VMMARK 2.5.2 VIRTUALIZATION PERFORMANCE OF DELL STORAGE SC4020 ARRAY

Dell™ Storage SC4020

achieved a VMware® VMmark® score of **31.35 @ 30 tiles**

SSD performance for virtualized mixed workloads

The efficiency of virtual machines (VMs) in data centers depends heavily on storage. Embracing the speed that solid-state drives (SSDs) offer over traditional hard disk drives (HDDs) allows organizations to run more VMs for increased levels of virtualized workloads leveraging the same infrastructure. However, multiple VMs sending input/output (I/O) streams to storage can decrease performance and increase latency, which negatively affects end-user applications.

Measuring and analyzing the storage performance of a virtualized environment can decrease the risk of latency bottlenecks but can be challenging. VMware VMmark 2.5.2 is a benchmark that measures the performance of virtual environments and exercises all layers of the virtualization stack. In addition to running workloads on the VMs, VMmark integrates VMware platform-level features such as vMotion® and Storage vMotion® into its testing. VMmark expresses scores in terms of tiles; a tile consists of eight VMs that include database servers, Web servers, mail servers, and standby servers.

In the Principled Technologies labs, the Dell Storage SC4020 array, paired with a cluster of Dell PowerEdge R620 servers, supported 30 VMmark tiles to total 240 running VMs, and achieved a score of 31.35@30 tiles. This score indicates that the Dell Storage SC4020 array can simultaneously handle multiple virtualized applications and hypervisor operations while maintaining a strong level of performance. The SC4020 can provide the benefits of increased virtualized workloads supported by SSDs without serious detriment to storage performance.

WHAT WE TESTED

Dell Storage SC4020 10GbE iSCSI storage array paired with Dell PowerEdge R620 servers

The Dell Storage SC4020 is a Flash-optimized solution designed to provide high-performance and low-latency. The 2U Fibre Channel SAN storage array features up to 24 internal drives slots and can additionally support up to 96 external slots, allowing for up to 408 TB of total storage. According to Dell, it offers the benefits of enterprise-class storage for small- to mid-sized deployments. To learn more about the Dell Storage SC4020, visit www.dell.com/us/business/p/dell-compellent-sc4020/pd.

As our goal was to discover the capabilities of the storage, we used six Dell PowerEdge R620 servers in a cluster. By splitting the workload responsibilities among the R620 servers, we achieved a score of 31.35@30 tiles.

VMmark 2.5.2

We selected VMmark 2.5.2 to measure the performance of the Dell Storage SC4020 array. To compare platforms for virtualization, users need meaningful and accurate metrics. Synthetic benchmarks developed to measure performance in non-virtualized environments work by exercising one or more of the underlying hardware resources. However, they can be less helpful in demonstrating the scalability of virtual environments supporting multiple simultaneous workloads.

Some multi-workload server consolidation benchmarks, such as VMware VMmark 1.1, measure single-host performance in virtualized environments. However, typical server usage is evolving as technological advances enable easier virtualization of bursty and heavy workloads, dynamic virtual machine relocation, dynamic virtual disk relocation, and the automation of many provisioning and administrative tasks across large-scale multi-host environments. Now, the underlying infrastructure operations may generate some stress on CPU, network, disk, and memory subsystems. Application performance also depends on effectively balancing load across multiple hosts. To be useful in this environment, a benchmark needs to look at both user-centric application performance and overall platform performance.

VMware VMmark 2.5.2, which has become an industry standard, meets these criteria. In addition to using this unique benchmark approach, VMware maintains very strict standards for execution and publication.

THE DELL STORAGE SC SERIES & VMWARE COMBINATION

In the past, lack of integration between the hypervisor and the underlying storage infrastructure prevented virtualized servers from taking full advantage of the data protection and performance features of enterprise-class storage. Thanks to VMware vSphere Storage APIs (VAAI), this is no longer the case. Dell Storage SC Series arrays fully support VAAI, and as such, all of their capabilities are integrated into the VMware infrastructure environment.

According to Dell, the SC4020 array delivers the following features and management capabilities, all of which are compatible with VMware environments:

- **Flash optimization.** SC Series arrays are built to leverage SSDs for pure Flash and hybrid solutions for better performance.
- **Write-layer performance improvements.** All writes are directed to Tier 1 drives at RAID 10 performance levels, which can speed up performance.
- **Auto-tiering efficiency.** Data written at RAID 10 is automatically converted to RAID 5 to save Tier 1 space without hurting performance.
- **Automated RAID provisioning.** Virtual RAID pools provision automatically when drives are changed to ease the management burden.
- **Integrated NAS.** The SC4020 integrates fully with Dell Storage FS8600.

Dell SC Storage, like VMware, is built upon a virtualization engine. VMware is built to virtualize guest operating systems while Dell Storage Center OS virtualizes the storage within a Dell SC Series array. This virtualization engine allows Dell to implement enterprise features such as Automatic Tiering, not only between disk tiers, but also between RAID types by intelligently placing data on the right disk tier at the right RAID type to maximize the efficiency and performance. This virtualized architecture allows for additional enterprise SAN technologies such as thin provisioning, thin writes, thin clones, and space-efficient snapshots. In addition, Dell has many VMware integrations to simplify operations for both VMware administrators and storage administrators. These include vCenter Operations Manager Solution Pack for Dell to gain deep storage analytics, vCenter Plugins to manage storage from the native and Web clients, VASA integration to assist with VM data placement, VAAI integrations to boost performance and efficiency, and a Site Recovery Manager Adapter to ease disaster-recovery planning and execution. Storage administrators can also easily view or create datastores for the VMware environment by just connecting the Dell Storage Enterprise Manager to the vCenter Infrastructure.

EASE OF MANAGEMENT

Dell Compellent Enterprise Manager provides tools for administrators to have a high-level view of the storage system, while providing the flexibility to make granular changes as needed.[1] Figure 1 depicts the Enterprise Manager UI, where administrators can manage the SAN and to monitor it for any issues.

