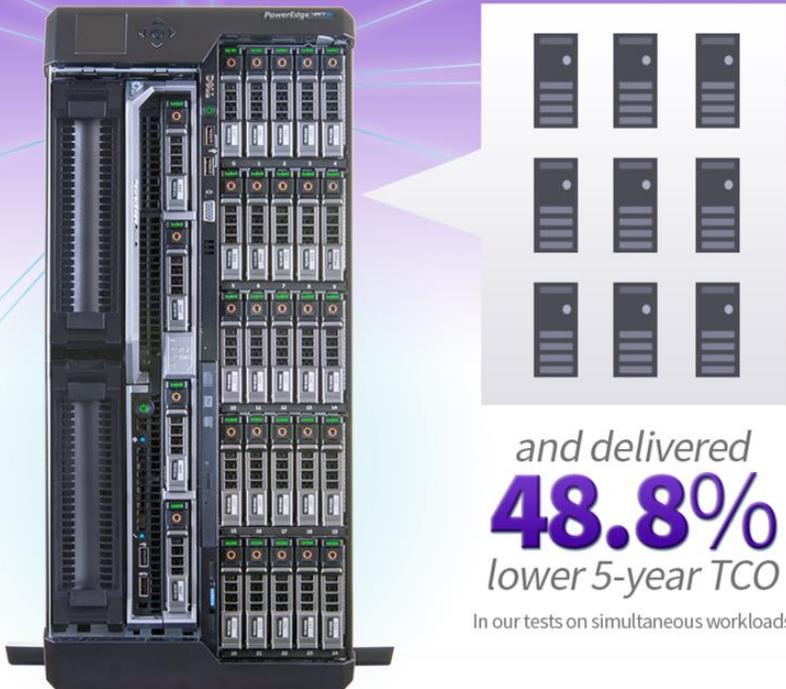


# COMPARING PERFORMANCE AND COST: DELL EMC POWEREDGE VRTX WITH ONE DELL EMC POWEREDGE M830 SERVER VS. A LEGACY SOLUTION

Dell EMC PowerEdge™ VRTX handled the workloads of 9 legacy servers



and delivered **48.8%** lower 5-year TCO

In our tests on simultaneous workloads

powered by the Intel® Xeon® processor E5 v3 family

Businesses using multiple outdated servers for email, database, and file and print workloads stand to benefit greatly by consolidating these workloads onto a single new server and running them in virtual machines. In tests in the Principled Technologies datacenter, the Dell EMC PowerEdge VRTX with a Dell EMC PowerEdge M830 blade server, powered by the Intel Xeon processor E5-4650 v3, was able to simultaneously run email, database, and simulated file and print workloads in a VMware® vSphere® virtual environment. The VRTX performed the work of nine older servers—four database servers, four file and print servers, and one Exchange server. It achieved similar or even better performance while requiring less space and power than a legacy disparate hardware solution,<sup>1</sup> which translates to a lower five-year TCO. Combining servers, networking, and shared storage into an all-in-one solution, the PowerEdge VRTX can deliver big performance and savings.

<sup>1</sup> In June 2013, Principled Technologies conducted testing comparing the performance of (1) the Dell PowerEdge VRTX with a Dell PowerEdge M620 server and (2) a legacy hardware solution. The results for the legacy solution that we cite in this report are from that earlier study. For more details, see the report for that study, available at [www.principledtechnologies.com/Dell/VRTX\\_performance\\_TCO\\_0713.pdf](http://www.principledtechnologies.com/Dell/VRTX_performance_TCO_0713.pdf).



# REPLACE NINE OLDER SERVERS WITH ONE DELL EMC POWEREDGE VRTX

We compared the performance, power consumption, space, and cost of running typical office applications (email, database, and file/print server) on the following solutions:

- **A Dell EMC PowerEdge VRTX with a Dell EMC PowerEdge M830 server powered by the Intel Xeon processor E5-4650 v3**, running VMware vSphere 5.5 with 10 Microsoft® Windows Server® 2012 R2 virtual machines (VMs) – four running SQL Server® 2014, four acting as file/print servers, and two running a single Exchange Server 2013 environment.
- **A legacy disparate hardware solution** consisting of older HP tower servers, a NETGEAR® switch, and an HP storage appliance. The legacy tower servers all ran bare metal instances of Windows Server 2012. One ran SQL Server 2012, another ran a dedicated file/print server, and the last ran Exchange Server 2010. By virtualizing four of the SQL workloads and four of the file/print simulated workloads, we extrapolated the consolidation to nine legacy servers.

We ran three benchmarks simultaneously to exercise the email, database, and file and print applications all at once. The performance of the legacy hardware solution we discuss in this report is from a June 2013 Principled Technologies study (available at [www.principledtechnologies.com/Dell/VRTX\\_performance\\_TCO\\_0713.pdf](http://www.principledtechnologies.com/Dell/VRTX_performance_TCO_0713.pdf)).<sup>2</sup> For this study, we ran multiples of the SQL Server and simulated file/print servers to demonstrate a consolidation scenario and show an even bigger savings.

We also measured the power consumption of the PowerEdge VRTX and the legacy solution while idle and during the simultaneous workloads. For detailed configuration information about the solutions we tested, see [Appendix A](#). For testing details, including the increased workload parameters we used, see [Appendix B](#). For detailed test results, see [Appendix C](#).

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<sup>2</sup> For our 2013 study, we tested only three servers: one running SQL Server 2012, one running as a dedicated file/print server, and one running Exchange Server 2010.

## Dell EMC PowerEdge VRTX with the Intel Xeon processor E5-4650 v3 optimized application performance while reducing power consumption and providing headroom for future growth

### Database performance

As Figure 1 shows, during our test running three workloads at the same time, each of the four database VMs we ran on the Dell EMC PowerEdge VRTX with the Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server outperformed a single database server in our legacy disparate hardware solution. This means the VRTX solution would be able to replace the four legacy database servers and deliver even more database orders per minute per VM. For this test, we upgraded from SQL Server 2012, which we ran on the legacy database servers, to SQL Server 2014 to reflect the newer technology now available.

Figure 1: While running simultaneous email, database, and simulated file and print workloads, each database VM on the Dell EMC PowerEdge VRTX with an Intel processor-powered M830 server delivered 8.0 percent greater database performance than a single server in the legacy disparate hardware solution.

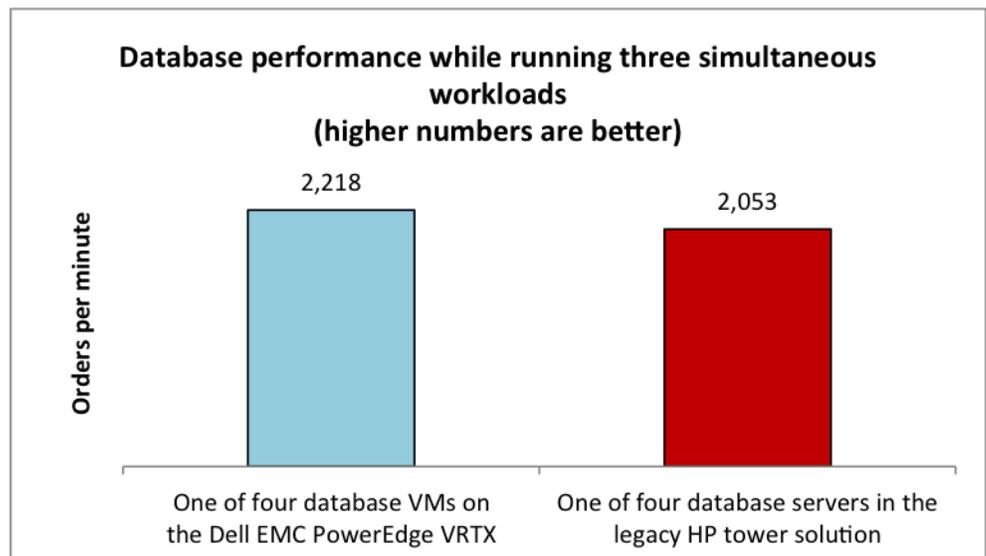
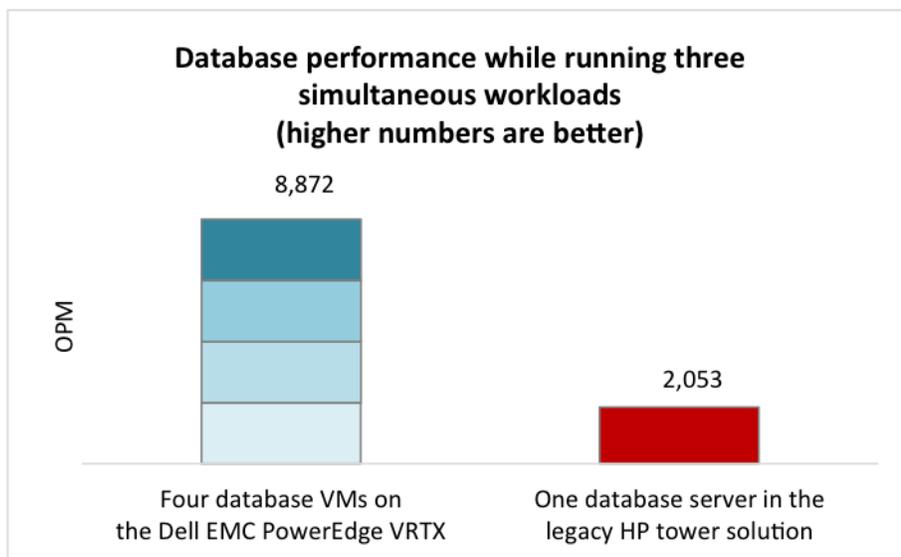


Figure 2 compares the performance of all four database VMs on the PowerEdge VRTX with an Intel processor-powered PowerEdge M830 server to the performance of the one legacy database server. As it shows, one PowerEdge VRTX with an Intel processor-powered PowerEdge M830 server delivered 4.3 times as many orders per minute as a single legacy server.

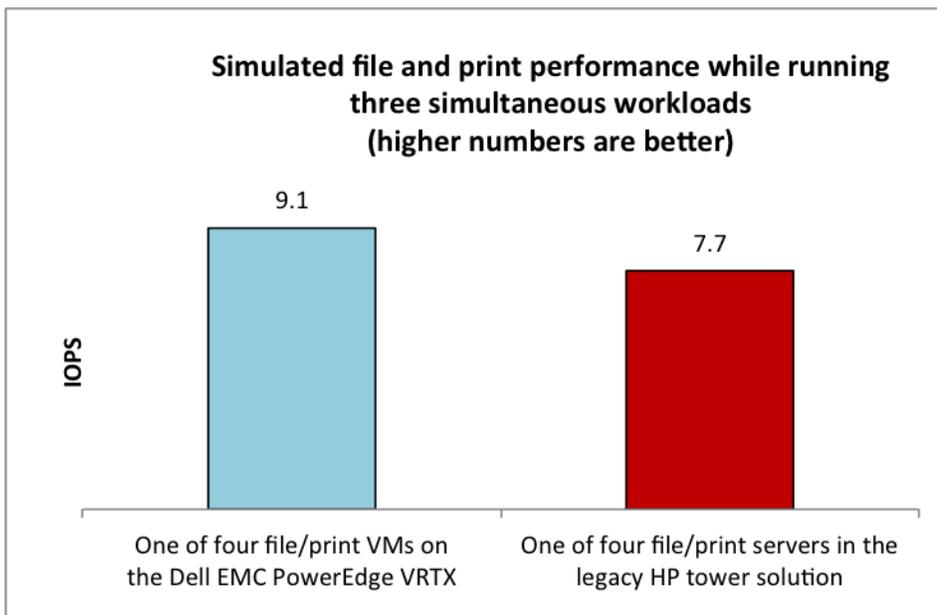
Figure 2: While running simultaneous email, database, and simulated file and print workloads, the four database VMs on the Dell EMC PowerEdge VRTX with an Intel processor-powered M830 server delivered total of 8,872 OPM, 4.3 times the database performance of a single server in the legacy disparate hardware solution.



### Simulated file and print performance

As Figure 3 shows, during our test running three workloads at the same time, each of the four simulated file and print VMs we ran on the Dell EMC PowerEdge VRTX with the Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server outperformed a single file and print server in our legacy disparate hardware solution. This means the VRTX solution would be able to replace the four legacy file and print servers and deliver even greater performance. Instead of pushing the systems to the maximum, we ran the utility at a low level of targeted IOPs to simulate a typical business.

