Desktop Virtualization with VMware Horizon View 5.2 on Dell EqualLogic PS6210XS Hybrid Storage Array

A Dell Storage Reference Architecture

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Acknowledgements

Feedback

We encourage readers of this publication to provide feedback on the quality and usefulness of this information by sending an email to chhandomay_mandal@dell.com.

Audience

This paper is intended for solution architects, storage network engineers, system administrators, and IT managers who need to understand how to design, properly size, and deploy VMware Horizon View based desktop virtualization solutions using Dell EqualLogic storage. It is expected that the reader has a working knowledge of the VMware Horizon View architecture, VMware vSphere system administration, iSCSI SAN network design, and Dell EqualLogic iSCSI SAN operation.

Executive summary

Desktop virtualization is an important strategy for organizations seeking to reduce the cost and complexity of managing an expanding variety of client desktops, laptops, and mobile handheld devices. Virtual Desktop Infrastructure (VDI) offers an opportunity to not only reduce the operational expenses for desktop management and provisioning but also to improve user mobility and data security.

A VDI deployment can place high capacity and performance demands on the storage platform. For example, consolidating large amounts of inexpensive stand-alone desktop storage into a centralized infrastructure can create tremendous capacity demands on centrally managed shared storage used in VDI deployments. Performance demands are determined by the number of I/O operations per second (IOPS) generated by basic desktop client operations such as system boot, logon and logoff, and by desktop usage operations from different users. Storm events such as morning logons and afternoon logoffs by many users at approximately the same time can cause I/O spikes that place high performance demands on the storage infrastructure. There may also be situations like an unexpected power shutdown which requires booting of all the virtual desktops at the same time. This boot storm creates significantly higher IOPS on the underlying storage platform than the regular business hour usage.

The Dell™ EqualLogic™ PS6210XS hybrid arrays are well suited for supporting VDI deployments because they are specifically designed for VDI type workloads where most frequently accessed data – the active data set – needing very high I/O rates resides in a relatively smaller portion of the utilized storage capacity. With high performance SSD drives and high capacity SAS hard disk drives within the same chassis, the hybrid arrays automatically move frequently accessed data from the SAS tier to the SSD tier. The automatic tiering function makes the hybrid EqualLogic SAN a cost efficient option for VDI environments where the peak load in an I/O storm from hundreds of virtual desktops is typically concentrated on the relatively small-sized base images.

This paper demonstrates how 2,000 standard user virtual desktops can be deployed in a VMware® Horizon View™ 5.2 (Horizon View) VDI environment leveraging a single EqualLogic PS6210XS hybrid array. The test infrastructure included VMware Horizon View 5.2, VMware vSphere™ 5.1 hypervisor, Dell PowerEdge™ servers, Dell Force10™ and PowerConnect™ switches, and Dell EqualLogic storage arrays. Details are provided for the storage I/O characteristics under various VDI workload scenarios like boot and login storms along with performance characteristics throughout the VDI stack (for example, ESXi server performance and user experience).

The 2,000 desktop VDI environment generated 17,514 IOPS during boot storm, 17,144 IOPS during login storm, and 16,773 IOPS during steady state. The EqualLogic PS6210XS delivered these IOPS requirements with less than 5 ms average latency, indicating more performance headroom as the latency was well below the standard maximum – 20 ms – allowed for acceptable storage performance. Additionally, performance results across all layers – user layer, hypervisor layer and storage layer – of the VDI stack were satisfactory as well. Details of these test results are available in Section 5 of this document.

1   Introduction

Desktop virtualization platforms like VMware Horizon View 5.2 (Horizon View) can provide organizations with significant cost savings, streamlined implementation, and ease of desktop management. In order to achieve these VDI benefits and to ensure optimal user experience, storage infrastructure design and sizing considerations need to be addressed carefully.

The goal of this paper is to present the results of a series of storage I/O performance tests and provide storage sizing guidance based on those results for a Horizon View based VDI solution leveraging EqualLogic PS6210XS hybrid storage arrays.

1.1   Objectives

The primary objectives of the tests conducted for this paper were:

- Determine how many virtual desktops can be deployed in a Horizon View environment using a single EqualLogic PS6210XS storage array with acceptable user experience indicators for a standard user workload profile
- Determine the performance impact on the storage array of peak I/O activity such as boot and login storms
- Develop sizing guidelines and best practices for Horizon View VDI deployments leveraging EqualLogic PS6210XS hybrid storage arrays

The test infrastructure used for the tests includes:

- VMware Horizon View 5.2
- VMware vSphere 5.1 hypervisor
- Dell PowerEdge M620 blade servers and R720 rack servers
- Dell Networking ToR and blade switches
- Dell EqualLogic PS6210XS and PS6510E storage arrays

2 Desktop virtualization with Horizon View

Horizon View is a VDI solution that includes a complete suite of tools for delivering desktops as a secure, managed service from a centralized infrastructure. A Horizon View infrastructure consists of many different software, network, and hardware layer components. This section presents an overview of the key Horizon View components and technologies that are critical for successful design and deployment of the virtual desktop environment.

2.1 Horizon View components

A functional list of Horizon View components used in this solution is shown below:

Table 1　Horizon View components

Component	Description
Client Devices	Personal computing devices used by end users to run the Horizon View Client. These can include special end point devices like Dell Wyse end points, mobile phones, PCs, and others.
Horizon View Connection Server	A software service that acts as a broker for client connections by authenticating and then directing the incoming user requests to the appropriate virtual desktop, physical desktop or terminal server.
Horizon View Client	Software that is used to access the Horizon View desktops.
Horizon View Agent	A service that runs on all systems used as sources for Horizon View desktops and facilitates communication between the Horizon View clients and the Horizon View server.
Horizon View Administrator	A web-based administration platform for the Horizon View infrastructure components.
vCenter® Server	Central administration platform for configuring, provisioning, and managing VMware virtualized data centers.
Horizon View Composer	A service running with Horizon View servers, used to create pools of virtual desktops from a shared base image to reduce storage capacity requirements.

2.2 Virtual desktops

Virtual desktops can be classified into two major categories: persistent and non-persistent.

Persistent desktop environment: All configuration and personalization on the assigned desktop is kept for the user between sessions. When using persistent desktops, the administrator usually has to provision additional storage along with other administrative requirements like patching and upgrading of individual desktops.

Non-persistent desktop environment: Users are dynamically assigned virtual desktop VMs from a pool of resources during login. This type of virtual desktop does not retain any information between sessions. At logoff, all changes are simply discarded and the virtual desktop is returned to the original state. Patching and upgrading non-persistent desktops only requires making the change to the base image and refreshing or recomposing the virtual desktop pool. Thus, these desktops are much easier to manage but lack the potential for persistent user customization.

2.3 Horizon View desktop pools

A desktop pool is a term VMware uses to describe a collection of desktops that are managed as a single entity by the Horizon View Administrator interface. Horizon View desktop pools allow administrators to group users depending on the type of service the user requires. There are two types of pools – Automated Pools and Manual Pools.

In Horizon View, an Automated Pool is a collection of VMs cloned from a base template, while a Manual pool is created by the Horizon View Manager from existing desktop sources, physical or virtual. For each desktop in the Manual pool, the administrator selects a desktop source to deliver Horizon View access to the clients.

VMware View Personas profile management features can be used to achieve persistent desktop-like behavior on non-persistent desktops. Using these features, the administrator can design a user account where the configuration settings are written to a remote profile that is stored separately from the virtual desktop image files. This reduces the need for additional management on individual virtual desktops while still providing a custom user experience.

2.4 Using linked clones

Significant storage space savings and increased efficiencies in desktop VM provisioning and administration are possible when using VMware linked clones. A linked clone is a duplicate VM that shares the same base image with the original VM, but has separate differential data disks to track the differences from the original one. Each linked clone functions as an independent desktop VM with its own unique identity.

Because linked clones share the same base image, they consume significantly less storage space than a set of completely independent VM images. Temporary system data and other data unique to each linked clone desktop VM are written to separate differential data storage and these temporary changes are discarded at reboot and/or user logoff. Persistent data such as user profiles, applications, and user data can be optionally redirected to a CIFS share. With this model, software maintenance updates, antivirus remediation, and patches need to be applied only on the base image. These base image changes automatically take effect on all linked clones without affecting any user settings and data.

To configure linked clones, the administrator creates a snapshot of a parent VM image with the required OS, settings, and software installed. Horizon View Composer first creates a full replica (clone) of the parent VM and then uses this replica to create linked clones. The replica can be placed on the same datastore as the linked clones or on a separate datastore.

> More information on configuring linked clones can be found in the "Creating Desktop Pools" section of the VMware Horizon View Online Library here: http://pubs.vmware.com/view-52/topic/com.vmware.view.administration.doc/GUID-0A9CA985-3A78-428A-BCFB-B3E2DCCA90AD.html

3 Infrastructure and test configuration

This section provides information on the test setup and configuration used for hosting Horizon View virtual desktops, including infrastructure components, networking, and storage sub-systems.

3.1 Host design considerations

The entire infrastructure and test configuration was installed in a single Dell PowerEdge M1000e blade chassis complete with 16 PowerEdge M620 blade servers and four additional PowerEdge R720 rack servers. The ESXi clusters used include:

- **Infrastructure Cluster:** PowerEdge M620 blade server hosting virtual machines for Active Directory services, VMware vCenter 5.1 server, Horizon View 5.2 server (primary and secondary), Horizon View Composer server, Microsoft™ Windows Server™ 2008 R2 based file server, and SQL Server® 2008 R2.
- **Horizon View Client Clusters:** Four PowerEdge R720 rack servers and 15 PowerEdge M620 blade servers hosting virtual desktops.

Additional PowerEdge servers were used for VDI load generation purposes.

