Desktop Virtualization with VMware Horizon View 5.2 on Dell EqualLogic PS-M4110XS Hybrid Blade Storage Arrays

A Dell EqualLogic Reference Architecture

Dell Storage Engineering
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The testing methodology contained within this document was collaborative effort between Dell Enterprise Storage Solutions Group and Dell Cloud Client Computing teams. This methodology is the same as described in other Dell DVS Enterprise Reference Architectures for VMware® Horizon View™ and follows the same workload generation tools, performance analysis techniques, and sizing guidelines.

Feedback

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

This paper presents a unified compute, storage, and switching all-in-blade-form-factor platform for hosting and running VDI workloads. This unified and integrated Dell solution delivers the performance, scalability, management simplicity, and desktop density that are essential for delivering the VDI potential.

A key component of this unified VDI solution is Dell™ EqualLogic™ PS-M4110XS hybrid arrays, which provide a blade form factor suitable for a complete, self-contained VDI solution within a modular and compact blade enclosure. Together with Dell PowerEdge™ blade servers and Dell Force10™ blade switches, these hybrid blade arrays create a “data center in a box” for VDI deployments. This approach helps organizations reduce virtual desktop deployment and operational costs through efficient use of switching resources, minimized cabling, and consolidated management.

The paper demonstrates how a modular 1,000 standard user virtual desktop environment – all self-contained within a Dell PowerEdge M1000e blade chassis – can be deployed in a VMware® Horizon View™ 5.2 (Horizon View) VDI infrastructure leveraging 12 PowerEdge M620 blade servers, four Force10 MXL blade switches, and two EqualLogic PS-M4110XS hybrid blade 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).

In the test environment, two PS-M4110XS arrays delivered approximately 19,000 IOPS during boot storm, 9,000 IOPS during login storm, and 4,400 IOPS during steady state with satisfactory performance results across all layers – user layer, hypervisor layer, and storage layer – of the stack. The detailed tests results are available in Section 6. Best practices are provided in Section 8.
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 Dell EqualLogic hybrid blade arrays. Another goal of this paper is to create a Horizon View reference architecture with the optimal server, storage, and switching infrastructure for a unified, self-contained VDI-within-a-blade-chassis solution that can be deployed in a modular fashion.

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

1.1 Objectives

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

- Develop best practices and sizing guidelines for a Horizon View based VDI solution deployed within a single Dell PowerEdge M1000e blade chassis
- Determine how many virtual desktops can be deployed in this environment using a single Dell EqualLogic PS-M4110XS blade storage array with acceptable user experience indicators for a standard user workload profile
- Analyze the impact on the user experience indicators when scaling the solution with an additional Dell EqualLogic PS-M4110XS blade storage array
- Determine the performance impact on the storage array of peak I/O activity such as boot and login storms
- Determine the optimal compute, storage, and switching infrastructure for a VDI deployment that is modular and completely self-contained within a blade chassis

The test infrastructure used for the tests includes:

- VMware Horizon View 5.2
- VMware vSphere® 5.1 hypervisor
- Dell PowerEdge M620 blade servers
- Dell Force10 MXL switches
- Dell EqualLogic PS-M4110XS blade storage arrays

1.1.1 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 Horizon View based VDI
Solutions using Dell EqualLogic blade storage. It is expected that the reader has a working knowledge of
the Horizon View architecture, VMware vSphere system administration, iSCSI SAN network design, and
Dell EqualLogic iSCSI SAN operation.
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>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client Devices</td>
<td>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.</td>
</tr>
<tr>
<td>Horizon View Connection Server</td>
<td>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.</td>
</tr>
<tr>
<td>Horizon View Client</td>
<td>Software that is used to access the Horizon View desktops.</td>
</tr>
<tr>
<td>Horizon View Agent</td>
<td>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.</td>
</tr>
<tr>
<td>Horizon View Administrator</td>
<td>A web-based administration platform for the Horizon View infrastructure components.</td>
</tr>
<tr>
<td>vCenter Server™</td>
<td>Central administration platform for configuring, provisioning, and managing VMware virtualized data centers.</td>
</tr>
<tr>
<td>Horizon View Composer</td>
<td>A service running with Horizon View servers, used to create pools of virtual desktops from a shared base image to reduce storage capacity requirements.</td>
</tr>
</tbody>
</table>

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 is 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.

Microsoft® Active Directory® folder redirection and roaming profile 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. The disadvantage of this method is that substantial time might be required to sync the remote profiles at logon and logoff depending on the profile size, infrastructure used, and the number of users performing these tasks. This can be improved by using a high performance file service appliance like the Dell EqualLogic FS series Unified NAS appliance.

For more information on the various types of the Horizon View Pools, see:

For more information on the Dell EqualLogic FS series Unified NAS appliance, see:

### 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 VDI with Dell EqualLogic PS Series Blade Storage

The Dell EqualLogic PS-M4110 blade arrays offer virtualized, enterprise-class storage in a consolidated blade form factor. These blade storage arrays offer intelligent self-optimization, automation, ease-of-use, and data protection. Integrating with Dell PowerEdge M-series blade servers and Dell Force10 MXL blade switches within a Dell PowerEdge M1000e blade chassis, these arrays enable modular, self-contained VDI solutions within the blade chassis form factor that help organizations to simplify management, enhance efficiency, and deploy and scale VDI solutions quickly.

