intel Ethernet CNA X520-DA2	Intel Ethernet CAN X520-DA2
Type	PCIe	PCIe

Figure 7: Detailed configuration information for the upgraded servers.

Figure 8 provides detailed configuration information about the external storage used in our testing.

Drive types	Hard disk drive	Solid-state drive
Storage array		
Vendor and model number	EliteSTOR® ES224X6+B	EliteSTOR ES224X6+B
Drive		
Vendor and model number	Dell Savvio 15k.3 SED	Intel SSD DC S370 Series
Number of disks in system	24	400
Size (GB)	300	N/A
Buffer size (MB)	64	N/A
RPM	15,000	SATA
Type	SAS	400
Controller	Dell PERC H800 / Dell PERC H810	Dell PERC H810

Figure 8: Detailed configuration information for the storage array and disks.

APPENDIX C - HOW WE TESTED

To quantify the performance advantages of upgrading each component, we started with a Dell PowerEdge R710 with Intel Xeon E5540 processors running Windows Server 2008 R2 with Hyper-V running SQL Server 2012 and Exchange Server 2010 VMs. We used another Dell PowerEdge R710 with a Dell PERC H800 running Microsoft iSCSI Software Target 3.3 to hold all the SQL Server 2012 and Exchange Server 2010 VMs on external JBOD storage.

For testing, we used DVD Store to stress the SQL 2012 VMs and LoadGen 2010 to stress the Exchange VMs. We used a one-to-one approach for the SQL Server and Exchange VMs so we ran an equal number of SQL Server and Exchange client VMs. We identify the total number of supported VMs based on the DVD Store results with an average of 25,000 orders per minute across all VMs. We added VMs until the performance level on any VM dropped below 25,000 OPM, 500 Exchange users, or had latency above 20ms.

After using the above approach to find the baseline server's total supported VMs, we performed incremental upgrades to a Dell PowerEdge R720 with Intel Xeon processor E5-2697 v2 processors running Windows Server 2012 R2, with Intel 200GB SSD drives and Intel X520 network adapter recording the total supported VMs at each upgrade. We also upgraded the storage server to a Dell PowerEdge R720 with a Dell PERC H810, connected to the same JBOD storage.

About DVD Store Version 2.1

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute that the system could handle, to show what kind of performance you could expect for your customers. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your ecommerce environment.

For more details about the DS2 tool, see www.delltechcenter.com/page/DVD+Store.

About Microsoft Load Generator 2010

To test the solutions' mail server performance, we used the Microsoft Load Generator 2010 (LoadGen) benchmark, performing tasks to simulate an Average user generating mail activity. For our workloads, we used the following settings:

- Number of users: 500
- Mailbox Profile: 100MB mailboxes
- Action Profile: Outlook 2007 cached

For more details about LoadGen, see www.microsoft.com/downloads/details.aspx?FamilyId=DDEC1642-F6E3-4D66-A82F-8D3062C6FA98&displaylang=en.

Test bed configuration

Figure 9 shows a diagram of our test bed. The baseline server used a 1GbE iSCSI connection between the test server and storage server. The upgraded server used both 1GbE and 10GbE iSCSI between the servers depending on the configuration under test.