3.2 Network design considerations

The following considerations were made for designing the network of the VDI solution presented in this reference architecture:

- **Two PowerConnect M8024-K blade switches in Fabric A for connectivity to the dedicated iSCSI SAN**
- **Two PowerConnect M6348 blade switches stacked in Fabric B for connectivity to the Management LAN, VDI client LAN, and a vMotion LAN.**
- **Each PowerEdge M620 blade server configured with one Broadcom 57810S Dual Port 10 GbE NIC card and one Broadcom 5719 Quad Port 1 GbE NIC Card. Broadcom 57810S card was assigned as Fabric A LOM and the other Broadcom 5719 1Gb NIC card was assigned as Fabric B on the blade chassis.**
- **Fabric A was a 10 GbE network dedicated for iSCSI traffic while Fabric B carried the VDI traffic for all 2,000 VMs.**
- **The PowerConnect switches in Fabric B were interconnected using the stacking modules to provide high availability and redundancy of the VDI fabric.**
- **Fabric C was unused.**
- **Two Force10 S4810 switches were used for external SAN access. These switches were stacked together for failure resiliency and ease of management.**

3.2.1 iSCSI SAN configuration

Figure 1 shows the network connectivity between a single PowerEdge M620 blade server and the storage array through the blade server chassis. The figure shows only one PowerEdge M620, but the topology is identical for all the remaining blade servers in the chassis.
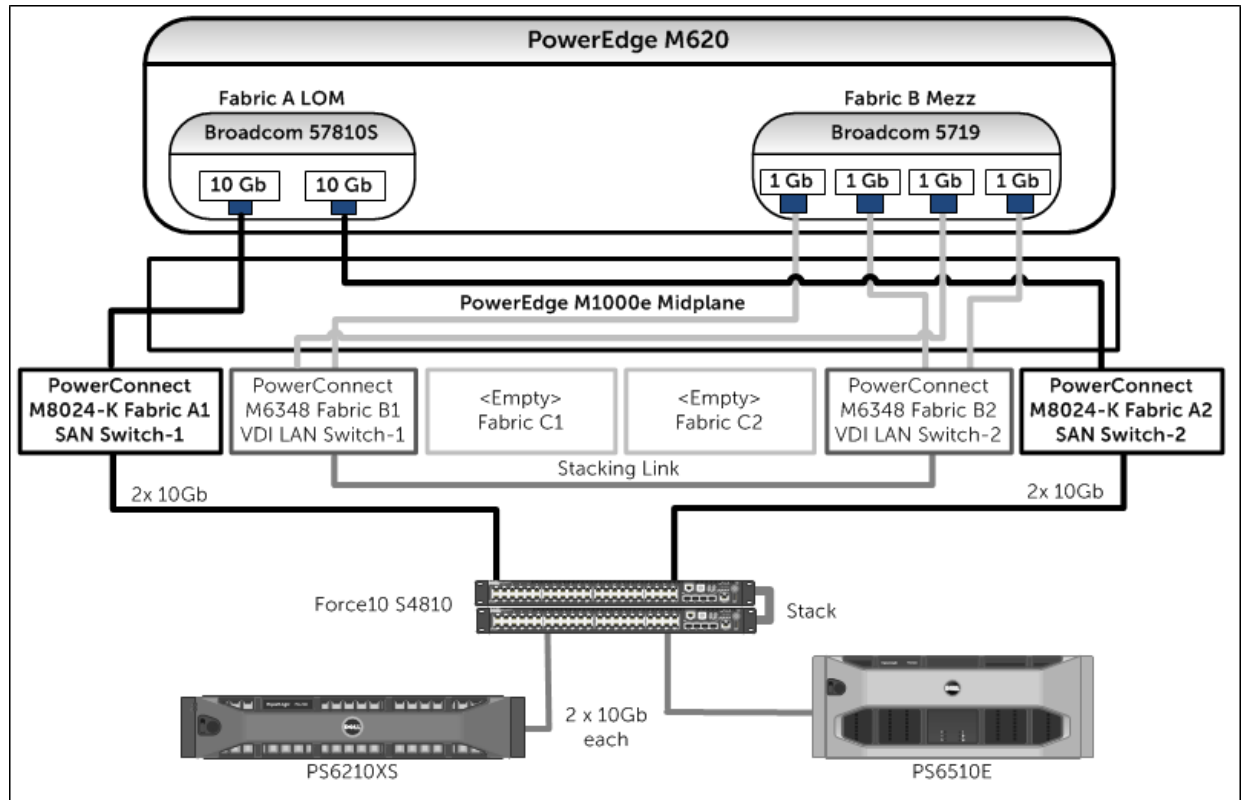
Figure 1   iSCSI SAN connectivity

3.2.2 LAN Configuration

The networks are segregated at the PowerConnect M6348 switch using VLANs to separate different types of traffic, namely:

- Management LAN: This network provides a separate management network for all the physical ESXi hosts. It also allowed communication between various infrastructure components such as Microsoft Active Directory Server, Microsoft SQL Server, and VMware vCenter Server.
- VDI Client LAN: This is the network over which the clients accessed the virtual desktops in the Horizon View desktop pools.
- VMware vMotion LAN: This is the network over which the VMs are migrated to provide high availability and load balancing between the hosts. The 15 PowerEdge M620s and four PowerEdge

R720s are divided into four clusters, and load balancing and HA can only be provided between hosts in the same cluster.

Appendix B has extended information on the vSwitch configuration for each ESXi host.

The LAN and iSCSI SAN configurations were similar for PowerEdge R720 servers hosting the virtual desktops, except that there were no blade switches involved. Each PowerEdge R720 server had one Broadcom 57810S Dual Port 10 Gb NIC card and one Broadcom 5719 Quad Port 1Gb NIC Card. The two 10 GbE ports were connected to the Force10 S4810 iSCSI SAN switches. The LAN configuration was similar (as described in this Section 3.2.2) and the 1 GbE ports were connected to the Force10 S4810 LAN switches.

3.3 Storage design considerations

The virtual desktop model comprises two data types, VM data and user data. VM data consists of the virtual desktop image, including OS and applications. User data is the daily work produced by the user of the VM, including documents, spreadsheets, images, and individual preferences. Managing VM data and user data optimally is critical to a successful, cost-effective VDI storage design.

3.3.1 Separation of VM data and user data

Typically, user data can be maintained on a separate file share through roaming profiles and folder redirections. In this approach, a desktop – comprised of the shared read-only base image and the individual differential data from temporary changes – is always stateless. When a user logs in, the personal data is mapped to the desktop and all the changes to the data are maintained on the file share over the network. When the user logs off, the personal data is no longer on the desktop and the desktop can be put back in the original state with the temporary data discarded.

This approach has two benefits. First, the advantages of the non-persistent desktop deployment model can be leveraged while using the persistent desktop model. For example, patching and upgrading these desktops will require only making the change to the base image and refreshing or recomposing the virtual desktop pool without affecting any user data and settings. Second, the performance needs of VM data and user data are distinctly different, with the former needing very high performance to handle the I/O storms. The VM data can be placed in a high-performance storage array, while the user data can be served from the file shares running on a capacity-oriented storage array.

3.3.2 EqualLogic storage array configuration

Two separate EqualLogic arrays were used for VM data and user data. An EqualLogic PS6210XS storage array hosted all the virtual desktops while the infrastructure virtual machines used in this solution are placed on an EqualLogic PS6510E array.

The volume layout used for the infrastructure functions including user data hosted by EqualLogic PS6510E array is shown in Table 2.

Table 2　EqualLogic volumes layout for hosting infrastructure components and user data

Volume name	Size	Purpose
Management	1TB	Storage for Active Directory, File Server, SQL Server, vCenter Server, Horizon View Composer, Horizon View Servers
Fileshare1	2 TB	Storage for User profiles and folder redirection space (Average, 2 GB per user)
Fileshare2	2 TB	Storage for User profiles and folder redirection space (Average, 2 GB per user)

A single EqualLogic PS6210XS hybrid array provided the shared storage for hosting the virtual desktops. The volume layout used for configuring the base image, replicas, and VDI volumes on the EqualLogic PS6210XS array is shown in Table 3.

Table 3　EqualLogic volumes layout for hosting virtual desktops

Volume name	Size	Purpose
VDI-Base Images	100 GB	Storage for Base image for VDI deployment
VDI-Replicas1-4 (4 volumes)	100 GB each	Storage for Replica images created by Horizon View
VDI-Images1-16 (16 volumes)	500 GB each	Storage for VDI Virtual Machines in Horizon View Clusters

3.4　ESXi host network configuration

VMware ESXi 5.1 hypervisor was installed on all servers hosting the virtual desktops. The network configuration on each of those hosts is described below. Each ESXi host was configured with three virtual switches - vSwitch0, vSwitch1 and vSwitch2 - to separate the different types of traffic on the system.

Table 4　vSwitch configuration in ESXi hosts

vSwitch	Description	Virtual NICs used
vSwitch0	Management Network and vMotion	vmnic2, vmnic3
vSwitch1	iSCSI SAN	vmnic0, vmnic1
vSwitch2	VDI LAN	vmnic4, vmnic5

For additional information on individual vSwitch configuration, refer to Appendix B.

3.5 Horizon View configuration

Horizon View 5.2 was installed by following the documentation provided by VMware.

> Horizon View 5.2 Documentation: http://pubs.vmware.com/view-52/index.jsp

Specific configuration decisions used in the tests:

- Two Horizon View servers were configured to provide load balancing and high availability.
- The Horizon View servers were installed as VMs with four virtual CPUs, 12 GB of RAM, and one 40 GB virtual hard drive.
- The first Horizon View Server was configured as a "View Standard Server" during the installation, while the second Horizon View Server was installed as a "View Replica Server".
- Horizon View Composer was installed in a separate VM with the same properties as the Horizon View servers.
- Self-signed SSL certificates were applied to the VMware vCenter Server VM, Horizon View servers, and the Horizon View Composer server.

3.6 Horizon View pool configuration

The Add pool wizard in Horizon View was used to choose the following specific configuration options to create the virtual desktop pool.

Table 5   Selected options for Horizon View pool configuration

Option	Selected setting
Virtual desktop pool type	Automated Pool
User Assignment	Floating
vCenter Server	View Composer linked clones
View Composer Disks	Redirect disposable files to a non-persistent disk of size 4,096 MB
Storage Optimization	Select separate datastores for replica and OS disk
Advanced Storage Options	Use host caching (2GB)
Guest Customization	Login VSI preparation script

> More information about Horizon View Pool configuration can be found in the VMware Horizon View 5.2 documentation:
> http://pubs.vmware.com/view-52/topic/com.vmware.view.administration.doc/GUID-0A9CA985-3A78-428A-BCFB-B3E2DCCA90AD.html

3.7 Windows 7 VM configuration

Following the guidelines from VMware and Login VSI, the Windows™ 7 base image was generated based on a generic base VM with the following properties:

- VMware Virtual Hardware version 8
- One virtual CPU
- 1.5 GB RAM
- Memory Reservation 1024MB
- 25 GB virtual hard drive
- One virtual NIC connected to the VDI Network
- Windows 7 32 bit OS

Additionally, the base image was customized using the VMware Optimization guide for Windows 7, available here: http://www.vmware.com/files/pdf/VMware-View-OptimizationGuideWindows7-EN.pdf

4 Horizon View test methodology

This section outlines the test objectives along with the test tools and criteria used to determine the sizing guidelines for deploying Horizon View on EqualLogic storage.

