EMC INFRASTRUCTURE FOR VIRTUAL DESKTOPS ENABLED BY EMC® VNX™ SERIES (NFS), VMWARE® vSPHERE™ 4.1, VMWARE VIEW™ 4.6, AND VMWARE VIEW COMPOSER 2.6

Proven Solutions Guide

EMC SOLUTIONS GROUP

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Chapter 1: Executive Summary

This chapter summarizes the proven solution described in this document and includes the following sections:

- Introduction to the EMC VNX series
- Business case
- Solution overview
- Key results and recommendations

Introduction to the EMC VNX series

Introduction

The EMC® VNX™ series delivers uncompromising scalability and flexibility for the midtier user while providing market-leading simplicity and efficiency to minimize total cost of ownership. Customers can benefit from the new VNX features such as:

- Next-generation unified storage, optimized for virtualized applications.
- Extended cache by using Flash drives with FAST Cache and Fully Automated Storage Tiering for Virtual Pools (FAST VP) that can be optimized for the highest system performance and lowest storage cost simultaneously on both block and file.
- Multiprotocol support for file, block, and object with object access through EMC Atmos™ Virtual Edition (Atmos VE).
- Simplified management with EMC Unisphere™ for a single management framework for all NAS, SAN, and replication needs.
- Up to three times improvement in performance with the latest Intel multicore CPUs, optimized for Flash.
- 6 Gb/s SAS back end with the latest drive technologies supported:
  - 3.5 in. 100 GB and 200 GB Flash, 3.5 in. 300 GB and 600 GB 15k or 10k rpm SAS, and 3.5 in. 2 TB 7.2k rpm NL-SAS
  - 2.5 in. 300 GB and 600 GB 10k rpm SAS
- Expanded EMC UltraFlex™ I/O connectivity—Fibre Channel (FC), Internet Small Computer System Interface (iSCSI), Common Internet File System (CIFS), network file system (NFS) including parallel NFS (pNFS), Multi-Path File System (MPFS), and Fibre Channel over Ethernet (FCoE) connectivity for converged networking over Ethernet.

The VNX series includes five new software suites and three new software packs that make it easier and simpler to attain the maximum overall benefits.
Chapter 1: Executive Summary

Software suites available

- VNX FAST Suite — Automatically optimizes for the highest system performance and the lowest storage cost simultaneously (FAST VP is not part of the FAST Suite for the EMC VNX5100™).
- VNX Local Protection Suite — Practices safe data protection and repurposing.
- VNX Remote Protection Suite — Protects data against localized failures, outages, and disasters.
- VNX Application Protection Suite — Automates application copies and proves compliance.
- VNX Security and Compliance Suite — Keeps data safe from changes, deletions, and malicious activity.

Software packages available

- VNX Total Efficiency Pack — Includes all five software suites (not available for the VNX5100).
- VNX Total Protection Pack — Includes local, remote, and application protection suites.
- VNX Total Value Pack — Includes all three protection software suites and the Security and Compliance Suite (the VNX5100 exclusively supports this package).

Business case

Customers require a scalable, tiered, and highly available infrastructure to deploy their virtual desktop environment. There are several new technologies available to assist them in architecting a virtual desktop solution. But the customers need to know how to best use these technologies to maximize their investment, support service-level agreements, and reduce their desktop total cost of ownership.

The purpose of this solution is to build a replica of a common customer virtual desktop infrastructure (VDI) environment and validate the environment for performance, scalability, and functionality. Customers will realize:

- Increased control and security of their global, mobile desktop environment, typically their most at-risk environment.
- Better end-user productivity with a more consistent environment.
- Simplified management with the environment contained in the data center.
- Better support of service-level agreements and compliance initiatives.
- Lower operational and maintenance costs.

Solution overview

This solution demonstrates how to use an EMC VNX platform to provide storage resources for a robust VMware® View™ 4.6 environment by using Windows 7 virtual desktops.

Planning and designing the storage infrastructure for VMware View is a critical step because the shared storage must be able to absorb large bursts of input/output (I/O) that occur during the course of a day, which can lead to periods of erratic and
unpredictable virtual desktop performance. Users can adapt to slow performance, but unpredictable performance will quickly frustrate them.

To provide predictable performance to a virtual desktop infrastructure, the storage must be able to handle peak I/O load from clients without resulting in high response time. Designing for this workload involves deploying several disks to handle brief periods of extreme I/O pressure. Such a deployment is expensive to implement. This solution uses EMC VNX FAST Cache to reduce the number of disks required.

EMC VNX FAST Cache provides measurable benefits in a desktop virtualization environment. It not only reduces the response time for both read and write workloads, but also effectively supports more users on fewer drives, and greater IOPS density with a lower drive requirement. Chapter 7: Testing and Validation provides more details.
Chapter 2: Introduction

Introduction

EMC’s commitment to consistently maintain and improve quality is led by the Total Customer Experience (TCE) program, which is driven by Six Sigma methodologies. As a result, EMC has built Customer Integration Labs in its Global Solutions Centers to reflect realworld deployments in which TCE use cases are developed and executed. These use cases provide EMC with an insight into the challenges that are currently facing its customers.

This Proven Solutions Guide summarizes a series of best practices that were discovered or validated during testing of the EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere™ 4.1, VMware View 4.6, and VMware View Composer 2.6 solution by using the following products:

- EMC VNX series
- VMware View Manager 4.6
- VMware View Composer 2.6
- VMware vSphere™ 4.1

This chapter includes the following sections:

- Document overview
- Reference architecture
- Prerequisites and supporting documentation
- Terminology

Document overview

Use case definition

The following seven use cases are examined in this solution:

- Boot storm
- Antivirus scan
- Microsoft security patch install
- Login storm
- User workload simulated with Login VSI tool
- View recompose
- View refresh

Chapter 7: Testing and Validation contains the test definitions and results for each use case.
Purpose

The purpose of this solution is to provide a virtualized infrastructure for virtual desktops powered by VMware View 4.6, VMware vSphere 4.1, EMC VNX series (NFS), VNX FAST Cache, and storage pools.

This solution includes all the components required to run this environment such as hardware and software including Active Directory, and the required VMware View configuration.

Information in this document can be used as the basis for a solution build, white paper, best practices document, or training.

Scope

This Proven Solutions Guide contains the results observed from testing the EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6 View 4.6 solution. The objectives of this testing are to establish:

- A reference architecture of validated hardware and software that permits easy and repeatable deployment of the solution.
- The storage best practices to configure the solution in a manner that provides optimal performance, scalability, and protection in the context of the midtier enterprise market.

Not in scope

Implementation instructions are beyond the scope of this document. Information on how to install and configure VMware View 4.6 components, vSphere 4.1, and the required EMC products is outside the scope of this document. Links to supporting documentation for these products are supplied where applicable.

Audience

The intended audience for this Proven Solutions Guide is:

- Internal EMC personnel
- EMC partners, and
- Customers

Prerequisites

It is assumed that the reader has a general knowledge of the following products:

- VMware vSphere 4.1
- VMware View 4.6
- EMC VNX series
- Cisco Nexus and Catalyst switches
Table 1 lists the terms that are frequently used in this paper.

Table 1. Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC VNX FAST Cache</td>
<td>A feature that enables the use of Flash drive as an expanded cache layer for the array.</td>
</tr>
<tr>
<td>Linked clone</td>
<td>A virtual desktop created by VMware View Composer from a writeable snapshot paired with a read-only replica of a master image.</td>
</tr>
<tr>
<td>Login VSI</td>
<td>A third-party benchmarking tool developed by Login Consultants that simulates real-world VDI workload by using an AutoIT script and determines the maximum system capacity based on the response time of the users.</td>
</tr>
<tr>
<td>Replica</td>
<td>A read-only copy of a master image that is used to deploy linked clones.</td>
</tr>
<tr>
<td>VMware View Composer</td>
<td>Integrates effectively with VMware View Manager to provide advanced image management and storage optimization.</td>
</tr>
</tbody>
</table>
Reference architecture

This Proven Solutions Guide has a corresponding Reference Architecture document that is available on EMC Powerlink® website and EMC.com. The *EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Reference Architecture* provides more details.

If you do not have access to these documents, contact your EMC representative.

The reference architecture and the results in this Proven Solution Guide are valid for 500 Windows 7 virtual desktops conforming to the workload described in “Validated environment profile” on page 49.