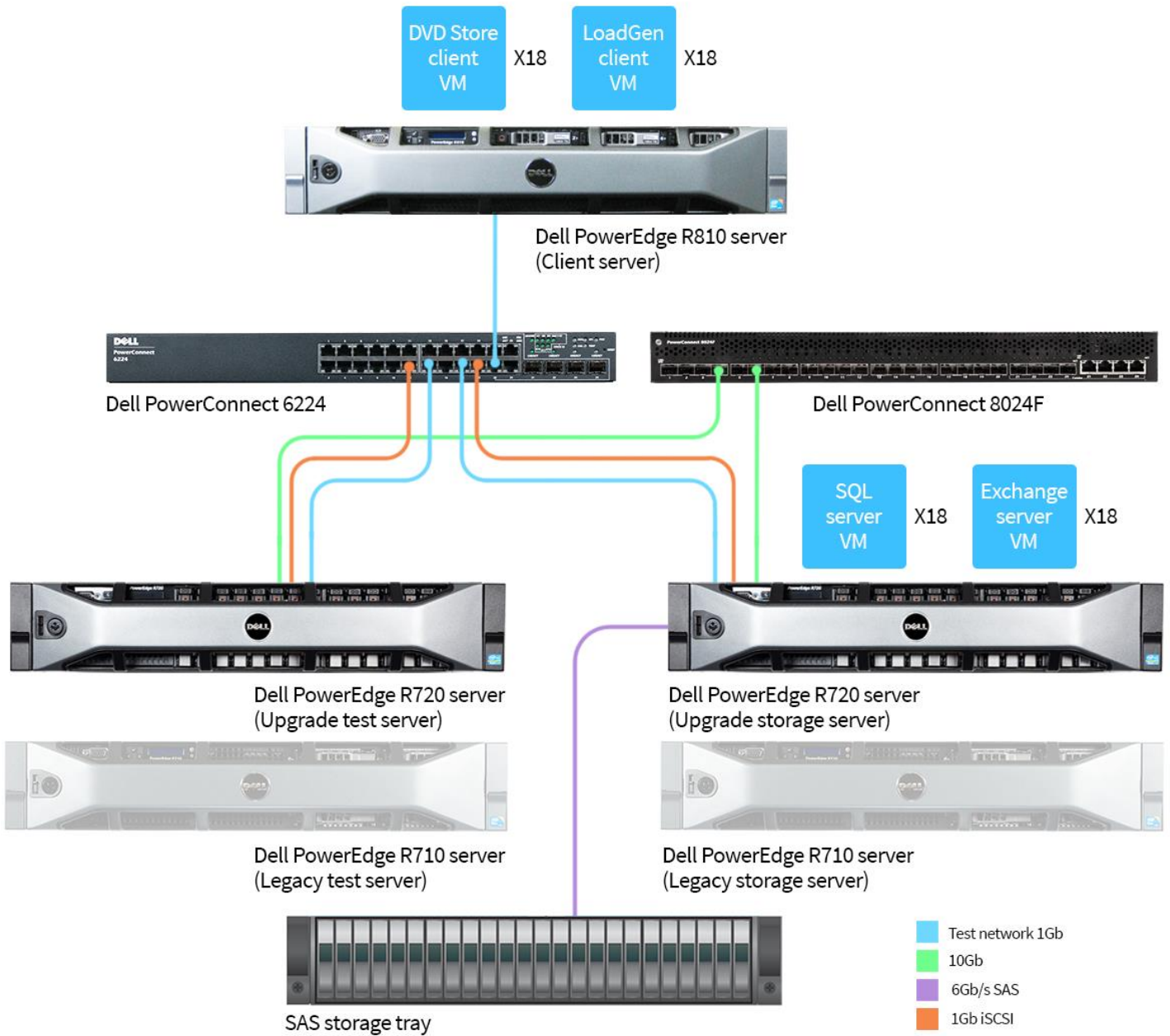


Figure 9: Test bed diagram.

Configuring the test bed

Installing the Microsoft Windows Server 2008 R2 operating system on the Dell PowerEdge R710

1. Choose the language, time and currency, and keyboard input. Click Next.

2. Click Install Now.
3. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
4. Accept the license terms, and click Next.
5. Click Custom.
6. Click the Disk, and click Next.
7. After the installation completes, click OK.
8. Enter the administrator password twice, and press Enter.
9. Click OK.