Figure 3: While running simultaneous email, database, and simulated file and print workloads, each file and print VM on the Dell EMC PowerEdge VRTX with an Intel processor-powered M830 server delivered 17.9 percent greater file and print performance than a single server in the legacy disparate hardware solution.



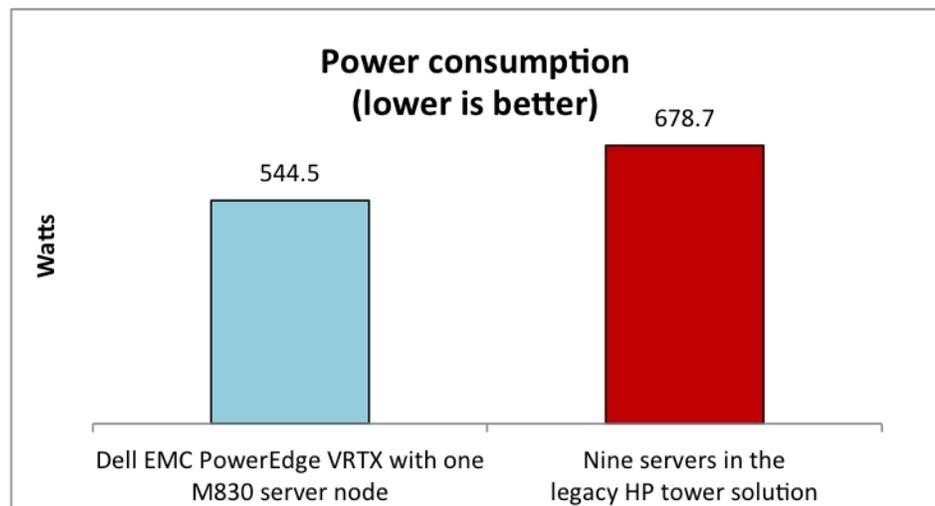
## Exchange

For the email server we ran on the Dell EMC PowerEdge VRTX, we upgraded from Exchange 2010 to Exchange 2013 and from Microsoft Load Generator 2010 to LoadGen 2013. While we cannot directly compare the results from these two test scenarios due to the differences between the two versions of Exchange, we compared the latency, or response time, in milliseconds to learn about their relative performance. We found that though latencies increased slightly—from 1.5 milliseconds on the legacy solution to 2.9 milliseconds on the new solution—they remained well within the average latency threshold of 50 milliseconds that Microsoft sets. Increased load on the storage from the additional workloads running simultaneously could account for the increase in latency. However, such a small increase would not likely be noticeable to end users.

## Power consumption

The compact Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 with PowerEdge VRTX not only supported more work than the legacy tower solution with nine servers, it also used significantly less power while under heavier load thanks to Dell EMC's performance-per-watt system power management policy. As Figure 4 shows, the M830 server with VRTX used 67.3 percent less power while running our three simultaneous workloads than the legacy disparate hardware solution did. This reduced consumption can translate directly to savings.

**Figure 4: The Dell EMC PowerEdge VRTX with an Intel processor-powered M830 server used less power while running simultaneous (and more robust) workloads than the legacy disparate hardware solution did.**



In our tests, we used a PowerEdge VRTX with only one server compared to the simulated nine physical servers in the legacy hardware solution. Adding server nodes and more or faster drives to the shared storage may achieve greater performance gains, though the current configuration still had plenty of room for growth. Additionally, adding new application VMs to your VMware vSphere environment may give the Intel Xeon processor E5-4650 v3-powered PowerEdge VRTX solution scalability and room to

grow as the demands of your business continue to increase. With a legacy disparate hardware solution, achieving similar results may require purchasing additional servers that take up more space and consume more power.

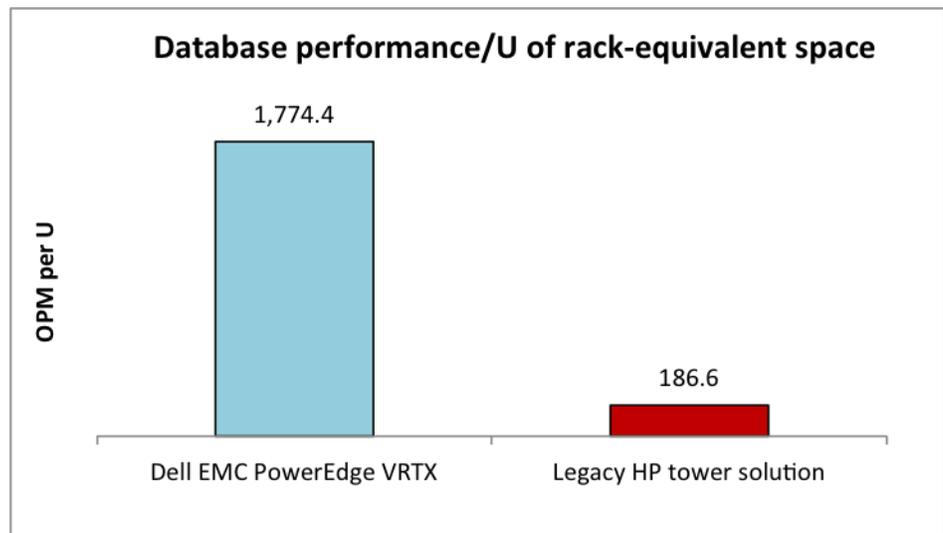
## Reduced space and physical complexity

In addition to the extra space that legacy disparate hardware solutions encompass, they often have a great deal of complexity when it comes to hardware pieces and cabling. If your business' location has premium square footage value, accommodating your legacy solution can mean sacrificing precious space. The Dell EMC PowerEdge VRTX is a compact all-in-one solution that fits easily under a desk and uses minimal cabling because the solution resides in one chassis.

Though the solution is unlikely to be in a server rack in a small or remote office, we looked at the rack-equivalent space each solution would occupy to make a universal size comparison. We found that the PowerEdge VRTX solution would fit into just 5U of rack-equivalent space—an 88.6 percent reduction in the space that the legacy solution would take up (a massive 44U).

For each U of rack-equivalent space, the VRTX with one Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server delivered a whopping 9.5 times the database performance, in orders per minute, than the four database servers in the legacy disparate hardware solution (see Figure 5).

**Figure 5: The compact form factor of the Dell EMC PowerEdge VRTX means that, with one Intel processor-powered M830 server, it packs more performance into less space than the legacy disparate hardware solution.**



As Figure 6 shows, regardless of the server configuration, the VRTX solution powered by the Intel Xeon processor E5 v3 family also used only 6 cables, 31 fewer than the legacy disparate hardware solution.

| Dell EMC PowerEdge VRTX            |                 |              |
|------------------------------------|-----------------|--------------|
|                                    | Ethernet cables | Power cables |
| Total by type                      | 2               | 4            |
| <b>Total cables</b>                | <b>6</b>        |              |
| Legacy disparate hardware solution |                 |              |
|                                    | Ethernet cables | Power cables |
| HP ProLiant ML310 G5               | 8               | 4            |
| HP ProLiant ML370 G5               | 2               | 1            |
| HP ProLiant ML110 G6               | 8               | 4            |
| NETGEAR ProSAFE® Smart Switch      | 1               | 1            |
| Storage                            | 6               | 2            |
| Total by type                      | 25              | 12           |
| <b>Total cables</b>                | <b>37</b>       |              |

Figure 6: The Dell EMC PowerEdge VRTX reduced cabling complexity compared to the legacy disparate hardware solution.

### Dell EMC PowerEdge VRTX with one Dell EMC PowerEdge M830 server offered more performance per TCO dollar, lower five-year TCO, and a rapid ROI

Choosing to keep a legacy disparate hardware solution might seem convenient and cost-effective. However, we found that purchasing and running the Dell EMC PowerEdge VRTX with the Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server could deliver as much as a 48.5 percent lower five-year total cost of ownership (TCO) than continuing to use the legacy solution (see Figure 7).

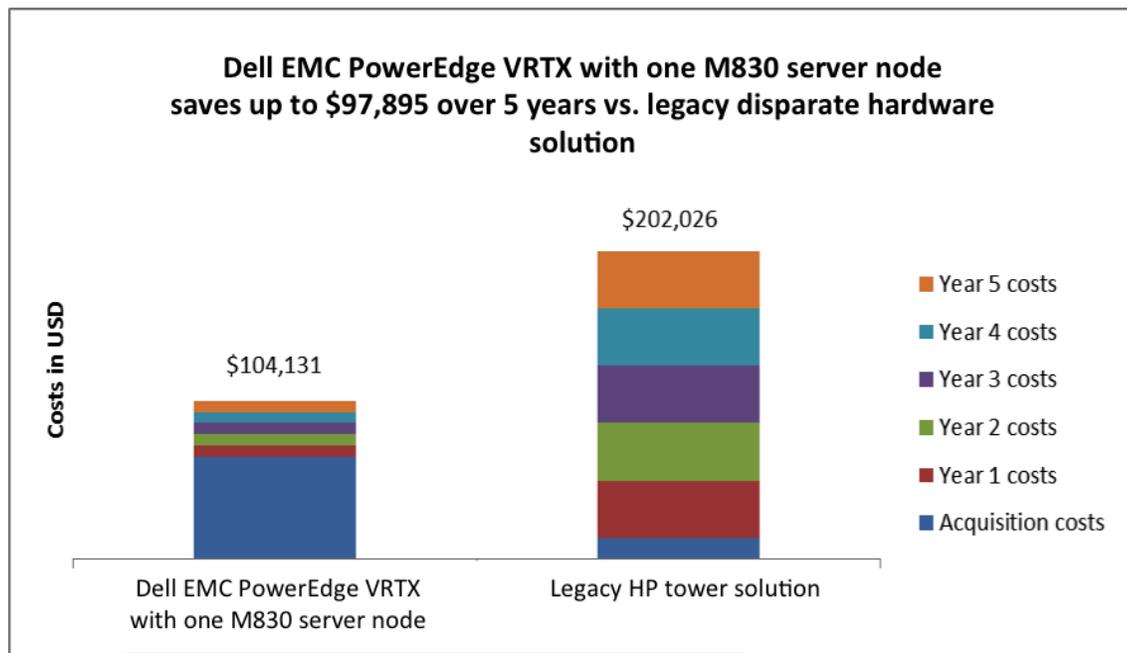


Figure 7: The Dell EMC PowerEdge VRTX with one M830 server could deliver a 48.5 percent lower TCO over five years than continuing to use the legacy disparate hardware solution.

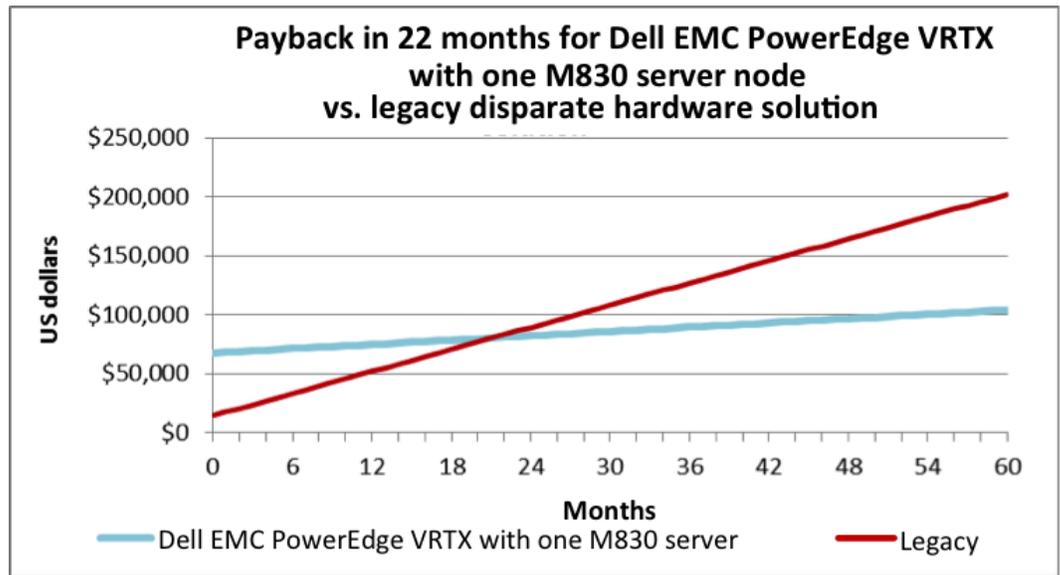
Savings in licensing, management, and support offset the larger acquisition costs of the Dell EMC PowerEdge VRTX with an Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server. After five years, the VRTX solution is \$97,895 less expensive, saving 48.5 percent (see Figure 8).

|                  | Dell EMC PowerEdge VRTX with one M830 server | Legacy disparate hardware solution |
|------------------|--|------------------------------------|
| Acquisition cost | \$67,471                                     | \$14,216                           |
| Year 1 costs     | \$7,332                                      | \$37,562                           |
| Year 2 costs     | \$7,332                                      | \$37,562                           |
| Year 3 costs     | \$7,332                                      | \$37,562                           |
| Year 4 costs     | \$7,332                                      | \$37,562                           |
| Year 5 costs     | \$7,332                                      | \$37,562                           |
| <b>Total</b>     | <b>\$104,131</b>                             | <b>\$202,026</b>                   |

Figure 8: The Dell EMC PowerEdge VRTX with an M830 server costs up to \$97,895 less than the legacy solution after five years. (Totals may not sum due to rounding.)