Figure 1: Monitoring the SAN using Compellent Enterprise Manager.
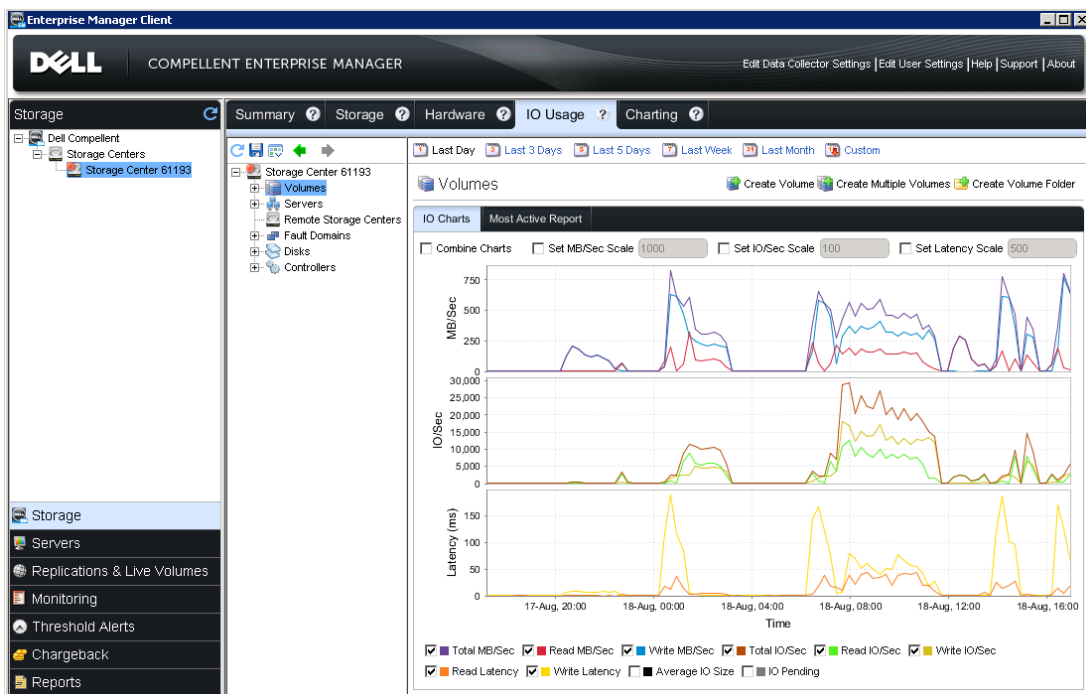
OUR TESTING

VMmark is a benchmarking tool that measures the performance and scalability of real-world applications running in virtualized environments. It is designed to measure virtual datacenter performance accurately and reliably using predefined tiles, or sets of VMs, and is used to compare the performance of different hardware and virtualization configurations. To successfully support a tile, acceptable QoS levels must be met, and scores are given based on the number of operations or transactions the multiple applications are able to complete during the test.

A VMmark tile is composed of the following:

- A virtual Microsoft Exchange Server 2007 with 1,000 heavy profile users
- Two Olio virtual machines (Olio Web and Olio Database) that simulate a Web 2.0 application focused and social networking and events

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[1] For more information on Dell Compellent Enterprise Manager, see www.dell.com/downloads/emea/products/pvaul/dell_compellent_management_suite_en.pdf.

- Four DVD Store Version 2 (DS2) virtual machines (three DS2 Web servers and one DS2 database) that simulate an E-commerce application
- One virtual Windows Server 2003 that serves as a standby machine

In addition to running the virtualized applications, VMmark also performs the following tasks during a test:
- Virtual machine cloning and deployment
- Dynamic virtual machine relocation using vMotion
- Dynamic Storage Relocation using Storage vMotion
- Automated virtual machine load balancing

To carry out the VMmark testing, we downloaded the benchmark from www.vmware.com/products/vmmark/. We followed the test directions in the VMware VMmark Benchmarking Guide (VMmark_Benchmarking_Guide_2.5.2.pdf), included with the download of VMmark 2.5.2 made publicly available on February 12, 2014. We used the guide's instructions to build the mail server, standby, and deploy template VMs from scratch. For the Oliodb, OlioWeb, DS2DB, and DS2Web VMs, we used the VMmark prebuilt templates.

Learn more about VMmark at www.vmware.com/products/vmmark/overview.html.

ANALYZING THE RESULTS

As Figure 2 shows, the Dell Storage SC4020 array offered consistent operations per second throughout the run, averaging 43,225 IOPS. VMmark provides a persistent load on the storage, and as Figure 2 shows, the storage was able to handle it well.
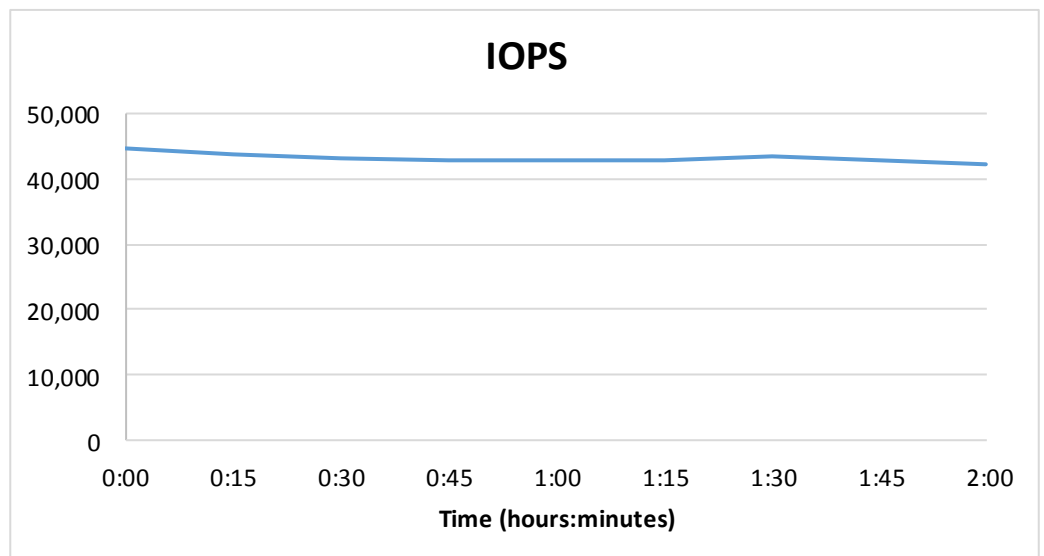
Figure 2: I/O operations per second during the VMmark run.

In addition to consistent level of IOPS, the Dell Storage SC4020 array demonstrated acceptably low latencies, with latencies averaging around 3 ms through the test run and experiencing peaks of only 8 to 10 ms. With lower latency from the SC4020, applications have lower wait times for retrieving data. The latency during the run was consistently below four milliseconds, spiking only during vMotion bursts.