Installing the Microsoft Windows Server 2012 R2 operating system on the Dell PowerEdge R720

1. Choose the language, time and currency, and keyboard input. Click Next.
2. Click Install Now.
3. Select Windows Server 2012 R2 Datacenter, and click Next.
4. Accept the license terms, and click Next.
5. Click Custom.
6. Click the Disk, and click Next.
7. After the installation completes, enter the administrator password twice, and click Finish.

Configuring the Microsoft Windows Server operating systems

1. Install all available Windows updates. Restart as necessary.
2. Enable remote desktop access.
3. Change the hostname, and reboot when the installer prompts you.
4. Set up networking for the management network:
 - a. Click Start→Control Panel, right-click Network Connections, and select Open.
 - b. Right-click the management traffic NIC, and select Properties.
 - c. Select TCP/IP (v4), and select Properties.
 - d. Set the IP address and subnet for the NIC, which will handle management traffic, and click OK.
 - e. Click OK, and click Close.
5. Set up networking for the VM traffic network:
 - a. Click Start→Control Panel, right-click Network Connections, and select Open.
 - b. Right-click the VM traffic NIC, and select Properties.
 - c. Select TCP/IP (v4), and select Properties.
 - d. Set the IP address and subnet for the NIC, which will handle VM traffic, and click OK.
 - e. Click OK, and click Close.
6. Set up networking for the iSCSI network:
 - a. Click Start→Control Panel, right-click Network Connections, and select Open.
 - b. Right-click the iSCSI traffic NIC, and select Properties.
 - c. Click Configure...
 - d. Select the Advanced tab, select Jumbo Packet from the Properties list, change the value to 9014 bytes, and click OK.

- e. Right-click the iSCSI traffic NIC, and select Properties.
- f. Select TCP/IP (v4), and select Properties.
- g. Set the IP address and subnet for the NIC, which will handle iSCSI traffic, and click OK.
- h. Click OK, and click Close.

Setting up the storage host

For our testing, we used a Dell PowerEdge R720XD running Windows Server 2012 R2.

Installing iSCSI Target in Windows Server 2012 R2

1. Open Server Manager, and click Manage→Add Roles and Features.
2. At the Before You Begin screen, click Next.
3. At the Installation Type screen, click Next.
4. At the Server Selection screen, click Next.
5. At the Server Roles screen, expand File And Storage Services→File and iSCSI Services, and select iSCSI Target Server. At the prerequisite pop-up, click Add Features. Click Next.
6. At the Features screen, click Next.
7. At the Confirmation screen, check the box to automatically restart the server after installation, and click Install.

Configuring iSCSI Target in Windows Server 2012 R2

1. Open Server Manager, and click File and Storage Services→iSCSI.
2. Click To create an iSCSI virtual disk, and start the New iSCSI Virtual Disk Wizard.
3. At the iSCSI Virtual Disk Location screen, select the target volume, and click Next.
4. At the iSCSI Virtual Disk Name screen, enter a name for the virtual disk, and click Next.
5. At the iSCSI Virtual Disk Size, enter the size displayed as free space, and click Next.
6. At the iSCSI Target screen, click Next.
7. At the Target Name and Access screen, enter a name for the target, and click Next.
8. At the Access Servers screen, click Add...
9. On the Add initiator ID window, select Enter a value for the selected type, select IP Address from the dropdown menu, enter the IP address of the system under test's iSCSI connection, and click OK.
10. Verify the IP address is listed, and click Next.
11. At the Enable authentication server screen, click Next.
12. At the Confirmation screen, click Create.

Configuring the iSCSI initiators on the system under test

1. Log into Windows using the appropriate credentials.
2. Right-click the network icon in the task bar, and select Open Network and Sharing Center.
3. Click on Change adapter settings at the left of the window.
4. Right-click the iSCSI network adapter, and click Properties.
5. Highlight Internet Protocol Version 4 (TCP/IP), and click Properties.
6. Select Use the following IP address, enter the desired IP for your iSCSI network, and click OK.
7. Click OK, and click Close.
8. Open the start menu, type `iSCSI Initiator`, and press Enter.