With the VRTX with an Intel Xeon processor E5-4650 v3-powered M830 server, we found that a business could achieve payback, or a return on investment (ROI), in as little as 22 months (see Figures 9 and 10).

Figure 9: The Dell EMC PowerEdge VRTX with an Intel processor-powered M830 server can deliver payback in as little as 22 months.

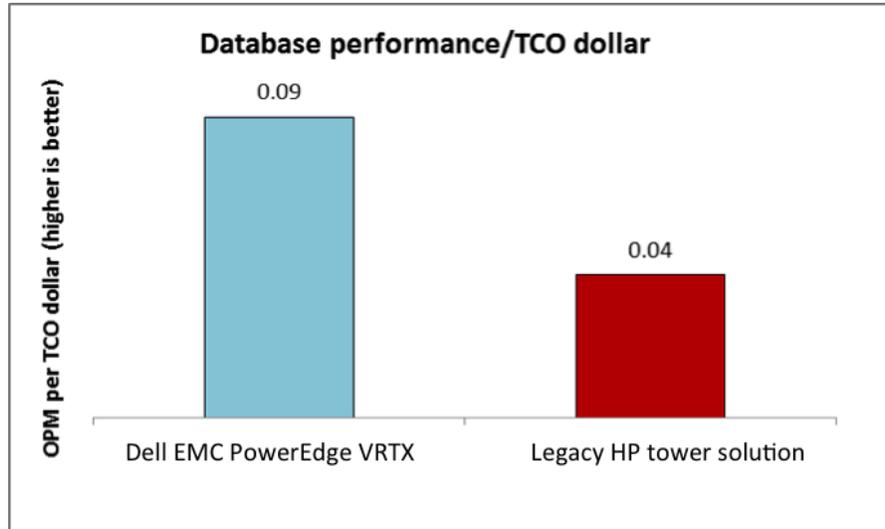


| Payback category            | Dell EMC PowerEdge VRTX with M830 server    | Legacy disparate hardware solution | Difference |
|-----------------------------|---|------------------------------------|------------|
| One-time initial investment | \$67,471                                    | \$14,216                           | \$53,255   |
| Monthly cost                | \$611                                       | \$3,130                            | \$2,519    |
| Payback period              | $\$53,255 \div \$2,519 = 22 \text{ months}$ |                                    |            |

Figure 10: The Dell EMC PowerEdge VRTX with one M830 server can pay back your investment in 22 months, so by the 22nd month, the return of investment is complete.

Using the calculations from our TCO analysis, we found that the Dell EMC PowerEdge VRTX with an Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server delivered 2.3 times as many database orders per minute per TCO dollar spent (see Figure 11).

**Figure 11: The Dell EMC PowerEdge VRTX with one Intel processor-powered M830 server delivered 8.4 times as many OPM per TCO dollar. Higher numbers are better.**



For complete details and assumptions of our TCO analysis, see [Appendix D](#).

## ALL-IN-ONE MODULAR INFRASTRUCTURE

The Dell EMC PowerEdge VRTX solution with an M-series server is an all-in-one solution designed to handle the performance needs of a small-to-medium business or remote office. Here, we provide information about each of the components we used as part of this solution.

### About the Dell EMC PowerEdge VRTX



**Dell EMC PowerEdge VRTX with 12 3.5-inch drives**

**Dell EMC PowerEdge VRTX with 25 2.5-inch drives**

The Dell EMC PowerEdge VRTX is a compact, all-in-one solution in a 5U rackable tower chassis. Designed to be quiet under normal operating conditions, the Dell EMC PowerEdge VRTX can be stowed under a desk in a small office without disrupting conversations. The four bays in the VRTX house a variety of different compute nodes, providing a space-saving alternative to four separate tower or rack servers. VRTX fans and blowers, based on Dell EMC Energy Smart Technologies, deliver low power consumption and use next-generation technologies to ensure they consume the least possible amount of fresh air to cool the enclosure.

In addition to accommodating office space, acoustics, thermal, and power considerations, the VRTX provides administrators with a unified interface, the Chassis Management Controller, for performing routine systems management tasks. Administrators can manage the VRTX locally or remotely from a centralized datacenter.

The VRTX chassis supports up to 120 TB of shared internal storage that is presentable as virtual drives to single or multiple compute nodes, and provides optional

pass-through and eight PCIe® slots for additional device connectivity. The chassis-integrated storage can be configured with 25 bays for 2.5-inch drives, which we tested in this report, or with 12 bays for 3.5-inch drives. The VRTX integrated switch, which is available as a 1GB or 10GB switch, contains multiple external network ports for easy expansion or integration into any computing environment. The VRTX is virtualization-ready and can enable a virtual desktop infrastructure for general-purpose computing in remote and branch offices.

For more information about the Dell EMC PowerEdge VRTX, visit <http://www.dell.com/en-us/work/learn/modular-infrastructure>.

### About the Dell EMC PowerEdge M830 server

According to Dell EMC, the PowerEdge M830 blade server “offers exceptional flexibility, reliability and efficiency to run business-critical applications in data centers yet to come.”

The M830 supports up to 88 Intel processor cores and 48 DIMMS of DDR4 memory, which offers tremendous computational horsepower for heavy-use workloads. With the M830, you can power through compute-intensive workloads with 50 percent more processing cores per socket than previous generation Intel processors.

For more information about the Dell EMC PowerEdge M830 blade server, visit [www.dell.com/us/partner/p/poweredge-m830/pd](http://www.dell.com/us/partner/p/poweredge-m830/pd).

### About the Intel Xeon processor E5-4600 v3 product family

According to Intel, the Intel Xeon processor E5-4600 v3 product family provides “high-density, energy-efficient compute resources to support larger workloads and high virtual machine densities in your data center or cloud.” It also delivers benefits in performance, power efficiency, virtualization, and security.

The E5-4600 v3 product family delivers up to 49 percent increased average performance than processors from the previous generation. Other features include the following:

- Intel Advanced Vector Extensions 2 (AVX2)
- Intel QuickAssist Technology for offloading cryptographic/data compression
- Up to 18 cores and 36 threads per socket
- Up to 45 MB of last-level cache
- Next-generation DDR4 memory support
- Intel AES-NI data encryption/decryption

The Intel Xeon processor E5-4600 v3 product family also uses Intel Intelligent Power technology and Per-core P states to maximize energy efficiency.

Learn more at [www.intel.com/content/dam/www/public/us/en/documents/product-briefs/xeon-e5-4600-v3-brief.pdf](http://www.intel.com/content/dam/www/public/us/en/documents/product-briefs/xeon-e5-4600-v3-brief.pdf).

## WHAT WE TESTED

### Database testing

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 customers could expect. 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](http://www.delltechcenter.com/page/DVD+Store).

### File and print testing

To test the file and print capabilities of the solutions, we simulated workloads using the Iometer benchmark. Iometer measures IOPS on single and clustered systems. Iometer performs I/O operations to stress a system, and then records the performance of these I/O operations and the system stress they create. We used Iometer version 1.1 on each solution to simulate the same file and print workloads on the solutions. For more details about Iometer, see [www.iometer.org](http://www.iometer.org).

### Mail testing

To test the solutions' mail server performance, we used the Microsoft Load Generator 2013 (LoadGen) benchmark, performing tasks to simulate a heavy user generating mail activity. For our workloads, we used the following settings:

- Number of users: 500
- Mailbox Profile: 250MB
- Action Profile: Outlook\_200

For more details about LoadGen, see

[www.microsoft.com/downloads/details.aspx?FamilyId=DDEC1642-F6E3-4D66-A82F-8D3062C6FA98&displaylang=en](http://www.microsoft.com/downloads/details.aspx?FamilyId=DDEC1642-F6E3-4D66-A82F-8D3062C6FA98&displaylang=en).

## IN CONCLUSION

Keeping a legacy disparate hardware solution composed of nine older servers instead of choosing the Dell EMC PowerEdge VRTX powered by the Intel Xeon processor E5-4650 v3 family may cost more than one would expect. We found that the VRTX with an Intel Xeon processor E5-4650 v3-powered Dell EMC PowerEdge M830 server could do the work of nine legacy servers running email, database, and file/print server workloads. The VRTX ran all nine workloads in VMs, achieving a slight performance boost on the database and file/print workloads while using much less datacenter space and reducing power consumption by 38.4 percent.

The VRTX achieved these savings using 88.6 percent less rack-equivalent space than the legacy disparate hardware solution and with one-third as many cables, to reduce complexity and reduce the burden of space in small offices.

Despite a larger initial investment, the PowerEdge VRTX with an Intel Xeon processor E5-4650 v3-powered PowerEdge M830 server could actually lower the total cost of ownership over five years by as much as 48.5 percent, delivering a solid return on investment in less than two years.

As our test results show, investing in the Dell EMC PowerEdge VRTX solution powered by the Intel Xeon processor E5-4600 v3 family could provide a compact solution to optimize application performance and reduce complexity at a lower lifetime cost than a legacy solution composed of nine older servers.

## APPENDIX A – SYSTEM CONFIGURATION INFORMATION

In September 2016, Dell EMC rebranded the Dell PowerEdge VRTX and Dell PowerEdge M830 as the Dell EMC PowerEdge VRTX and Dell EMC PowerEdge M630. We completed our testing prior to that rebranding.

Figures 12 and 13 provide detailed configuration information for the test systems.

| System  | Dell PowerEdge VRTX solution                 |
|---|--|
| <b>Enclosure</b>                                    |  |
| Compute node enclosure                              | Dell PowerEdge VRTX                          |
| <b>General dimensions of compute node enclosure</b> |  |
| Height (inches)                                     | 8  |
| Width (inches)                                      | 19   |
| Depth (inches)                                      | 29.5   |
| U size in server rack equivalent (U)                | 5  |
| <b>Power supplies</b>                               |  |
| Total number  | 4  |
| Vendor and model number                             | Dell 80 Plus Platinum E1100E-S0 (P/N OYT39Y) |
| Wattage of each (W)                                 | 1,100  |
| <b>Cooling fans</b>                                 |  |
| Total number  | 6  |
| Vendor and model number                             | Delta Electronics, Inc.                      |
| Dimensions (h × w) of each                          | 60 mm × 60 mm                                |
| Volts   | 12   |
| <b>Chassis RAID controller</b>                      |  |
| Vendor and model number                             | Dell SPERC8                                  |
| Firmware version                                    | 23.11.46-0079                                |
| Cache size (GB)                                     | 1  |
| <b>Chassis shared hard drives</b>                   |  |
| <b>Hard drive #1</b>                                |  |
| Vendor and model number                             | Dell ST300MM0006                             |
| Number of drives                                    | 14   |
| Size (GB)   | 300  |
| RPM   | 10k  |
| Type  | SAS 6.0 Gbps                                 |
| <b>Hard drive #2</b>                                |  |
| Vendor and model number                             | Dell C06VX                                   |
| Number of drives                                    | 2  |
| Size (TB)   | 400  |
| RPM   | SSD  |
| Type  | SAS 12.0 Gbps                                |
| <b>Chassis USB ports</b>                            |  |
| Number  | 2  |
| Type  | 2.0  |
| <b>Platform</b>                                     |  |
| Vendor and model number                             | Dell PowerEdge M830                          |

| <b>System</b>                                 | <b>Dell PowerEdge VRTX solution</b>              |
|---|--|
| Motherboard model number                      | 0W4W8N   |
| Motherboard chipset                           | Intel C610                                       |
| BIOS name and version                         | Dell BIOS 1.0.6                                  |
| BIOS settings                                 | Default  |
| <b>General</b>                                |  |
| Number of processor packages                  | 4  |
| Number of cores per processor                 | 12   |
| Number of hardware threads per core           | 2  |
| System power management policy                | Performance/watt                                 |
| <b>CPU</b>                                    |  |
| Vendor  | Intel  |
| Name  | Xeon E5-4650 v3                                  |
| Stepping                                      | C1   |
| Socket type                                   | Socket 2011-3 LGA                                |
| Core frequency (GHz)                          | 2.10   |
| L1 cache                                      | 32 KB (per core)                                 |
| L2 cache                                      | 256 KB (per core)                                |
| L3 cache                                      | 30 MB (shared)                                   |
| <b>Memory modules</b>                         |  |
| Total RAM in system (GB)                      | 128  |
| Vendor and model number                       | Hynix Semiconductor<br>M393A1G43DB0-CPB          |
| Type  | PC4-2133P  |
| Speed (MHz)                                   | 2,133  |
| Speed in the system currently running @ (MHz) | 2,133  |
| Timing/latency (tCL-tRCD-iRP-tRASmin)         | 13-13-13-33                                      |
| Size (GB)                                     | 8  |
| Number of RAM modules                         | 16   |
| Chip organization                             | Double-sided                                     |
| Rank  | Dual   |
| <b>RAID controller</b>                        |  |
| Vendor and model number                       | Dell PERC H730 Mini                              |
| Firmware version                              | 25.2.2-0001                                      |
| Cache size (GB)                               | 1024 MB  |
| <b>Network adapter</b>                        |  |
| Vendor and model number                       | Broadcom® NetXtreme® II 10 Gb Ethernet BCM57810s |
| Type  | Integrated                                       |
| Number of Network Adapters                    | 2  |
| <b>USB ports</b>                              |  |
| Number  | 2  |
| Type  | 3.0  |