Figure 1 depicts the architecture of the midsize solution.
## Configuration

**Table 2** lists the hardware used to validate the solution.

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Quantity</th>
<th>Configuration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC VNX5300™</td>
<td>1</td>
<td>Two Data Movers (active/passive)</td>
<td>VNX shared storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Three disk-array enclosures (DAEs) configured with:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Twenty five 300 GB, 15k rpm 3.5-inch SAS disks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Nine 2 TB, 7,200 rpm 3.5-inch NL-SAS disks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Three 100 GB, 3.5-inch Flash drives</td>
<td></td>
</tr>
<tr>
<td>Intel-based servers</td>
<td>8</td>
<td>• Memory: 72 GB of RAM</td>
<td>Virtual desktop ESX cluster</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CPU: Two Intel Xeon X5550 with 2.67 GHz quad core processors</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Internal storage: One 73 GB internal SAS disk</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• External storage: VNX5300 (NFS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• NIC: Quad-port Broadcom BCM5709 1000Base-T adapters</td>
<td></td>
</tr>
<tr>
<td>Other servers</td>
<td>2</td>
<td>• Memory: 20 GB RAM</td>
<td>ESX cluster to host infrastructure virtual machines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CPU: Two Intel Xeon 5450 3.0 GHz quad core processors</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Internal storage: One 73 GB internal disk</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• External storage: VNX5300 (NFS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• NIC: Two Broadcom NetXtreme II BCM 1000 Base-T adapters</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 2: Introduction

EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Proven Solutions Guide

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Quantity</th>
<th>Configuration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco Catalyst 6509</td>
<td>2</td>
<td>• WS-6509-E switch</td>
<td>1 Gb host connections distributed over two line cards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• WS-x6748 1 Gb line cards</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• WS-SUP720-3B supervisor</td>
<td></td>
</tr>
<tr>
<td>Cisco Nexus 5020</td>
<td>2</td>
<td>Forty 10 Gb ports</td>
<td>Redundant LAN A/B configuration</td>
</tr>
</tbody>
</table>

Software resources Table 3 lists the software used to validate the solution.

Table 3. Solution software

<table>
<thead>
<tr>
<th>Software</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>VNX5300 (shared storage, file systems)</td>
<td></td>
</tr>
<tr>
<td>VNX OE for file</td>
<td>Release 7.0.14.0</td>
</tr>
<tr>
<td>VNX OE for block</td>
<td>Release 31 (05.31.000.5.006)</td>
</tr>
<tr>
<td>VSI for VMware vSphere: Unified Storage Management</td>
<td>Version 4.1</td>
</tr>
<tr>
<td>VSI for VMware vSphere: Storage Viewer</td>
<td>Version 4.0.1</td>
</tr>
<tr>
<td>Cisco Nexus</td>
<td></td>
</tr>
<tr>
<td>Cisco Nexus 5020</td>
<td>Version 4.2(1)N1(1)</td>
</tr>
<tr>
<td>ESX servers</td>
<td></td>
</tr>
<tr>
<td>ESX</td>
<td>ESX 4.1 update 1</td>
</tr>
<tr>
<td>vCenter Server</td>
<td></td>
</tr>
<tr>
<td>OS</td>
<td>Windows 2008 R2</td>
</tr>
<tr>
<td>VMware vCenter Server</td>
<td>4.1 update 1</td>
</tr>
<tr>
<td>VMware View Manager</td>
<td>4.6</td>
</tr>
<tr>
<td>VMware View Composer</td>
<td>2.6</td>
</tr>
<tr>
<td>Virtual Desktops</td>
<td></td>
</tr>
<tr>
<td>Note: This software is used to generate the test load.</td>
<td></td>
</tr>
<tr>
<td>OS</td>
<td>MS Windows 7 Enterprise (32-bit)</td>
</tr>
<tr>
<td>VMware tools</td>
<td>8.3.7</td>
</tr>
<tr>
<td>Microsoft Office</td>
<td>Office Enterprise 2007 Version 12</td>
</tr>
</tbody>
</table>
## Chapter 2: Introduction

EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Proven Solutions Guide

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet Explorer</td>
<td>8.0.7600.16385</td>
</tr>
<tr>
<td>Adobe Reader</td>
<td>9.1.0</td>
</tr>
<tr>
<td>McAfee Virus Scan</td>
<td>8.7.0i Enterprise</td>
</tr>
<tr>
<td>Adobe Flash Player</td>
<td>10</td>
</tr>
<tr>
<td>Bullzip PDF Printer</td>
<td>6.0.0.865</td>
</tr>
<tr>
<td>Login VSI (VDI workload generator)</td>
<td>2.1.2 Professional Edition</td>
</tr>
</tbody>
</table>
This chapter describes the general design and layout instructions that apply to the specific components used during the development of this solution. This chapter includes the following sections:

- VMware View 4.6
- vSphere 4.1 infrastructure
- Windows infrastructure

### VMware View 4.6

**Introduction**

VMware View delivers rich and personalized virtual desktops as a managed service from a virtualization platform built to deliver the entire desktop, including the operating system, applications, and user data. With VMware View 4.6 desktop, administrators can virtualize the operating system, applications, and user data, and deliver modern desktops to end users. VMware View 4.6 provides centralized automated management of these components with increased control and cost savings. VMware View 4.6 improves business agility while providing a flexible high-performance desktop experience for end users across a variety of network conditions.

**Deploying VMware View components**

This solution is deployed by using a single View Manager server instance that is capable of scaling up to 2,000 virtual desktops. Deployments of up to 10,000 virtual desktops are possible by using multiple View Manager servers.

The core elements of a VMware View 4.6 implementation are:

- View Manager Connection Server 4.6
- View Composer 2.6
- vSphere 4.1

Additionally, the following components are required to provide the infrastructure for a VMware View 4.6 deployment:

- Microsoft Active Directory
- Microsoft SQL Server
- DNS server
- Dynamic Host Configuration Protocol (DHCP) server
Chapter 3: VMware View Infrastructure

**View Manager Connection Server**

The View Manager Connection Server is the central management location for virtual desktops and has the following key roles:

- Broker connections between users and virtual desktops
- Control the creation and retirement of virtual desktop images
- Assign users to desktops
- Control the state of the virtual desktops
- Control access to the virtual desktops

**View Composer 2.6**

View Composer 2.6 works directly with vCenter Server to deploy, customize, and maintain the state of the virtual desktops when using linked clones. The tiered storage capabilities of View Composer 2.6 allow the read-only replica and the linked clone disk images to be on the dedicated storage. This allows superior scaling in large configurations.

**View Composer linked clones**

VMware View with View Composer 2.6 uses the concept of linked clones to quickly provision virtual desktops. This solution uses the tiered storage feature of View Composer to build linked clones and place their replica images on separate datastores as shown in Figure 2.

![Linked Clones Diagram](image)

**Figure 2. Linked clones**

The operating system reads all the common data from the read-only replica and the unique data that is created by the operating system or user, which is stored on the linked clone. A logical representation of this relationship is shown in Figure 3.
vSphere 4.1 infrastructure

vSphere 4.1 overview

VMware vSphere 4.1 is the market-leading virtualization hypervisor used across thousands of IT environments around the world. VMware vSphere 4.1 can transform or virtualize computer hardware resources, including the CPU, RAM, hard disk, and network controller to create fully functional virtual machines that run their own operating systems and applications just like physical computers.

The high-availability features in VMware vSphere 4.1 along with VMware Distributed Resource Scheduler (DRS) and Storage vMotion® enable seamless migration of virtual desktops from one ESX server to another with minimal or no impact to the customers.

vSphere cluster

Two vSphere clusters are deployed in this solution.

The View 4.6 cluster consists of eight ESX servers to support 500 desktops, resulting in around 62 to 63 virtual machines per ESX server. Each cluster has access to four datastores for desktop provisioning for a total of 125 virtual machines per datastore.