4.1 Test objectives

As noted in Section 1.1, the test objectives are:

- Determine how many virtual desktops can be deployed in a Horizon View environment using a single EqualLogic PS6210XS storage array with acceptable user experience indicators for a standard user workload profile
- Determine the performance impact on the storage array of peak I/O activity such as boot and login storms
- Develop sizing guidelines for Horizon View VDI deployments leveraging EqualLogic PS6210XS hybrid storage arrays

4.2 Test tools

All tests were conducted using Login VSI 3.7 as the workload generator. Login VSI is a benchmarking tool to measure the performance and scalability of centralized desktop environments such as Server Based Computing (SBC) and VDI.

> Note: More information can be found at the Login VSI website: http://www.loginvsi.com

4.2.1 Load generation

The "Medium" workload from Login VSI was used to simulate the standard user workload. The characteristics of the Medium workload are:

- Up to five applications are open simultaneously.
- Applications include Microsoft Internet Explorer, Microsoft Word, Microsoft Excel, Microsoft PowerPoint, PDF reader, 7-Zip compression software, and Movie player.
- Once a session is started, the medium workload repeats approximately every 12 minutes.
- During a loop, the response time is measured every two minutes.
- Idle time is about two minutes in each 12 minute loop.
- Type rate is approximately 130 ms per character.

Although Login VSI provides other workloads, the Medium workload was used in the testing because it closely resembles the workload of a standard user.

> More information on the classifications of the user types can be found in Appendix C

4.2.2 Monitoring tools

The following monitoring tools were used:

- Dell EqualLogic SAN Headquarters (SAN HQ) for monitoring storage array performance
- VMware vCenter statistics for ESXi performance
- Liquidware Labs Stratusphere UX for end user performance statistics

Detailed performance metrics were captured from the storage arrays, hypervisors, virtual desktops, and the load generators during the tests.

4.3 Test criteria

The primary focus of the tests was to determine the maximum number of desktops which can be deployed on a single EqualLogic PS6210XS hybrid storage array while using VMware Horizon View Composer to provide Linked Clone virtual desktops in an automated pool.

VDI configurations involve many components at different layers – application, hypervisor, server, network, and storage. As a result, multiple metrics need to be captured at different layers to ensure that the environment is healthy and performing optimally and appropriately for all users.

The specific test criteria are described in the following sections.

4.3.1 Storage capacity and I/O latency

The typical industry standard latency limit for storage disk I/O is 20 ms. Maintaining this limit ensures good user application response times when there are no other bottlenecks at the infrastructure layer. In addition to this, it is also recommended to maintain a 10% spare capacity on the storage array for optimal performance.

4.3.2 System utilization at the hypervisor

Even though the primary focus of these tests was storage characterization, additional metrics at the hypervisor infrastructure layer were defined to ensure solution consistency. These are:

- CPU utilization on any ESXi server should not exceed 85%
- No memory ballooning on the VMs
- Total network bandwidth utilization should not exceed 90% on any one link
- TCP/IP storage network retransmissions should be less than 0.5%

4.3.3 Virtual desktop user experience

Stratusphere UX was used to gather data for user experience and desktop performance. Data gathered from the hosts in VMware vCenter and the virtual desktops (via software installed on the VM) is reported back to the Stratusphere Hub. The Stratusphere Hub was used to generate the comprehensive report "Desktop Virtualization Performance Analysis." This report includes information about the host

performance, virtual machine performance and user performance. The report also provides a scatter plot that shows the performance of all the users in the system.

Liquidware Labs Stratusphere UX can generate a variety of reports that compare and validate user experience metrics. More information about these reports, including sample reports can be found here: http://www.liquidwarelabs.com/products/stratusphere-ux-validation-reports.asp

Stratusphere UX user experience metric was used to ensure that all desktops had acceptable levels of application performance.

4.4   Test configuration

Four virtual desktop pools were configured using the Horizon View Administrator interface. Each pool was built from a Windows 7 base image. The Windows 7 configuration information is available in Section 3.7.

Desktop pool properties:

- Four Horizon View desktop pools
- Each pool populated with 500 desktops, spread across four 500 GB volumes
- Base images are stored on a separate 100 GB volume
- Replica images are stored on separate 100 GB volumes
- Storage over-commit for all volumes was set to moderate
- Horizon View Composer disposable disk size was 4,096 MB
- Disposable disk drive letter was set to auto
- Host caching (Horizon View Storage Accelerator) was enabled for all hosts and set to 2,048 MB

5 Test results and analysis

This section presents the results from the different Horizon View VDI characterization tests and the key findings from each test. The standard user workload represents a majority of the VDI users in the industry today, and the testing was focused on this workload profile.

5.1 Test scenarios

The following tests were conducted to gather results and analysis on the solution stack:

1. Boot storm: Boot storms represent the worst-case scenario where many virtual desktops are powered on at the same time and they all contend for the system resources simultaneously. This test was used to evaluate if the storage array hosting the desktops was capable of handling huge spikes in storage I/O without causing significant impact on other services.
2. Login storm: Login storms also represent a heavy I/O scenario where many users are logging into their virtual desktops at the beginning of a work day or a shift at the same time. In this test, all the desktops were pre-booted and left in an idle state for more than 20 minutes to let their I/O settle before running the Login VSI Medium workload to simulate users logging in to their virtual desktops.
3. Steady state workload for standard users: Once the login storm for the previous test is completed, the Login VSI Medium workload is allowed to run for at least one hour to simulate the real world scenario of users performing their daily tasks. Stratusphere UX is used to capture user and machine performance during testing.

The following sections provide results from the boot storm, login storm, and steady state testing for a standard user on a single EqualLogic PS6210XS hybrid storage array.

5.1.1 Boot storm I/O

To simulate a boot storm, the virtual desktops were reset simultaneously from the VMware vSphere client. Figure 2 shows the storage characteristics during the boot storm – the EqualLogic PS6210XS array delivered 17,514 IOPS (8.7 IOPS per VM) with less than 3 ms average latency under the peak load during this test and all 2,000 desktops were available in about 25 minutes.
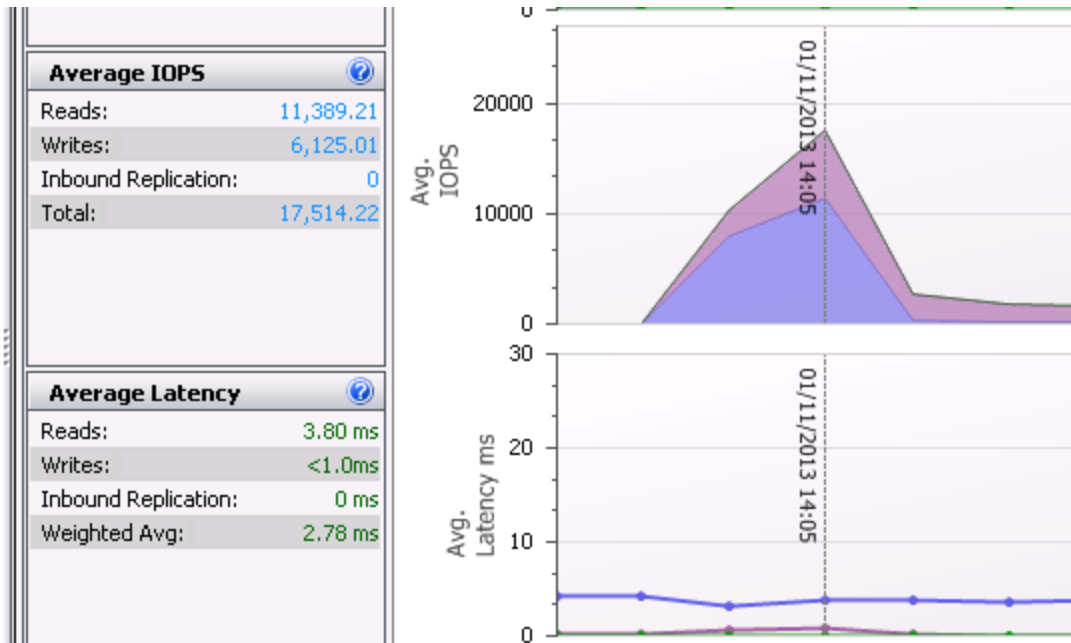
Figure 2   SAN HQ data showing EqualLogic PS6210XS array IOPS and latency during boot storm

The above screenshot represents the boot storm for 2,000 VMware Linked Clone VMs with a read/write ratio of 65% read and 35% write. The Replica volumes contributed to the majority of the I/O. Latency was extremely low at a weighted average of 2.78 ms.

Due to the large number of VMs being powered on, each Replica volume generated its individual maximum IOPS at different times during the boot storm, depending on when VMs on a particular Replica volume got powered on. Figure 3 below shows two Replica volumes generating the majority of IOPS when the boot storm itself was at its peak. I/O on Replica volumes were virtually 100% read operations.

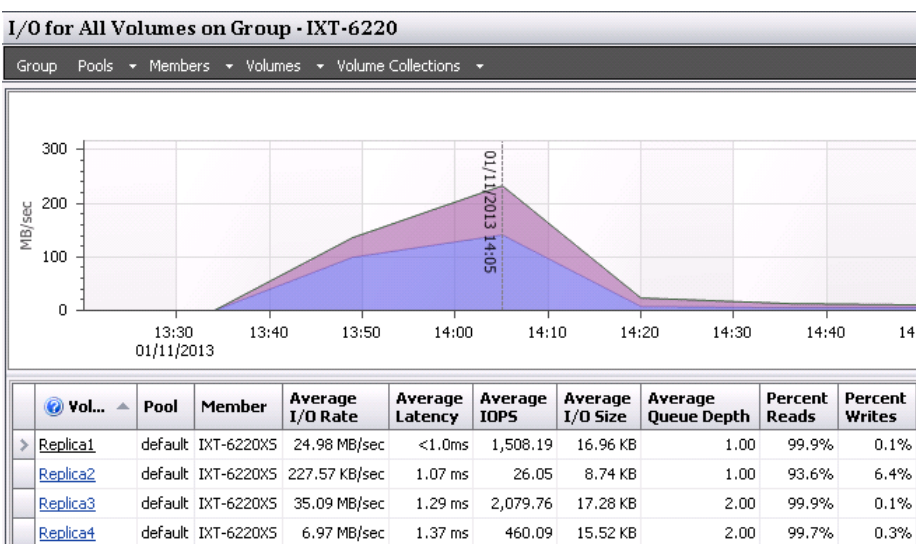| Vol...	Pool	Member	Average I/O Rate	Average Latency	Average IOPS	Average I/O Size	Average Queue Depth	Percent Reads	Percent Writes
Replica1	default	IXT-6220XS	24.98 MB/sec	<1.0ms	1,508.19	16.96 KB	1.00	99.9%	0.1%
Replica2	default	IXT-6220XS	227.57 KB/sec	1.07 ms	26.05	8.74 KB	1.00	93.6%	6.4%
Replica3	default	IXT-6220XS	35.09 MB/sec	1.29 ms	2,079.76	17.28 KB	2.00	99.9%	0.1%
Replica4	default	IXT-6220XS	6.97 MB/sec	1.37 ms	460.09	15.52 KB	2.00	99.7%	0.3%

Figure 3   Read and write IOPS on the replica volumes

The remaining I/O operations were handled by the linked clone volumes with an average ratio of 40% read and 60% write operations.