Figure 12: Detailed configuration information for the Dell PowerEdge VRTX solution.

| Server                               | HP ProLiant ML110 G6         | HP ProLiant ML310 G5         | HP ProLiant ML370 G5                  |
|--------------------------------------|------------------------------|------------------------------|---------------------------------------|
| <b>General dimensions of server</b>  |                              |                              |                                       |
| Height (inches)                      | 14.4                         | 17.0                         | 17.5                                  |
| Width (inches)                       | 6.9                          | 7.9                          | 8.6                                   |
| Depth (inches)                       | 16.8                         | 24.0                         | 28.5                                  |
| U size in server rack equivalent (U) | 4                            | 5                            | 5                                     |
| <b>Power supplies</b>                |                              |                              |                                       |
| Total number                         | 1                            | 1                            | 1                                     |
| Vendor and model number              | Delta Electronics® DPS300AB  | Delta Electronics DPS-410DB  | HP Switching Power Supply DPS-800GB A |
| Wattage of each (W)                  | 300                          | 410                          | 850                                   |
| <b>Cooling fans</b>                  |                              |                              |                                       |
| Total number                         | 1                            | 1                            | 3                                     |
| Vendor and model number              | HP 576930-001                | HP 459188-001                | Nidec Beta V35633-94                  |
| Dimensions (h × w) of each           | 92 mm × 25 mm                | 120 mm × 25 mm               | 130 mm × 125 mm                       |
| Volts                                | 12                           | 12                           | 12                                    |
| <b>General</b>                       |                              |                              |                                       |
| Motherboard model number             | 576924-001                   | A61TR1                       | 434719-001                            |
| Motherboard chipset                  | Intel 3400 Chipset           | Intel 3210 Chipset           | Intel C600                            |
| BIOS name and version                | HP System BIOS - 0270126_TAN | ProLiant System BIOS - W05   | ProLiant System BIOS P57              |
| BIOS settings                        | Performance                  | Performance                  | Performance                           |
| Number of processor packages         | 1                            | 1                            | 2                                     |
| Number of cores per processor        | 4                            | 4                            | 4                                     |
| Number of hardware threads per core  | 2                            | 1                            | 1                                     |
| System power management policy       | Static High Performance      | Static High Performance      | Static High Performance               |
| <b>CPU</b>                           |                              |                              |                                       |
| Vendor                               | Intel                        | Intel                        | Intel                                 |
| Name                                 | Xeon X3460                   | Xeon X3370                   | Xeon E5450                            |
| Stepping                             | B1                           | E0                           | E0                                    |
| Socket type                          | LGA 1156                     | LGA 775                      | LGA 771                               |
| Core frequency (GHz)                 | 2.80                         | 3.00                         | 3.00                                  |
| L1 cache                             | 32 KB (per core)             | 32 KB (per core)             | 32 KB (per core)                      |
| L2 cache                             | 256 KB (per core)            | 12 MB (shared)               | 12 MB (shared)                        |
| L3 cache (MB)                        | 8                            | N/A                          | N/A                                   |
| <b>Memory modules</b>                |                              |                              |                                       |
| Total RAM in system (GB)             | 4                            | 4                            | 8                                     |
| Vendor and model number              | Samsung® M391B5673EH1-CH9    | Micron® MT18HTF25672AY-800E1 | Samsung M395T5160QZ4                  |

| Server  | HP ProLiant ML110 G6                       | HP ProLiant ML310 G5             | HP ProLiant ML370 G5                       |
|---|--|----------------------------------|--|
| Type  | PC3-10600E DDR3                            | PC2-6400E DDR2                   | DDR2-5300F                                 |
| Speed (MHz)                                   | 1,333                                      | 800                              | 666  |
| Speed in the system currently running @ (MHz) | 1,333                                      | 800                              | 666  |
| Timing/latency (tCL-tRCD-iRP-tRASmin)         | 9-9-9-24                                   | 6-6-6-18                         | 5-5-5-15                                   |
| Size (GB)                                     | 2  | 2                                | 4  |
| Number of RAM modules                         | 4  | 2                                | 8  |
| Chip organization                             | Double-Sided                               | Double-sided                     | Double-sided                               |
| <b>RAID controller</b>                        |  |                                  |  |
| Vendor and model number                       | HP Smart Array B110i                       | HP Smart Array E200              | HP Smart Array P400                        |
| Cache size (MB)                               | N/A  | 128                              | 256  |
| <b>Hard drive #1</b>                          |  |                                  |  |
| Vendor and model number                       | Hitachi® HDS721032CLA362                   | HP DF0792A9844                   | HP EG0146FAWHU                             |
| Number of drives                              | 1  | 2                                | 2  |
| Size (GB)                                     | 320  | 72                               | 146  |
| RPM   | 7.2K                                       | 15K                              | 10K  |
| Type  | SATA                                       | SAS                              | SAS  |
| <b>Hard drive #2</b>                          |  |                                  |  |
| Vendor and model number                       | N/A  | ST500NM001                       | N/A  |
| Number of drives                              | N/A  | 2                                | N/A  |
| Size (GB)                                     | N/A  | 500                              | N/A  |
| RPM   | N/A  | 7.2                              | N/A  |
| Type  | N/A  | SAS                              | N/A  |
| <b>Network adapter</b>                        |  |                                  |  |
| Vendor and model number                       | Intel Pro/1000 PT Dual Port Server Adapter | Intel Pro/1000 PT Server Adapter | Intel Pro/1000 PT Dual Port Server Adapter |
| Type  | PCIe                                       | PCIe                             | PCIe                                       |
| Number of ports                               | 2  | 1                                | 2  |
| <b>Network adapter 2</b>                      |  |                                  |  |
| Vendor and model number                       | HP NC 107i PCIe Gigabit                    | Intel Pro/1000 PT Server Adapter | N/A  |
| Type  | Integrated                                 | PCIe                             | N/A  |
| Number of ports                               | 1  | 1                                | N/A  |
| <b>USB ports</b>                              |  |                                  |  |
| Number  | 6  | 2                                | 4  |
| Type  | 2.0  | 2.0                              | 2.0  |

Figure 13: Detailed configuration information for the towers in the legacy hardware solution.

## APPENDIX B – HOW WE TESTED

Our test scenario used one PowerEdge M830 and a PowerEdge R710, which we used for our infrastructure server and to host client VMs. Figure 14 presents the virtual machines in our test environment.

| VM name               | vCPUs                     | Memory | OS                                  | OS drive                   | Additional drive  |
|-----------------------|---------------------------|--------|-------------------------------------|----------------------------|---|
| ExchangeCAS           | 8 sockets, each w/ 1 core | 16 GB  | Windows Server 2012 R2 Standard     | 100 GB stored on VRTX HDDs | None  |
| ExchangeMB            | 8 sockets, each w/ 1 core | 16 GB  | Windows Server 2012 R2 Standard     | 100 GB stored on VRTX HDDs | 750 GB, Thick Provisioned Eager Zeroed, Stored on VRTX HDDs |
| Iometer               | 4 sockets, each w/ 1 core | 8 GB   | Windows Server 2012 R2 Standard     | 100 GB stored on VRTX HDDs | 50 GB, Thick Provisioned Eager Zeroed, Stored on VRTX SSDs  |
| SQL                   | 8 sockets, each w/ 1 core | 8 GB   | Windows Server 2012 R2 Standard     | 100 GB stored on VRTX HDDs | 100 GB, Thick Provisioned Eager Zeroed, Stored on VRTX SSDs |
| DVD Store client      | 1 socket w/ 4 cores       | 8 GB   | Windows Server 2012 R2 Standard     | 100 GB stored on R710 HDDs | None  |
| Exchange AD/DNS       | 1 socket w/ 1 core        | 8 GB   | Windows Server 2012 R2 Standard     | 100 GB stored on R710 HDDs | None  |
| LoadGen client        | 1 socket w/ 4 cores       | 8 GB   | Windows Server 2008 R2 Enterprise   | 100 GB stored on R710 HDDs | None  |
| NAT                   | 1 socket w/ 4 cores       | 8 GB   | Windows Server 2012 R2 Standard     | 100 GB stored on R710 HDDs | None  |
| VMware vCenter Server | 2 sockets, each w/ 1 core | 8 GB   | VMware vCenter Server Appliance 5.5 | 25 GB stored on R710 HDDs  | 100 GB, Thin Provisioned, Stored on the R710 disks          |

Figure 14: The virtual machines in our test environment.

We also followed the following guidelines:

1. All OS drives were thin provisioned.
2. All VMs hosted on the blade server were stored on the VRTX storage.
3. All VMs hosted by the infrastructure server were stored on the infrastructure's drives.
4. On all Oses, we installed all Windows updates available up to 05/15/2015.

In addition to its first drive, ExchangeMB had a 100 GB, Thick Provisioned Eager Zeroed drive stored on the OS storage volume used for storing backups.

### Installing and configuring the infrastructure server

We configured a Dell PowerEdge R710 server with VMware vSphere (ESXi) 5.5.0 with Dell Drivers to host the Active Directory® VMs and the VMware vCenter VM.

## Installing VMware vSphere 5.5 with Dell Drivers (ESXi) on the Dell PowerEdge R710

1. Insert the ESXi 5.5 disk, and select Boot from disk.
2. On the Welcome screen, press Enter.
3. On the End User License Agreement (EULA) screen, press F11.
4. On the Select a Disk to install or Upgrade Screen, select the relevant volume to install ESXi on, and press Enter.
5. On the Please Select a Keyboard Layout screen, press Enter.
6. On the Enter a Root Password screen, assign a root password, and confirm the password by entering it again. Press Enter to continue.
7. On the Confirm Install Screen, press F11 to install.
8. On the Installation complete screen, press Enter to reboot.

## Configuring ESXi after installation

1. On the ESXi 5.5 screen, press F2, enter the root password, and press Enter.
2. On the System Customization screen, select Troubleshooting Options, and press Enter.
3. On the Troubleshooting Mode Options screen, select enable ESXi Shell, and press Enter.
4. Select Enable SSH, press Enter, and press Esc.
5. On the System Customization screen, select Configure Management Network.
6. On the Configure Management Network screen, select IPv4 Configuration.
7. On the IPv4 Configuration screen, select Set static IP; enter an IP address, subnet mask, and default gateway; and press Enter.
8. On the Configure Management Network screen, press Esc. When the installer asks if you want to apply the changes, press Y.
9. Log in as `root` with the vSphere client.
10. Select the Configuration tab, and click Networking.
11. Click Add Networking...
12. Create a virtual machine network called `PRIV-NET`, and select the adapter with access to the private test network.
13. Click OK.
14. Select the Configuration tab, and click DNS and routing.
15. Type a name, and select `test.local` for domain.