The double-wide, half-height blade form factor of the EqualLogic PS-M4110 blade array plugs into the PowerEdge M1000e enclosure. It features dual, hot-pluggable 10GbE controllers. The array is available in a variety of disk configurations, with the EqualLogic PS-M4110XS hybrid blade array being optimal for VDI deployments. This hybrid blade configuration consists of 14 2.5” drives – five 400 GB solid state drives (SSDs) and nine 600 GB 10,000 RPM SAS hard disk drives (HDDs) – for 7.4 TB of raw storage capacity. Like the other EqualLogic hybrid arrays, EqualLogic PS-M4110XS offers automated load balancing and data tiering within the SSDs and HDDs and is highly adaptive to the utilization spikes of the VDI workload.

For more information on Dell EqualLogic hybrid array load balancer, see: http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/20349614/download.aspx

The modular VDI architecture with compute, storage, and switching all contained within a single PowerEdge M1000e chassis creates a comprehensive, end-to-end desktop virtualization solution that enables IT organizations to do more while consuming less space, power, and cabling than the traditional rack-mounted storage approaches. Specifically, shared resources such as chassis-based power and cooling and backplane connectivity help reduce cabling and minimize space requirements cost-effectively. Additionally, unified management through the Dell Chassis Management Controller (CMC) enables rapid deployment and infrastructure provisioning without requiring specialized expertise.

Figure 1 below shows the modular, all-within-the-blade-chassis VDI building block architecture for 1,000 standard user desktops for Horizon View-based environments with 12 PowerEdge M620 servers, four Force10 MXL switches, and two EqualLogic PS-M4110XS blade arrays. Out of the 12 blade servers, 10 were used to host virtual desktop VMs, and the remaining two were used for hosting infrastructure VMs (as shown in Figure 1). Information about how this reference architecture was developed ensuring the optimal utilization across the servers, switches, and storage arrays is detailed in the rest of this paper.
Figure 1  Compute, storage, and network layout in the PowerEdge M1000e blade chassis for the solution
4 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.

4.1 Host design considerations

The entire infrastructure and test configuration is installed in a single Dell PowerEdge M1000e blade chassis. As shown in Figure 2 below, the 12 PowerEdge M620 blade servers used in this solution are divided into two ESXi clusters.

![ESXi blade clusters on PowerEdge M1000e](image)

The two clusters included:

- **Infrastructure Cluster**: Two M620 blade servers 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 Cluster**: Ten M620 blade servers hosting virtual desktops.

**Note**: VMware has removed the limitation of having a maximum of eight hosts per vCenter cluster in a non-NFS shared datastore with release 5.2 of Horizon View. More information can be found here: [http://www.vmware.com/support/view52/doc/horizon-view-52-release-notes.html](http://www.vmware.com/support/view52/doc/horizon-view-52-release-notes.html)
In addition to the above servers, three Dell PowerEdge R810 rack servers were used for VDI load generation purposes.

4.2 Network design considerations

Figure 3 below shows the network layout of one of the 12 PowerEdge M620 blade servers that has ESXi 5.1 installed on it.

The M1000e blade chassis consisted of the following switches:

- Two Force10 MXL blade switches in Fabric A for connectivity to the Management LAN, VDI client LAN, and a vMotion LAN
- Two Force10 MXL blade switches in Fabric B for connectivity to the dedicated iSCSI SAN

Network Interface Card Partitioning (NPAR) was used to divide the physical NICs in Fabric A into multiple logical NICs. This allows for dynamic allocation of bandwidth for the different partitions and this helps reduce the total cost of ownership for the solution. In these tests, all partitions were given access to the 100% of the available 10 Gb bandwidth. This allows the partitions to use all the bandwidth when required.


The following partitions were created on the Broadcom NICs on Fabric A.
Table 2  NPAR partitions and their minimum bandwidths

<table>
<thead>
<tr>
<th>Partition Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>Management access to the ESXi hosts and infrastructure VMs.</td>
</tr>
<tr>
<td>vMotion</td>
<td>VMware vMotion access to provide live migrations with zero downtime as well as load balancing on ESXi hosts.</td>
</tr>
<tr>
<td>VDI</td>
<td>VDI LAN over which the clients access their desktops.</td>
</tr>
</tbody>
</table>

The networks are segregated at the Force10 MXL 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 allows 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 access the virtual desktops in the Horizon View desktop pools. The connectivity to the existing network of the client is provided by uplink modules on the Force10 MXL switches.
- **VMware vMotion LAN**: This is the network over which the VMs are migrated to provide high availability and load balancing between the hosts. Since the 12 M620s are divided into two clusters, only hosts in the same cluster can provide HA and load balancing.

A pair of dedicated switches provide access to a dedicated iSCSI SAN through which all the virtual desktops and other infrastructure components access the EqualLogic storage arrays.

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

### 4.3 iSCSI SAN configuration

Figure 4 shows the network connectivity between a single M620 blade server and the blade storage array through the blade server chassis. The figure shows only one M620, though all 12 of the blades were used in the testing. The topology is identical for all the remaining blades in the chassis.