Figure 3: Latency for the Dell Storage SC2040 during the VMmark run.
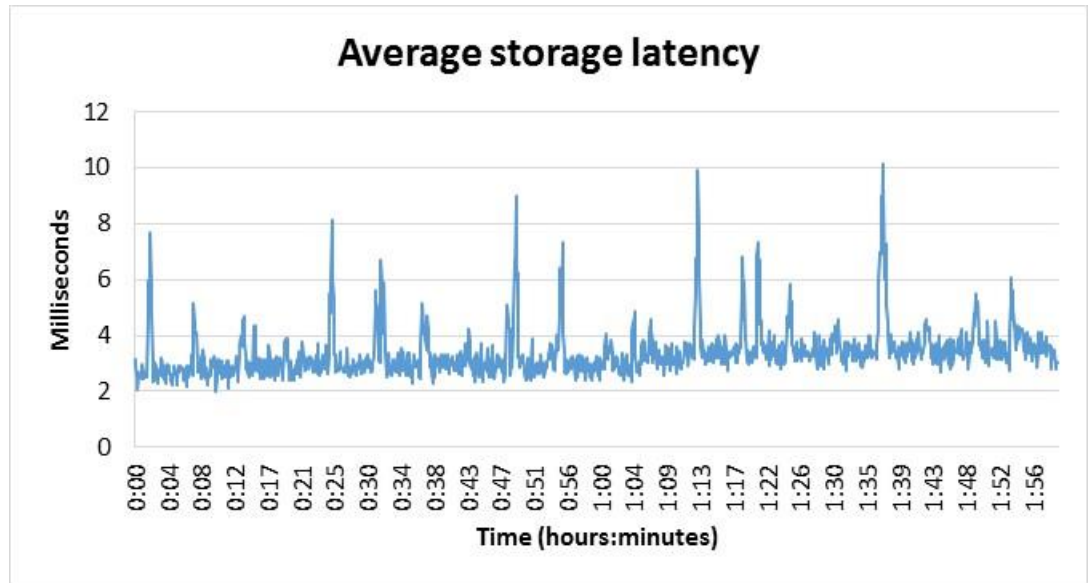
For a detailed look at our hardware configuration, see Appendix A. See Appendix B for our test bed diagram and Appendix C for detailed VMmark 2.5.2 results.

CONCLUSION

The Dell Storage SC4020 array, paired with a cluster of Dell PowerEdge M620 servers, ran 30 VMmark tiles totaling 240 running VMs, and achieved a score of 31.35@30 tiles. This performance, along with its value and ease of management, make the Dell Storage SC4020 array an excellent investment.

APPENDIX A – STORAGE DISCLOSURE AND SYSTEM CONFIGURATION

Figure 4 presents detailed configuration information about the servers we used in testing.

System	Dell PowerEdge R620 (servers under test)	Dell PowerEdge M620 (virtual client hosts)
Enclosure /chassis		
Blade enclosure/chassis	N/A	Dell PowerEdge M1000e Blade Enclosure with 2x MXL 10/40Gbe and 4x Force 10 XML 10/40GbE switch
General		
Number of processor packages	2	2
Number of cores per processor	12	8
Number of hardware threads per core	2	2
CPU		
Vendor	Intel®	Intel
Name	Xeon®	Xeon
Model number	E5-2695 v2	E5-2660
Socket type	LGA2011	LGA2011
Core frequency (GHz)	2.40	2.20
Bus frequency	8.0 GT/s	8.0 GT/s
L1 cache	32 KB + 32 KB	32 KB + 32 KB
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache	20 MB	20 MB
Platform		
Vendor and model	Dell PowerEdge R620	Dell PowerEdge M620
BIOS name and version	Dell 2.2.2	Dell 2.2.7
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	384	32
Vendor and model number	Hynix® HMT42GR7MFR4C-PB	Hynix HMT42GR7MFR4C-PB
Type	PC3-12800R	PC3-12800R
Speed (MHz)	1,600	1,600
Speed running in the system (MHz)	1,600	1,600
Size (GB)	16	16
Number of RAM module(s)	24	2
Rank	Dual	Dual
OS/hypervisor		
Name	VMware ESXi 5.5.0	VMware ESXi 5.5.0
Build number	1881737	1746018
File system	VMFS	VMFS
Language	English	English
RAID controller		
Vendor and model number	PERC H710P Mini	PERC H310 Mini

System	Dell PowerEdge R620 (servers under test)	Dell PowerEdge M620 (virtual client hosts)
Hard drives		
Vendor and model number	Dell MBF2600RC	Dell MBF2600RC
Number of drives	2	2
Size (GB)	600	600
Type	SAS	SAS
Network adapter		
Vendor and model number	Broadcom® NetXtreme® II BCM57800 10GB	Broadcom NetXtreme II BCM57810 10GB
Number of ports	2	2
Type	Integrated	Integrated
Ethernet adapter B		
Vendor and model number	Broadcom® NetXtreme® II BCM57810 10GB	Intel 82599EB 10GB
Number of ports	2	2
Type	PCIe card	Mezzanine card
Ethernet adapter C		
Vendor and model number	Broadcom® NetXtreme® II BCM57800 1GB	Intel 82599EB 10GB
Number of ports	2	2
Type	Integrated	Mezzanine card

Figure 4: System configuration information for our test servers.

Figure 5 provides configuration information about the Dell Storage SC4020 array we used in our tests.

Storage array	Dell Storage SC4020
Number of storage shelves	1 x 24 disks enclosure
Number of storage controllers	2
Firmware revision	6.5.2.8
Disk model number	12 x LB406S
Disk size (GB)	372
Disk type	SAS SSD
Disk model number	12 x LB1606R
Disk size (TB)	1.46
Disk type	SAS SSD

Figure 5: Detailed configuration information for the storage array.