## Setting up two VMs to host the Microsoft Windows® Active Directory server and the NAT server

1. In your web browser, connect to the vSphere server, and browse to the ESXi host hosting the management VMs (in our case, the PowerEdge R710).
2. Right-click the ESXi host, and choose New Virtual Machine.
3. On the Create New Virtual Machine window, select custom, and click Next.
4. Assign a name to the virtual machine, and click Next.
5. Select the LUN for the storage, and click Next.
6. Select Virtual Machine Version 11, and click Next.

7. Choose Windows, select Microsoft Windows Server 2012, and click Next.
8. Choose the VM's virtual hardware options, and click Next (see each VM's section below for additional VM configuration data).
  - Select one virtual processor socket, and one core per virtual socket.
  - Select 4GB RAM.
  - Select the NIC interface with access to the private test network.
  - Leave the default option for SCSI controller.
9. Choose to create a new virtual disk, and click Next.
10. Make the OS virtual disk size 100 GB, choose thin provisioned, specify external storage, and click Next.
11. Keep the default virtual device node (0:0), and click Next.
12. Click Finish.
13. Right-click the VM, and select Edit Settings.
14. Click the Resources tab, and click Memory.
15. Select Reserve all guest memory, and click OK.
16. Connect the VM virtual CD-ROM to the Microsoft Windows Server 2012 R2 installation disk.
17. Start the VM.

### **Installing Microsoft Windows Server 2012 R2 Standard Edition**

1. Connect the installation media and power on the VM.
2. When the option appears, press F11 to enter the Boot Manager.
3. Select the connected boot media, and press Enter.
4. Press any key when prompted to boot from DVD.
5. When the installation screen appears, click My language is English.
6. Leave language, time/currency format and input method as default, and click Next.
7. Click Install now.
8. When the Windows Setup window appears, click No thanks when prompted to go online to install updates.
9. Select Windows Server 2012 R2 Standard (Server with a GUI), and click Next.
10. Check I accept the license terms, and click Next.
11. Click Custom: Install Windows only (advanced).
12. Press Alt+A to open advanced partition options. Delete any partitions until there is only Drive 0 Unallocated Space.
13. Select Drive 0 Unallocated Space, and click Next, at which point Windows will begin installing, and will restart automatically after completing.
14. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
15. Log in with the previously set up password.

### **Configuring Windows Update**

1. In the left pane of the Server Manager window, click Local Server.
2. In the main frame, next to Windows Update, click Not configured.
3. In the Windows Update window, in the main pane, click Let me choose my settings.

4. Under Important updates, select Never check for updates (not recommended), and then click OK.
5. In the left pane, click Check for updates, and install all available updates.
6. Close the Windows Update window.

### Configuring Windows Firewall

1. In Server Manager, click Tools→Windows Firewall with Advanced Security.
2. In the Overview section, click Windows Firewall Properties.
3. In the Domain Profile tab, for Firewall state, click Off.
4. In the Private Profile tab, for Firewall state, click Off.
5. In the Public Profile tab, for Firewall state, click Off.
6. Click OK.
7. Close the Windows Firewall Properties window.

### Setting up Remote Desktop

1. In the Local Server tab of the Server Manager window, next to Remote Desktop, click Disabled.
2. In the System Properties window that appears, in the Remote Desktop section, select the Allow remote connections to this computer radio button, and click OK when the warning message appears.
3. Uncheck Allow connections only from computers running Remote Desktop with Network Level Authentication (recommended), and click OK.

### Disabling IE Enhanced Security Configuration

1. In the Local Server tab of the Server Manager window, next to IE Enhanced Security Configuration, click On.
2. In the Internet Explorer Enhanced Security Configuration window, select the Off radio buttons for both Administrators and Users, and click OK.

### Installing VMware Tools

1. Install VMware Tools. For more information, see [kb.vmware.com/selfservice/microsites/search.do?language=en\\_US&cmd=displayKC&externalId=340](http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340).

Repeat the virtual machine, OS installation, and OS configuration described above to create a VM for the NAT server.

### Installing Active Directory and DNS services

1. Power on the Active Directory VM.
2. On the Active Directory server, open Windows PowerShell®.
3. Run the following command: `Install-WindowsFeature RSAT-ADDS`
4. When the installation is finished, close PowerShell.
5. On the VM, open Server Manager.
6. On the Welcome screen, click 2, and click Add roles and features.
7. At the initial Before you begin screen, click Next three times.
8. At the Server Roles screen, select Active Directory Domain Services.
9. On the pop-up window, click Add Features.
10. Click Next three times.
11. Verify the desired role is being installed, and click Install.

12. Once installation has finished, close the Add roles and features wizard.
13. In Server Manager, click the flag at the top, and select the Promote this server to a domain controller link.
14. Select Add a new forest, enter a root domain name of `test.local` and click Next.
15. On the Domain Controller Options screen, enter a password, and click Next.
16. On the DNS Options screen, click Next.
17. On the Additional Options screen, click Next.
18. On the Paths screen, click Next.
19. On the Review Options screen, click Next.
20. On the Prerequisites screen, verify all prerequisites have passed, and click Install.
21. Once Active Directory Domain Services finishes installing, click Finish, and restart the system.

## Installing the NAT on the NAT server

Before installing the network address translation (NAT) service, you will need to plug a second network cable into the R710 server that has access to the internet and configure vSphere to make that connection available as a second NIC for the NAT VM.

1. On the NAT server, open the Add Roles and Feature Wizard.
2. On the Before you Being screen, click Next.
3. On the Installation Type screen, click Next.
4. On the Server Selection screen, click Next.
5. On the Server Roles screen, select Remote Access, and click Next.
6. On the Features screen, click Next.
7. On the Remote Access screen, click Next.
8. On the Role Services screen, select Routing, click Add Features on the popup, and click Next.
9. On The Web Server Role (IIS) screen, click Next.
10. On the Role Services screen, click Next.
11. On the Confirmation screen, click Install.
12. Once the installation is complete, click Close.
13. From Administrative Tools, open Routing and Remote Access...
14. In the left panel, right-click the target server and select Configure and Enable Routing and Remote Access.
15. In the Routing and Remote Access Server Setup Wizard, click Next.
16. On the Configuration screen, select Network Address Translation (NAT).
17. On the NAT Internet Connection screen, select the Ethernet port that will provide internet connection and click Next.
18. On the Completion screen, click Finish. When setting static IP address, the vCenter server's IP can now be used as the gateway on the isolated testing network.

## Configuring the VMware vSphere environment for the VRTX server

### Installing and configuring vCenter Server

1. In the vSphere client, select File, then Deploy OVF Template.

2. In the Deploy OVF Template window, click Browse, then browse to the location of the vCenter Server Appliance .ovf file, click Open, and click Next.
3. On the OVF Template Details screen, click Next.
4. In the Name and Location screen, enter `vCenter Server` for the name, and click Next.
5. In the Storage screen, select the appropriate datastore, and click Next.
6. In the Disk Format screen, select Thin Provision, and click Next.
7. In the Network Mapping screen, select the private test network.
8. In the Ready to Complete screen, check the Power on after deployment checkbox, and click Finish.
9. In the vSphere client, right-click the new vCenter, and select Open Console.
10. Note the instructions and the address to use for configuration.
11. Open a web browser to the address listed in the console.
12. Log in with `root` and the password `vmware`
13. In the vCenter Server Setup window, check the box to accept the license agreement, and click Next.
14. In the Configure Options screen, select the Configure with default settings, and click Next.
15. In the Review Configuration screen, click Start. Setup will complete, and a new database will be configured automatically. When it is finished, click Close.
16. Click the Admin Tab.
  - a. In the current administrator password section, enter `vmware`
  - b. Enter a new password into both password fields.

## Configuring the VRTX shared storage

1. Open a web browser, and enter the address listed for the CMC IP on the front LCD display.
2. Log in with the appropriate credentials.
3. Expand Storage.
4. Click Storage.
5. Click the Setup tab.
  - a. Under Assignment Mode, select the Multiple Assignment radio button, and click Apply.
  - b. To confirm the Operation Successful message box, click OK.
6. Configure virtual disks:
  - a. Click Storage → Virtual Disks.
  - b. On the Virtual Disks tab, click Create.
    - i. For Media Type, select HDD.
    - ii. For Choose a virtual disk type, select RAID 10.
    - iii. Select the 10 available 300 GB hard disk drives.
    - iv. For the first volume (to be used for Microsoft Exchange), enter 850GB and click Create Virtual Disk.
    - v. To confirm the message box indicating Operation Successful, click OK.
    - vi. Repeat steps i through iv for the next external volume (to be used for system operating systems), choosing 500GB.
    - vii. For Media Type select SDD.

- viii. For Choose a virtual disk type, select RAID 1.
- ix. Select the two available 400 GB SSDs.
- x. For the first volume (to be used for Microsoft SQL Server), enter 120GB and click Create Virtual Disk.
- xi. To confirm the message box indicating Operation Successful, click OK.
- xii. Repeat steps ix through for the next external volume (to be used for Iometer), choosing 100GB.
- c. On the Virtual Disks tab, click Manage.
  - i. Select the Virtual Disks Action drop-down menu for Virtual Disk 0, and initialize the drives.
  - ii. Click Apply.
  - iii. To confirm the message box indicating Operation Successful, click OK.
  - iv. Repeat steps i through iii for the remaining virtual disks.
- d. Allow shared LUN access to all slots. On the Virtual Disks tab, click Assign.
  - i. Use the drop-down menu for all virtual disks and SLOT-01, and select Full Access.
  - ii. Use the drop-down menu for all virtual disks and SLOT-02, and select Full Access.
  - iii. Use the drop-down menu for all virtual disks and SLOT-03, and select Full Access.
  - iv. Use the drop-down menu for all virtual disks and SLOT-04, and select Full Access.
  - v. Click Apply.
  - vi. To confirm the Operation Successful message box, click OK.

## Configuring the VMware vSphere environment for the VRTX server

### Configuring boot properties of the Dell PowerEdge M830 server

1. Open a web browser, and enter the address listed for the CMC IP on the front LCD display.
2. Log in with the appropriate credentials.
3. Expand Server Overview, and select Slot-01.
4. Click the Setup Tab. Perform the following steps in the iDRAC settings:
  - a. Check the Enable LAN checkbox.
  - b. Check the Enable IPv4 checkbox.
  - c. Check the DHCP checkbox.
  - d. Check the IPMI Over LAN checkbox.
  - e. Click Apply iDRAC Network Settings.
  - f. To confirm changes to the iDRAC network settings, click OK.
5. Power on the server.
  - a. Click the Power Tab.
  - b. Select Power On Server.
  - c. Click Apply.
  - d. To confirm server control action, click OK.
  - e. To confirm operation was successful, click OK.
6. Click the Properties tab.
7. Click Launch Remote Console.
8. On new browser page, click Continue to website (not recommended) if prompted.
  - a. If a message appears indicating a pop-up was blocked, select Always allow pop-ups from this site.

- b. Close the browser tab for the iDRAC.
  - c. Click Launch Remote Console.
  - d. If a message appears indicating the Web page wants to run an add-on called “Virtual Console from Dell Inc.,” select Allow for all websites.
9. A new window appears showing the console for the server to configure. Select Power→Reset System.
10. Change the boot disk order in System Setup.
- a. When prompted during POST, press F2 to enter System Setup.
  - b. Click System BIOS.
  - c. Click Boot Settings.
  - d. Click BIOS Boot Settings.
  - e. Scroll down, and click Hard Disk Drive Sequence.
    - i. Highlight the SD card or USB drive entry, and move it to the top using the + key.
    - ii. Click OK.
  - f. Click Back twice.
  - g. Click Finish.
  - h. Click Yes.
  - i. Click Finish.
  - j. Click OK. The system will restart.

### **Installing VMware vSphere 5.5 (ESXi) on the Dell PowerEdge M830 server**

1. Mount the ESXi 5.5 ISO via the iDRAC, and boot the M830 to that ISO.
2. On the Welcome screen, press Enter.
3. On the End User License Agreement (EULA) screen, press F11.
4. On the Select a Disk to install or Upgrade Screen, select the an SD card or USB drive to install ESXi on, and press Enter.
5. On the Please Select a Keyboard Layout screen, press Enter.
6. On the Enter a Root Password Screen, assign a root password, and confirm the password by entering it again. Press Enter to continue.
7. On the Confirm Install Screen, press F11 to install.
8. On the Installation complete screen, press Enter to reboot.

### **Configuring VMware vSphere (ESXi) embedded on the server**

1. Complete configuration of ESXi host:
  - a. Press F2.
  - b. Enter the root account password, and press Enter.
  - c. Select Configure Management Network, and press Enter.
  - d. Select Network Adapters.
  - e. Select the adapter that connects your server to the private testing network.
  - f. Press Esc.
  - g. To restart networking, press Y.
  - h. Select Troubleshooting Options.
    - i. Select Enable ESXi shell, and press Enter.