9. If it asks you to start the service, click OK.
10. In the Quick Connect Target field, enter the iSCSI IP assigned to the storage host, and click Quick Connect...
11. Select the desired target, select Enable Multi-pathing, and click Connect.
12. Select the discovered target, and click Properties...
13. Click Add session, select Enable Multi-pathing, and click OK.
14. Select the Volumes and Devices tab.
15. Click the Auto Configure button, and click OK.
16. Open the start menu, type `Hard Disk Partitions`, select Settings, and click the displayed tile.
17. Right-click the newly added disk, and select Online.
18. Right-click the disk, select Initialize Disk, and click Ok.
19. Right-click the volume space, and select Create Simple Volume.
20. At the Specify Volume Size window, leave the default selection, and click Next.
21. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
22. At the Format Partition window, choose NTFS, and click Next.
23. At the Completing the New Simple Volume Wizard window, click Finish.

Installing the Hyper-V role on the system under test

1. Open Server Manager, and click Manage→Add Roles and Features.
2. At the Before You Begin screen, click Next.
3. At the Installation Type screen, click Next.
4. At the Server Selection screen, select one of the servers in the failover cluster.
5. At the Server Roles screen, check the Hyper-V checkbox. At the prerequisite pop-up, click Add Features. Click Next.
6. At the Features screen, click Next.
7. At the Hyper-V screen, click Next.
8. At the Virtual Switches screen, click Next.
9. At the Migration screen, click Next.
10. At the Default Stores screen, enter the iSCSI storage location. Click Next.
11. At the Confirmation screen, check the box to automatically restart the server after installation, and click Install.

Creating the VM

1. Click Start, type `Hyper-V Manager`, and press Enter.
2. In the right pane, click Virtual Machines→New Virtual Machine.
3. Select a node on which to install the VM, and click OK.
4. At the Before You Begin screen, click Next.
5. At the Specify Name and Location screen, verify that the location is on iSCSI storage. Give the VM a name, and click Next.
6. At the Assign Memory screen, type `8 GB`, and click Next.
7. At the Configure Networking screen, use the drop-down menu to select the virtual switch, and click Next.

- At the Connect Virtual Hard Disk screen, create a new disk, enter a size appropriate for the server role, and click Finish. We sized every VHD at 30 GB.
- At the Summary screen, click Finish.

Installing the VM operating system on the first VM

- From the VM console, connect to the ISO image of the installation DVD for Windows Server 2012 R2 Datacenter. If the ISO image is not stored on the host, start the VM, and connect to the ISO image.
- Start the VM.
- At the Language Selection Screen, click Next.
- Click Install Now.
- Select Windows Server 2012 R2 Enterprise (Full Installation), and click Next.
- Click the I accept the license terms checkbox, and click Next.
- Click Custom.
- Click Next.
- At the User's password must be changed before logging on warning screen, click OK.
- Enter the desired password for the administrator in both fields, and click the arrow to continue.
- At the Your password has been changed screen, click OK.
- Install the latest Host Integration Tools package on the VM. Restart as necessary.
- Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
- Enable remote desktop access.
- Change the hostname, and reboot when prompted.
- Create a shared folder to store test script files. Set permissions as needed.
- Set up networking:
 - Click Start→Control Panel, right-click Network Connections, and choose Open.
 - Right-click the VM traffic NIC, and choose Properties.
 - Select TCP/IP (v4), and choose Properties.
 - Assign the VM a static IP address.

Installing and configuring Microsoft Exchange Server

We installed Microsoft Exchange 2010 SP3 on a VM with Windows Server 2012 R2 residing on the system under test.

Creating the Exchange 2010 VM

After cloning, modify the Exchange 2010 VM to contain the following settings:

- Memory: 8GB
- Virtual Processors: 1
- Additional virtual disks:
 - 1 x 100GB virtual disk for mailbox storage and logs

Configuring the Exchange 2010 VM

- Log into Windows using the appropriate credentials.
- Select Start→Control Panel→Network Connections→Ethernet 2.