APPENDIX B – TEST BED CONFIGURATION

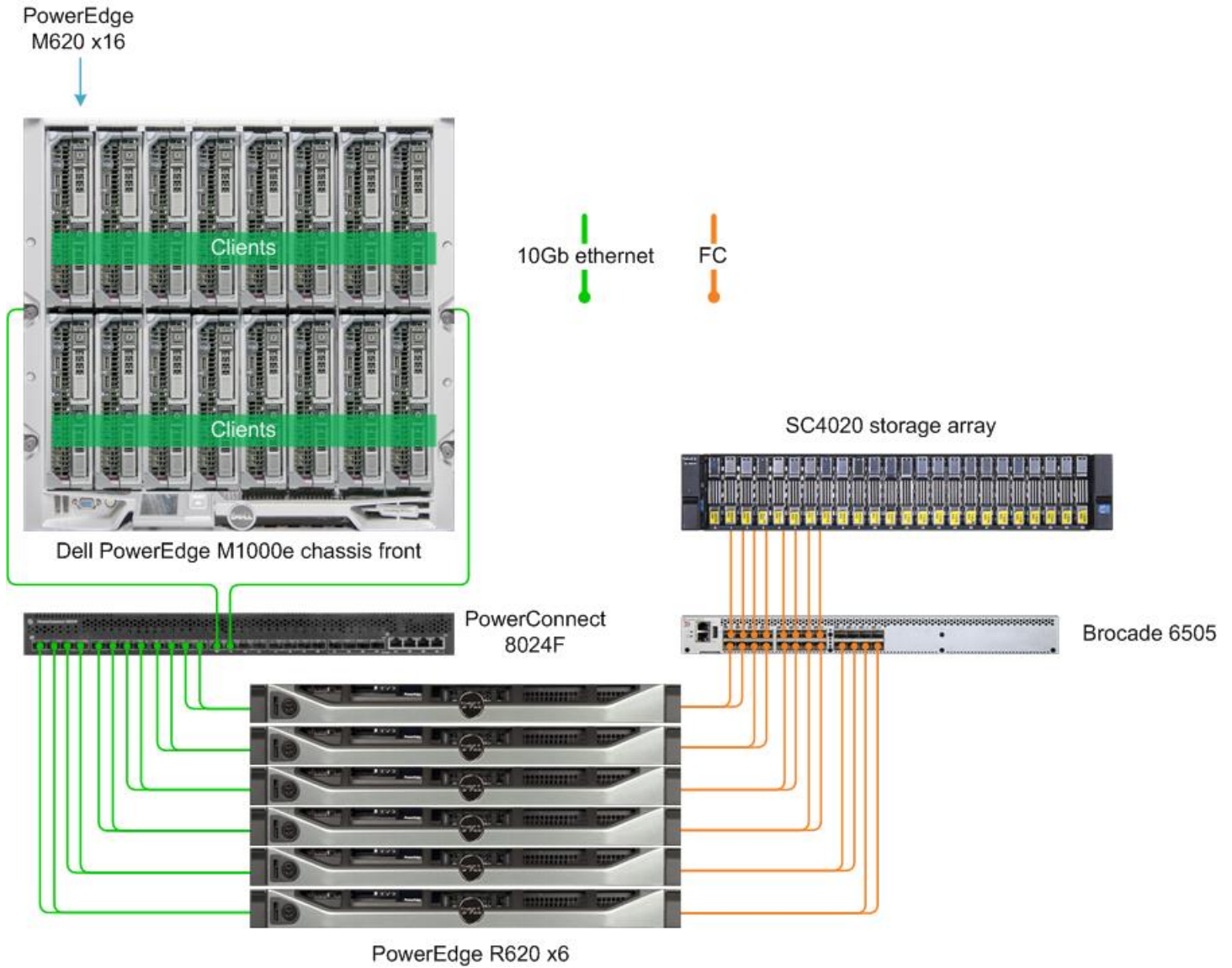Figure 6 shows how we set up the test configuration.

Figure 6: Configuration of our test bed.

APPENDIX C – VMMARK 2.5.2 DETAILED RESULTS

VMware® VMmark® V2.5.2 Results

Vendor and Hardware Platform: Dell PowerEdge R620
Virtualization Platform: VMware ESXi 5.5.0 Update 1 Build 1881737
VMware vCenter Server 5.5.0 Build 1750787

VMmark V2.5.2 Score = 31.35 @ 30 Tiles

Number of Hosts: 6	Uniform Hosts [yes/no]: yes	Total sockets/cores/threads in test: 12/144/288

Tested By: Principled Technologies	Test Date: [08-21-2014]

Performance Section	Configuration Section	Notes Section
Performance	Configuration	Notes for Workload

Performance

	mailserver			olio			dvdstoreA			dvdstoreB			dvdstoreC			
TILE_0	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	328.25	0.99	120.42	4757.48	1.03	67.25	3316.75	1.51	99.46	2313.20	1.52	111.36	1623.47	1.53	119.22	1.29
p1	325.20	0.98	137.25	4754.68	1.02	70.97	3123.75	1.42	111.19	2332.97	1.54	122.92	1655.17	1.56	133.85	1.28
p2	328.05	0.99	149.25	4750.43	1.02	78.33	3058.55	1.39	115.48	2098.57	1.38	131.08	1530.42	1.45	141.29	1.23
TILE_1	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.00	0.99	126.75	4774.05	1.03	68.42	3295.45	1.50	100.15	2440.70	1.61	107.46	1730.97	1.64	115.80	1.32
p1	328.70	1.00	147.75	4772.70	1.03	76.67	3203.28	1.46	105.15	2308.72	1.52	117.84	1715.25	1.62	125.60	1.30
p2	327.75	0.99	158.25	4757.80	1.03	81.75	3141.40	1.43	109.88	2170.35	1.43	123.77	1505.40	1.42	135.02	1.24
TILE_2	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM

	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.98	0.99	118.75	4759.98	1.03	63.34	3411.28	1.55	94.02	2554.78	1.68	104.30	1896.92	1.79	106.16	1.37
p1	331.45	1.00	141.50	4757.95	1.03	70.90	3413.22	1.55	93.09	2393.40	1.58	104.16	1779.95	1.68	109.33	1.33
p2	326.57	0.99	155.00	4759.77	1.03	72.85	3311.97	1.51	98.51	2330.40	1.53	108.79	1655.00	1.56	114.45	1.30
TILE_3	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	321.12	0.97	123.28	4744.77	1.02	70.73	3307.15	1.50	100.98	2370.68	1.56	114.01	1774.85	1.68	120.81	1.31
p1	326.10	0.99	147.25	4754.65	1.02	76.22	3327.07	1.51	97.72	2334.32	1.54	108.35	1636.72	1.55	116.74	1.29
p2	324.07	0.98	161.25	4759.07	1.03	81.90	3185.80	1.45	106.10	2305.10	1.52	117.35	1648.85	1.56	124.45	1.28
TILE_4	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	326.32	0.99	138.50	4765.35	1.03	76.65	3239.12	1.47	104.34	2327.25	1.53	117.27	1655.40	1.56	125.22	1.29
p1	326.32	0.99	155.75	4743.05	1.02	84.97	3252.53	1.48	101.55	2289.65	1.51	112.29	1621.25	1.53	118.64	1.28
p2	331.60	1.00	166.93	4769.12	1.03	82.72	3184.62	1.45	106.37	2310.38	1.52	117.43	1712.42	1.62	125.41	1.30
TILE_5	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	326.12	0.99	134.75	4761.77	1.03	69.20	3266.93	1.49	102.53	2350.80	1.55	115.65	1667.12	1.58	124.04	1.30
p1	329.85	1.00	155.75	4751.23	1.02	75.69	3339.20	1.52	96.95	2450.45	1.61	105.85	1738.60	1.64	113.56	1.33
p2	324.57	0.98	164.00	4763.18	1.03	77.41	3233.03	1.47	103.36	2255.20	1.49	115.88	1662.70	1.57	123.23	1.28
TILE_6	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	322.15	0.98	122.33	4758.30	1.03	65.12	3383.38	1.54	96.27	2368.82	1.56	107.64	1668.78	1.58	114.86	1.31
p1	325.10	0.98	140.20	4774.50	1.03	70.04	3483.18	1.58	89.64	2538.80	1.67	99.08	1903.70	1.80	105.26	1.37
p2	329.90	1.00	151.50	4763.10	1.03	75.00	3301.78	1.50	100.42	2291.57	1.51	112.66	1608.45	1.52	121.55	1.29

	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
TILE_7	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.32	0.99	132.25	4754.18	1.02	72.11	3318.12	1.51	99.76	2486.38	1.64	110.10	1773.92	1.68	119.66	1.33
p1	328.95	1.00	152.00	4766.45	1.03	77.35	3166.55	1.44	108.67	2192.40	1.44	122.18	1593.00	1.51	132.05	1.26
p2	324.48	0.98	163.25	4768.32	1.03	82.03	3115.53	1.42	111.90	2164.80	1.43	125.31	1494.75	1.41	136.48	1.24
TILE_8	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.48	0.99	123.70	4752.02	1.02	68.90	3107.62	1.41	113.33	2190.78	1.44	130.47	1618.85	1.53	138.97	1.26
p1	328.50	0.99	143.72	4764.68	1.03	69.09	3139.20	1.43	109.67	2164.10	1.43	124.97	1494.62	1.41	136.23	1.24
p2	329.50	1.00	157.00	4759.23	1.03	75.98	3001.47	1.36	119.85	2127.35	1.40	135.92	1498.15	1.42	146.46	1.23
TILE_9	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	322.20	0.98	137.50	4767.57	1.03	65.58	3258.68	1.48	103.00	2258.72	1.49	116.86	1665.78	1.57	124.26	1.28
p1	328.05	0.99	161.25	4761.35	1.03	72.68	3218.57	1.46	104.42	2236.78	1.47	118.02	1570.75	1.48	125.48	1.27
p2	331.40	1.00	176.25	4775.75	1.03	81.85	3146.18	1.43	108.08	2280.25	1.50	120.74	1689.72	1.60	129.10	1.29
TILE_10	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	328.15	0.99	138.00	4749.88	1.02	70.51	3264.55	1.48	102.47	2274.00	1.50	115.16	1591.30	1.50	123.89	1.28
p1	327.60	0.99	157.75	4756.88	1.02	73.21	3185.78	1.45	107.82	2312.80	1.52	118.33	1621.35	1.53	127.93	1.28
p2	327.25	0.99	169.25	4761.25	1.03	78.89	3205.62	1.46	105.18	2236.40	1.47	117.49	1653.42	1.56	124.41	1.28
TILE_11	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.65	0.99	133.25	4765.68	1.03	71.95	3317.45	1.51	99.41	2323.15	1.53	110.98	1624.17	1.54	119.95	1.29
p1	325.38	0.99	153.00	4776.70	1.03	72.50	3300.10	1.50	99.60	2390.85	1.57	110.52	1791.50	1.69	116.60	1.32

	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p2	330.95	1.00	156.75	4749.82	1.02	79.99	3268.35	1.49	101.48	2271.78	1.50	114.32	1602.03	1.51	120.96	1.28
TILE_12	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	325.82	0.99	164.50	4745.05	1.02	78.34	3124.80	1.42	111.59	2258.00	1.49	124.03	1611.47	1.52	132.01	1.27
p1	324.55	0.98	182.50	4744.73	1.02	80.62	3109.60	1.41	111.67	2147.15	1.41	125.99	1594.03	1.51	132.70	1.25
p2	328.18	0.99	190.75	4750.23	1.02	87.55	3035.78	1.38	115.97	2100.47	1.38	130.96	1484.00	1.40	138.58	1.22
TILE_13	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	323.40	0.98	181.07	4741.73	1.02	91.41	3208.30	1.46	106.43	2313.28	1.52	119.11	1726.67	1.63	126.14	1.29
p1	323.12	0.98	197.25	4736.60	1.02	94.91	3103.40	1.41	112.79	2149.70	1.42	126.68	1494.03	1.41	137.11	1.23
p2	325.45	0.99	207.50	4734.65	1.02	102.75	3043.85	1.38	116.30	2185.95	1.44	129.77	1547.15	1.46	138.81	1.24
TILE_14	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	329.27	1.00	179.00	4733.18	1.02	87.33	3277.95	1.49	102.24	2248.78	1.48	118.38	1668.10	1.58	124.73	1.29
p1	330.38	1.00	191.75	4757.25	1.02	92.17	3163.60	1.44	107.94	2188.05	1.44	122.14	1546.95	1.46	129.37	1.25
p2	330.73	1.00	200.75	4729.80	1.02	97.50	3146.72	1.43	108.45	2351.07	1.55	120.37	1693.70	1.60	128.42	1.29
TILE_15	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	326.57	0.99	185.00	4744.02	1.02	86.14	1975.17	0.90	102.81	2325.45	1.53	111.39	1603.97	1.52	122.53	1.16
p1	321.02	0.97	202.75	4738.15	1.02	90.09	1838.10	0.84	116.95	2256.05	1.49	124.61	1591.90	1.50	134.14	1.13
p2	330.43	1.00	217.25	4750.65	1.02	98.50	1862.72	0.85	113.33	2315.05	1.52	117.86	1708.00	1.61	126.29	1.16
TILE_16	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	323.18	0.98	180.00	4725.25	1.02	91.11	3242.47	1.47	104.15	2272.30	1.50	116.18	1582.15	1.50	124.73	1.27