The infrastructure cluster consists of two ESX servers and stores the following virtual machines:

- Windows 2008 R2 domain controller — Provides DNS, Active Directory, and DHCP services.
- SQL Server 2008 SP2 on Windows 2008 R2 — Provides databases for vCenter Server and View Composer and other services in the environment.
- vCenter Server on Windows 2008 R2 — Provides management services for the VMware clusters and View Composer.
- View 4.6 on Windows 2008 R2 — Provides services to manage the virtual desktops.
- Windows 7 Key Management Service (KMS) — Provides a method to activate Windows 7 desktops.
**Windows infrastructure**

**Introduction**

Microsoft Windows provides the infrastructure that is used to support the virtual desktops and includes the following components:

- Microsoft Active Directory
- Microsoft SQL Server
- DNS server
- DHCP server

**Microsoft Active Directory**

The Windows domain controller runs the Active Directory service that provides the framework to manage and support the virtual desktop environment. Active Directory performs the following functions:

- Manages the identities of users and their information
- Applies group policy objects
- Deploys software and updates

**Microsoft SQL Server**

Microsoft SQL Server is a relational database management system (RDBMS). A dedicated SQL Server 2008 SP2 is used to provide the required databases to vCenter Server and View Composer.

**DNS server**

DNS is the backbone of Active Directory and provides the primary name resolution mechanism for Windows servers and clients.

In this solution, the DNS role is enabled on the domain controller.

**DHCP server**

The DHCP server provides the IP address, DNS server name, gateway address, and other information to the virtual desktops.

In this solution, the DHCP role is enabled on the domain controller. The DHCP scope is configured to accommodate the range of IP addresses for 500 or more virtual desktop machines.
Chapter 4: Storage Design

The storage design described in this chapter applies to the specific components of this solution.

EMC VNX series storage architecture

Introduction

The EMC VNX series is a dedicated network server optimized for file and block access that delivers high-end features in a scalable and easy-to-use package.

The VNX series delivers a single-box block and file solution that offers a centralized point of management for distributed environments. This makes it possible to dynamically grow, share, and cost-effectively manage multiprotocol file systems and provide multiprotocol block access. Administrators can take advantage of simultaneous support for NFS and CIFS protocols by allowing Windows and Linux/UNIX clients to share files by using the sophisticated file-locking mechanisms of VNX for file and VNX for block for high-bandwidth or for latency-sensitive applications.

This solution uses file-based storage to leverage the benefits that each of the following provides:

- File-based storage over the NFS protocol is used to store the VMDK files for all virtual desktops. This has the following benefit:
  - Unified Storage Management plug-in provides seamless integration with VMware vSphere to simplify the provisioning of datastores or virtual machines.

- File-based storage over the Common Internet File System (CIFS) protocol is used to store user data and roaming profiles. This has the following benefits:
  - Redirection of user data and roaming profiles to a central location for easy backup and administration.
  - Single instancing and compression of unstructured user data to provide the highest storage utilization and efficiency.

This section explains the configuration of the storage that was provided over NFS to the ESX cluster to store the VMDK images, and the storage that was provided over CIFS to redirect user data and roaming profiles.
**Figure 4** shows the storage layout of the disks.

The following storage configurations were used in the solution:

- Four SAS disks (0_0 to 0_3) are used for the VNX OE.
- Disks 0_4, 1_5, and 2_13 are hot spares. These disks are denoted as hot spare in the storage layout diagram.
- Two Flash drives (1_6 and 1_7) are used for EMC VNX FAST Cache. There are no user-configurable LUNs on these drives.
- Fifteen SAS disks (0_5 to 0_14 and 1_0 to 1_4) on the RAID 5 storage pool 1 are used to store linked clones and replicas. FAST Cache is enabled for the entire pool. 15 LUNs of 200 GB each are carved out of the pool to form three striped volumes, which are used to create six NFS. The file systems are presented to the ESX servers as datastores.
- Eight NL-SAS disks (2_5 to 2_12) on the RAID 6 (6+2) group are used to store user data and roaming profiles. Two VNX file systems are created on two LUNs, a 2 TB file system for profiles and a 4 TB file system for user data.
- Five SAS disks (2_0 to 2_4) on the RAID 5 storage pool 2 are used to store infrastructure virtual machines. A 1 TB LUN is carved out of the pool to form an NFS file system. The file system is presented to the ESX servers as a datastore.
- Disks 1_8 to 1_14 and 2_14 are unbound. They are not used to test this solution.
**File system layout**  

Figure 5 shows the layout of the file systems.

![File system layout diagram]

**Figure 5. File system layout**

Fifteen LUNs of 200 GB each are carved out of the storage pool to create three NAS pools. Each NAS pool stripes across five dvols. Two file systems are carved out of each NAS pool and presented to the ESX servers as datastores. File systems 1 and 2 are used to store replicas. File systems 3 to 6 are used to store the linked clones. A total of 500 desktops are created and each replica is responsible for 250 linked clones.

**EMC VNX FAST Cache**

VNX Fully Automated Storage Tiering (FAST) Cache, a part of the VNX FAST Suite, enables Flash drives to be used as an expanded cache layer for the array. VNX5300 is configured with two 100 GB Flash drives in a RAID 1 configuration for a 93 GB read/write capable cache. This is the minimum amount of FAST Cache. Larger configurations are supported for scaling beyond 500 desktops.

FAST Cache is an array-wide feature available for both file and block storage. FAST Cache works by examining 64 KB chunks of data in FAST Cache enabled objects on the array. Frequently accessed data is copied to the FAST Cache and subsequent accesses to the data chunk are serviced by FAST Cache. This enables immediate promotion of very active data to the Flash drives. This dramatically improves the response times of very active data and reduces data hot spots that can occur within the LUN.

FAST Cache is an extended read/write cache that enables VMware View to deliver consistent performance at Flash drive speeds by absorbing read-heavy activities such
EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Proven Solutions Guide

Chapter 4: Storage Design

EMC Virtual Storage Integrator (VSI) for VMware vSphere is a plug-in to the vSphere client that provides a single management interface to manage EMC storage within the vSphere environment. Features can be added and removed from VSI independently, which provides flexibility for customizing VSI user environments. Features are managed by using the VSI Feature Manager. VSI provides a unified user experience that allows new features to be introduced rapidly in response to changing customer requirements.

The following features were used during the validation testing:

- **Storage Viewer (SV)** — Extends the vSphere client to facilitate the discovery and identification of EMC VNX storage devices that are allocated to VMware ESX hosts and virtual machines. SV presents the underlying storage details to the virtual datacenter administrator, merging the data of several different storage mapping tools into a few seamless vSphere client views.

- **Unified Storage Management** — Simplifies storage administration of the EMC VNX unified storage platform. It enables VMware administrators to provision new NFS and VMFS datastores, and RDM volumes seamlessly within vSphere client.

The EMC VSI for VMware vSphere product guides available on the EMC Online Support website provide more information.

vCenter Server storage layout

pool 1_1 through pool 1_4—Each of the 500 GB datastores accommodates 125 users. This allows each desktop to grow to a maximum average size of approximately 4 GB. The pool of desktops created in View Manager is balanced across these datastores.

nfs_replica1 and nfs_replica2—Each of the 50 GB datastores stores a replica that is responsible for 250 linked clone desktops. The input/output to these LUNs is strictly read-only except during operations that require copying a new replica into the datastore.
Virtual desktops use two VNX shared file systems, one for user profiles and the other to redirect user storage. Each file system is exported to the environment through a CIFS share. Table 4 lists the file systems used for user profiles and redirected user storage.

**Table 4. File systems**

<table>
<thead>
<tr>
<th>File system</th>
<th>Use</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>profiles_fs</td>
<td>Profile data of the users</td>
<td>2 TB</td>
</tr>
<tr>
<td>userdata1_fs</td>
<td>User data</td>
<td>4 TB</td>
</tr>
</tbody>
</table>

Local user profile is not recommended in a VDI environment. A performance penalty is incurred when a new local profile is created whenever a user logs in to a new desktop image. On the other hand, roaming profiles and folder redirection allow user data to be stored centrally on a network location that resides on a CIFS share hosted by VNX. This reduces the performance impact during user logon, while allowing user data to roam with the profiles.

The EMC VNX for File Home Directory feature uses the userdata1_fs file system to automatically map the H: drive of each virtual desktop to the users' own dedicated subfolder on the share. This ensures that each user has exclusive rights to a dedicated home drive share. This share need not be created manually. The Home Directory feature automatically maps this share for each user.

The Documents folder for each user is also redirected to this share. This allows users to recover the data in the Documents folder by using the VNX Snapshots for File. The file system is set at an initial size of 1 TB, and can extend itself automatically when more space is required.
Profile export

The profiles_fs file system is used to store user roaming profiles. It is exported through CIFS. The UNC path to the export is configured in Active Directory for roaming profiles as shown in Figure 6.