3. Click Properties.
4. Highlight Internet Protocol (TCP/IP), and click Properties.
5. Select the Use the following IP address radio button, and enter the desired IP for your iSCSI network.
6. Click OK.
7. Open the start menu, type `iSCSI Initiator` and select the displayed tile.
8. If the installation asks you to start the service, click OK.
9. In the Quick Connect Target field, enter the IP assigned to the HP RAID Controller, and click Quick Connect...
10. Select the desired target, and click Connect.
11. Select the Volumes and Devices tab.
12. Click the Auto Configure button.
13. Click OK.
14. Open the start menu, type `Hard Disk Partitions`, from the right side, select Settings, and click the displayed tile.
15. Right-click the disk sized 100GB, and select Online.
16. Right-click the disk, select Initialize Disk, and click OK.
17. Right-click the volume space, and select Create Simple Volume.
18. Click Next four times to accept all defaults, and click Finish.

Installing Active Directory and DNS services

1. On the VM, open Server Manager.
2. On the Welcome screen, click 2, and click Add roles and features.
3. At the initial Before you begin screen, click Next three times.
4. At the Server Roles screen, select Active Directory Domain Services.
5. On the pop-up window, click Add Features.
6. Click Next three times.
7. Verify the desired role is being installed, and click Install.
8. Once installation has finished, close the Add roles and features wizard.
9. In Server Manager, click the flag at the top, and select the Promote this server to a domain controller link.
10. Select Add a new forest, type a root domain name of `test.local`, and click Next.
11. On the Domain Controller Options window, enter a password, and click Next.
12. On the DNS Options screen, click Next.
13. On the Additional Options screen, click Next.
14. On the Review Options screen, click Next.
15. On the Prerequisites screen, verify all prerequisites have passed, and click Install.
16. Once Active Directory Domain Services finishes installing, click Finish, and restart the system.

Installing .NET Framework 3.5.1 Features and Internet Information Services

1. Select Start→Administrative Tools→Server Manager.
2. Click Features.
3. Click Add Features.

4. Select .NET Framework 3.5.1 Features
5. Click Add Required Role Services.
6. Click Next.
7. Click Next.
8. At the Select Role Services screen, select the IIS 6 Metabase Compatibility, IIS 6 Management Console, Basic Authentication, Windows Authentication, Digest Authentication, Static content compression, and Dynamic content Compression checkboxes, and click Next.
9. At the Confirm Installation Selections screen, click Install.
10. At the Installation Results screen, click Close.

Installing Microsoft Filter Pack 2.0

1. Download the Microsoft Filter Pack 2.0 from www.microsoft.com/downloads/en/details.aspx?FamilyID=5cd4dcd7-d3e6-4970-875e-aba93459fbee.
2. Run FilterPackx64.EXE.
3. Click Next.
4. Click I accept the terms in the License Agreement, and click Next.
5. When the installation is complete, click OK.

Installing Exchange Server 2010

1. Click Start, type `services.msc`, and press Enter.
2. Right-click the Net.Tcp Port Sharing service, and click Properties.
3. Change the Net.Tcp Port Sharing startup type to Automatic, and click OK.
4. Open command prompt and type `ServerManagerCmd -i RSAT-ADDS`, and press Enter.
5. Reboot the VM.
6. Mount the installation ISO to the VM, and click Setup.EXE when prompted.
7. The installer should consider steps 1 and 2 complete, and gray them out.
8. Click Step 3: Choose Exchange Language Option.
9. Click Install only languages from the DVD.
10. Click Step 4: Install Microsoft Exchange Server 2010 SP1.
11. To go past the introduction screen, click Next.
12. Accept the license agreement, and click Next.
13. Select No for error reporting, and click Next.
14. Select Typical Exchange Server Installation, and click Next.
15. Leave the organization name at default (First Organization), and click Next.
16. At the question about client computers running Outlook 2003 and earlier, select Yes, and click Next.
17. Click Next to accept defaults for Configure Client Access server external domain.
18. At the Customer Experience Improvement Program screen, select I don't want to join the program at this time, and click Next.
19. If a warning about a lack of SMTP appears after the check finishes, ignore it.
20. To start the installation process, click Install.