- Each PowerEdge M620 blade server is configured with two Broadcom 57810S-k Dual Port 10 Gb NIC cards. One card was assigned as the Fabric A LOM and the other as Fabric B on the blade chassis.
- Fabric A is entirely used to provide Management LAN, VDI Client LAN, and vMotion LAN functionality while Fabric B is entirely used to provide dedicated iSCSI SAN connectivity.
- Dual Force10 MXL switches were installed in Fabrics A and B on the blade server chassis. The NIC cards on the blade servers are internally connected to each of these switches through the mid-plane on the blade server chassis.
- The Force10 MXL switches in Fabric B are interconnected using two 40 GbE links to provide high availability and redundancy of the iSCSI fabric.
- The EqualLogic blade storage arrays are set up to communicate on Fabric B. These are connected to the servers through the MXL blade switch internally.
- Fabric C is unused.

![Diagram of EqualLogic blade storage arrays and Dell EqualLogic PS-M4110XS](image)

**PowerEdge M620**

- **Fabric A LOM**
  - Broadcom 57810s
  - 10 Gb
  - 10 Gb

- **Fabric B Mezz**
  - Broadcom 57810s
  - 10 Gb
  - 10 Gb

**PowerEdge M1000e Midplane**

- **Force10 MXL Fabric A1**
- **Force10 MXL Fabric B1**
- **<Empty> Fabric C1**
- **<Empty> Fabric C2**
- **Force10 MXL Fabric B2**
- **Force10 MXL Fabric A2**

**EqualLogic PSM4110XS**

**Figure 4** iSCSI SAN connectivity

### 4.4 Separation of user data and virtual desktop 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. 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.

Additionally, if a single storage array can cost-effectively serve both the performance and capacity needs of VM data and user data, then separate volumes (maintaining the VM data and user data separation) from the same storage array can be used for this deployment model. EqualLogic hybrid arrays are ideal for this approach as it automatically tiers data based on the I/O workload, which lowers the storage costs for VDI deployments. For these reasons, the user data and the VM data were stored on the same EqualLogic...
hybrid blade arrays (but on different volumes) in the test environment. Each user was assigned about 2 GB of user data space on a 2 TB volume that can support up to a 1,000 users.

4.5 **EqualLogic storage array configuration**

Dell EqualLogic PS-M4110XS blade storage arrays hosted all the virtual desktops as well as the infrastructure virtual machines used in this solution. Initially, tests were conducted with a single PS-M4110XS hybrid array. Once all the tests were performed with one array, an additional PS-M4110XS hybrid array was added to the same pool and the tests were repeated. The volume layout used for the infrastructure functions including user data is shown in Table 3.

<table>
<thead>
<tr>
<th>Volume name</th>
<th>Size</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infra-1</td>
<td>500 GB</td>
<td>Storage for Active Directory, SQL Server, vCenter Server, Horizon View Server-1</td>
</tr>
<tr>
<td>Infra-2</td>
<td>500 GB</td>
<td>Storage for File server, Horizon View Server-2, Horizon View Composer</td>
</tr>
<tr>
<td>UserSpace</td>
<td>2 TB</td>
<td>Storage for User profiles and folder redirection space (Average, 2 GB per user)</td>
</tr>
</tbody>
</table>

In addition to the infrastructure volumes, the storage arrays also provided shared storage for hosting the virtual desktops. The volume layout used for configuring the base image, replicas, and VDI volumes on the two arrays is shown in Table 4.

<table>
<thead>
<tr>
<th>Volume name</th>
<th>Size</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDI-BaseImages</td>
<td>100 GB</td>
<td>Storage for Base image for VDI deployment</td>
</tr>
<tr>
<td>VDI-Replicas</td>
<td>100 GB</td>
<td>Storage for Replica images created by Horizon View</td>
</tr>
<tr>
<td>VDI-Images1</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images2</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images3</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images4</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images5</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images6</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images7</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
<tr>
<td>VDI-Images8</td>
<td>500 GB</td>
<td>Storage for VDI Virtual Machines in Horizon View Cluster</td>
</tr>
</tbody>
</table>
4.6 ESXi host network configuration
VMware ESXi 5.1 hypervisor was installed on all 12 blades. The network configuration on each of those hosts is described below. Each ESXi host was configured with four virtual switches - vSwitch0, vSwitch1, vSwitch2, and vSwitch3 - to separate the different types of traffic on the system.

Table 5 vSwitch configuration in ESXi hosts

<table>
<thead>
<tr>
<th>vSwitch</th>
<th>Description</th>
<th>Virtual NICs used</th>
</tr>
</thead>
<tbody>
<tr>
<td>vSwitch0</td>
<td>Management Network</td>
<td>vmnic0, vmnic1</td>
</tr>
<tr>
<td>vSwitch1</td>
<td>iSCSI SAN</td>
<td>vmnic8, vmnic9</td>
</tr>
<tr>
<td>vSwitch2</td>
<td>VDI LAN</td>
<td>vmnic4, vmnic5</td>
</tr>
<tr>
<td>vSwitch3</td>
<td>vMotion LAN</td>
<td>vmnic2, vmnic3</td>
</tr>
</tbody>
</table>

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

4.7 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](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 on two separate hosts 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.