The table below shows that the majority of the I/O operations were handled by the SSDs during the boot storm.

Table 6   Disk usage on EqualLogic PS6210XS during boot storm

Member	Disk	Description	Average IOPS	Read I/O Rate	Write I/O rate	Status
IXT-6210XS	0	SSD 800GB SAS	3,025.16	31.81 MB/sec	25.79 MB/sec	online
IXT-6210XS	1	SSD 800GB SAS	3,030.44	31.87 MB/sec	25.80 MB/sec	online
IXT-6210XS	2	SSD 800GB SAS	3,003.07	31.78 MB/sec	25.85 MB/sec	online
IXT-6210XS	3	SSD 800GB SAS	3,045.40	31.77 MB/sec	25.84 MB/sec	online
IXT-6210XS	4	SSD 800GB SAS	3,010.06	31.65 MB/sec	25.85 MB/sec	online
IXT-6210XS	5	SSD 800GB SAS	3,020.25	31.86 MB/sec	25.76 MB/sec	online
IXT-6210XS	6	SSD 800GB SAS	3,030.88	31.70 MB/sec	25.75 MB/sec	online
IXT-6210XS	7	10K 1TB SAS	79.31	2.20 MB/sec	541.45 KB/sec	online
IXT-6210XS	8	10K 1TB SAS	49.67	1.96 MB/sec	516.03 KB/sec	online
IXT-6210XS	9	10K 1TB SAS	47.79	2.08 MB/sec	542.55 KB/sec	online
IXT-6210XS	10	10K 1TB SAS	47.06	1.91 MB/sec	501.67 KB/sec	online
IXT-6210XS	11	10K 1TB SAS	46.34	1.99 MB/sec	540.34 KB/sec	online
IXT-6210XS	12	10K 1TB SAS	45.01	1.91 MB/sec	501.67 KB/sec	online
IXT-6210XS	13	10K 1TB SAS	43.85	1.88 MB/sec	512.72 KB/sec	online
IXT-6210XS	14	10K 1TB SAS	42.38	1.87 MB/sec	510.51 KB/sec	online
IXT-6210XS	15	10K 1TB SAS	42	1.85 MB/sec	509.40 KB/sec	online
IXT-6210XS	16	10K 1TB SAS	42.13	1.85 MB/sec	509.40 KB/sec	online
IXT-6210XS	17	10K 1TB SAS	43.32	1.85 MB/sec	509.40 KB/sec	online
IXT-6210XS	18	10K 1TB SAS	45.2	1.87 MB/sec	511.61 KB/sec	online
IXT-6210XS	19	10K 1TB SAS	43.53	1.87 MB/sec	507.19 KB/sec	online

IXT-6210XS	20	10K 1TB SAS	44.08	1.87 MB/sec	509.40 KB/sec	online
IXT-6210XS	21	10K 1TB SAS	44.3	1.91 MB/sec	499.46 KB/sec	online
IXT-6210XS	22	10K 1TB SAS	45.26	1.91 MB/sec	499.46 KB/sec	online
IXT-6210XS	23	10K 1TB SAS	0	0 KB/sec	0 KB/sec	spare

Storage network utilization was well within the available bandwidth. The peak network utilization during the boot storm reached approximately 6% of the total storage network bandwidth and then gradually declined once all the VMs were booted up. There were also no retransmissions on the iSCSI SAN.

The above results show that EqualLogic PS6210XS hybrid array can handle a heavy I/O load like a boot storms in a VDI environment with no issues.

5.1.2   Login storm I/O

Login VSI was configured to launch 2,000 virtual desktops over a period of about 30 minutes after pre-booting the virtual desktops. The peak IOPS observed during the login storm was about 17,144 IOPS (8.5 IOPS per VM).

Login storms generate significantly more write IOPS than a boot storm due to multiple factors including:

- User profile activity
- Starting operating system services on the desktop
- First launch of applications

Once a virtual desktop has achieved a steady state after user login, the Windows 7 OS has cached applications in memory and does not need to access storage each time the application is launched. This leads to lower IOPS during the steady state. Figure 4 below shows the IOPS and latency observed during the login storm.
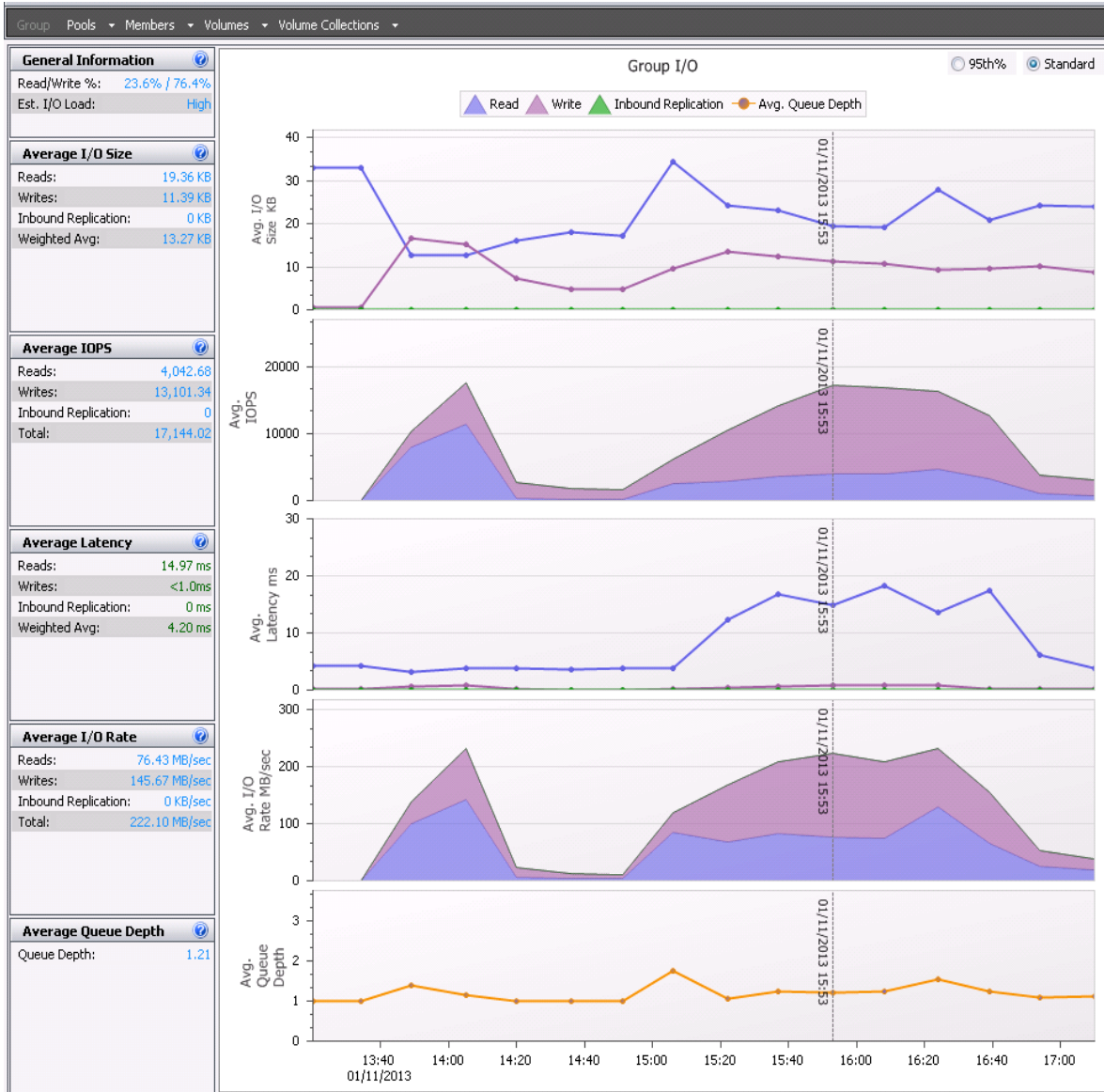
Figure 4   SAN HQ data showing boot and login storm I/O

EqualLogic PS6210XS easily handled logging in 2,000 sessions in a short time delivering the required 17,144 IOPS with 4.2 ms of average latency at the peak of the login storm. Table 7 shows the overall disk usage in the array during the login storm.