21. Once installation is complete, click Finish.
22. Click OK when prompted to reboot.
23. Click Close.
24. To confirm exit, click Yes.
25. Reboot the VM.

Installing SP3 for Microsoft Exchange 2010

1. Download Service Pack 3 for Microsoft Exchange 2010 (Exchange2010-SP3-x64.exe) from www.microsoft.com/en-us/download/details.aspx?id=36768 to c:\SP3 on the VM.
2. To extract the installation files, double-click the downloaded file.
3. To accept the destination directory for the extracted files, click OK.
4. To launch the installer, double-click setup.exe.
5. Click Install Microsoft Exchange Server upgrade.
6. At the Introduction screen, click Next.
7. Accept the terms in the license agreement, and click Next. The Readiness Checks should begin.
8. Install any roles in Server Manager that the Readiness Checks prompt you to install.
9. When the checks successfully complete, click Upgrade.
10. Click Finish, and reboot the VM.

Configuring Exchange Server 2010 connector

1. In the VM, Select Start→All Programs→Microsoft Exchange Server 2010→Exchange Management Console.
2. In the left pane, click Microsoft Exchange On-Premises.
3. In the left pane, expand Organization Configuration, and select Hub Transport.
4. In the action pane on the far right, select New Send Connector.
5. Name the send connector SMTP, select the intended use as Internet, and click Next.
6. In the Address space screen, click Add.
7. In the SMTP Address Space screen, type * as the address, ensure that the installer has checked Include all subdomains, and click OK.
8. Click Next.
9. To accept defaults for the next two pages, click Next.
10. At the New Connector page, click New to create the connector.
11. To close the New SMTP Send Connector wizard, click Finish.

Configuring the Exchange Server 2010 Mailbox role

1. Select Start→All Programs→Microsoft Exchange Server 2010→Exchange Management Console.
2. In the left pane, expand Organization Configuration, and click Mailbox.
3. Click the Database Management tab.
4. Right-click Mailbox Database, and select Properties.
5. Select the Maintenance tab.
6. Check the Enable circular logging box.
7. Check the box beside This database can be overwritten by a restore.

8. Next to Maintenance interval, click Customize.
9. Remove all blue from the boxes so the system will not perform maintenance, and click OK.
10. Click OK.
11. Click OK to any warnings about circular logging being applied after the database is remounted.
12. On the far right pane, click Move Databases.
13. Change the Database file and Log folder path locations to point to the additional attached virtual disk, and click Move.
14. If the application prompts you to dismount, click Yes.
15. Click Finish.
16. Right-click Public Folder Database, and select Properties.
17. Check the Enable circular logging checkbox, and uncheck the ESE scanning checkbox.
18. Next to Maintenance interval, click Customize.
19. Remove all blue from the boxes so the system will not perform maintenance, and click OK.
20. Click OK.
21. On any warnings about circular logging being applied after the database is remounted, click OK.
22. On the far right pane, click Move Database.
23. Change the Database file and Log folder path locations to point to the additional attached virtual disk, and click Move.
24. If the application prompts you to dismount, click Yes.
25. Click Finish.