4.8 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 6  Selected options for Horizon View pool configuration

<table>
<thead>
<tr>
<th>Option</th>
<th>Selected setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual desktop pool type</td>
<td>Automated Pool</td>
</tr>
<tr>
<td>User Assignment</td>
<td>Floating</td>
</tr>
<tr>
<td>vCenter Server</td>
<td>View Composer linked clones</td>
</tr>
<tr>
<td>View Composer Disks</td>
<td>Redirect disposable files to a non-persistent disk of size 4096 MB</td>
</tr>
<tr>
<td>Storage Optimization</td>
<td>Select separate datastores for replica and OS disk</td>
</tr>
<tr>
<td>Advanced Storage Options</td>
<td>Use host caching</td>
</tr>
<tr>
<td>Guest Customization</td>
<td>Sysprep</td>
</tr>
</tbody>
</table>


4.9 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
- 25 GB virtual hard drive
- One virtual NIC connected to the VDI Network
- Windows 7 64 bit OS

5 Horizon View test methodology

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

5.1 Test objectives

As noted in Section 1.1, the test objectives are:

- Develop best practices and sizing guidelines for a Horizon View based VDI solution deployed within a single Dell PowerEdge M1000e blade chassis
- Determine how many virtual desktops can be deployed in this environment using a single Dell EqualLogic PS-M4110XS blade storage array with acceptable user experience indicators for a standard user workload profile
- Analyze the impact on the user experience indicators when scaling the solution with an additional Dell EqualLogic PS-M4110XS blade storage array
- Determine the performance impact on the storage array of peak I/O activity such as boot and login storms
- Determine the optimal compute, storage, and switching infrastructure for a VDI deployment that is modular and completely self-contained within a blade chassis

5.2 Test tools

All tests were conducted using Login VSI 3.7 as the workload generator and user experience analyzer tool. 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

5.2.1 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.
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
- Login VSI Analyzer and 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.

Test criteria

The primary focus of the tests was to determine the maximum number of desktops which can be deployed on a single PS-M4110XS blade storage array in this environment while using VMware Horizon View Composer to provide Linked Clone virtual desktops in an automated pool. The tests were then rerun to find the maximum number of desktops that can be hosted on two PS-M4110XS blade storage arrays.

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.

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.

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%
- Minimal 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%

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

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

Additionally, Login VSI Analyzer was also used to gather metrics on the user experience at the virtual desktop layer to ensure that all the desktops had acceptable levels of application performance. See Appendix C for details about Login VSI’s VSImax (Dynamic) parameter results.

5.4 Test configuration
A single virtual desktop pool was 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 4.9.

Desktop pool properties:

- One Horizon View desktop pool
- Pool with 500 desktops, spread across four 500 GB volumes (VDI-Images1 through 4)
- 500 desktops were deployed across five hosts (100 desktops per host)
- Base Images are stored on a separate 100 GB volume (VDI-BasImage)
- Replica images are stored on a separate 100 GB volume (VDI-Replicas)
- Storage over-commit for all volumes was set to aggressive
- 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

When an additional PS-M4110XS blade storage array was added, the desktop pool was modified so that the additional 500 desktops were hosted on four additional VDI-Images volumes.
6 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.

6.1 Test scenarios

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

1. One array tests for standard users
   a. 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.
   b. 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.
   c. 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. The VSImax (Dynamic) parameter from Login VSI is used to evaluate the user experience of a simulated user working on the virtual desktop throughout this test.

2. Two array tests for standard users

In these tests, an additional EqualLogic PS-M4110XS blade storage array was added to the chassis and the number of desktops was doubled. The boot storm, login storm, and steady state tests were repeated for this configuration. The intent of this test was to show the linear scalability of adding an EqualLogic array.

6.2 One array tests for standard users

The following sections provide results from the boot storm, login storm, and steady state testing for a standard user on one PS-M4110XS array.

6.2.1 Boot storm I/O

To simulate a boot storm, the virtual desktops were reset simultaneously from the VMware vSphere client. Figure 5 shows the storage characteristics during the boot storm – the PS-M4110XS array delivered 9,130 IOPS (14-18 IOPS per VM) under the peak load during this test and all 500 desktops were available in about 10 minutes.
The spike seen in Figure 5 above was primarily due to read operations that occur on the replica volume. This is because the boot operation causes many simultaneous reads to the replica image. The read and write ratios during the boot storm were about 66% reads to 34% writes.

On the replica image volume, nearly 100% reads and negligible writes were observed, as seen in Figure 6 below. This is because the replica volume only hosts a copy of the base image that all the VMs are linked to and due to this almost all of the I/O operations on this volume are reads.

The read and write ratios on the remaining volumes that hosted the virtual machines were about 56% reads and 44% writes. The mix of reads and writes here is because changes made to the OS are written to
these volumes. The IOPS on one such volume are shown in the Figure 7 below. The other volumes that hosted the VMs showed similar IOPS.

The ESXi hosts did not show any bottlenecks with respect to meeting CPU and memory resource demands during the boot operation. Other infrastructure servers, such as the Horizon View servers and Active Directory servers, did not show any exceptional load during the boot storm.