Table 7   Disk usage on EqualLogic PS6210XS during login storm

Member	Disk	Description	Average IOPS	Read I/O Rate	Write I/O Rate	Status
IXT-6210XS	0	SSD 800GB SAS	4,945.26	52.19 MB/sec	52.61 MB/sec	online
IXT-6210XS	1	SSD 800GB SAS	4,948.01	52.14 MB/sec	52.68 MB/sec	online
IXT-6210XS	2	SSD 800GB SAS	4,961.39	52.29 MB/sec	52.78 MB/sec	online
IXT-6210XS	3	SSD 800GB SAS	4,937.53	52.33 MB/sec	52.79 MB/sec	online
IXT-6210XS	4	SSD 800GB SAS	4,940.79	52.25 MB/sec	52.80 MB/sec	online
IXT-6210XS	5	SSD 800GB SAS	4,934.91	52.24 MB/sec	52.72 MB/sec	online
IXT-6210XS	6	SSD 800GB SAS	4,932.05	52.09 MB/sec	52.55 MB/sec	online
IXT-6210XS	7	10K 1TB SAS	65.15	2.50 MB/sec	752.52 KB/sec	online
IXT-6210XS	8	10K 1TB SAS	67.55	2.36 MB/sec	745.92 KB/sec	online
IXT-6210XS	9	10K 1TB SAS	63.98	2.48 MB/sec	748.12 KB/sec	online
IXT-6210XS	10	10K 1TB SAS	65.68	2.25 MB/sec	734.92 KB/sec	online
IXT-6210XS	11	10K 1TB SAS	62.22	2.35 MB/sec	740.42 KB/sec	online
IXT-6210XS	12	10K 1TB SAS	60.11	2.23 MB/sec	736.02 KB/sec	online
IXT-6210XS	13	10K 1TB SAS	59.46	2.19 MB/sec	750.32 KB/sec	online
IXT-6210XS	14	10K 1TB SAS	58.56	2.18 MB/sec	745.92 KB/sec	online
IXT-6210XS	15	10K 1TB SAS	57.25	2.15 MB/sec	737.12 KB/sec	online
IXT-6210XS	16	10K 1TB SAS	57.18	2.14 MB/sec	732.72 KB/sec	online
IXT-6210XS	17	10K 1TB SAS	56.71	2.13 MB/sec	739.32 KB/sec	online
IXT-6210XS	18	10K 1TB SAS	56.9	2.13 MB/sec	736.02 KB/sec	online
IXT-6210XS	19	10K 1TB SAS	58.48	2.14 MB/sec	742.62 KB/sec	online
IXT-6210XS	20	10K 1TB SAS	58.27	2.13 MB/sec	739.32 KB/sec	online
IXT-6210XS	21	10K 1TB SAS	57.64	2.16 MB/sec	717.31 KB/sec	online
IXT-6210XS	22	10K 1TB SAS	57.75	2.16 MB/sec	714.01 KB/sec	online
IXT-6210XS	23	10K 1TB SAS	0	0 KB/sec	0 KB/sec	spare

Table 7 shows that most of the login storm I/O operations are handled by SSDs and therefore the array is able to provide the best possible performance. Each SSD handled approximately 4,950 IOPS at the peak of login storm; the average latency was very low during the entire login storm time period, and the array clearly demonstrated its ability to handle the workload.

5.1.3   Steady state I/O

Following the completion of the login storm, the I/O profile changed to approximately 24% Read and 76% Write I/O operations at steady state. The total IOPS required during the peak load at steady state with all the users logged in was around 16,773 (8.3 IOPS per VM). EqualLogic PS6210XS delivered these IOPS with 5 ms average latency, which is well below the 20 ms threshold. The average load during the entire steady

state test period was approximately 15,000 IOPS, which EqualLogic PS6210XS delivered with 4.7 ms average latency as shown in Figure 5.

All changes that occur on the virtual desktop (including temporary OS writes such as memory paging) are being written to disk. The I/O pattern is mostly writes due to this activity. Once the desktops are booted and in a steady state, the read I/O becomes minimal due to Horizon View Storage Accelerator enabling content based read caching (CBRC) on the ESXi hosts.

During steady state there is minimal activity on the replica volume and most of the activity is seen on the VDI-Images volumes that host the virtual desktops.

Figure 5 shows the performance of the array during the steady state test.
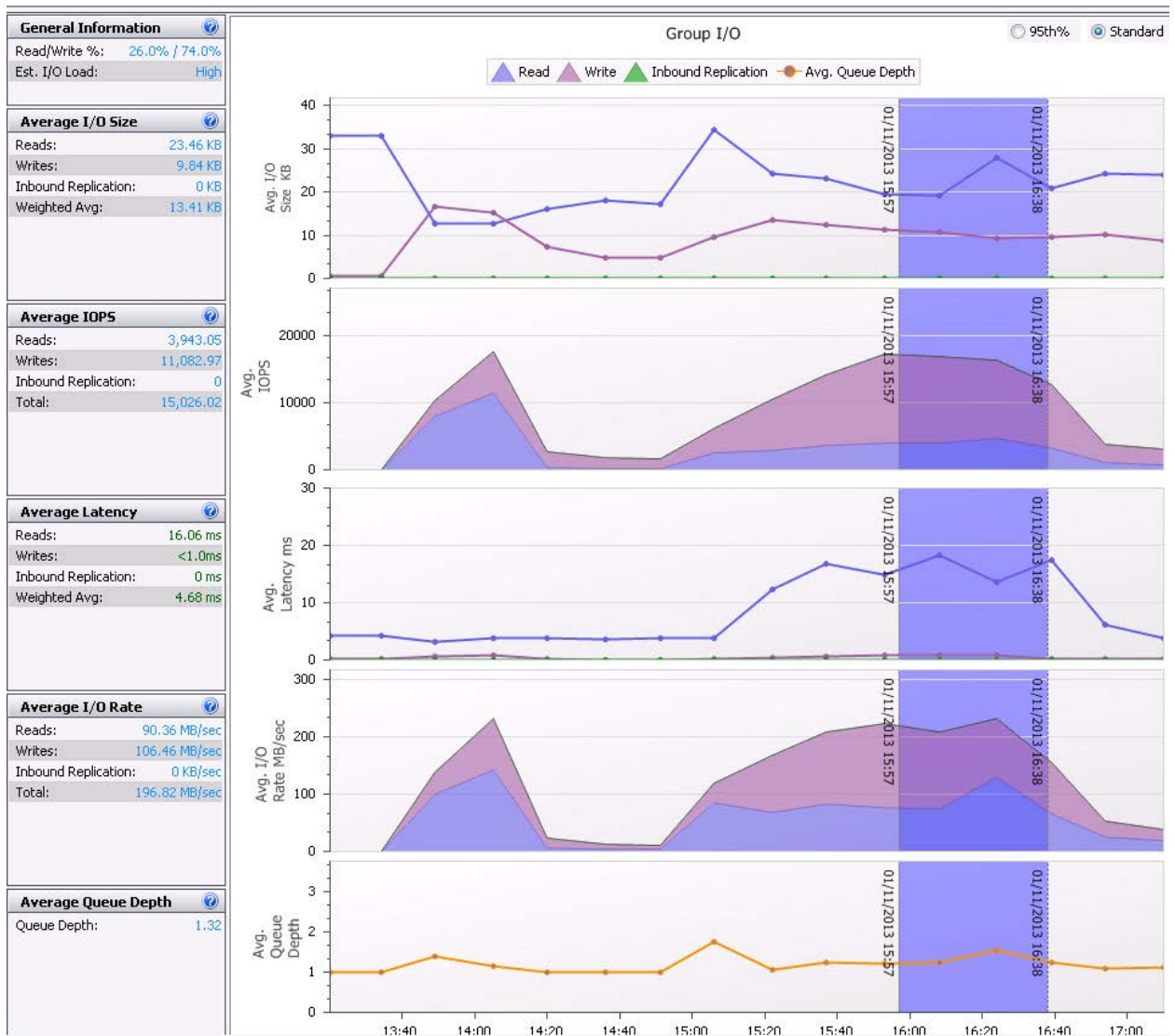
Figure 5   SAN HQ data showing steady state I/O

5.2 Server host performance

During the login storm and steady state of the test, the ESXi host CPU, memory, network, and storage performance was measured on all the servers hosting the virtual desktops. The performance of one such ESXi server is presented here. The other ESXi servers had similar performance characteristics.