![Figure 6. UNC path for roaming profiles](image)

Capacity

The file systems leverage EMC Virtual Provisioning™ and compression to provide flexibility and increased storage efficiency. If single instancing and compression are enabled, unstructured data such as user documents typically leads to a 50 percent reduction in consumed storage.

The VNX file systems for user profiles and documents are configured as follows:

- profiles_fs is configured to consume 2 TB of space. With 50 percent space saving, each profile can grow up to 4 GB in size. The file system can be extended if more space is needed.

- userdata1_fs is configured to consume 4 TB of space. With 50 percent space saving, each user will be able to store 8 GB of data. The file system can be extended if more space is needed.
Network Design

This chapter describes the network design used in this solution and contains the following sections:

- Considerations
- VNX for file network configuration
- Cisco Nexus 5020 configuration
- Cisco Catalyst 6509 configuration

Considerations

Figure 7 shows the 10 Gb Ethernet connectivity between the two Cisco Nexus 5020 switches and the EMC VNX storage. The uplink Ethernet ports from the Nexus switches can be used to connect to 10 Gb or 1 Gb external LAN. In this solution, 1 Gb LAN through Cisco Catalyst 6509 switches is used to extend Ethernet connectivity to the desktop clients, VMware View components, and Windows server infrastructure.

Figure 7. Network layout overview
Logical design considerations

This validated solution uses virtual local area networks (VLANs) to segregate network traffic of various types to improve throughput, manageability, application separation, high availability, and security.

The IP scheme for the virtual desktop network must be designed with enough IP addresses in one or more subnets for the DHCP server to assign them to each virtual desktop.

Link aggregation

VNX platforms provide network high availability or redundancy by using link aggregation. This is one of the methods used to address the problem of link or switch failure.

Link aggregation enables multiple active Ethernet connections to appear as a single link with a single MAC address, and potentially multiple IP addresses.

In this solution, Link Aggregation Control Protocol (LACP) is configured on VNX, combining two 10 GbE ports into a single virtual device. If a link is lost in the Ethernet port, the link fails over to another port. All network traffic is distributed across the active links.

VNX for file network configuration

Data Mover ports

EMC VNX5300 consists of two Data Movers. The Data Movers can be configured in an active/active or an active/passive configuration. In the active/passive configuration, the passive Data Mover serves as a failover device for the active Data Mover. In this solution, the Data Movers operate in the active/passive mode.

The VNX5300 Data Movers are configured for two 10-gigabit interfaces on a single I/O module. Link Aggregation Control Protocol (LACP) is used to configure ports fxg-1-0 and fxg-1-1 to support virtual machine traffic, home folder access, and external access for roaming profiles.

Figure 8 shows the rear view of two VNX5300 Data Movers that include two 10-gigabit fiber Ethernet (fxg) ports each in I/O expansion slot 1.

Figure 8. Rear view of the two VNX5300 Data Movers
Chapter 5: Network Design

**LACP configuration on the Data Mover**

To configure the link aggregation that uses fxg-1-0 and fxg-1-1 on Data Mover 2, run the following command:

$ server_sysconfig server_2 -virtual -name <Device Name> -create trk -option "device=fxg-1-0,fxg-1-1 protocol=lacp"

To verify if the ports are channeled correctly, run the following command:

$ server_sysconfig server_2 -virtual -info lacpl
server_2:
*** Trünk lacpl: Link is Up ***
*** Trünk lacpl: Timeout is Short ***
*** Trünk lacpl: Statistical Load Balancing is IP ***
Device   Local Grp  Remote Grp    Link   LACP Duplex Speed
--------------------------------------------------------------
fxg-1-0   10000   4480   Up   Up   Full 10000 Mbs
fxg-1-1   10000   4480   Up   Up   Full 10000 Mbs

The remote group number must match for both ports and the LACP status must be “Up.” Verify if appropriate speed and duplex are established as expected.

**Data Mover interfaces**

It is recommended to create two Data Mover interfaces and IP addresses on the same subnet with the VMkernel port on the ESX servers. Half of the NFS datastores are accessed by using one IP address and the other half by using the second IP. This allows the VMkernel traffic to be load balanced among the ESX NIC teaming members. The following command shows an example of assigning two IP addresses to the same virtual interface named lacp1:

$ server_ifconfig server_2 -all
server 2:
lacp1-1 protocol=IP device=lacp1
   inet=192.168.16.2 netmask=255.255.255.0 broadcast=192.168.16.255
   UP, Ethernet, mtu=9000, vlan=276, macaddr=0:60:48:1b:76:92
lacp1-2 protocol=IP device=lacp1
   inet=192.168.16.3 netmask=255.255.255.0 broadcast=192.168.16.255
   UP, Ethernet, mtu=9000, vlan=276, macaddr=0:60:48:1b:76:93

**Enable jumbo frames on Data Mover interface**

To enable jumbo frames for the link aggregation interface in the previous step, run the following command to increase the MTU size:

$ server_ifconfig server_2 lacp1-1 mtu=9000

To verify if the MTU size is set correctly, run the following command:

$ server_ifconfig server_2 lacp1-1
server 2:
lacp1 protocol=IP device=lacp1
   inet=192.168.16.2 netmask=255.255.255.0 broadcast=192.168.16.255
   UP, Ethernet, mtu=9000, vlan=276, macaddr=0:60:48:1b:76:92
ESX network configuration

NIC teaming

All network interfaces on the ESX servers in this solution use 1 Gb Ethernet connections. All virtual desktops are assigned an IP address by using a DHCP server. The Intel-based servers use four onboard Broadcom Gb Ethernet Controllers for all the network connections. Figure 9 shows the vSwitch configuration in vCenter Server.

Figure 9. vSwitch configuration

vSwitch0 and vSwitch1 use two physical NICs each. Table 5 lists the configured port groups in vSwitch0 and vSwitch1.

Table 5. Port groups in vSwitch0 and vSwitch1

<table>
<thead>
<tr>
<th>Virtual switch</th>
<th>Configured port groups</th>
<th>Used for</th>
</tr>
</thead>
<tbody>
<tr>
<td>vSwitch0</td>
<td>Service console</td>
<td>Public network administration traffic</td>
</tr>
<tr>
<td>vSwitch0</td>
<td>Production</td>
<td>Network connection for virtual desktops, LAN</td>
</tr>
<tr>
<td>vSwitch1</td>
<td>Vmkprivate</td>
<td>Used for NFS datastore traffic</td>
</tr>
</tbody>
</table>

The NIC teaming load balancing policy for the vSwitches needs to be set to Route based on IP hash as shown in Figure 10.
EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Proven Solutions Guide

Chapter 5: Network Design

Figure 10. Load balancing policy

By default, a vSwitch is configured with 24 or 120 virtual ports (depending on the ESX version), which may not be sufficient in a VDI environment. On the ESX servers that host the virtual desktops, each port is consumed by a virtual desktop. Set the number of ports based on the number of virtual desktops that will run on each ESX server as shown in Figure 11.

Note: Reboot the ESX server for the changes to take effect.

Figure 11. vSwitch virtual ports
If an ESX server goes down or needs to be placed in the maintenance mode, other ESX servers within the cluster must accommodate the additional virtual desktops that are migrated from the ESX server that goes offline. One must take into account the worst-case scenario when determining the maximum number of virtual ports per vSwitch. If there are not enough virtual ports, the virtual desktops will not be able to obtain IP addresses from the DHCP server.

For a VMkernel port to access the NFS datastores by using jumbo frames, the MTU size for the vSwitch to which the VMkernel port belongs must be set accordingly by using the following ESX command:

```
# esxcfg-vswitch -m 9000 vSwitch1
```

To verify if the MTU size is set correctly, run the following command:

```
# esxcfg-vswitch -l vSwitch1
```
Cisco Nexus 5020 configuration

Overview
The two forty-port Cisco Nexus 5020 switches provide redundant high-performance, low-latency 10-gigabit Ethernet, delivered by a cut-through switching architecture for 10-gigabit Ethernet server access in next-generation data centers.

Cabling
In this solution, the VNX Data Mover cabling is spread across two Nexus 5020 switches to provide redundancy and load balancing of the network traffic.