Table 7 below shows that most of the operations during the boot storm were handled by SSDs in the hybrid array. This ensured that the boot storm lasted for a short time and all the desktops were available quickly. The SSD drives also acted as an accelerated write cache on the storage array providing additional caching for the write I/O load.
Table 7  Disk usage on PS-M4110XS during boot storm

<table>
<thead>
<tr>
<th>Member</th>
<th>Disk</th>
<th>Description</th>
<th>Average IOPS</th>
<th>Read I/O rate</th>
<th>Write I/O rate</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-M4110XS</td>
<td>0</td>
<td>SSD 400GB SAS</td>
<td>2266.16</td>
<td>32.60 MB/sec</td>
<td>16.82 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>1</td>
<td>SSD 400GB SAS</td>
<td>2261.68</td>
<td>32.58 MB/sec</td>
<td>16.79 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>2</td>
<td>SSD 400GB SAS</td>
<td>2269.99</td>
<td>32.49 MB/sec</td>
<td>16.80 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>3</td>
<td>SSD 400GB SAS</td>
<td>2267.08</td>
<td>32.61 MB/sec</td>
<td>16.75 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>4</td>
<td>SSD 400GB SAS</td>
<td>2296.26</td>
<td>32.56 MB/sec</td>
<td>16.77 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>5</td>
<td>10K 600GB SAS</td>
<td>2.53</td>
<td>3.52 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>6</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>7</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>8</td>
<td>10K 600GB SAS</td>
<td>&lt;1.0</td>
<td>29.96 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>9</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>10</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>11</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>12</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>13</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>spare</td>
</tr>
</tbody>
</table>

Storage network utilization was well within the available bandwidth. The peak network utilization during the boot storm reach approximately 7.7% of the total network bandwidth and then gradually declined once all the VMs were booted up. There were also no retransmissions on the iSCSI SAN.

These results show that the EqualLogic PS-M4110XS hybrid array can handle a heavy random I/O load like a boot storm with no issues.

6.2.2 Login storm I/O

Login VSI was programmed to launch 500 virtual desktops over a period of about 15 minutes after pre-booting the virtual desktops. The peak IOPS observed during the login storm was about 4,900 IOPS (7-10 IOPS per VM).

Login storms generate significantly more write IOPS than a boot storm or steady state 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 8 below shows the IOPS and latency observed during the login storm.
The peak latency seen on the storage array is less than 20 ms, and the storage array is able to handle the 500 users logging in over such a short duration with no performance issues. Table 8 shows the overall usage of the disks in the array during a login storm as collected by SAN HQ.
Table 8  Disk usage on PS-M4110XS during login storm

<table>
<thead>
<tr>
<th>Member</th>
<th>Disk</th>
<th>Description</th>
<th>Average IOPS</th>
<th>Read I/O rate</th>
<th>Write I/O rate</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-M4110XS</td>
<td>0</td>
<td>SSD 400GB SAS</td>
<td>1838.53</td>
<td>19.41 MB/sec</td>
<td>26.28 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>1</td>
<td>SSD 400GB SAS</td>
<td>1838.99</td>
<td>19.47 MB/sec</td>
<td>26.22 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>2</td>
<td>SSD 400GB SAS</td>
<td>1852.14</td>
<td>19.55 MB/sec</td>
<td>26.34 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>3</td>
<td>SSD 400GB SAS</td>
<td>1840.26</td>
<td>19.53 MB/sec</td>
<td>26.24 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>4</td>
<td>SSD 400GB SAS</td>
<td>1836.91</td>
<td>19.49 MB/sec</td>
<td>26.29 MB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>5</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>6</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>7</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>8</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>9</td>
<td>10K 600GB SAS</td>
<td>&lt;1.0</td>
<td>4.06 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>10</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>11</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>12</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>online</td>
</tr>
<tr>
<td>PS-M4110XS</td>
<td>13</td>
<td>10K 600GB SAS</td>
<td>0</td>
<td>0 KB/sec</td>
<td>0 KB/sec</td>
<td>spare</td>
</tr>
</tbody>
</table>

Table 8 clearly shows that most of the login storm I/O is handled by SSDs and therefore the array is able to provide the best possible performance.

6.2.3  Steady state I/O

The total IOPS on the EqualLogic PS-M4110XS array averaged during the steady state with all the users logged in was around 2,300 (6–8 IOPS per VM). Of this, the read IOPS accounted for about 295 (approximately 13% of the total I/O load) and the remaining 2,000 IOPS or 87% were write IOPS. Read and write latencies were also well below 20 ms throughout the test.

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 9 shows the performance of the array during the steady state test.

![Figure 9 SAN HQ data showing steady state I/O](image-url)
### 6.3 Two array tests for standard users

The following sections provide results from the boot storm, login storm, and steady state testing for a standard user on two PS-M4110XS arrays.

#### 6.3.1 Boot storm I/O

The boot storm test from Section 6.2.1 was repeated after adding another PS-M4110XS array and an additional 500 desktops.

Figure 10 shows the I/O pattern on the pool comprised of the two PS-M4110XS arrays.

![Boot storm I/O with two PS-M4110XS arrays](image)

With 1,000 desktops, the boot storm generated over 19,000 total IOPS with a majority of them being read operations. All desktops were available in less than 15 minutes. This follows the pattern as described in Section 6.2. The read-write ratio for the pool was 75% reads to 25% writes.