Statistics for the ESXi hosts were captured using VMware vCenter Server. The figures below show the CPU, memory, network and disk utilization for boot storm, login storm and steady state of one of the ESXi servers hosting the virtual desktops. Other ESXi servers had similar performance characteristics.
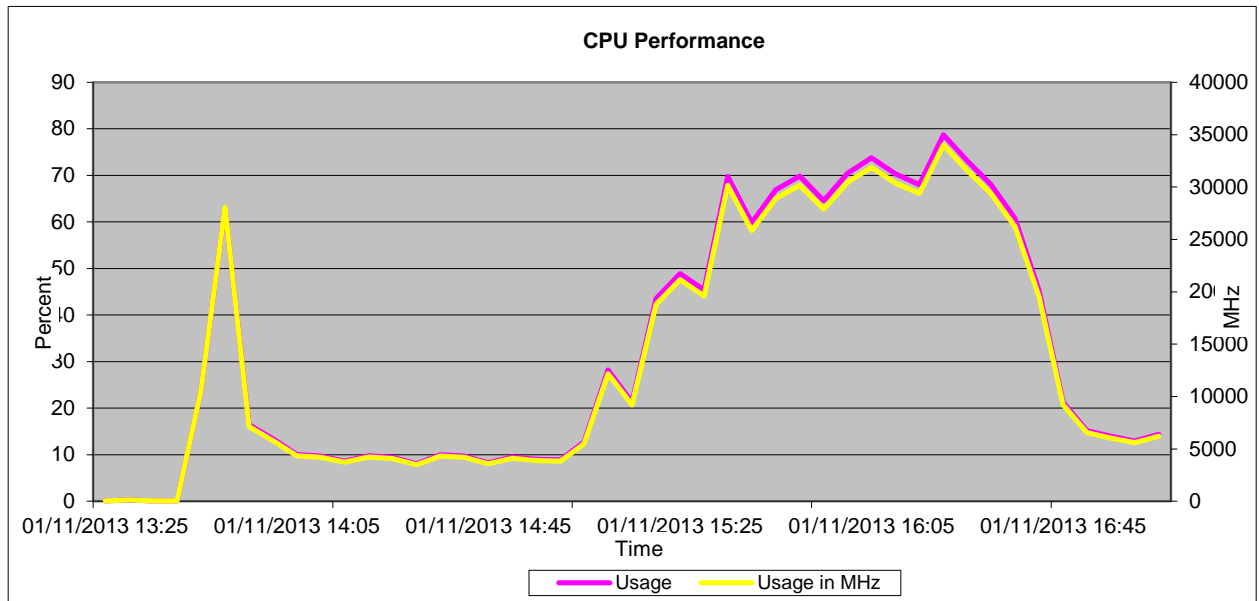
Figure 6   CPU performance during boot storm, login storm and steady state
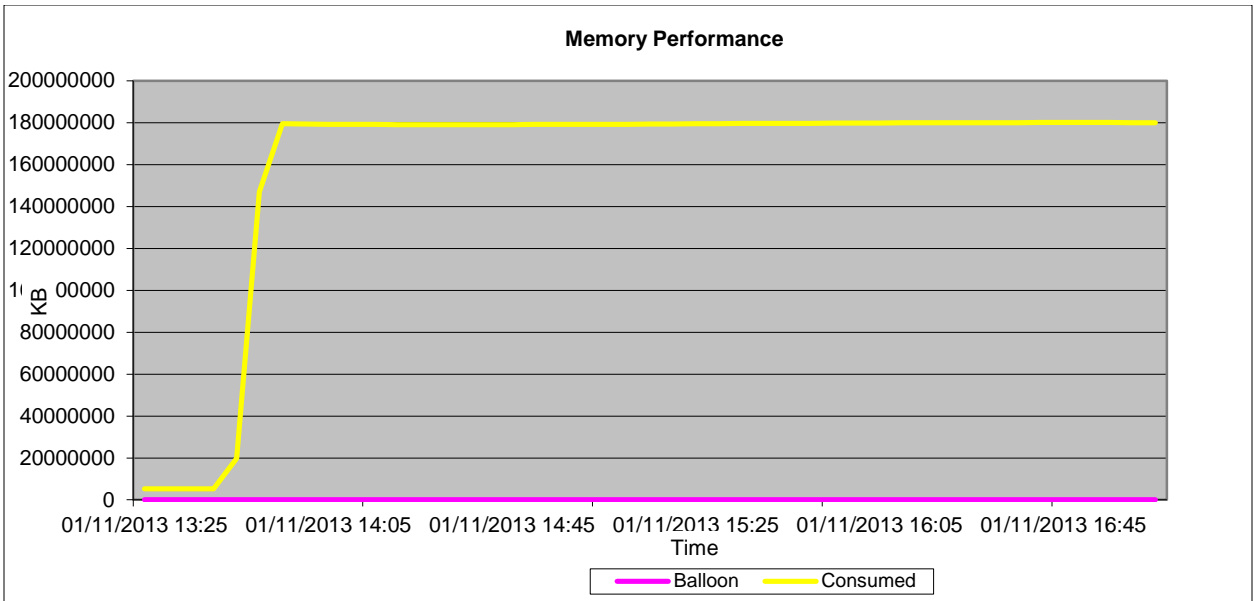
Figure 7   Memory performance during boot storm, login storm and steady state
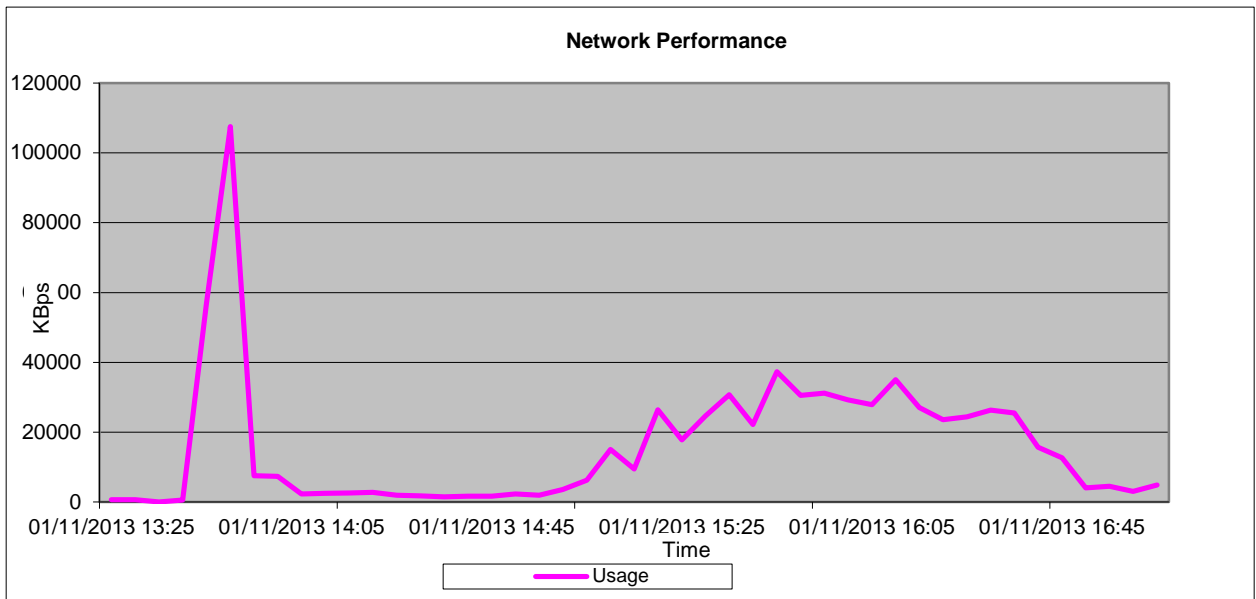

Figure 8   Network performance during boot storm, login storm and steady state
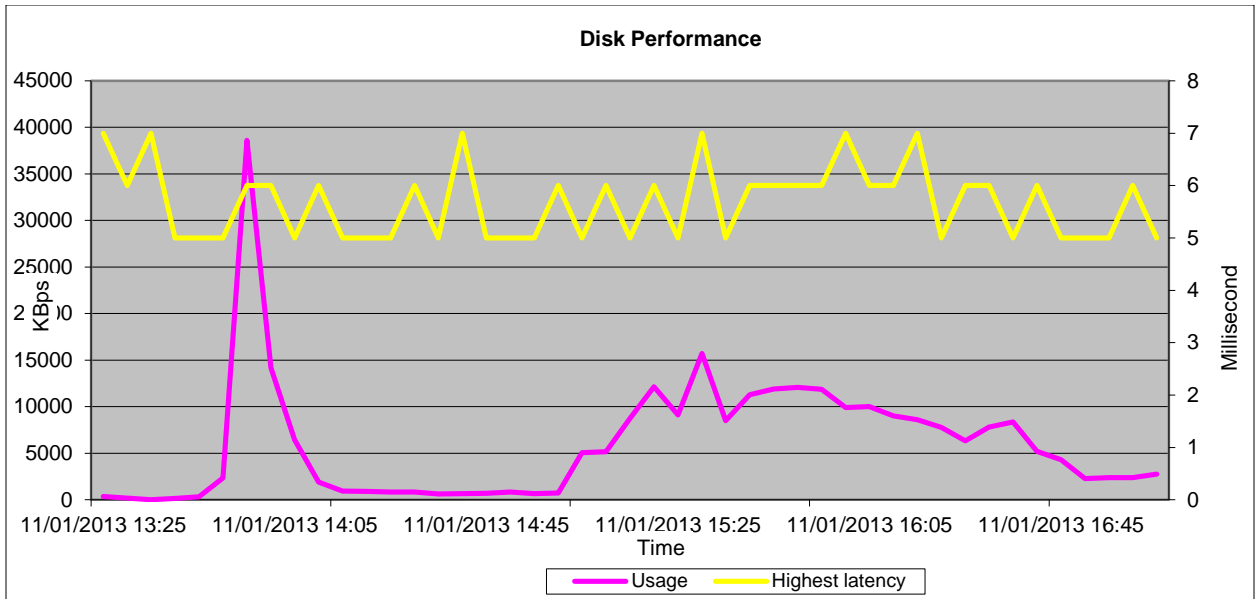
Figure 9   Disk performance during boot storm, login storm and steady state

The key observations from the statistics were:

- CPU utilization was well below the 85% threshold throughout the test.
- There was minimal or no memory ballooning observed. Active memory usage was around 40% during the login and steady state.
- Network utilization was about 31% which included all the networks including iSCSI SAN, VDI LAN, Management LAN and vMotion LAN.
- The *maximum* disk latency never exceeded 7 ms, well below the maximum latency threshold allowed.
- No bottlenecks from the ESXi servers hosting the 2,000 virtual desktops.

5.3   User experience monitoring

Based on the criteria in Section 4.3.3, Figure 10 shows Stratusphere UX scatter plot for user experience. Virtually all the users are in the Good category. This shows that the EqualLogic PS6210XS array is capable of easily providing adequate user experience for all the users in the VDI environment.

Note that Stratusphere UX was able to register 1,860 of the total 2,000 desktops for the scatter plot in Figure 10 below, but the Good performance of the remaining ones were verified in other reports.
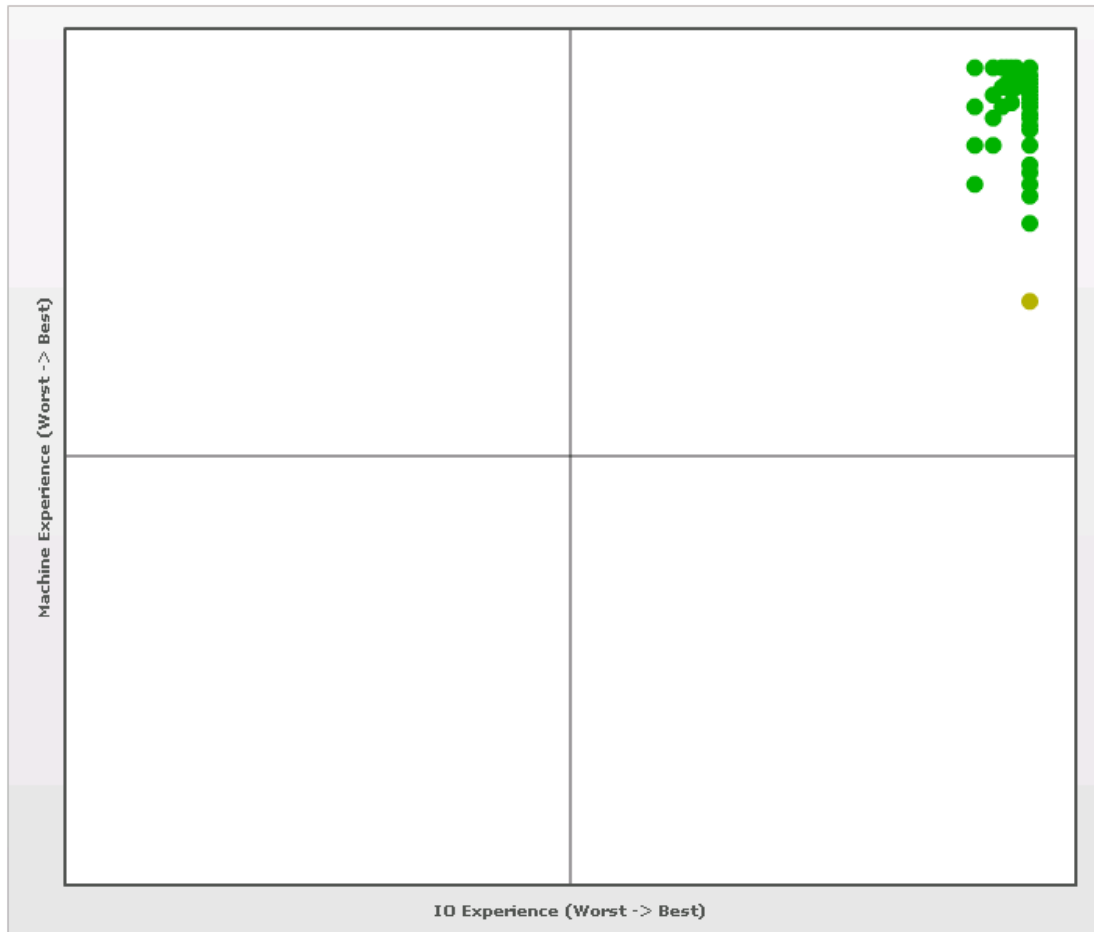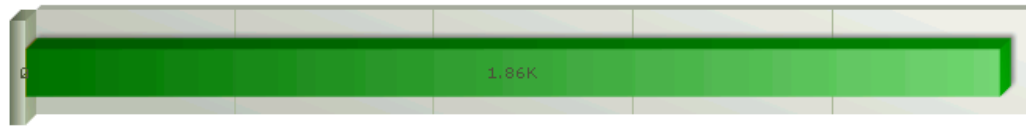
Figure 10   Average VDI user experience for all users

5.4   Results summary

The key observations from the test results are listed below.