	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p1	329.05	1.00	193.25	4732.93	1.02	93.03	3095.50	1.41	113.92	2217.25	1.46	127.32	1631.90	1.54	137.28	1.26
p2	327.93	0.99	202.75	4733.35	1.02	97.31	3188.15	1.45	106.83	2300.10	1.51	118.51	1548.25	1.46	128.84	1.27
TILE_17	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	329.85	1.00	182.75	4766.02	1.03	80.87	3281.88	1.49	101.57	2410.70	1.59	110.75	1695.22	1.60	120.62	1.31
p1	325.82	0.99	194.00	4757.27	1.02	84.43	3222.20	1.47	104.66	2254.00	1.48	117.14	1664.42	1.57	123.70	1.28
p2	329.95	1.00	197.00	4763.85	1.03	91.21	3261.15	1.48	101.83	2365.68	1.56	113.03	1682.60	1.59	120.60	1.30
TILE_18	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.18	0.99	179.05	4743.68	1.02	83.49	3200.43	1.46	105.56	2333.53	1.54	115.81	1746.50	1.65	122.09	1.30
p1	327.10	0.99	193.72	4745.02	1.02	86.79	3057.12	1.39	115.30	2140.22	1.41	128.30	1496.20	1.41	137.41	1.23
p2	329.10	1.00	201.75	4718.82	1.02	96.08	3131.65	1.42	109.04	2266.75	1.49	121.42	1614.15	1.53	129.49	1.27
TILE_19	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	327.55	0.99	295.55	4750.30	1.02	82.42	3188.25	1.45	108.60	2231.32	1.47	119.49	1595.67	1.51	132.62	1.27
p1	327.25	0.99	252.50	4731.55	1.02	84.87	3095.60	1.41	114.60	2208.20	1.45	128.34	1540.28	1.46	140.31	1.25
p2	324.95	0.98	241.00	4730.40	1.02	91.59	3063.10	1.39	116.70	2197.90	1.45	129.33	1518.55	1.44	142.70	1.24
TILE_20	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	328.35	0.99	177.00	4747.02	1.02	94.70	3416.75	1.55	94.39	2400.60	1.58	104.40	1681.47	1.59	112.49	1.32
p1	325.30	0.99	188.25	4721.82	1.02	98.39	3241.45	1.47	103.79	2343.12	1.54	115.29	1671.47	1.58	122.78	1.29
p2	327.85	0.99	199.50	4740.73	1.02	100.71	3280.43	1.49	100.70	2371.70	1.56	112.13	1762.70	1.67	119.67	1.32
TILE_21	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM

	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	331.70	1.00	203.50	4711.43	1.02	107.86	3237.45	1.47	102.96	2281.88	1.50	113.38	1592.00	1.50	123.08	1.28
p1	334.85	1.01	223.75	4726.15	1.02	112.25	3103.93	1.41	111.27	2341.12	1.54	120.95	1674.20	1.58	130.26	1.29
p2	327.35	0.99	232.05	4728.93	1.02	115.71	3087.70	1.40	112.47	2160.35	1.42	124.29	1585.92	1.50	132.62	1.25
TILE_22	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	328.98	1.00	203.68	4745.95	1.02	96.20	3172.65	1.44	107.00	2951.03	1.94	72.90	2116.12	2.00	78.38	1.42
p1	326.12	0.99	209.35	4748.77	1.02	99.56	3065.50	1.39	113.64	2905.12	1.91	75.22	2205.22	2.08	78.44	1.41
p2	325.80	0.99	216.50	4727.07	1.02	104.75	3076.30	1.40	112.82	2757.88	1.82	79.00	1997.95	1.89	80.93	1.37
TILE_23	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	326.57	0.99	193.75	4752.82	1.02	92.16	3344.20	1.52	97.01	2511.95	1.65	106.87	1829.15	1.73	112.58	1.35
p1	326.90	0.99	205.00	4761.35	1.03	93.91	3194.40	1.45	107.15	2208.90	1.45	121.28	1620.08	1.53	130.02	1.27
p2	326.12	0.99	214.00	4725.68	1.02	98.21	3249.60	1.48	102.70	2287.53	1.51	113.35	1586.53	1.50	123.64	1.27
TILE_24	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	325.38	0.99	190.95	4752.45	1.02	94.71	3498.28	1.59	89.15	2460.62	1.62	98.83	1824.42	1.72	104.84	1.35
p1	322.40	0.98	203.75	4715.88	1.02	95.71	3272.97	1.49	102.77	2334.68	1.54	116.32	1664.20	1.57	124.30	1.29
p2	325.38	0.99	211.25	4751.12	1.02	106.33	3266.80	1.49	101.10	2384.88	1.57	110.83	1708.05	1.61	116.96	1.31
TILE_25	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	329.80	1.00	196.05	4746.35	1.02	91.84	3294.32	1.50	100.35	2376.53	1.56	112.92	1567.55	1.48	125.88	1.29
p1	326.12	0.99	204.00	4742.80	1.02	89.07	3075.32	1.40	115.41	2145.72	1.41	128.56	1536.47	1.45	141.88	1.24
p2	323.12	0.98	203.93	4751.95	1.02	95.80	3031.43	1.38	117.57	2184.32	1.44	130.61	1591.00	1.50	142.46	1.24