The replica volumes and the volumes hosting the virtual desktops showed similar behavior as in the single array test. The network utilization on the SAN with two PS-M4110XS hybrid arrays reached a maximum of about 9.1% when the 1,000 desktops were reset.

#### 6.3.2 Login storm I/O

The tests were repeated after adding a second PS-M4110XS hybrid array to the pool. The results from the login storm with 1,000 desktops can be seen in Figure 11.
Figure 11  SAN HQ data showing login storm I/O with two PS-M4110XS arrays
As seen in the 500 desktops case, the maximum latency seen in this test was also well below the 20 ms criteria and the two arrays were able to sustain about 9,000 total IOPS for the login storm. This shows that the arrays are able to support the 1,000 desktops with no issues.

6.3.3 Steady state I/O

Just like the boot storm and the login storm, the test was repeated after adding another PS-M4110XS hybrid array to the pool. During the steady state for 1,000 desktops, the array was able to sustain about 4,400 IOPS (6-8 IOPS per VM). The read – write ratio changed marginally to 11% reads (460 IOPS) and 89% writes (3,900 IOPS). The latency was well below 20 ms indicating that the two arrays were able to sustain the 1,000 desktops without any issues.

Figure 12 below shows the performance of the two array pool during a steady state of 1,000 desktops.
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, and network utilization for boot storm, login storm and steady state of one of the ESXi servers hosting the virtual desktops. The results shown below are for a test run with 1,000 desktops in the desktop pool.

![CPU performance during login storm and steady state](image1.png)

**Figure 13**  Average CPU Performance per core on one ESXi host during login storm and steady state

![Memory performance](image2.png)

**Figure 14**  Memory usage during login storm and steady state
The key observations from the statistics were:

- CPU utilization was well below the 85% threshold throughout the test.
- Active memory usage was about 80% during the boost storm and about 60% during login storm and steady state. There was minimal or no memory ballooning observed.
Network utilization was about 30% which included all the networks including iSCSI SAN, VDI LAN, Management LAN and vMotion LAN.

Average read and write latencies at the storage adapter level were very close to the observed latencies in SAN HQ.

6.5 User experience monitoring

Based on the criteria in Section 5.4.3, Figure 17 shows the Liquidware Stratusphere UX scatter plot for user experience. Virtually all the users are in the Good category. This shows that the EqualLogic PS-M4110XS arrays are capable of easily providing adequate user experience for all the users in the VDI environment.

Note that Stratusphere UX was able to register 962 of the total 1000 desktops for the scatter plot in Figure 17, but the Good performance of the remaining ones were verified in other reports.

Average VDI UX - Users

<table>
<thead>
<tr>
<th>VDI UX, All Users</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>961</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 17  Average VDI user experience for all users

See Appendix C for user experience results using Login VSI’s VSImax (Dynamic) parameter.

6.6 Results summary

The key observations from the test results are listed below.

- A single EqualLogic PS-M4110XS was able to host 500 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 85% writes and less than 15% 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 9,100 IOPS were observed and all the 500 desktops were available in Horizon View within 20 minutes of the storm.
• With 1,000 desktops, the arrays observed nearly 19,000 IOPS and all desktops were available within 20 minutes of the storm.
• To simulate a login storm, 500 users were logged in within a span of 15 minutes. A single PS-M4110XS array was able to easily sustain this login storm with latency well below 20 ms and had most of the I/O served by the SSDs on the array.
• When 1,000 users were logged in within 30 minutes, two PS-M4110XS storage arrays were able to easily handle this aggressive login storm with low latency.
• The user experience for 500 and 1,000 desktops was well within acceptable limits and virtually all the desktops were in the good category on the Liquidware Stratusphere UX scatter plot.
• Adding a second EqualLogic PS-M4110XS array to the solution linearly scaled the number of desktops supported by the solution to 1,000 virtual desktops.
• A PowerEdge M1000e blade chassis fully populated with 12 PowerEdge M620 blade servers and two EqualLogic PS-M4110XS hybrid blade storage arrays was able to provide a self-contained 1,000 desktop VDI solution.
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:

8  Best practices
This section provides the best practices derived from the testing and analysis from Section 6.

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

8.1.1  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.

8.1.2  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.

8.1.3  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

8.1.4  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.

8.1.5  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.
More information on Adobe Flash quality and throttling settings can be found here:

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.

8.2 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.

VMware KB article on best practices for installing ESXi 5.1: http://kb.vmware.com/kb/2032756

Installing and configuring the Dell EqualLogic MEM for VMware vSphere 5:
http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19991633.aspx

8.3 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 should be disabled on switch ports connected to end devices for server and storage ports. The PortFast setting should be enabled in the switch configuration for these ports. 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:

8.4 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.
9 Conclusions

The paper demonstrates how a modular, 1,000 standard user virtual desktop environment – all self-contained within the blade chassis – can be deployed using Horizon View VDI platform leveraging 12 PowerEdge M620 blade servers, four Force10 MXL blade switches, and two EqualLogic PS-M4110XS hybrid blade arrays. 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 (for example, ESXi server performance and user experience) demonstrate the optimal configuration of all the elements across this VDI building block.