- A single EqualLogic PS6210XS was able to host 2,000 virtual desktops and support a standard user type of I/O activity.
- The VDI I/O was mostly write-intensive I/O with more than 74% writes and less than 26% reads.
- None of the system resources on the ESXi servers hosting the virtual desktops reached maximum utilization levels at any time.
- During the boot storm simulation, nearly 17,500 IOPS with less than 2.8 ms of average latency were observed and all the 2,000 desktops were available in Horizon View within 25 minutes of the storm.
- To simulate a login storm, 2,000 users were logged in within a span of 30 minutes. A single EqualLogic PS6210XS array was able to easily sustain this login storm with approximately 17,150 IOPS and 4.2 ms average. Most of the I/O was served by the SSDs on the array.
- The user experience for 2,000 desktops was well within acceptable limits. All sessions were in the upper right quadrant and virtually all of them were in the Good category on Stratusphere UX scatter plot.

6 Sizing guidelines for EqualLogic SANs

The storage array selected for the solution should be able to handle various I/O patterns that occur throughout the day for a VDI solution. These include the login storm at the beginning of a shift or a work day when employees login to their virtual desktops in a relatively short period of time. Once they are logged in, the virtual desktops reach a steady state where they generate predictable IOPS as the employees go about their work day. The same storage array needs to handle recovery situations due to unexpected events such as power outages which might cause boot and login storms.

A good way to deploy the storage infrastructure for VDI is to understand the VDI workload characteristics including the performance characteristics of the applications being deployed. These include:

- Capacity requirements
- Performance requirements
    - IOPS
    - Average disk latency
    - Read and write ratios
    - Type of I/O (Sequential or Random)

For more information on sizing guidelines, see the paper "Sizing and Best Practices for Deploying VMware View 5.1 on VMware vSphere 5.0 U1 with Dell EqualLogic Storage" at:
http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/20219029/download.aspx.

7 Best practices

This section provides the best practices derived from the testing and analysis from Section 5.

7.1 Application layer

This sub-section provides best practices for the implementation of VDI using Horizon View.

7.1.1 Implement roaming profiles and folder redirection

It is highly recommended that all users in the VDI environment be configured with roaming profiles and folder redirection. This preserves user profiles and user data across boots while using non-persistent virtual desktops.

It is also recommended to use a high performance file service to provide the profile and folder redirection. A separate array may be used to host these volumes for best performance.

7.1.2 Boot and login storm considerations

To avoid I/O bursts due to boot storms, it is recommended that all desktops be pre-booted, preferably with the boots staggered over time before users begin login at the start of a shift or a workday.

It is important to size storage based on the IOPS needs of boot and login storms. The storage subsystem should be designed to handle these storms in addition to the steady state IOPS. Sizing a storage system only on the steady state IOPS is not recommended because this can cause degraded user experience and performance during a boot or login storm.

7.1.3 Windows 7 master image for desktop VMs

It is recommended that the operating system be customized in order to provide the best performance in a VDI environment. This includes disabling some services which may not be required. This can improve performance for the end user. VMware has a specific set of recommendations and settings for Windows 7 that allow for faster logins, quicker screen refreshes, and generally better performance.

> The VMware recommendations for Windows 7 image customization can be found here:
> http://www.vmware.com/resources/techresources/10157

7.1.4 SSL certificate requirements

It is recommended that all servers use either signed SSL certificates or use self-signed SSL certificates to provide the best security for your infrastructure. Horizon View servers and Horizon View Composer servers require valid SSL certificates to communicate with each other and to operate correctly.

7.1.5 Horizon View recommendations

Depending on the actual applications and the actual usage of the virtual desktop, it is recommended to adjust the Adobe Flash settings for the remote sessions.

Enabling Horizon View Storage Accelerator is recommended to get the best performance from the storage layer and the best user experience on the virtual desktops. Additionally, use blackout times to ensure that the cache is not regenerated when the users are active on the system because this process puts additional load on the ESXi host and the storage array causing a performance drop that could affect the user experience.

7.2 Server host layer

The ESXi servers hosting the infrastructure service providers and the virtual desktops are recommended to be configured as follows:

- Follow VMware and Dell best practices for installing and configuring ESXi.
- Install and configure EqualLogic Multipathing Extension Module (MEM) for vSphere 5.1 to get the best performance from the storage array.
- Separate virtual switches to segregate iSCSI SAN traffic, VDI traffic, vMotion traffic, and Management network traffic.
- Each network path should be assigned to a minimum of two physical NICs for high availability.

7.3 Network layer

It is recommended that at least two physical NICs on each server be dedicated to each of the following logical networks:

- Management network for Infrastructure service, vMotion services, and VDI LAN
- iSCSI SAN

This allows the solution to work even in the event of the failure of a single blade switch, rack switch, or individual NIC port on the storage array or on the ESXi host server.

Use VLANs to segregate different types of network traffic on the same physical network. In this case, it is recommended to separate the infrastructure, vMotion, and VDI LAN traffic into separate VLANs.

Do not use VLANs to segregate iSCSI SAN traffic. It is required that SAN traffic be on a separate physical network to provide the best performance. The recommended way to provide a converged fabric for iSCSI

SAN traffic is through the use of Data Center Bridging (DCB) technologies which allows the iSCSI SAN to have lossless end to end connections while guaranteeing a minimum bandwidth.

Virtual switches in ESXi have a default limit of 120 ports. If the number of virtual desktops on each host exceeds the available ports, vSwitch properties should be changed to support the required number of virtual desktops. This change requires a reboot of the host ESXi server.

On iSCSI SAN switches, spanning tree portfast (or an equivalent setting) should be enabled for ports connected to hosts and end-devices (such as storage controllers). Jumbo frames and Flow control (if the NICs support it) should be enabled for all components of the iSCSI network.

> More information on configuring Dell Networking switches for use with EqualLogic iSCSI SANs is available here:
> http://en.community.dell.com/techcenter/storage/w/wiki/4250.switch-configuration-guides-by-sis.aspx

7.4   Storage

For VDI environments, it is recommended to use the EqualLogic PS Series hybrid arrays, which consist of SSD drives and 10,000 RPM SAS drives within a single chassis. These hybrid arrays automatically move hot data to the SSD tier, which improves performance in VDI environments in a cost-effective way.

It is recommended to have separate volumes for base images, replica images, and virtual desktops. This aids in better manageability of the volumes, easier performance monitoring, and allows for easy future growth.

It is recommended to use a separate high performance file service to provide file shares for roaming profiles and user shares. Dell EqualLogic FS7610 NAS appliance with Dell Fluid File System is an ideal platform for this purpose.

Enabling Horizon View Storage Accelerator is recommended to get the best performance from the storage layer and the best user experience on the virtual desktops.

8 Conclusions

The paper demonstrates how a 2,000 standard user virtual desktop environment can be deployed using Horizon View VDI platform leveraging a single EqualLogic PS6210XS hybrid array as the storage platform. The storage I/O characteristics under various VDI workload scenarios – boot storm, login storm and steady state – along with performance characteristics throughout the VDI stack demonstrate the effectiveness of EqualLogic PS6210XS as a storage building block for desktop virtualization deployments.

The testing of the EqualLogic storage platform showed that the EqualLogic PS6210XS arrays can easily support very fast access to high-demand data in a VDI workload environment. It can easily handle high IOPS spikes that occur during boot and login storms (for example, delivering nearly 17,500 IOPS with less than 2.8 ms of average storage latency in a 2,000 desktop boot storm test). With EqualLogic hybrid arrays automatically tiering data between SSDs and HDDs, the solution can sustain large IOPS needs with a relatively small amount of SSD capacity thereby cost-effectively boosting the storage performance in a VDI deployment and delivering a great experience for users of hosted desktops.

With the ability to support a large number of desktops in a single array, the EqualLogic PS6210XS can help organizations that are limited by the cost-per-desktop hurdle start their VDI deployment plans much sooner. Moreover, the peer storage architecture of the EqualLogic arrays achieves linear scalability of both controller throughput and storage capacity as new arrays are added with the VDI environment growth. This linear scaling in both performance and capacity keeps the storage-per-virtual-desktop cost low even in very large VDI deployments.

In addition to improved performance and flexible scalability, the EqualLogic PS6210XS hybrid arrays help reduce VDI deployment costs by handling workloads on highly cost-effective storage media, enhance VDI performance by placing read-intensive replica images on low-latency SSDs, and simplify VDI deployments through automated and intelligent data tiering. Combined with the ease of administration of EqualLogic arrays, these benefits reduce the total cost for VDI in many organizations and make EqualLogic PS6210XS a great storage platform for desktop virtualization.