Installing and configuring the Exchange 2010 mail test client (LoadGen)

For our testing, we used a virtual client for the LoadGen workload. To create this client, we installed Windows Server 2008 R2 and several other software components. We followed this process for the configuration:

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 Use the following IP address, and enter the desired IP for your VM.
5. Select Use the following DNS server addresses, and enter the IP of the AD server in the Preferred DNS server field. Click OK.
6. Right-click My Computer, and select Properties.
7. Under the Computer Name tab, click Change.
8. In the Computer Name Changes screen, under Computer name, type `loadgen` as your computer name.
9. In the Computer Name Changes screen, under the Member of section, select Domain, and type `test.local`
10. To join the domain, select OK.
11. When the screen appears asking for a person qualified on the domain, type `administrator` as the username and `Password1` as the password.

12. At the Welcome pop-up and the window warning that you must reset the computer for the changes to take effect, click OK.
13. At the System Properties screen, click OK.
14. When a pop-up appears asking if you want to restart now, click Yes to restart your computer.

Installing Internet Information Services

1. Click Start→Administrative Tools→Server Manager.
2. On the left pane, click Roles.
3. Click Add Roles.
4. Click the Application Server checkbox.
5. When the Add features required for Application Server? screen appears, click Add Required Features.
6. Click Next.
7. Click Next.
8. At the Select Role Services page for Application Server, click the Web Server (IIS) Support checkbox.
9. Click Add Required Support Role Services.
10. Click Next.
11. Click Next.
12. At the Select Role Services page for Web Server (IIS), click IIS 6 Management Compatibility, ASP, and CGI checkboxes; and click Next.
13. Click Install.
14. Click Close.

Installing Load Generator 2010

1. Download and install Load Generator 2010 using all defaults.

Preparing Load Generator

1. Log into the mail client using the tester account.
2. Select Start→All Programs→Microsoft Exchange→Exchange Load Generator 2010.
3. When the Load Generator screen appears, select Start a new test.
4. Select Create a new test configuration, and click Continue.
5. Change the total length of simulation to 45 minutes.
6. In the Specify test settings screen, type `Password1` as the Directory Access Password and Mailbox Account Master Password, and click Continue with recipient management.
7. Make 500 users in the Mailbox Database, and click Continue.
8. To accept defaults for Advanced recipient settings, click Continue.
9. In the Specify test user groups screen, select the plus sign to add a user group.
10. Change the Client Type to Outlook 2007 Cached, the Action Profile to Exchange_200, and the Mailbox size to 100 MB.
11. In Remote configurations, click Continue.
12. Click Save the configuration file as, and name it `testcfg.xml`
13. After saving the configuration file, click Start the initialization phase (recommended before running the test).

Installing and configuring Microsoft SQL Server 2012

We installed Microsoft SQL Server 2012 on a VM residing on the system under test.

Configuring the SQL Server VM

After cloning, modify the SQL VM to contain the following settings:

- Memory: 8GB
- Virtual Processors: 2
- Additional virtual disks:
 - 2 x 15GB virtual disks for SQL database and log data (Thick provisioned, eager-zeroed)

In the VM, configure the VM storage:

1. In the taskbar, click the Server Manager icon.
2. In the left pane, expand Storage, and click Disk Management.
3. Right-click the first volume, and choose Initialize Disk.
4. In the right pane, right-click the volume, and choose New Simple Volume...
5. At the welcome window, click Next.
6. At the Specify Volume Size window, leave the default selection, and click Next.
7. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
8. At the Format Partition window, choose NTFS, and click Next.
9. At the Completing the New Simple Volume Wizard window, click Finish.

Installing SQL Server 2012

1. Open the console for the VM or connect to the VM with RDP.
2. Mount the installation ISO to the VM.
3. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2012 DVD, and double-click.
4. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
5. In the left pane, click Installation.
6. Click New SQL Server stand-alone installation or add features to an existing installation.
7. At the Setup Support Rules screen, wait for the rule check to complete. If there are no failures or relevant warnings, click OK.
8. Select the Specify a free edition and from the drop-down menu, and select Evaluation. Click Next.
9. Click the checkbox to accept the license terms, and click Next.
10. If no failures are displayed after the setup support files are installed, click Next.
11. At the Setup Role screen, choose SQL Server Feature Installation.
12. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete. Click Next.
13. At the Installation Rules screen, click Next after the check completes.
14. At the Instance configuration screen, leave the default selection of default instance, and click Next.
15. At the Disk Space Requirements screen, click Next.