- ii. Select Enable SSH, and press Enter.
- iii. Press Esc.
- i. To log out, press Esc.

### Adding the M830 to the vCenter Server

1. In a web browser, navigate to the vCenter IP, click Log in to vSphere Web Client, and log in using `root` and your password.
2. In the left panel, select vCenter, then Datacenters.
3. Right-click in the empty panel, and select New Datacenter.
4. In the New Datacenter window, give the Datacenter a name and click OK. We used `VRTX-01`
5. Select your test datacenter.
6. On the left panel, select Hosts, then click Add a host.
7. On the Name and Location screen, enter the IP address for the R710 client and click Next.
8. On the Connection settings screen, enter the User name and Password and click Next.
9. On the Host summary screen, click Next.
10. On the Assign license screen, click Next.
11. On the Lockdown mode screen, click Next.
12. On the VM location screen, click Next.

### Configuring the external volumes

1. In the vSphere client, select the target host.
2. Click the Configuration tab.
3. Click Storage, and click Add Storage...
4. Choose Disk/LUN.
5. Select the disk, and click Next.
6. Accept the default of VMFS-5 for the file system.
7. Review the disk layout, and click Next.
8. Enter the datastore name, and click Next.
9. Accept the default of using maximum capacity, and click Next.
10. Click Finish.
11. Repeat for all volumes available through the Shared PERC 8 Mini.

### Creating the first VM

1. Using the vSphere client, connect to the vCenter Server.
2. Right-click the cluster, and choose New Virtual Machine.
3. On the Configuration screen, choose Custom, and click Next.
4. On the Name and Location screen, add a name, select the datacenter, and click Next.
5. On the specific Host screen, choose the PowerEdge M830 blade and click Next.
6. On the Storage screen, select the OS datastore on the external storage, and click Next.
7. On the Virtual Machine Version screen, choose Virtual Machine Version 8, and click Next.

8. On the Guest Operating System screen, choose Windows, select Microsoft Windows Server 2012 R2 (64-bit), and click Next.
9. On the CPUs screen, choose 1 virtual socket, and 4 virtual processors per core, and click Next.
10. On the Memory screen, choose 8 GB RAM, and click Next.
11. On the Network screen, click 1 for the number of NICs, select the NIC connected to the isolated testing network, and click Next.
12. On the SCSI Controller screen, leave the default virtual storage controller, and click Next.
13. On the Select a Disk screen, choose to create a new virtual disk, and click Next.
14. On the Create a Disk screen, make the OS virtual disk size 100 GB, and choose thin provisioned.
15. On the Advanced Options screen, leave the default virtual device node (0:0), and click Next.
16. On the Ready to Complete screen, click Finish.
17. Right-click the VM, select Upgrade Virtual Hardware, and click Yes.
18. Start the VM.
19. Attach the Windows Server 2012 R2 ISO image to the VM, and install Windows Server 2012 R2 on your VM.

## Installing the operating system on the VMs

Repeat the sections above regarding the initial creation of the virtual machines and installation of Windows Server 2012 R2 Standard.

### Cloning the VM

1. Using the vSphere Client, right-click the first VM and select Template, then Clone to Template.
2. On the Name and Location screen, enter a Template Name.
3. On the Host / Cluster screen, select the management server.
4. On the Datastore screen, select a datastore, and click Next.
5. On the Ready to Complete screen, click Finish.

The template created will be used to clone out the rest of the VMs.

## Installing and configuring Microsoft Exchange Servers

We installed Microsoft Exchange 2013 SP3 CAS server and mailbox server on two VMs residing on the Dell PowerEdge M830.

### Configuring the Exchange 2013 VMs on the VRTX

After cloning, modify the Exchange 2013 VMs to contain the following settings:

- Memory: 16 GB
- Virtual Processors: 8
- Additional virtual disks for the mailbox server.
  - 1 × 750GB virtual disk for mailbox storage (Thick-provisioned, eager-zeroed)
  - 1 × 100GB virtual disk for log storage (Thick-provisioned, eager-zeroed)

After adding the drives from the vSphere client, configure additional drives in Windows using the following steps.

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.

## Testing overview

We used the RAID 10 consisting of 300GB hard drives on the VRTX shared storage to store the Exchange mailbox. We added two virtual drives to the Exchange Mailbox: one for Exchange data and one for logs.

For our workloads, we used the following settings:

- Users: 750
- Mailbox Profile: 250MB mailboxes
- Action Profile: Outlook\_200
- Client Type: Outlook 2007 Cached

## Configuring the Active Directory server

### Installing the Active Directory Domain Services role

Before completing this step, you will need to apply a static IP address for the server. In our case, we used 192.168.1.10.

1. Launch Server Manager, and select Add roles and features.
2. Click Next at the Add Roles and Features Wizard.
3. Select Role-based or feature-based installation, and click Next.
4. Select the AD server from the server pool, and click Next.
5. Select Active Directory Domain Services from the list of Roles, click the Add Features button to add features that are required by Active Directory Domain Services, and click Next.
6. Accept the defaults selected by setup at the Select Features screen, and click Next.
7. Click Next at the AD DS screen.
8. Select Restart the destination server automatically if required at the confirmation screen, and click Install.
9. Click the yellow warning triangle in the server manager window.
10. Click Promote this server to a domain controller.
11. Select Add a new forest, type in the Root domain name (`fqdn`), and click Next. For our testing, we used `test.local`
12. Type in and confirm the password, and click Next.
13. Click Next at the DNS Options screen.
14. Verify the NetBIOS name, and click Next.
15. Accept the default paths, and click Next.
16. Review the options, and click Next.
17. Verify the prerequisite check passes successfully, and click Install.

## Preparing AD for Exchange

1. Create a reverse lookup zone:
  - a. Click the start button, and type `DNS` in the search field.
  - b. Open the DNS manager by clicking on it in the results field.
  - c. Expand your Active Directory domain, and click on Reverse Lookup Zones.
  - d. Click Action→New Zone.
  - e. Click Next on the Welcome screen.
  - f. Chose Primary Zone, and click Next.
  - g. Leave default replication scope, and click Next.
  - h. Choose IPv4, and click Next.
  - i. Enter the IP address of your domain (`192.168.3` for our example).
  - j. Choose Allow both nonsecure and secure dynamic updates, and click Next.
  - k. Click Finish.
2. Insert the Exchange 2012 SP1 Installation ISO in the AD VM DVD drive.
3. In Windows Explorer, double-click the Exchange DVD icon.
4. In the Exchange installation folder, hold down shift, and right-click.
5. Choose Open a command window here.
6. Run the following command: `Setup.exe /PrepareSchema /IAcceptExchangeServerLicenseTerms`
7. When the previous command completes, run the following command: `Setup.exe /PrepareAD /OrganizationName:"organization name" /IAcceptExchangeServerLicenseTerms`
8. Close the command window when the setup finishes.

## Installing Active Directory Certificate Services

1. Launch Server Manager, and select Add roles and features.
2. Click Next at the Add Roles and Features Wizard.
3. Select Role-based or feature-based installation, and click Next.
4. Choose Active Directory Certificate Services.
5. Click Add Features, if prompted, to install any required features.
6. Click Next.
7. Click Next.
8. Click Next.
9. Choose Certificate Authority and Certification Authority Web Enrollment.
10. Click Add Features, if prompted, to install any required features.
11. Click Next.
12. Leave defaults, and click Next.
13. Click Install.
14. Click Close when the install finishes.

15. Click on the yellow warning symbol in the Server Manager, and click Configure Active Directory Certificate Services
16. Leave defaults, and click Next.
17. Check both Certification Authority and Certification Authority Web Enrollment, and click Next.
18. Choose Enterprise CA, and click Next.
19. Choose Root CA, and click Next.
20. Choose Create a new private key, and click Next.
21. Leave defaults, and click Next.
22. Leave defaults, and click Next.
23. Leave 5 years, and click Next.
24. Leave default locations, and click Next.
25. Click Configure.
26. Close when the configuration finishes.
27. Open Internet Explorer and navigate to `localhost/certsrv/Default.asp` to verify that the installation succeeded.

## Installing Exchange Server 2013 SP1 Mailbox and Client Access Server roles

Using the template, clone two VMs: one for the Exchange Client Access Server, or CAS, and the other for the Exchange Mailbox Server. Edit the hardware settings in each. The Mailbox server should have eight vCPUs (eight virtual sockets each with one core) and 16 GB of memory. Using the Exchange datastore, add a 750 GB disk and a 100 GB disk to the Mailbox server for the Exchange mailbox and Exchange logs respectively. Set static IPs on both VMs and join the domain.

1. On the Exchange Mailbox Server, log into the server using domain administrator credentials.
2. Open Windows PowerShell and run the following command:

```
Install-WindowsFeature AS-HTTP-Activation, Desktop-Experience, NET-Framework-45-Features, RPC-over-HTTP-proxy, RSAT-Clustering, RSAT-Clustering-CmdInterface, RSAT-Clustering-Mgmt, RSAT-Clustering-PowerShell, Web-Mgmt-Console, WAS-Process-Model, Web-Asp-Net45, Web-Basic-Auth, Web-Client-Auth, Web-Digest-Auth, Web-Dir-Browsing, Web-Dyn-Compression, Web-Http-Errors, Web-Http-Logging, Web-Http-Redirect, Web-Http-Tracing, Web-ISAPI-Ext, Web-ISAPI-Filter, Web-Lgcy-Mgmt-Console, Web-Metabase, Web-Mgmt-Console, Web-Mgmt-Service, Web-Net-Ext45, Web-Request-Monitor, Web-Server, Web-Stat-Compression, Web-Static-Content, Web-Windows-Auth, Web-WMI, Windows-Identity-Foundation
```
3. Restart the server.
4. Download the Microsoft Unified Communications Managed API 4.0, Core Runtime 64-bit ([go.microsoft.com/fwlink/p/?linkId=258269](http://go.microsoft.com/fwlink/p/?linkId=258269)).
5. Run `UcmaRuntimeSetup.exe`.
6. When the installation completes, click Finish.
7. Navigate to the location of the Exchange installation media, and double-click `Setup.exe`.
8. At the Check for Updates? screen, check the Connect to the Internet and check for updates checkbox, and click Next.

9. When the updates complete, click Next.
10. At the Introduction screen, click Next.
11. At the License Agreement screen, check the box to accept the terms, and click Next.
12. At the Recommended Settings screen, check the Don't use recommended settings checkbox, and click Next.
13. At the Server Role Selection, select Mailbox or Client Access role, and click Next.
14. At the Installation Space and Location screen, leave the default location for the installation, and click Next.
15. At the Malware Protection Settings, select Yes to disable, and click Next.
16. At the Readiness Checks screen, allow the verification to complete. If there are no failures, click Install.
17. When the installation completes, click Finish, and restart the server.
18. Repeat steps 1 –17 for the Exchange CAS server.

## Configuring Exchange

1. On the CAS server, open the Exchange Admin Center by using a browser and navigating to `https://localhost/ecp`
2. Enter the domain administrator credentials, and click Sign in.
3. If prompted, select the language and time zone, and click Save.
4. In the left pane, click Mail Flow, then click Send Connectors.
5. On the Send Connectors page, click the New icon.
6. In the New Send Connector wizard, specify SMTP as the name and select Internet as the type. Click Next.
7. In the Network settings screen, choose MX record associated with recipient domain, and click Next.
8. In the Address space screen, click the Add icon.
9. In the Add domain window, enter \* in the Fully Qualified Domain Name (FQDN) field, and click Save.
10. Click Next.
11. In the Source Server screen, click the Add icon.
12. In the Select a Server window, select the mailbox server, click Add, and then click OK.
13. Click Finish.
14. In the left pane of the EAC, click servers, select the name of the CAS server, and click Edit.
15. Click Outlook Anywhere, and enter the appropriate FQDN of the Client Access Server for the external and internal hostname field. For example, `exchangeserver.test.local`
16. Choose NTLM as the authentication method, and click Save.
17. Click Virtual Directories, and then click the Configure external access domain icon.
18. In the Select the Client Access servers to use with the external URL window, click the Add icon.
19. Select the CAS server, and click Add. Click OK.
20. Type the FQDN of the CAS server in the Enter the domain, and click Save.
21. Log into the Active Directory server using administrator credentials, and complete the following steps:
  - a. Open Server Manager, then click Tools→DNS.
  - b. In DNS Manager, expand the Active Directory server name→Forward Lookup Zones→test.local in the left pane.
  - c. In the right pane, verify or create the DNS records as presented in Figure 15.

| Type                | Host or child domain/alias name | FQDN                    | FQDN of mail server  |
|---------------------|---------------------------------|-------------------------|----------------------|
| Mail Exchanger (MX) | Leave blank                     | domain.com              | casserver.domain.com |
| Alias (CNAME)       | Autodiscover                    | Autodiscover.domain.com | casserver.domain.com |
| Alias (CNAME)       | Owa                             | Owa.domain.com          | casserver.domain.com |

Figure 15: DNS records.