A   VMware Horizon View 5.2 solution configuration

Solution configuration – Hardware components:		Description
Blade enclosure	1 x Dell PowerEdge M1000e blade chassis	All components, (storage, networking and compute), for this solution are held within this blade chassis.
Virtual Desktops	15 x Dell PowerEdge M620 Servers: • BIOS Version: 1.7.6 • 2 x Intel® Xeon® E5-2680 2.7 GHz Processors • 196 GB RAM • 2 x 146 GB 10K SAS internal disk drives • 1 x Broadcom 57810S Dual-Port 10 GbE NIC (LAN on motherboard) • 1 x Broadcom 5719 Quad-Port 1 GbE Mezz NIC	ESXi 5.1 with Dell EqualLogic MEM 1.1.2 installed on all PowerEdge M620 servers Windows 7 (32 Bit) VMs with 1.5GB RAM
Virtual Desktops	4 x Dell PowerEdge R720 Servers: • BIOS Version: 1.7.6 • 2 x Intel® Xeon® E5-2680 2.7 GHz Processors • 196 GB RAM • 2 x 146 GB 10K SAS internal disk drives • 1 x Broadcom 57810S Dual-Port 10 GbE NIC • 1 x Broadcom 5719 Quad-Port 1 GbE NIC	ESXi 5.1 with Dell EqualLogic MEM 1.1.2 installed on all PowerEdge R720 servers Windows 7 (32 Bit) VMs with 1.5GB RAM
Infrastructure Server	1 x Dell PowerEdge M620 server: • BIOS Version: 1.7.6 • 2 x Intel® Xeon® E5-2680 2.7 GHz Processors • 196 GB RAM, • 2 x 146 GB 10K SAS internal disk drives • 1 x Broadcom 57810S Dual-Port 10 GbE NIC (LAN on motherboard) • 1 x Broadcom 5719 Quad-Port 1 GbE Mezz NIC	ESXi 5.1 with Dell EqualLogic MEM 1.1.2 installed on all PowerEdge M620 servers VMs are loaded with Microsoft Windows 2008 R2. • Active Directory • VMware Horizon View 5.2 Server 1 • VMware Horizon View 5.2 Server 2 • VMware vCenter Server 5.1 • VMware Horizon View Composer • SQL Server • File Server

Login VSI Launchers	Dell Cloud Client Computing Launcher Solution	ESXi 5.1 installed on all PowerEdge servers VMs are loaded with Microsoft Windows 7 32bit Each VM supports 20 Login VSI launcher sessions.
Network	**Management, VDI LAN, vMotion:** • **2 x Dell PowerConnect M6348 Ethernet Switches** • **2 x Dell Force10 S4810 Ethernet switches** **iSCSI SAN:** • **2 x Dell PowerConnect M8024-K Ethernet Switches** • **2 x Dell Force10 S4810 Ethernet switches**	
Storage	**1 x Dell EqualLogic PS6210XS:** • **7 x 800GB SSDs** • **17 x 1.2TB 10K SAS disks** • **Dual 10GbE controllers** • **Firmware: 7.0.0** **1 x Dell EqualLogic PS6510E:** • **48 x 1TB 7.2K SATA II SAS disks** • **Dual 10GbE controllers** • **Firmware: 7.0.0**	**Virtual Desktops are stored on the EqualLogic PS6210XS** **Infrastructure VMs and user data stored on EqualLogic PS6510E**
Performance Monitoring	• **SAN HQ** • **vCenter Performance monitoring** • **Stratusphere UX**	**Performance monitoring on EqualLogic arrays** **Performance monitoring and capture at the ESXi host** **User experience monitoring on the virtual desktop**

Solution configuration - Software components:	Description / Version
VMware Horizon View Server	5.2.0 build-987719
VMware Horizon View Composer	5.2.0 build-983460
VMware Horizon View Agent	5.2.0 build-987719
VMware Horizon View Client 32bit	5.3.0 build-1042023
VMware ESXi Hypervisor	5.1.0 build-1065491
VMware vCenter Server	5.1.0 build-1064113
EqualLogic Multipathing Extension Module	1.1.2
EqualLogic SAN Headquarters	2.6.0
Microsoft SQL Server 2008R2 Enterprise x64	10.50.1600.1
Microsoft Windows 7 Enterprise x32 SP1	VDI Clients for characterization tests, Login VSI launchers.
Microsoft Windows Server 2008 Enterprise R2 x64 SP1	VMs for hosting Horizon View Server, vCenter Server, MS-SQL server, and other infrastructure VMs
Login VSI	Version 3.7, Load generator for VDI clients and user experience analysis
Microsoft Office 2007 Standard	Service Pack 3 (12.0.4518.1014)

B ESXi host network configuration

Each ESXi host was configured with three virtual switches - vSwitch0, vSwitch1 and vSwitch2.

B.1 vSwitch0

vSwitch0 provides connection paths for all management LAN traffic including vMotion. Two 1 Gb adapters from the NICs on Fabric B were assigned to this switch.
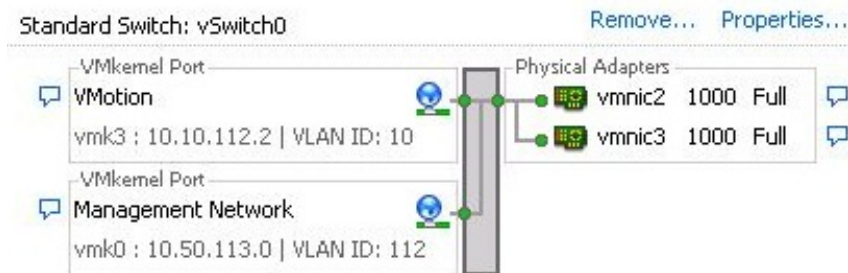

Figure 11 vSwitch0 – vMotion and Management LAN

B.2 vSwitch1

This virtual switch provided paths for all the iSCSI SAN traffic. The two 10 Gb adapters on Fabric A were assigned to this switch.
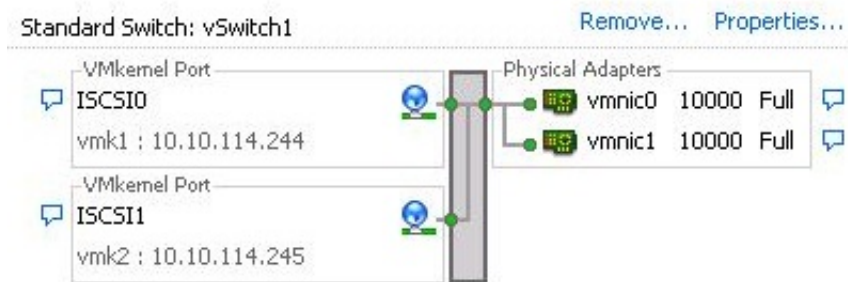

Figure 12 vSwitch1 – iSCSI virtual switch

B.3   vSwitch2

This vSwitch carries all the traffic for the VDI LAN. Two 1 Gb adapters in Fabric B were assigned to this virtual switch.
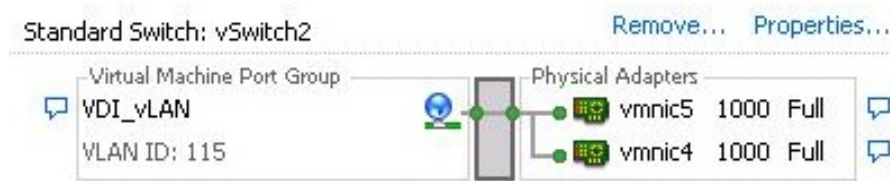

Figure 13   vSwitch2 – VDI LAN

C   Workload characterizations

The Client Cloud Computing group at Dell defines three primary types of workloads for a VDI solution.

Basic workload: This workload profile consists of simple application tasks. Typically a repetitive application use profile with a non-personalized desktop image. Sample use cases may be kiosks or call-centers which do not require a personalized desktop environment and where the application stack is static. The workload requirements for a Basic user are the lowest in terms of CPU, memory, network, and disk I/O and allow the greatest density and scalability of the infrastructure.

Standard workload: This workload profile consists of email, typical office productivity applications, and web browsing for research/training. There is minimal image personalization required in a standard user workload profile. The workload requirement for a Standard user is moderate and most closely matches the majority of office worker profiles in terms of CPU, memory, network, and disk I/O and will allow moderate density and scalability of the infrastructure.

Premium workload: This workload profile represents and advanced knowledge worker. All office applications are configured and used. The user is typically working with moderate-to-large file sizes and may include some graphics creation or editing. The Premium user requires extensive image personalization for shortcuts, macros, menu layouts, etc. The workload requirements for a Premium user are heavier than typical office workers in terms of CPU, memory, network, and disk I/O and allow limited density and scalability of the infrastructure.

The three types of user workloads are summarized in Table 8 below.

Table 8   User workload characterizations

User workload	VM memory allocation	vCPU's assigned	Approximate IOPS	User data disk space	Simultaneous Applications	Login VSI session idle time
Basic	1 GB	1	7-8	5 GB	2	105s
Standard	1.5 GB	1	8-9	5 GB	5	120s
Premium	2.5 GB	1	9-10	5 GB	8	120s

More information about the user workload types can be found in Appendix A.3 of the document "Introduction to the Dell DVS Enterprise Solution" here:
http://i.dell.com/sites/doccontent/business/solutions/engineering-docs/en/Documents/dvs-enterprise-6020.pdf

Additional resources

Support.dell.com is focused on meeting your needs with proven services and support.

DellTechCenter.com is an IT Community where you can connect with Dell Customers and Dell employees to share knowledge, best practices, and information about Dell products and your installations.

Referenced or recommended Dell publications:

- **Desktop Virtualization with VMware VMware Horizon View 5.2 on Dell EqualLogic PS-M4110XS Hybrid Blade Storage Arrays:**
  http://en.community.dell.com/techcenter/extras/m/white_papers/20432213/download.aspx
- **Sizing and Best Practices for Deploying VMware View 5.1 on VMware vSphere 5.0 u1 with Dell EqualLogic Storage:**
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/20219029/download.aspx
- **Dell EqualLogic Configuration Guide:**
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19852516/download.aspx
- **Dell EqualLogic PS Series arrays – Scalability and Growth in Virtual Environments:**
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19992296/download.aspx
- **Installing and configuring the Dell EqualLogic MEM for VMware vSphere 5:**
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19991633/download.aspx
- **Dell EqualLogic PS Series Architecture: Load Balancers:**
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19949521/download.aspx
- **Dell Force10 MXL 10/40GbE Blade Switch Configuration Guide:**
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/20279157/download.aspx

The following VMware publications are referenced in this document or are recommended sources of additional information:

- **VMware Horizon View 5.2 Documentation:**
  http://pubs.vmware.com/view-52/index.jsp
- **VMware Horizon View 5.2 Release notes:**
  http://www.vmware.com/support/view52/doc/horizon-view-52-release-notes.html
- **VMware View Optimization Guide for Windows 7:**
  http://www.vmware.com/resources/techresources/10157
- **VMware KB article on best practices for installing ESXi 5.1:**
  http://kb.vmware.com/kb/2032756
- **VMware blog entry on Optimizing Storage with View Storage Accelerator:**
  http://blogs.vmware.com/euc/2012/05/optimizing-storage-with-view-storage-accelerator.html
- **VMware blog entry on View Storage Accelerator – In Practice:**
  http://blogs.vmware.com/euc/2012/05/view-storage-accelerator-in-practice.html