Enable jumbo frames on Nexus switch
The excerpt of the switch configuration shows the commands that are required to enable jumbo frames at the switch level because per-interface MTU is not supported:

```
policy-map type network-qos jumbo
  class type network-qos class-default
    mtu 9216
system qos
  service-policy type network-qos jumbo
```

vPC for Data Mover ports
Because the Data Mover connections for the two 10-gigabit network ports are spread across two Nexus switches and LACP is configured for the two Data Mover ports, virtual Port Channel (vPC) must be configured on both switches.

The following excerpt is an example of the switch configuration pertaining to the vPC setup for one of the Data Mover ports. The configuration on the peer Nexus switch is mirrored for the second Data Mover port:

```
n5k-1# show running-config
...
feature vpc
...
vpc domain 2
  peer-keepalive destination <peer-nexus-ip>
...
interface port-channel13
  description channel uplink to n5k-2
  switchport mode trunk
  vpc peer-link
  spanning-tree port type network
interface port-channel14
  switchport mode trunk
  vpc 4
  switchport trunk allowed vlan 275-277
...
interface Ethernet1/4
  description 1/4 vnx dm2 fxg-1-0
  switchport mode trunk
  switchport trunk allowed vlan 275-277
  channel-group 4 mode active
interface Ethernet1/5
  description 1/5 uplink to n5k-2 1/5
  switchport mode trunk
  channel-group 3 mode active
```
interface Ethernet1/6
  description 1/6 uplink to n5k-2 1/6
  switchport mode trunk
  channel-group 3 mode active

To verify if the vPC is configured correctly, run the following command on both the switches. The output should look like this:

```
n5k-1# show vpc
Legend:
  (*) - local vPC is down, forwarding via vPC peer-link

vPC domain id : 2
Peer status : peer adjacency formed ok
vPC keep-alive status : peer is alive
Configuration consistency status: success
vPC role : secondary
Number of vPCs configured : 1
Peer Gateway : Disabled
Dual-active excluded VLANs : -

vPC Peer-link status

<table>
<thead>
<tr>
<th>id</th>
<th>Port</th>
<th>Status</th>
<th>Active vlans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Po3</td>
<td>up</td>
<td>1,275-277</td>
</tr>
</tbody>
</table>

vPC status

<table>
<thead>
<tr>
<th>id</th>
<th>Port</th>
<th>Status</th>
<th>Consistency</th>
<th>Reason</th>
<th>Active vlans</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Po4</td>
<td>up</td>
<td>success</td>
<td>success</td>
<td>275-277</td>
</tr>
</tbody>
</table>
Cisco 6509 configuration

Overview
The nine-slot Cisco Catalyst 6509-E switch provides high port densities that are ideal for many wiring closet, distribution, and core network deployments as well as data center deployments.

Cabling
In this solution, the ESX server cabling is evenly spread across two WS-x6748 1 Gb line cards to provide redundancy and load balancing of the network traffic.

Server uplinks
The server uplinks to the switch are configured in a port channel group to increase the utilization of server network resources and to provide redundancy. The vSwitches are configured to load balance the network traffic based on IP hash.

The following is an example of the configuration for one of the server ports:

```
description 8/10 9048-43 rtpsol189-1
switchport
switchport trunk encapsulation dot1q
switchport trunk allowed vlan 276,516-527
switchport mode trunk
mtu 9216
no ip address
spanning-tree portfast trunk
channel-group 23 mode on
```
6 Installation and Configuration

This chapter describes how to install and configure this solution and includes the following sections:

- Installation overview
- VMware View components
- Storage components

Installation overview

This section provides an overview of the configuration of the following components:

- Desktop pools
- Storage pools
- FAST Cache
- VNX Home Directory

The installation and configuration steps for the following components are available on the VMware website:

- VMware View Connection Server 4.6
- VMware View Composer 2.6
- VMware ESX 4.1
- VMware vSphere 4.1

The installation and configuration steps for the following components are not covered:

- Microsoft System Center Configuration Manager (SCCM)
- Microsoft Active Directory, DNS, and DHCP
- Microsoft SQL Server 2008 SP2
VMware View components

VMware View installation overview

The *VMware View Installation Guide* available on the VMware website has detailed procedures to install View Connection Server and View Composer 2.6. No special configuration instructions are required for this solution.

The *ESX Installable and vCenter Server Setup Guide* available on the VMware website has detailed procedures to install vCenter Server and ESX and is not covered in further detail in this paper. No special configuration instructions are required for this solution.

VMware View setup

Before deploying the desktop pools, ensure that the following steps from the *VMware View Installation Guide* have been completed:

- Prepare Active Directory
- Install View Composer 2.6 on vCenter Server
- Install View Connection Server
- Add a vCenter Server instance to View Manager

VMware recommends using a maximum of 250 desktops per replica image, which requires creating a unique pool for every 250 desktops. In this solution, persistent automated desktop pools were used.

To create a persistent automated desktop pool as configured for this solution, complete the following steps:

1. Log in to the *VMware View Administration* page, which is located at https://server/admin where “server” is the IP address or DNS name of the View Manager server.
2. Click the **Pools** link in the left pane.
3. Click **Add** under the **Pools** banner. The **Add Pool** page appears.
4. Under Pool Definition, click **Type**. The **Type** page appears on the right pane.
5. Select **Automated Pool** as shown in Figure 12.
Figure 12. Select Automated Pool

6. Click **Next**. The **User Assignment** page appears.
7. Select **Dedicated** and ensure that **Enable automatic assignment** is selected.
8. Click **Next**. The **vCenter Server** page appears.
9. Select **View Composer linked clones** and select a vCenter Server that supports View Composer as shown in Figure 13.

![Image of User Assignment page]

**Figure 13. Select View Composer linked clones**

10. Click **Next**. The **Pool Identification** page appears.
11. Enter the required information.
12. Click **Next**. The **Pool Settings** page appears.
13. Make the required changes.
14. Click **Next**. The **View Composer Disks** page appears.
15. Select **Do not redirect Windows profile**.
16. Click **Next**. The **Provisioning Settings** page appears.
17. Perform the following as shown in Figure 14:
   a. Select **Use a naming pattern**.
   b. In the **Naming Pattern** field, type the naming pattern.
   c. In the **Max number of desktops** field, type the number of desktops to provision.
18. Click Next. The vCenter Settings page appears.

19. Perform the following as shown in Figure 15:

   a. Click Browse to select a default image, a folder for the virtual machines, the cluster hosting the virtual desktops, and the resource pool to store the desktops.

   b. In the Datastores field, click Browse. The Select Datastores page appears.

20. Select Use different datastore for View Composer replica disks and in the Use For list box, select Replica disks or Linked clones as shown in Figure 16.
Figure 16. Select Datastores

21. Click OK. The **vCenter Settings** page appears as shown in Figure 17.

Figure 17. vCenter Settings

22. Verify the settings and Click **Next**. The **Guest Customization** page appears.

23. Perform the following:
   a. In the **Domain** list box, select the domain.
   b. In the **AD container** field, click **Browse** and select the AD container.
   c. Select **Use QuickPrep**.
Figure 18. Guest Customization

24. Click Next. The Ready to Complete page appears.

25. Verify the settings for the pool and then click Finish to start the deployment of the virtual desktops.

Storage components

Storage pools

Storage pools in the EMC VNX OE support heterogeneous drive pools. In this solution, a RAID 5 storage pool was configured from 15 SAS drives. Fifteen 200 GB thick LUNs were created from this storage pool as shown in Figure 19. FAST Cache was enabled for the pool.

Figure 19. Fifteen 200 GB thick LUNs
Chapter 6: Installation and Configuration

**NFS active threads per Data Mover**

The default number of threads dedicated to serve NFS requests is 384 per Data Mover on VNX. Some use cases such as scanning of desktops might require more number of NFS active threads. It is recommended to increase the number of active NFS threads to the maximum of 2048 on each Data Mover. The `nthreads` parameter can be set by using the following command:

```
#server_param server_2 -facility nfs -modify nthreads -value 2048
```

Reboot the Data Mover for the change to take effect.

Type the following command to confirm the value of the parameter:

```
#server_param server_2 -facility nfs -info nthreads
```

**NFS performance fix**

VNX file software contains a performance fix that significantly reduces NFS write latency. The minimum software patch required for the fix is 7.0.13.0. In addition to the patch upgrade, the performance fix only takes effect when the NFS file system is mounted by using the `uncached` option as shown below:

```
#server_mount server_2 -option uncached fs1 /fs1
```

The `uncached` option can be verified by using the following command:

```
#server_mount server_2
server_2 :
root_fs_2 on / uxfs,perm,rw
root_fs_common on /.etc_common uxfs,perm,ro
userprofiles on /userprofiles uxfs,perm,rw
homedir on /homedir uxfs,perm,rw
InfraOS on /InfraOS uxfs,perm,ro,uncached
nfs_replica1 on /nfs_replica1 uxfs,perm,ro,uncached
nfs_replica2 on /nfs_replica2 uxfs,perm,ro,uncached
pool1_1 on /pool1_1 uxfs,perm,ro,uncached
pool1_2 on /pool1_2 uxfs,perm,ro,uncached
pool1_3 on /pool1_3 uxfs,perm,ro,uncached
pool1_4 on /pool1_4 uxfs,perm,ro,uncached
```

**Enable FAST Cache**

FAST Cache is enabled as an array-wide feature in the system properties of the array in EMC Unisphere™. Click the **FAST Cache** tab, then click **Create** and select the Flash drives to create the FAST Cache. There are no user-configurable parameters for FAST Cache.
Chapter 6: Installation and Configuration

EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Proven Solutions Guide

Figure 20. FAST Cache tab

To enable FAST Cache for any LUN in a pool, go to the pool properties in Unisphere and click the Advanced tab. Select Enabled to enable FAST Cache, as shown in Figure 21.

Figure 21. Enable FAST Cache

VNX Home Directory feature

The VNX Home Directory installer is available on the NAS Tools and Applications CD for each VNX OE for file release, and can be downloaded from the EMC Online Support website.

After the VNX Home Directory feature is installed, use the Microsoft Management Console (MMC) snap-in to configure the feature. A sample configuration is shown in Figure 22 and Figure 23.
For any user account that ends with a suffix between 1 and 500, the sample configuration shown in Figure 23 automatically creates a user home directory in the following location and maps the H: drive to this path:

\userdata1_fs file system in the format
\userdata1_fs\<domain>\<user>

Each user has exclusive rights to the folder.
Chapter 7: Testing and Validation

7 Testing and Validation

This chapter provides a summary and characterization of the tests performed to validate the solution. The goal of the testing is to characterize the performance of the solution and its component subsystems during the following scenarios:

- Boot storm of all desktops
- McAfee antivirus full scan on all desktops
- Security patch install with Microsoft SCCM on all desktops
- User workload testing using Login VSI on all desktops
- View recompose
- View refresh

Validated environment profile

Table 6 provides the validated environment profile.

<table>
<thead>
<tr>
<th>Profile characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of virtual desktops</td>
<td>500</td>
</tr>
<tr>
<td>Virtual desktop OS</td>
<td>Windows 7 Enterprise (32-bit)</td>
</tr>
<tr>
<td>CPU per virtual desktop</td>
<td>1 vCPU</td>
</tr>
<tr>
<td>Number of virtual desktops per CPU core</td>
<td>7.8125</td>
</tr>
<tr>
<td>RAM per virtual desktop</td>
<td>1 GB</td>
</tr>
<tr>
<td>Average storage available for each virtual desktop</td>
<td>4 GB (vmdk and vswap)</td>
</tr>
<tr>
<td>Average IOPS per virtual desktop at steady state</td>
<td>6</td>
</tr>
<tr>
<td>Average peak IOPS per virtual desktop during boot storm</td>
<td>127</td>
</tr>
<tr>
<td>Number of datastores used to store linked clones</td>
<td>4</td>
</tr>
<tr>
<td>Number of datastores used to store replicas</td>
<td>2</td>
</tr>
<tr>
<td>Number of virtual desktops per datastore</td>
<td>125</td>
</tr>
<tr>
<td>Disk and RAID type for datastores</td>
<td>RAID 5, 300 GB, 15k rpm, 3.5-in SAS disks</td>
</tr>
</tbody>
</table>
Chapter 7: Testing and Validation

<table>
<thead>
<tr>
<th>Profile characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk and RAID type for CIFS shares to host roaming user profiles and home directories</td>
<td>RAID 6, 2 TB, 7,200 rpm, 3.5-in NL-SAS disks</td>
</tr>
<tr>
<td>Number of VMware clusters</td>
<td>1</td>
</tr>
<tr>
<td>Number of ESX servers per cluster</td>
<td>8</td>
</tr>
<tr>
<td>Number of virtual desktops in a cluster</td>
<td>500</td>
</tr>
</tbody>
</table>

Use cases

Six common use cases were executed to validate whether the solution performed as expected under heavy load situations.

The following use cases were tested:

- Simultaneous boot of all desktops
- Full antivirus scan of all desktops
- Installation of a security update using SCCM on all desktops
- Login and steady state user load simulated using the Login VSI medium workload on all desktops
- Recompose all desktops
- Refresh of all desktops

In each use case, a number of key metrics are presented showing the overall performance of the solution.

Login VSI

To run a user load on the desktops, the Virtual Session Index (VSI) version 2.0 was used. VSI provided the guidance to gauge the maximum number of users a desktop environment can support. The Login VSI workload can be categorized as light, medium, heavy, and custom. A medium workload was selected for this testing and had the following characteristics:

- The workload emulated a medium knowledge worker who used Microsoft Office, Internet Explorer, and Adobe Acrobat Reader.
- After a session started, the medium workload repeated every 12 minutes.
- The response time was measured every 2 minutes during each loop.
- The medium workload opened up to five applications simultaneously.
- The type rate was 160 ms for each character.
- The medium workload in VSI 2.0 was approximately 35 percent more resource-intensive than VSI 1.0.
- Approximately 2 minutes of idle time was included to simulate real-world users.
Each loop of the medium workload used the following applications:

- **Microsoft Outlook 2007** — Browsed 10 email messages.
- **Microsoft Internet Explorer** — On one instance of Internet Explorer (IE), the BBC.co.uk website was left open, another instance browsed Wired.com, Lonelyplanet.com, and another instance opened the heavy Flash application gettheglass.com (not used with MediumNoFlash workload).
- **Microsoft Word 2007** — One instance of MS Word 2007 was used to measure the response time, while another instance was used to edit a document.
- **Bullzip PDF Printer and Adobe Acrobat Reader** — The Word document was printed and the PDF was reviewed.
- **Microsoft Excel 2007** — A very large Excel worksheet was opened and random operations were performed.
- **Microsoft PowerPoint 2007** — A presentation was reviewed and edited.
- **7-zip** — Using the command line version, the output of the session was zipped.

**Login VSI launcher**

A Login VSI launcher is a Windows system that launches desktop sessions on target virtual desktops. There are two types of launchers—master and slave. There is only one master in a given test bed, but there can be as many slave launchers as required.

The number of desktop sessions a launcher can run is typically limited by CPU or memory resources. By default, the GDI limit is not tuned. In such a case, Login consultants recommend using a maximum of 45 sessions per launcher with two CPU cores (or two dedicated vCPUs) and 2 GB RAM. When the GDI limit is tuned, this limit extends to 60 sessions per two-core machine.

In this validated testing, 500 desktop sessions were launched from 13 launchers, for an approximate total of 40 sessions per launcher. Each launcher was allocated two vCPUs and 4 GB of RAM. No bottlenecks were observed on the launchers during the VSI-based tests.

**FAST Cache configuration**

For all tests, FAST Cache was enabled for the storage pool holding replica and linked clone datastores were used to store the 500 desktops.
Boot storm results

Test methodology

This test was conducted by selecting all the desktops in vCenter Server and then selecting Power On. Overlays are added to the graphs to show when the last power-on task completed and when the IOPS to the pool LUNs achieved a steady state.

For the boot storm test, all 500 desktops were powered on within three minutes and achieved a steady state approximately two minutes later. The total start-to-finish time for all desktops was approximately five minutes. This section describes the boot storm results for each of the three use cases when powering on the desktop pools.

Pool individual disk load

Figure 24 shows the disk IOPS for a single SAS drive in the storage pool. Because the statistics from all the drives in the pool were similar, a single drive is reported for clarity and readability of the graph.

During peak load, the disk serviced a maximum of 155 IOPS. FAST Cache and Data Mover cache helped to reduce the disk load.
Figure 25 shows the replica LUN IOPS and the response time of one of the storage pool LUN. Because the statistics from each LUN were similar, a single LUN is reported for clarity and readability of the graph.

During peak load, the LUN response time did not exceed 1 ms and the datastore serviced nearly 4,500 IOPS.

Figure 26 shows the linked clone LUN IOPS and the response time of one of Storage pool LUN. Because the statistics from each LUN were similar, a single LUN is reported for clarity and readability of the graph.