22. Log back into your CAS server.
23. In the Exchange Power Shell, run the following commands, replacing "\$HostName" with the host name (not FQDN) of your CAS server.

```
Set-EcpVirtualDirectory "$HostName\ECP (Default Web Site)" -InternalUrl
((Get-EcpVirtualDirectory "$HostName\ECP (Default Web
Site)").ExternalUrl)
```

```
Set-WebServicesVirtualDirectory "$HostName\EWS (Default Web Site)" -
InternalUrl ((get-WebServicesVirtualDirectory "$HostName\EWS (Default Web
Site)").ExternalUrl)
```

```
Set-ActiveSyncVirtualDirectory "$HostName\Microsoft-Server-ActiveSync
(Default Web Site)" -InternalUrl ((Get-ActiveSyncVirtualDirectory
"$HostName\Microsoft-Server-ActiveSync (Default Web Site)").ExternalUrl)
```

```
Set-OabVirtualDirectory "$HostName\OAB (Default Web Site)" -InternalUrl
((Get-OabVirtualDirectory "$HostName\OAB (Default Web
Site)").ExternalUrl)
```

```
Set-OwaVirtualDirectory "$HostName\OWA (Default Web Site)" -InternalUrl
((Get-OwaVirtualDirectory "$HostName\OWA (Default Web
Site)").ExternalUrl)
```

```
Set-PowerShellVirtualDirectory "$HostName\PowerShell (Default Web Site)"
-InternalUrl ((Get-PowerShellVirtualDirectory "$HostName\PowerShell
(Default Web Site)").ExternalUrl)
```

```
Get-OfflineAddressBook | Set-OfflineAddressBook -
GlobalWebDistributionEnabled $True -VirtualDirectories $Null
```

24. Create a folder at the root of C: on the CAS server, and share it to Everyone with read/write permissions.
25. Log back into the Exchange admin center, and navigate to Servers → certificates.
26. Choose the CAS server in the drop-down menu, and click the plus sign to create a new certificate.
27. Choose Create a request for a certificate from a certification authority, and click Next.
28. Name the certificate, and click Next.
29. Do not request a wildcard certificate, and click Next.
30. Click Browse, choose the CAS server, and click OK. Click Next.
31. Leave defaults, and click Next.
32. Leave defaults, and click Next.

33. Enter your organization information, and click Next.
34. Enter the path to the share you created on the CAS server, and click Finish. Example:  
`\\cas\share\myrequest.REQ`
35. Log into the AD server, and open Internet Explorer.
36. Browse to localhost/CertSrv
37. Click Request a certificate.
38. Choose advanced certificate request.
39. Choose Submit a certificate request by using a base-64-encoded CMC...
40. Open Windows Explorer and navigate to the share folder on the CAS server where the certificate request is stored.
41. Open the certificate with notepad and copy the content between BEGIN NEW CERTIFICATE REQUEST and END NEW CERTIFICATE REQUEST.
42. Paste the copied content into the Saved Request window.
43. Choose Web Server in the Certificate Template drop-down menu, and click Submit.
44. Choose Base 64 encoded, and download the certificate.
45. Copy the new certificate into the share folder on the CAS server.
46. Log back into the CAS server and open the Exchange Admin Center.
47. Go to Servers→Certificates, and highlight the certificate you began before (should say Pending request in the status column).
48. Click Complete on the right side.
49. Type the path to the certificate, including the certificate name, and click OK. Example:  
`\\cas\share\certnew.CER`
50. Verify that the status has changed to Valid.
51. Edit the new entry, and click Edit.
52. Go to services and check SMTP and IIS, click Save.
53. Click Yes on the warning message.
54. Run the following steps on the CAS and AD servers.
  - a. Click Start, and type MMC
  - b. Click File→Add/Remove Snap-in
  - c. Choose Certificates, and click Add.
  - d. Choose Computer account, and click Next.
  - e. Choose Local computer, and click Finish.
  - f. Click OK.
  - g. Expand Certificates→Trusted Root Certificate Authorities→Certificates
  - h. Click Action→All Tasks→Import
  - i. Click Next.
  - j. Browse to the share folder on the CAS server, and choose the new certificate you created. Click Next.
  - k. Leave defaults, and click Next.

- l. Click Finish.
- m. Click OK on the Import was successful message.

55. Log into the CAS server and open the Exchange admin center.

56. Navigate to Servers→Databases.

57. Restart the Microsoft Exchange Information Store service on the MB server.

58. Using the Edit button, disable the maintenance schedule and enable circular logging for each mailbox database.

59. Dismount and remount the databases.

60. Open the Exchange Management shell, and enter the following to move the paths of the default mailbox:

```
Move-Databasepath "DatabaseName" -EdbFilepath "E:\Newlocation\DBname.edb" -  
LogFolderPath "F:\Newlocation"
```

61. When prompted, type A and press Enter.

62. Open Exchange Management Shell, and enter the following:

```
Get-OutlookAnywhere |Set-OutlookAnywhere -ExternalHostname cas.domain.com -  
DefaultAuthenticationMethod NTLM -ExternalClientsRequireSsl $true
```

## Installing and configuring the Exchange 2013 mail test clients and completing LoadGen configuration on the Exchange 2013

For our testing, we used one virtual client machine to run LoadGen 2013. To create the mail clients, we installed several software components. We followed this process for each installation:

### Installing Windows Server 2008 R2 SP1 Enterprise Edition

1. Insert the installation DVD for Windows Server 2008 R2 SP1 Enterprise into the DVD drive.
2. At the Language Selection Screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
5. Click the I accept the license terms checkbox, and click Next.
6. Click Custom.
7. Click Next.
8. At the User's password must be changed before logging on warning screen, click OK.
9. Enter the desired password for the administrator in both fields, and click the arrow to continue.
10. At the Your password has been changed screen, click OK.
11. Click Start, type `change power-saving settings` and press Enter.
12. Click Change plan settings.
13. Change the Turn off the display drop-down menu to Never.
14. Click Save changes, and close the Power Options, Screen Saver Settings, and Personalization screens.

To set up this server, we had to install several additional software components. The following subsections detail the necessary installation processes.

### Joining the domain

1. Set a static IP.
2. Select Start→Control Panel→Network Connections→Local Area Connection.

3. Click Properties.
4. Highlight Internet Protocol (TCP/IP), and click Properties.
5. Select the Use the following DNS server addresses radio button, and enter the IP of the DNS server in the Preferred DNS server field. Click OK.
6. Right-click My Computer, and select Properties.
7. Under the Computer Name tab, click Change.
8. In the Computer Name Changes screen, under the Member of section, select the Domain radial box, and type `test.local`
9. Select OK to start joining the domain.
10. When the screen appears asking for a person qualified on the domain, type `Administrator` as the username and `Password1` as the password.
11. At the Welcome pop-up window and the window warning that you must reset the computer for the changes to take effect, click OK.
12. At the System Properties screen, click OK.
13. 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

Download and install Load Generator 2013 using all defaults.

### Importing the certificate and editing the hosts file

1. Click Start, and type MMC
2. Click File→Add/Remove Snap-in
3. Choose Certificates, and click Add.
4. Choose Computer account, and click Next.

5. Choose Local computer, and click Finish.
6. Click OK.
7. Expand Certificates→Trusted Root Certificate Authorities→Certificates.
8. Click Action→All Tasks→Import.
9. Click Next.
10. Browse to the share folder on the CAS server, and choose the new certificate you created. Click Next.
11. Leave defaults, and click Next.
12. Click Finish.
13. Click OK on the Import was successful message.
14. Open the Notepad program, and use File→Open to open the hosts file stored at  
C:\Windows\System32\drivers\etc
15. Add the IP and FQDN of the CAS server.
16. Save and close Notepad.

### Preparing Load Generator

1. Log into the mail client.
2. Select Start→All Programs→Microsoft Exchange→Exchange Load Generator 2013.
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 1 hour.
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. Create 750 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 Outlook\_200, and the Mailbox size to 250 MB, and click Continue.
11. In Remote configurations, check the checkbox to enable distributing the workload, enter the computer names of all of the test clients, and click Continue.
12. Click Save the configuration file as, and name it testcfg.xml
13. Click Start the initialization phase (recommended before running the test).
14. Once you have initialized the database, create a backup copy of the Exchange mailbox databases.

### Installing and configuring Microsoft SQL Server 2014

We installed Microsoft SQL Server 2014 on a VM residing on the second Dell PowerEdge M830.

#### Configuring the SQL Server VM (VRTX only)

1. After cloning, modify the SQL VM to contain the following settings:
  - Memory: 16 GB
  - Virtual Processors: 8
  - Additional virtual disks:

- 1 × 100GB virtual disks for SQL database and log data (Thick provisioned, eager-zeroed)

## Installing SQL Server 2014

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 2014 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. On the Product Key screen, enter a product key for standard, and click Next.
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, 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 Next.
22. At the Error and usage reporting screen, click Next.
23. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
24. At the Ready to Install screen, click Install.
25. After installation completes, click Close.
26. Create a SQL Server login for the ds2user (see the [Configuring the database \(Data generation overview\)](#) section for the specific script to use).
27. Copy the pre-created DVD Store backup to the specified backup volume.
28. Download and install any available updates for Microsoft SQL Server 2014. We installed SQL Server 2014 SP1 and CU5.

## Configuring the database workload client

For our testing, we used a single client machine for the Microsoft SQL Server client. To create this client, we created a Windows Server 2013 R2 VM, assigned a static IP address, and installed .NET 3.5. We used this client to drive the DVD Store benchmark we ran against the SQL database.

## 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 10GB 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 2014. We built the 10GB database in SQL Server 2014, 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 10GB 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
```

9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.
12. 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 16 shows our initial file size modifications.

| Logical name          | Filegroup      | Initial size (MB) |
|-----------------------|----------------|-------------------|
| <b>Database files</b> |                |                   |
| primary               | PRIMARY        | 3.25              |
| cust1                 | DS_CUST_FG     | 5,767             |
| cust2                 | DS_CUST_FG     | 5,767             |
| ind1                  | DS_IND_FG      | 2,621             |
| ind2                  | DS_IND_FG      | 2,621             |
| ds_misc               | DS_MISC_FG     | 2,621             |
| orders1               | DS_ORDERS      | 2,621             |
| orders2               | DS_ORDERS      | 2,621             |
| <b>Log files</b>      |                |                   |
| ds_log                | Not Applicable | 20,480            |

Figure 16: Our initial file size modifications.

## Installing and configuring Iometer

We installed Iometer using all defaults on a VM residing on the second Dell PowerEdge M830.

### Configuring the Iometer VM (VRTX only)

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

- Memory: 8 GB
- Virtual Processors: 4
- Additional virtual disks:
  - 1 × 50GB virtual disk for Iometer target (Thick provisioned, eager-zeroed)

### Installing and configuring Iometer on the VM

1. Download the Iometer 1.1 package for Windows from [www.iometer.org/doc/downloads.html](http://www.iometer.org/doc/downloads.html).
2. Double-click the installer, and click Run.
3. At the Welcome window, click Next.
4. At the License Agreement window, click I Agree.
5. At the Choose Components window, leave the defaults selected, and click Next.
6. At the Choose Install Location window, change the Destination Folder to C:\Iometer 1.1, and click Install.
7. When the installation completes, click Finish.

8. Copy the relevant access specification file to the VM.

## Configuring the Iometer workloads (both legacy and VRTX)

We set up Iometer to deliver a light file/print server-like I/O load through the duration of the tests. Below we review the specific configuration of our Iometer workload.

### *Iometer workload specifications*

- 50GB dataset, 1 Outstanding I/O per target (sectors)
- 512KB transfer request size
- 100ms transfer delay
- 1 Burst I/O
- 80% read, 100% random
- 45 minute run time
- 60 second ramp up time
- Cycling – normal

## 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 750 Exchange users targeting the Exchange VM using LoadGen's Exchange\_200 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](http://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=12 --db_size=10GB --think_time=0.1 --detailed_view=Y --  
warmup_time=15
```

### About running the lometer tests

1. Log into the lometer machine.
2. Open the lometer specification for the machine.
3. Click the start button.
4. After all access specifications finish running, remove the result files from the machine.