TILE_26	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	324.35	0.98	180.25	4763.80	1.03	86.85	3502.22	1.59	89.51	2520.53	1.66	101.22	1783.90	1.69	109.43	1.35
p1	323.05	0.98	194.00	4746.70	1.02	95.16	3185.75	1.45	107.16	2328.38	1.53	117.09	1642.00	1.55	127.11	1.28
p2	327.68	0.99	202.25	4737.77	1.02	102.40	3292.40	1.50	99.73	2305.60	1.52	111.48	1697.15	1.60	118.67	1.30
TILE_27	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	328.38	0.99	199.00	4734.70	1.02	88.79	3475.15	1.58	89.76	2568.15	1.69	97.77	1834.97	1.73	103.84	1.36
p1	323.15	0.98	209.50	4741.20	1.02	92.79	3218.95	1.46	104.31	2347.15	1.55	115.11	1749.10	1.65	121.81	1.30
p2	327.75	0.99	221.75	4761.60	1.03	93.76	3278.45	1.49	100.21	2323.07	1.53	110.04	1628.22	1.54	118.14	1.29
TILE_28	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	326.98	0.99	193.78	4739.15	1.02	91.69	3319.20	1.51	98.30	2515.95	1.66	107.04	1807.55	1.71	114.97	1.34
p1	327.52	0.99	202.75	4743.45	1.02	92.95	3095.05	1.41	113.94	2153.75	1.42	127.58	1551.78	1.47	139.81	1.24
p2	328.32	0.99	209.00	4718.38	1.02	99.48	3123.40	1.42	110.61	2200.97	1.45	121.22	1541.80	1.46	130.50	1.25
TILE_29	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	Actual	Ratio	QoS	GM
p0	325.25	0.98	199.25	4763.88	1.03	91.20	3320.00	1.51	99.53	2398.45	1.58	110.69	1797.85	1.70	116.45	1.33
p1	327.90	0.99	204.00	4750.32	1.02	89.67	3222.78	1.47	105.13	2251.43	1.48	117.03	1585.42	1.50	124.52	1.27
p2	326.73	0.99	206.75	4737.88	1.02	97.50	3099.93	1.41	112.98	2238.25	1.47	125.12	1596.47	1.51	132.72	1.26

p0_score:	39.16
p1_score:	38.33
p2_score:	38.07

Infrastructure_Operations_Scores:	vmotion	svmotion	deploy
Completed_Ops_PerHour	52.50	30.00	15.00
Avg_Seconds_To_Complete	25.97	60.30	362.67
Failures	0.00	0.00	0.00
Ratio	3.28	3.33	3.75
Number_Of_Threads	3	3	3

Summary	Run_Is_Compliant	Turbo_Setting:0
	Number_Of_Compliance_Issues(0)*	Median_Phase(p1)
Unreviewed_VMmark2_Applications_Score	38.33	
Unreviewed_VMmark2_Infrastructure_Score	3.45	
Unreviewed_VMmark2_Score	31.35	

Configuration

Virtualization Software	
Hypervisor Vendor, Product, Version, and Build / Availability Date (MM-DD-YYYY)	VMware ESXi 5.5.0 Update 1 Build 1881737 / 06-10-2014
Datacenter Management Software Vendor, Product, Version, and Build / Availability Date (MM-DD-YYYY)	VMware vCenter Server 5.5.0 Build 1750787 / 04-19-2014
Supplemental Software	None
Servers	
Quantity	6
Server Manufacturer and Model	Dell PowerEdge R620
Processor Vendor and Model	Intel Xeon E5-2695 v2
Processor Speed (GHz)	2.4

Total Sockets/Total Cores/Total Threads	2 Sockets / 24 Cores / 48 Threads
Primary Cache	32 KB I + 32 KB D on chip per core
Secondary Cache	256KB I+D on chip per core
Other Cache	30MB I+D on chip per core
BIOS Version	2.2.2
Memory Size (in GB, Number of DIMMs)	384, 24 DIMMs
Memory Type and Speed	16GB DIMMs 2Rx4 DDR3-1600MHz Registered ECC
Disk Subsystem Type	FC SAN
Number of Disk Controllers	1
Disk Controller Vendors and Models	Dell Storage SC4020
Number of Host Bus Adapters	1
Host Bus Adapter Vendors and Models	QLogic QLE2670-CK 16Gbps dual-port fibre channel HBA
Number of Network Controllers	1
Network Controller Vendors and Models	Broadcom® 10Gbps dual-port NetXtreme® II BCM57810 adapter
Other Hardware	None
Other Software	The following drivers were installed as part of the Dell-customized image for ESXi 5.5: tg3 - 3.133d.v55.1, bnx2 - 2.2.3t.v55.7, bnx2x - 1.78.28.v55.2, cnic - 1.78.12.v55.6, cnic-register - 1.78.1.v55.7, bnx2fc - 1.78.16.v55.4, bnx2i - 2.78.11.v55.4, qlnativefc - 1.1.7.0 - 1OEM.550.0.0.1198610, qla4xxx - 634.55.20.0-1vmw, qlcnic - 5.5.164, qlge - v3.00.00.57, igb - 4.2.16.8, ixgbe - 3.18.7iov, lpfc - 10.0.575.8-1OEM.550.0.0.1198611, elxnet - 10.0.575.7-10EM-550.0.0.1198611, be2iscsi - 4.6.261.0, mpt2sas - 16.00.01.00.1vmw
Hardware Availability Date (MM-DD-YYYY)	01-16-2014
Software Availability Date (MM-DD-YYYY)	06-10-2014
Network	
Network Switch Vendors and Models	Dell PowerConnect 8024F 10Gbps switch
Network Speed	10Gbps for all traffic
Storage	
Array Vendors, Models, and Firmware Versions	Dell Storage SC4020, Firmware version 6.5.2.8

Fibre Channel Switch Vendors and Models	Brocade 6505
Disk Space Used	8,266.5 GB
Array Cache Size	16 GB
Total Number of Physical Disks Used	24
Total Number of Enclosures/Pods/Shelves Used	1
Number of Physical Disks Used per Enclosure/Pod/Shelf	24
Total Number of Storage Groups Used	1
Number of LUNs Used	13
LUN Size and Number of Disks Per LUN	Details in section Storage Notes
RAID Type	Details in section Storage Notes
Number of Members per RAID Set	Details in section Storage Notes
Disk Vendors, Models, and Speeds	12 x SanDisk LB406S, 372GB SSD 12 x SanDisk LB1606R, 1.46TB SSD

Datacenter Management Server	
System Model	Dell PowerEdge M620
Processor Vendor and Model	Intel Xeon E5-2660
Processor Speed (GHz)	2.2 GHz
Total Sockets/Total Cores/Total Threads	2 Sockets / 16 Cores / 32 Threads
Memory	32 GB
Network Controller(s) Vendors and Models	Broadcom® 10Gbps dual-port NetXtreme® II BCM57810 adapter, 2 x 10GB dual-port Intel 82599EB adapter
Operating System, Version, Bitness, and Service Pack	- Microsoft Windows Server 2008 R2 Enterprise 64-bit (prime client) - VMware ESXi 5.5.0 Update 1 Build 1881737 (virtual client hosts) - Microsoft Windows Server 2008 R2 Enterprise 64-bit (virtual client)
Other Hardware	None
Other Software	None