During peak load, the LUN response time did not exceed 3 ms and the datastore serviced 1,678 IOPS.

**Figure 27** shows the total IOPS serviced by the storage processors during the test.

During peak load, the storage processors serviced 40,000 IOPS.

**Figure 28** shows the storage processor utilization during the test. The pool-based LUNs were split across both storage processors to balance the load equally.

The virtual desktops generated high levels of I/O during the peak load of the boot storm test. The storage processor utilization remained below 45 percent.
Figure 29. Boot storm — FAST Cache IOPS

At peak load, FAST Cache serviced over 37,700 IOPS from the datastores. The FAST Cache hits included IOPS serviced by Flash drives and SP memory cache. If memory cache hits are excluded, the pair of Flash drives alone serviced roughly 10,960 IOPS at peak load. A sizing exercise using EMC’s standard performance estimate (180 IOPS) for 15k rpm SAS drives suggests that it would take roughly 61 SAS drives to achieve the same level of performance. However, EMC does not recommend using a 61:2 (or 30.5:1) ratio for SAS to SSD replacement. EMC’s recommended ratio is 20:1 because workloads may vary.
Figure 30 shows the Data Mover CPU utilization during the boot storm test.

The Data Mover briefly achieved a CPU utilization of approximately 50 percent during peak load in this test.

Figure 31 shows the NFS operations per second on the Data Mover during the boot storm test.

At peak load, the total NFS operations per second were 63,352.
Figure 32 shows the CPU load from the ESX servers in the VMware clusters. Each server had similar results. Therefore, only a single server is reported.

![ESX CPU load graph]

**Figure 32. Boot storm — ESX CPU load**

The ESX server briefly achieved a CPU utilization of approximately 55 percent during peak load in this test. It is important to note that hyperthreading was enabled to double the number of logical CPUs.
Figure 33 shows the Average Guest Millisecond/Command counter, which is shown as GAVG in esxtop. This counter represents the response time for I/O operations initiated to the storage array. The average of both datastores hosting the replica storage is shown as replica LUN - GAVG, and the average of all the datastores hosting the linked clone storage is shown as Linked Clone LUN - GAVG in the graph.

Figure 33. Boot storm — Average Guest Millisecond/Command counter

The peak GAVG values for the virtual desktop storage on the datastores were approximately 11 ms. This indicates excellent performance under this load.
Antivirus results

Test methodology

This test was conducted by scheduling a full scan of all desktops with a custom script by using McAfee 8.7. The full scans were started on all the desktops and the total start-to-finish time was approximately one hour.

Pool individual disk load

Figure 34 shows the disk I/O for a single SAS drive in the storage pool that stores the virtual desktops. Because the statistics from all drives in the pool were similar, only a single drive is reported for clarity and readability of the graph.

Figure 34. Antivirus — Disk I/O for a single SAS drive

The peak IOPS serviced by the individual drives was nearly 25 IOPS and the disk response time was within 10 ms. FAST Cache and Data Mover cache helped to reduce the load on the disks.
Figure 35 shows the replica LUN IOPS and the response time of one of the storage pool LUNs. Because the statistics from the LUNs were similar, a single LUN is reported for clarity and readability of the graph.

**Figure 35. Antivirus — Replica LUN IOPS and response time**

During peak load, the LUN response time remained within 3 ms, and the datastore serviced over 2,200 IOPS. The majority of the read I/O was served by the FAST Cache and Data Mover cache.
Figure 36 shows the linked clone LUN IOPS and the response time of one of the storage pool LUNs. Because the statistics from the LUNs were similar, only a single LUN is reported for clarity and readability of the graph.

During peak load, the LUN response time remained within 3 ms and the datastore serviced nearly 300 IOPS.

Figure 37 shows the total IOPS serviced by the storage processor during the test. During peak load, the storage processors serviced over 13,700 IOPS.
Figure 38 shows the storage processor utilization during the antivirus scan test.

**Figure 38. Antivirus — Storage processor utilization**

During peak load, the antivirus scan operations caused moderate CPU utilization. The load was shared between two storage processors during the antivirus scan. EMC VNX5300 had sufficient scalability headroom for this workload.
Figure 39 shows the IOPS serviced from FAST Cache during the test.

**Figure 39.** Antivirus — FAST Cache IOPS

At peak load, FAST Cache serviced nearly 12,400 IOPS from the datastores. The FAST Cache hits include IOPS serviced by Flash drives and storage processor memory cache. If memory cache hits are excluded, the pair of Flash drives alone serviced almost all of the 12,400 IOPS at peak load. A sizing exercise using EMC’s standard performance estimate (180 IOPS) for 15k rpm SAS drives suggests that it would take roughly 69 SAS drives to achieve the same level of performance. However, EMC does not recommend using a 69:2 ratio for SAS to SSD replacement. EMC’s recommended ratio is 20:1 because workloads may vary.
Figure 40 shows the Data Mover CPU utilization during the antivirus scan test.

The Data Mover briefly achieved a CPU utilization of over 65 percent during peak load in this test.

Figure 41 shows the NFS operations per second from the Data Mover during the antivirus scan test.

At peak load, the NFS operations per second were approximately 45,000.
ESX CPU load

Figure 42 shows the CPU load from the ESX servers in the VMware clusters. A single server is reported because all the servers had similar results.

Figure 42. Antivirus — ESX CPU load

The peak CPU load on the ESX server was 40 percent during this test. It is important to note that hyperthreading was enabled to double the number of logical CPUs.

ESX disk response time

Figure 43 shows the Average Guest Millisecond/Command counter, which is shown as GAVG in esxtop. This counter represents the response time for I/O operations initiated to the storage array. The average of both datastores hosting the replica storage is shown as replica LUN- GAVG, and the average of all the datastores hosting the linked clone storage is shown as Linked Clone LUN- GAVG in the graph.

Figure 43. Antivirus — Average Guest Millisecond/Command counter
The peak replica GAVG value never crossed 30 ms whereas the peak GAVG of linked clone was around 13 ms. The FAST Cache performed an enormous amount of read operations during this test.
Patch install results

Test methodology

This test was performed by pushing a security update to all desktops using Microsoft System Center Configuration Manager (SCCM). The desktops were divided into five collections of 100 desktops each. The collections were configured to install updates in a 1-minute staggered schedule that was 30 minutes after the patch was downloaded. All patches were installed within six minutes.

Pool individual disk load

Figure 44 shows the disk IOPS for a single SAS drive that is part of the storage pool. Because the statistics from each drive in the pool were similar, the statistics of a single drive are shown for clarity and readability of the graph.

![Graph showing disk IOPS for a single SAS drive](image)

Figure 44. Patch install — Disk IOPS for a single SAS drive

The drives did not get saturated during the patch download phase. During the patch installation phase, the disk serviced a little over 100 IOPS at peak load while a response time spike of 9 ms was recorded within the 6-minute interval.
Figure 45 shows the replica LUN IOPS and response time of one of the storage pool LUN. Because the statistics from each LUN in the pool were similar, the statistics of a single LUN are shown for clarity and readability of the graph.

During patch installation, the peak LUN response time was below 8 ms.

Figure 46 shows the linked clone LUN IOPS and response time of one of the storage pool LUN. Because the statistics from each LUN in the pool were similar, the statistics of a single LUN are shown for clarity and readability of the graph.
During peak load, the LUN response time was below 2.5 ms and the datastore serviced nearly 950 IOPS.

Storage processor IOPS

*Figure 47* shows the total IOPS serviced by the storage processor during the test.

![Graph showing total IOPS serviced by storage processor during the test.](image)

**Figure 47.  Patch install — Storage processor IOPS**

During peak load, the storage processors serviced over 11,000 IOPS. The load was shared between two storage processors during the patch install operation on each collection of virtual desktops.

Storage processor utilization

*Figure 48* shows the storage processor utilization during the test.

![Graph showing storage processor utilization during the test.](image)

**Figure 48.  Patch install — Storage processor utilization**
The patch install operations caused moderate CPU utilization during peak load. EMC VNX5300 had sufficient scalability headroom for this workload.