Organizations can leverage this modular VDI solution to start small and then grow as needed without any disruption. For example, this architecture allows customers to start with a partially-populated chassis with fewer blade servers and blade storage. As the demand grows, more server and storage arrays can be added to the chassis to support a larger number of desktops. Once the chassis is fully populated completing the building block, another modular block can be added to the solution for further scaling of the solution. Additionally, this testing of the EqualLogic storage platform showed that the EqualLogic PS-M4110XS 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. 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.

With the ability to support a large number of desktops in a single array, the EqualLogic PS-M4110XS 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, as demonstrated in this paper, keeps the storage-per-virtual-desktop cost low even in very large VDI deployments.

In addition to improved performance and flexible scalability, the PS-M4110XS hybrid arrays help reduce VDI deployment costs by handling workloads on highly cost-effective storage media, enhance VDI performance by placing read-sensitive 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 PS-M4110XS a great storage platform for desktop virtualization.
## VMware Horizon View 5.2 solution configuration

<table>
<thead>
<tr>
<th>Solution configuration - Hardware components:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blade enclosure</strong></td>
<td>1 x Dell PowerEdge M1000e blade chassis</td>
</tr>
<tr>
<td><strong>Virtual Desktops</strong></td>
<td>10 x Dell PowerEdge M620 Servers:</td>
</tr>
<tr>
<td></td>
<td>• BIOS Version: 1.4.9</td>
</tr>
<tr>
<td></td>
<td>• 2 x Intel® Xeon® E5-2650 2.00 GHz Processors</td>
</tr>
<tr>
<td></td>
<td>• 128 GB RAM</td>
</tr>
<tr>
<td></td>
<td>• 2 x 300 GB 10K SAS internal disk drives</td>
</tr>
<tr>
<td></td>
<td>• 1 x Dual-port Broadcom NetXtreme II 57810 10GbE NIC (LAN on motherboard)</td>
</tr>
<tr>
<td></td>
<td>• 1 x Dual-port Broadcom NetXtreme II 57810 10GbE NIC</td>
</tr>
<tr>
<td></td>
<td>ESXi 5.1 with Dell EqualLogic MEM 1.1.2 installed on all M620 servers</td>
</tr>
<tr>
<td></td>
<td>Windows 7 (64 Bit) VMs with 1.5GB RAM</td>
</tr>
<tr>
<td><strong>Infrastructure Servers</strong></td>
<td>2 x Dell PowerEdge M620 servers:</td>
</tr>
<tr>
<td></td>
<td>• BIOS Version: 1.4.9</td>
</tr>
<tr>
<td></td>
<td>• 2 x Intel® Xeon® E5-2650 2.00 GHz Processors</td>
</tr>
<tr>
<td></td>
<td>• 128 GB RAM,</td>
</tr>
<tr>
<td></td>
<td>• 2 x 300 GB 10K SAS internal disk drives</td>
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</tr>
<tr>
<td></td>
<td>• 1 x Dual-port Broadcom NetXtreme II 57810 10GbE NIC</td>
</tr>
<tr>
<td></td>
<td>ESXi 5.1 with Dell EqualLogic MEM 1.1.2 installed on all M620 servers</td>
</tr>
<tr>
<td></td>
<td>VMs are loaded with Microsoft Windows 2008 R2.</td>
</tr>
<tr>
<td></td>
<td>• Active Directory</td>
</tr>
<tr>
<td></td>
<td>• VMware Horizon View 5.2 Server 1</td>
</tr>
<tr>
<td></td>
<td>• VMware Horizon View 5.2 Server 2</td>
</tr>
<tr>
<td></td>
<td>• VMware vCenter Server 5.1b</td>
</tr>
<tr>
<td></td>
<td>• VMware Horizon View Composer</td>
</tr>
<tr>
<td></td>
<td>• SQL Server</td>
</tr>
<tr>
<td></td>
<td>• File Server</td>
</tr>
<tr>
<td><strong>Login VSI Launchers</strong></td>
<td>3 x Dell PowerEdge R810 servers</td>
</tr>
<tr>
<td></td>
<td>• BIOS Version: 2.7.0</td>
</tr>
<tr>
<td></td>
<td>• 2 x Intel® Xeon® E-7540 2.00 GHz Processors</td>
</tr>
<tr>
<td></td>
<td>• 64 GB RAM</td>
</tr>
<tr>
<td></td>
<td>• 4 x 146 GB 10K SAS internal disk drives</td>
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<tr>
<td></td>
<td>• 1 x Dual-port Broadcom NetXtreme II 57711 10GbE NIC</td>
</tr>
<tr>
<td></td>
<td>ESXi 5.1 installed on all R810 servers</td>
</tr>
<tr>
<td></td>
<td>VMs are loaded with Microsoft Windows 7 64bit</td>
</tr>
<tr>
<td></td>
<td>Each VM supports 30 Login VSI launcher sessions.</td>
</tr>
</tbody>
</table>
Network
- Management, VDI LAN
  2 x Dell Force10 MXL 10Gb Ethernet Switch
- iSCSI SAN
  2 x Dell Force10 MXL 10Gb Ethernet Switch

| 2 x 40GbE LAG interconnect for HA and load balancing
| Firmware: 8.3.16.2

Storage
2 x Dell EqualLogic Blade Storage Array PS-M4110XS:
- 5 x 400GB SSD
- 9 x 600GB 10K SAS disks
- Dual 10GbE controllers
- Firmware: 6.0.2

User Data, Infrastructure VMs, Virtual Desktops are all stored on the PS-M4110XS blade storage arrays.