Clients	
Total Number of Clients / Total Physical Clients / Total Virtual Client Hosts	31 / 1 / 6
System Model(s)	Dell PowerEdge M620

Processor Vendor(s) and Model(s)	Intel Xeon E5-2660
Processor Speed(s) (GHz)	2.2 GHz
Total Sockets/Total Cores/Total Threads	2 Sockets / 16 Cores / 32 Threads
Memory per Physical Client	32 GB (prime client), 64 GB (virtual client hosts)
Network Controller(s) Vendors and Models	Broadcom® 10Gbps dual-port NetXtreme® II BCM57810 adapter, 2 x 10GB dual-port Intel 82599EB adapter
Operating System, Version, Bitness, and Service Pack	• Microsoft Windows Server 2008 R2 Enterprise 64-bit (prime client) • VMware ESXi 5.5.0 Update 1 Build 1881737 (virtual client hosts) • Microsoft Windows Server 2008 R2 Enterprise 64-bit (virtual client)
Number of Virtual Clients	30
Number of vCPUs Per Virtual Client	4
Number of vMem (GB) Per Virtual Client	4
Virtual Client Networking Notes	None
Virtual Client Storage Notes	All clients stored on EqualLogic PS6210X storage array in a single LUN
Other Hardware	Dell PowerEdge M1000e Blade Enclosure with 2x MXL 10/40Gbe and 4x Force 10 XML 10/40GbE switch
Other Software	None

Notes for Workload

Virtualization Software Notes

- Virtual hardware for all VMs was set to V10
- Ethernet adapter type set to vmxnet3 for all VMs (default vmxnet2)
- CD and floppy were removed from all VMs (default attached)
- Logging was disabled for all VMs (default enabled)
- All VMs except standby configured as single virtual socket with multiple cores (default one core per multiple virtual sockets)
- SCSI adapter type PVSCSI used for all Standby VMs (default LSI Logic parallel)
- SCSI adapter type PVSCSI used for all MailServer and Linux VMs (default LSI Logic SAS)
- VMware tools were version 9344 on all VMs except standby VMs which used version 9227
- vSphere DRS Migration Threshold set to Fully Automated Level 2

- /adv/Cpu/CoschedCrossCall = 0 (default 1)
- /adv/Cpu/HTWholeCoreThreshold = 0 (default 200)
- /adv/DataMover/HardwareAcceleratedInit = 0 (default 1)

- /adv/DataMover/HardwareAcceleratedMove = 0 (default 1)
- /adv/Mem/BalancePeriod = 0 (default 15)
- /adv/Mem/SamplePeriod = 0 (default 60)
- /adv/Mem/ShareScanGHz = 0 (default 4)
- /adv/Misc/TimerMaxHardPeriod = 4000 (default 100000)
- /adv/Net/MaxNetifRxQueueLen = 500 (default 100)
- /adv/Net/MaxNetifTxQueueLen = 1000 (default 500)
- /adv/Net/NetTxCompletionWorldlet = 0 (default 1)
- /adv/Irq/IRQRebalancePeriod = 20000 (default 50)
- /adv/Irq/BestVcpuRouting = 1 (default 0)
- /adv/Numa/LTermFairnessInterval = 0 (default 5)
- /adv/Numa/PreferHT = 1 (default 0)
- /adv/Numa/MonMigEnable = 0 (default 1)
- /adv/Numa/PageMigEnable = 0 (default 1)
- /adv/Numa/RebalancePeriod = 60000 (default 2000)
- /adv/Numa/SwapLoadEnable = 0 (default 1)
- /adv/Numa/SwapLocalityEnable = 0 (default 1)

Server Notes

- CPU C6 Report disabled (default enabled)
- Package C state limit set to C0 (default no limit)

Networking Notes

vSwitch Configuration:

- vSwitch1 on vmnic4 (10Gb) for VMotion (vSwitch2 on Host 2)
- vSwitch1 (vSwitch2 on Host 2) MTU size was modified to 9000 (default 1500)
- vSwitch0 on vmnic5 (10Gb) for Service Console, all Standby, Mail, Olio, DS2, and Deploy VMs

Storage Notes

- ESX was installed on a two-disk RAID 1 volume from the internal 300GB SAS hard drives in each system under test.
- The Dell storage array was configured into one RAID 6 storage pool with a hotspare 10K RPM disk.
- The storage pool was mapped to all servers.
- Storage pool layout:
- 1 LUN at 3TB, as the transfer volume
- 1 LUN at 2TB, containing the DS2 DB VMs
- 1 LUN at 1.6TB, containing the DS Web VMs
- 1 LUN at 3.3TB, containing the Mailserver VMs
- 1 LUN at 700GB, containing the Olio DB VMs
- 1 LUN at 3.6TB, containing the Olio Web VMs
- 1 LUN at 240GB, containing the standby VMs
- 4 LUNs at 75GB, containing the Standby source targets
- 1 LUN at 30GB, containing the Deploy cloning target location
- 1 LUN at 30GB, containing the Deploy template VMs

Datacenter Management Server Notes

The Datacenter Management Server was a virtual machine configured with 4 vCPU and 12GB RAM on a separate ESXi host.

Operating System Notes

All Mailservers ran Microsoft Windows Server 2008 R2 Enterprise 64-bit

Software Notes

None

Client Notes

- Microsoft Windows Server 2008 R2 Enterprise 64-bit installed on client virtual machines and updated through Windows Update
- Prime client was running Microsoft Windows Server 2008 R2 Enterprise 64-bit and VMware vSphere PowerCLI 5.5 Release 2 build 1671586
- Prime client ran as a physical client
- All other clients ran as virtual machines that were each defined with 4 virtual CPUs, 4GB of memory, 1 vmxnet3 network, and 36GB of disk space
- Virtual clients 0-4 were hosted on virtual client host 1
- Virtual clients 5-9 were hosted on virtual client host 2
- Virtual clients 10-14 were hosted on virtual client host 3
- Virtual clients 15-19 were hosted on virtual client host 4
- Virtual clients 20-24 were hosted on virtual client host 5
- Virtual clients 25-29 were hosted on virtual client host 6
- Clients ran with default ESX settings

Other Notes

None

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