16. At the Server Configuration screen, check that NT AUTHORITY\SYSTEM is selected for SQL Server Agent and SQL Server Database Engine. Click Next.
17. Assuming there are no failures, click Next.
18. At the Database Engine Configuration screen, select Mixed Mode.
19. Enter and confirm a password for the system administrator account.
20. Click Add Current user. This may take several seconds.
21. Click the Data Directories tab, and enter the appropriate drive and folders for database and logs.
22. Click Next.
23. At the Error and usage reporting screen, click Next.
24. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
25. At the Ready to Install screen, click Install.
26. After installation completes, click Close.
27. Create a SQL Server login for the ds2user (see the [Configuring the database \(Data generation overview\)](#) section for the specific script to use).
28. Copy the pre-created DVD Store backup to the specified backup volume.
29. Download and install any available updates for Microsoft SQL Server 2012. We installed SQL Server 2012 SP1 and CU5.

Configuring the database workload client

For our testing, we used a virtual client for the Microsoft SQL Server client. To create this client, we installed Windows Server 2008 R2, assigned a static IP address, and installed .NET 3.5.

Configuring the database

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 5GB database size and the database platform on which we ran: Microsoft SQL Server. We ran the Install.pl script on a utility system running Linux. The database schema was also generated by the Install.pl script.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2012. We built the 5GB database in SQL Server 2012, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore the server between test runs.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Besides this file size modification, the database schema was created and loaded according to the DVD Store documentation. Specifically, we followed the steps below:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 5GB database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.

3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
    DEFAULT_DATABASE=[master],
    DEFAULT_LANGUAGE=[us_english],
    CHECK_EXPIRATION=OFF,
    CHECK_POLICY=OFF
GO
```

1. We set the database recovery model back to full.
2. We created the necessary full text index using SQL Server Management Studio.
3. We created a database user and mapped this user to the SQL Server login.
4. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

Figure 10 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
Database files		
primary	PRIMARY	4
cust1	DS_CUST_FG	2,560
cust2	DS_CUST_FG	2,560
ind1	DS_IND_FG	1,536
ind2	DS_IND_FG	1,536
ds_misc	DS_MISC_FG	1,536
orders1	DS_ORDERS	1,536
orders2	DS_ORDERS	1,536
Log files		
ds_log	Not applicable	10,240

Figure 10: Our initial file size modifications.

Running the test

Test start and run times

We ran all workloads concurrently in order to start and record all performance counters for this report. The specific testing parameters we used for each benchmark are included in the setup sections, and specifics for launching these tests are described below.

About running the LoadGen test

To run the test, we installed the LoadGen client and server components and simulated 500 Exchange users targeting the Exchange VM using LoadGen's Outlook 2007 cached Workload profile. We ran the LoadGen benchmark for 45 minutes, and beginning at the 15-minute mark, we used a 30-minute measurement window for performance monitoring.

For more details about LoadGen, see www.microsoft.com/download/en/details.aspx?displaylang=en&id=14060.

About running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the last OPM reported by each client/target pair.

Each complete test cycle consisted of the general steps listed below.

1. Clean up prior outputs from the target system and the client driver system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the host and client system.
6. Wait for a ping response from the server under test (the hypervisor system), the client system, and the target.
7. Let the test server idle for 20 minutes.
8. Start the DVD Store driver on the client.

We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --  
n_threads=32 --db_size=5GB --think_time=0 --detailed_view=Y --warmup_time=15  
--report_rate=1 --csv_output=<drive path>
```

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