Performance Monitoring
- SAN HQ
- vCenter Performance monitoring
- Login VSI Analyzer

Performance monitoring on EqualLogic arrays
Performance monitoring and capture at the ESXi host
User experience monitoring on the virtual desktop

Solution configuration - Software components:

<table>
<thead>
<tr>
<th>Description / Version</th>
<th>Software component</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMware Horizon View Server</td>
<td>5.2.0 build-987719</td>
</tr>
<tr>
<td>VMware Horizon View Composer</td>
<td>5.2.0 build-983460</td>
</tr>
<tr>
<td>VMware Horizon View Agent</td>
<td>5.2.0 build-987719</td>
</tr>
<tr>
<td>VMware Horizon View Client 64bit</td>
<td>5.3.0 build-1042023</td>
</tr>
<tr>
<td>VMware ESXi Hypervisor</td>
<td>5.1.0 build-914609</td>
</tr>
<tr>
<td>VMware vCenter Server</td>
<td>5.1.0 build-1064983</td>
</tr>
<tr>
<td>EqualLogic Multipathing Extension Module</td>
<td>1.1.2</td>
</tr>
<tr>
<td>EqualLogic SAN Headquarters</td>
<td>2.5.0</td>
</tr>
<tr>
<td>Microsoft SQL Server 2008R2 Enterprise x64</td>
<td>10.50.1600.1</td>
</tr>
<tr>
<td>Microsoft Windows 7 Enterprise x64 SP1</td>
<td>VDI Clients for characterization tests, Login VSI launchers.</td>
</tr>
<tr>
<td>Microsoft Windows Server 2008 Enterprise R2 x64 SP1</td>
<td>VMs for hosting Horizon View Server, vCenter Server, MS-SQL server, and other infrastructure VMs</td>
</tr>
<tr>
<td>Software</td>
<td>Version/Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Login VSI</td>
<td>Version 3.7, Load generator for VDI clients and user experience analysis</td>
</tr>
<tr>
<td>Microsoft Office 2007 Standard</td>
<td>Service Pack 3 (12.0.6607.1000)</td>
</tr>
</tbody>
</table>
ESXi host network configuration

Each ESXi host was configured with four virtual switches - vSwitch0, vSwitch1, vSwitch2, and vSwitch3.

B.1 vSwitch0

vSwitch0 provides connection paths for all management LAN traffic. The first partition of the physical adapters from the two on board NICs (Fabric A) was assigned to this switch.

![Figure 18 vSwitch0 - Management LAN](image)

B.2 vSwitch1

This virtual switch provided paths for all the iSCSI SAN traffic. Two 10GbE physical adapters were assigned to this virtual switch from the mezzanine card on Fabric B.

![Figure 19 vSwitch1 - iSCSI virtual switch](image)

B.3 vSwitch2

Two partitions from the physical adapters in Fabric A are assigned to this virtual switch. This vSwitch carries all the traffic for the VDI LAN.
Figure 20  vSwitch2 – VDI LAN

B.4  vSwitch3

Two partitions from the physical adapters in Fabric A are assigned to this virtual switch. This vSwitch carries the traffic required to provide VMware vMotion services.

Figure 21  vSwitch3 – vMotion LAN
User experience monitoring with Login VSI

Login VSI uses the VSImax parameter to determine the maximum number of sessions that can be obtained from a deployed solution.

The calculation methodology used in VSImax is available here: http://www.loginvsi.com/documentation/v3/analyzing-results/calculating-vsimax

Figure 22 below shows the response time as experienced by each user as calculated by Login VSI. The graph clearly shows that the VSImax (Dynamic) value has not been reached and there were no hung or inactive sessions. This means that the array is capable of supporting the 1,000 desktops and all users have acceptable response times for applications that the user is running.

Figure 22  Login VSI generated graph showing average response time per user and VSImax for 1,000 VMs
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 an 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 9 below.

<table>
<thead>
<tr>
<th>User workload</th>
<th>VM memory allocation</th>
<th>vCPUs assigned</th>
<th>Approximate IOPS</th>
<th>User data disk space</th>
<th>Simultaneous Applications</th>
<th>Login VSI session idle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>1 GB</td>
<td>1</td>
<td>7-8</td>
<td>5 GB</td>
<td>2</td>
<td>105s</td>
</tr>
<tr>
<td>Standard</td>
<td>1.5 GB</td>
<td>1</td>
<td>8-9</td>
<td>5 GB</td>
<td>5</td>
<td>120s</td>
</tr>
<tr>
<td>Premium</td>
<td>2.5 GB</td>
<td>1</td>
<td>9-10</td>
<td>5 GB</td>
<td>8</td>
<td>120s</td>
</tr>
</tbody>
</table>

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:

- 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:
- 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

For EqualLogic best practices white papers, reference architectures, and sizing guidelines for enterprise applications and SANs, refer to Storage Infrastructure and Solutions Team Publications at:

- http://dell.to/sM4hJt
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