## APPENDIX C – DETAILED TEST RESULTS

Figure 17 shows the results of our database, mail, and file and print testing as well as power data for the Dell PowerEdge VRTX with a Dell PowerEdge M830 server. The median run was determined by OPM.

| Dell PowerEdge VRTX with one Dell PowerEdge M830 server | Run 1 | Run 2 | Run 3 | Median run |
|---|-------|-------|-------|------------|
| <b>Power</b>  |       |       |       |            |
| Idle power (W)  | 390.9 | 389.4 | 390.3 | 389.4      |
| Active power (W)  | 420.9 | 418.0 | 418.0 | 418.0      |
| <b>Database</b>   |       |       |       |            |
| Orders per minute                                       | 8,867 | 8,872 | 8,877 | 8,872      |
| <b>Mail</b>   |       |       |       |            |
| Average latency (ms)                                    | 2.9   | 2.9   | 3.0   | 2.9        |
| <b>File and print</b>                                   |       |       |       |            |
| IOPS  | 36.3  | 36.3  | 36.3  | 36.3       |

Figure 17: Detailed run results for the Dell PowerEdge VRTX with one Dell PowerEdge M830 server.

Figure 18 shows the results of our database, mail, and file and print testing as well as power data for the legacy disparate hardware solution we tested. The median run was determined by OPM.

| Legacy, disparate hardware | Run 1 | Run 2 | Run 3 | Median run |
|----------------------------|-------|-------|-------|------------|
| <b>Power</b>               |       |       |       |            |
| Idle power (W)             | 660.2 | 671.4 | 662.9 | 671.4      |
| Active power (W)           | 679.7 | 678.7 | 678.1 | 678.7      |
| <b>Database</b>            |       |       |       |            |
| Orders per minute          | 2,050 | 2,053 | 2,053 | 2,053      |
| <b>Mail</b>                |       |       |       |            |
| Average latency (ms)       | 1.22  | 1.4   | 1.5   | 1.4        |
| <b>File and print</b>      |       |       |       |            |
| IOPS                       | 7.8   | 7.7   | 7.8   | 7.7        |

Figure 18: Detailed run results for the legacy disparate hardware solution from our testing.

## APPENDIX D – TCO CALCULATIONS

In this appendix, we estimate and compare five-year costs for the two solutions we tested in this report. Each solution supports one SQL Server 2014 Standard Edition instance, one Microsoft Exchange 2013 Standard Edition instance, and one instance for file/print—in three VMs on the Dell PowerEdge VRTX solution and on individual servers in the legacy solution.

- Dell PowerEdge VRTX—we include acquisition costs and annual costs to run the Dell PowerEdge VRTX solution we tested in this report.
- Legacy solution—we compared performance of the Dell PowerEdge VRTX to a set of three 4- to 5-year-old HP servers, a shared HP storage array, and a switch. We estimate costs for this solution.

### Assumptions

#### General

- We use current U.S. dollars for all calculations.
- We assume all tasks are executed by a system administrator earning in salary and benefits the equivalent of \$56.09 an hour.<sup>3</sup>
- For the Dell PowerEdge VRTX solution, we assume an existing VMware vCenter server that is not included in this cost analysis.
- We consider only the costs that are platform specific. We thus omit staff costs for tasks that would be common to the two solutions and would require equal or similar effort and cost for the two solutions. These include the cost of setting up and maintaining the SQL Server and Exchange databases, updating the operating system versions, and updating the SQL server versions as updates become available over the five-year TCO timeframe.
- We include only server licensing in this model and omit client access license costs and other client licensing.
- For the legacy solution, we assume the business would repurpose legacy equipment from other uses, so it would need to purchase software for both the legacy and VRTX solutions.
- We include software license costs with acquisition costs and software support costs with annual costs.
- We do not include datacenter costs such as space or build costs because we assume the company would install these solutions in the main office or a branch office, not in a centralized enterprise data center.

#### Acquisition costs

- Acquisition costs for both solutions include software licenses for Microsoft Windows Server, Microsoft SQL Server, and Microsoft Exchange Server. Costs for the Dell PowerEdge M830 server also include VMware vSphere license costs.
- Acquisition costs for the Dell PowerEdge VRTX solution include hardware and five-year hardware support, software licenses, and setup costs.
- Acquisition costs for the Dell PowerEdge M830 server include the 29 percent discount available for this server model in the Dell online store.

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<sup>3</sup> [swz.salary.com/salarywizard/Systems-Administrator-II-Salary-Details.aspx?hdcbxbonus=off&isshowpiechart=true&isshowjobchart=false&isshowsalarydetailcharts=false&isshownextsteps=false&isshowcompanyfct=false&isshowaboutyou=false](http://swz.salary.com/salarywizard/Systems-Administrator-II-Salary-Details.aspx?hdcbxbonus=off&isshowpiechart=true&isshowjobchart=false&isshowsalarydetailcharts=false&isshownextsteps=false&isshowcompanyfct=false&isshowaboutyou=false)

## Yearly costs

- Costs for both solutions include Microsoft Software Assurance costs, energy costs for power and cooling, and hardware management costs.
- We include costs to power and cool the solutions using power utilization measurements we made during testing. We estimate cooling costs equal to power costs.
- For the legacy solution, we assume the business purchases post-warranty hardware support each year from the vendor for the servers and storage array. We include that in yearly costs, not acquisition costs.
- We also include estimates of the cost of additional downtime for the aging legacy servers. We estimate negligible downtime for VRTX and 10 hours per server per year for the older legacy servers. We estimate the cost of that downtime at \$300 an hour assuming a number of users are affected each time one of the servers becomes unavailable.
- Costs for the Dell PowerEdge VRTX solution also include staff costs for the Dell PowerEdge VRTX solution to manage the VMware vSphere 5 virtualization.

## Dell PowerEdge VRTX solution cost

Figure 19 shows the costs we calculated for the Dell PowerEdge VRTX solution.

| Dell PowerEdge VRTX with one Dell PowerEdge M830 server   | Unit  | Cost per unit | Quantity description   | Quantity | Total cost      |
|---|---|---------------|--|----------|-----------------|
| <b>Acquisition costs</b>                                  |   |               |  |          |                 |
| <b>Hardware</b>   |   |               |  |          |                 |
| Dell PowerEdge VRTX platform                              | Platform with 29% discount  | \$20,891      | One VRTX   | 1        | \$20,891        |
| Dell PowerEdge M820 blade server                          | Server with 29% discount  | \$28,089      | One blade  | 1        | \$28,089        |
| <b>Software licenses</b>                                  |   |               |  |          |                 |
| Windows Server 2012 Standard Edition (Software Assurance) | Each server with up to two processors. Up to two VMs per license. | \$883         | One server with four processors requires a license pack for each VM. | 10       | \$8,830         |
| Microsoft SQL Server 2014 Standard (Software Assurance)   | One license per SQL VM  | \$898         | One SQL Server VM for each legacy SQL server                         | 4        | \$3,592         |
| Microsoft Exchange Server 2013 (Software Assurance)       | One license per Exchange VM                                       | \$708         | Two Exchange VMs per legacy exchange server                          | 2        | \$1,416         |
| VMware vSphere 5 Standard Basic support                   | One per processor   | \$995         | Number of processors   | 4        | \$3,980         |
| <b>Setup</b>  | Cost per hour   | \$56          | Number of hours  | 12       | \$673           |
| <b>Total acquisition costs</b>                            |   |               |  |          | <b>\$44,000</b> |

| Dell PowerEdge VRTX with one Dell PowerEdge M830 server   | Unit                                  | Cost per unit | Quantity description   | Quantity | Total cost     |
|---|---------------------------------------|---------------|--|----------|----------------|
| <b>Annual costs</b>                                       |                                       |               |  |          |                |
| <b>Software support</b>                                   |                                       |               |  |          |                |
| Windows Server 2012 Standard Edition (Software Assurance) | Each server with up to two processors | \$221         | One server with four processors requires a license pack for each VM. | 10       | \$2,210        |
| Microsoft SQL Server 2012 Standard (Software Assurance)   | One license per SQL VM                | \$225         | One SQL Server VM for each legacy SQL server                         | 4        | \$898          |
| Microsoft Exchange Server 2013 (Software Assurance)       | One server                            | \$177         | Two Exchange VMs per legacy exchange server                          | 2        | \$354          |
| VMware vSphere 5 Standard Basic support                   | One per processor per year            | \$273         | Number of processors   | 4        | \$1,092        |
| <b>Energy cost for power and cooling</b>                  | Platform                              | \$759         | One VRTX   | 1        | \$759          |
| <b>Hardware management</b>                                | Cost per hour                         | \$56          | Number hours   | 12       | \$673          |
| <b>VMware management</b>                                  | Cost per hour                         | \$56          | Number hours   | 24       | \$1,346        |
| <b>Total annual costs</b>                                 |                                       |               |  |          | <b>\$7,332</b> |
| <b>Average cost per month</b>                             |                                       |               |  |          | <b>\$611</b>   |

Figure 19: Cost analysis for the Dell PowerEdge VRTX with one Dell PowerEdge M830 server. (Totals may not sum due to rounding.)

## Legacy solution costs

Figure 20 shows the costs we calculated for the legacy solution.

| Legacy costs  | Unit  | Cost per unit | Quantity description                    | Quantity | Total cost      |
|---|---|---------------|---|----------|-----------------|
| <b>Acquisition costs</b>                                  |   |               |   |          |                 |
| <b>Software licenses</b>                                  |   |               |   |          |                 |
| Windows Server 2012 Standard Edition (processor licenses) | Each server with up to two processors. Up to two VMs per license. | \$883         | Servers with one or two processors each | 9        | \$7,947         |
| Microsoft SQL Server 2012 Standard (processor licenses)   | One server  | \$898         | Servers with SQL installed              | 4        | \$3,592         |
| Microsoft Exchange Server 2013 Standard (server licenses) | One server  | \$708         | Servers with Exchange                   | 1        | \$708           |
| <b>Setup</b>  |   |               |   |          |                 |
|   | Cost per hour   | \$56          | Number hours                            | 36       | \$2,019         |
| <b>Total acquisition costs</b>                            |   |               |   |          | <b>\$14,266</b> |
| <b>Annual costs</b>                                       |   |               |   |          |                 |
| <b>Support</b>  |   |               |   |          |                 |
| Windows Server 2012 Standard Edition (Software Assurance) | Each server with up to two processors                             | \$221         | Servers with one or two processors each | 9        | \$1,989         |
| Microsoft SQL Server 2012 Standard (Software Assurance)   | One server  | \$225         | Servers with SQL installed              | 4        | \$898           |
| Microsoft Exchange 2013 Standard (Software Assurance)     | One server  | \$177         | Server with Exchange installed          | 1        | \$177           |
| Hardware support - SQL Server                             | HP extended support agreement with one year term for one server   | \$338         | One year                                | 4        | \$1,352         |
| Hardware support - Exchange server                        | HP extended support agreement with one year term for one server   | \$986         | One year                                | 1        | \$986           |
| Hardware support - File server                            | HP extended support agreement with one year term for one server   | \$214         | One year                                | 4        | \$856           |

| Legacy costs                             | Unit  | Cost per unit | Quantity description   | Quantity | Total cost      |
|--|---|---------------|--|----------|-----------------|
| Hardware support - storage array         | HP extended support agreement with one year term for one server | \$1,553       | One year   | 1        | \$1,553         |
| <b>Energy cost for power and cooling</b> |   |               |  |          |                 |
|  | Legacy configuration  | \$2,401       | One year   | 1        | \$2,401         |
| <b>Hardware management</b>               |   |               |  |          |                 |
|  | Per solution  | \$50          | Estimate at two hours a month per server + one hour a month for storage array per year | 228      | \$11,400        |
| <b>Downtime cost</b>                     |   |               |  |          |                 |
|  | Per hour downtime cost  | \$300         | Each server down for multiple hours a year   | 54       | \$16,200        |
| <b>Legacy annual costs</b>               |   |               |  |          | <b>\$37,812</b> |
| <b>Average cost per month</b>            |   |               |  |          | <b>\$3,151</b>  |

Figure 20: Cost analysis for the legacy solution. (Totals may not sum due to rounding.)

## ABOUT PRINCIPLED TECHNOLOGIES



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