**FAST Cache IOPS**

Figure 49 shows the IOPS serviced from FAST Cache during the test.

![Figure 49](image)

**Figure 49. Patch install — FAST Cache IOPS**

During patch installation, FAST Cache serviced over 9,000 IOPS from datastores. The FAST Cache hits include IOPS serviced by Flash drives and storage processor memory cache. If memory cache hits are excluded, the pair of Flash drives alone serviced over 3,816 IOPS at peak load. A sizing exercise using EMC's standard performance estimate (180 IOPS) for 15k rpm SAS drives suggests that it would take roughly 21 SAS drives to achieve the same level of performance.
Figure 50 shows the Data Mover CPU utilization during the patch install test.

![Data Mover CPU utilization](chart)

The Data Mover briefly achieved a CPU utilization of approximately 14 percent during peak load in this test.

Figure 51 shows the NFS operations per second from the Data Mover during the patch install test.

![Data Mover NFS load](chart)

At peak load, the Data Mover serviced over 11,700 IOPS.
Figure 52 shows the CPU load from the ESX servers in the VMware clusters. Because each server had similar results, the results from a single server are shown for clarity and readability of the graph.

![ESX CPU load graph](image)

**Figure 52. Patch install — ESX CPU load**

The ESX server CPU load was well within the acceptable limits during the test. It is important to note that hyperthreading was enabled to double the number of logical CPUs.
Figure 53 shows the Average Guest Millisecond/Command counter, which is shown as GAVG in esxtop. This counter represents the response time for I/O operations initiated to the storage array. The average of both datastores hosting the replica storage is shown as Replica LUN- GAVG and the average of all the datastores hosting the linked clone storage is shown as Linked Clone LUN- GAVG in the graph.

![Graph showing ESX disk response time](image)

**Figure 53.** Patch install — Average Guest Millisecond/Command counter

The peak replica GAVG value was approximately 15 ms whereas the peak GAVG of linked clone never crossed 12 ms. FAST Cache performed an enormous amount of I/O operations during this test.
Login VSI results

Test methodology
This test was conducted by scheduling 500 users to connect over Remote desktop connection in approximately a 41-minute window, and starting the Login VSI-medium workload. The workload was run for one hour in a steady state to observe the load on the system.

Pool individual disk load
Figure 54 shows the disk IOPS for a single SAS drive that is part of the storage pool. Because the statistics from each drive in the pool were similar, the statistics of a single drive are shown for clarity and readability of the graph.

![Login VSI — Disk IOPS for a single SAS drive](image)

**Figure 54.** Login VSI — Disk IOPS for a single SAS drive

During peak load, the SAS disk serviced over 70 IOPS and the disk response time was less than 7 ms.
Figure 55 shows the Replica LUN IOPS and response time from one of the storage pool LUNs. Because the statistics from each LUN were similar, only a single LUN is reported for clarity and readability of the graph.

![Graph showing Replica LUN IOPS and response time](image)

**Figure 55. Login VSI — Replica LUN IOPS and response time**

During peak load, the LUN response time remained under 2 ms and the datastore serviced 530 IOPS.

Figure 56 shows the linked clone LUN IOPS and response time from one of the storage pool LUN. Because the statistics from each LUN were similar, only a single LUN is reported for clarity and readability of the graph.

![Graph showing linked clone LUN IOPS and response time](image)

**Figure 56. Login VSI — Linked clone LUN IOPS and response time**
During peak load, the LUN response time remained under 2 ms and the datastore serviced nearly 530 IOPS.

**Figure 57.** Login VSI — Storage processor IOPS

During peak load, the storage processors serviced approximately 9,000 IOPS.

**Figure 58.** Login VSI — Storage processor utilization
The storage processor peak utilization was below 20 percent during the logon storm. The load was shared between two storage processors during the VSI load test.

**FAST Cache IOPS**

*Figure 59* shows the IOPS serviced from FAST Cache during the test.

*Figure 59. Login VSI — FAST Cache IOPS*

At peak load, FAST Cache serviced over 7,000 IOPS from the datastores. The FAST Cache hits included IOPS serviced by Flash drives and storage processor memory cache. If memory cache hits are excluded, the pair of Flash drives alone serviced nearly 2,990 IOPS at peak load. A sizing exercise using EMC’s standard performance estimate (180 IOPS) for 15k rpm SAS drives suggests that it would take about 17 SAS drives to achieve the same level of performance.
Figure 60 shows the Data Mover CPU utilization during the Login VSI test. The Data Mover briefly achieved a CPU utilization of below 12 percent during peak load in this test.

Figure 61 shows the NFS operations per second from the Data Mover during the Login VSI test. At peak load, the NFS operations per second were nearly 8,000.
Figure 62 shows the CPU load from the ESX servers in the VMware clusters. A single server is reported because each server had similar results.

The CPU load on the ESX server was less than 50 percent utilization during peak load. It is important to note that hyperthreading was enabled to double the number of logical CPUs.
Figure 63 shows the Average Guest Millisecond/Command counter, which is shown as GAVG in esxtop. This counter represents the response time for I/O operations initiated to the storage array. The average of both datastores hosting the replica storage is shown as Replica LUN- GAVG, and the average of all the datastores hosting the linked clone storage is shown as Linked Clone LUN- GAVG in the graph.

Figure 63. Login VSI — Average Guest Millisecond/Command counter

The peak replica GAVG value never crossed 4 ms whereas the peak GAVG of linked clone was below 6 ms. The FAST Cache performed an enormous amount of read operations during this test.
Recompose results

Test methodology
This test was conducted by creating new pools from the View Manager console. No users were logged in after deploying new desktops. Overlays are added to the graphs to show when the last power-on task completed and when the IOPS to the pool LUNs achieved a steady state.

A recompose operation deletes existing desktops and creates new desktops. To enhance the readability of the graphs and to show the array behavior during high I/O periods, only those tasks involved in creating new desktops were performed and shown in the graphs. Both desktop pools were created simultaneously and took approximately 120 minutes to complete the entire process.

Pool individual disk load

Figure 64 shows the disk IOPS for a single SAS drive that is part of the storage pool. Because the statistics from each drive in the pool were similar, the statistics of a single drive are shown for clarity and readability of the graph.

Figure 64. Recompose — Disk IOPS for a single SAS drive
During peak load, the SAS disk serviced little over 100 IOPS and the disk response time was within 6 ms.
Figure 65 shows the replica LUN IOPS and response time from one of the storage pool LUNs. Because the statistics from each LUN were similar, only a single LUN is reported for clarity and readability of the graph.

![Graph showing LUN IOPS and response time](image)

**Figure 65. Recompose — Replica LUN IOPS and response time**

Copying the new replica image caused heavy sequential write workloads on the LUN during the initial 7-minute interval. At peak load, the LUN serviced approximately 500 IOPS while the peak response time was less than 8 ms.
Figure 66 shows the linked clone LUN IOPS and response time from one of the storage pool LUNs. Because the statistics from each LUN were similar, only a single LUN is reported for clarity and readability of the graph.

During peak load, the LUN serviced over 650 IOPS while the response time was within 3 ms.

Figure 67 shows the total IOPS serviced by the storage processor during the test.

During peak load, the storage processors serviced over 10,400 IOPS.
Figure 68 shows the storage processor utilization during the test.

![Storage processor utilization](image1)

**Figure 68.** Recompose — Storage processor utilization

The storage processor peak utilization was 25 percent during the logon storm. The load was shared between two storage processors during the peak load.

FAST Cache IOPS

Figure 69 shows the IOPS serviced from FAST Cache during the test.

![FAST Cache IOPS](image2)

**Figure 69.** Recompose — FAST Cache IOPS

At peak load, FAST Cache serviced nearly 8,000 IOPS from the datastores. The FAST Cache hits included IOPS serviced by Flash drives and storage processor memory cache. If memory cache hits are excluded, the pair of Flash drives alone serviced
nearly 2,450 IOPS at peak load. A sizing exercise using EMC’s standard performance estimate (180 IOPS) for 15k rpm SAS drives suggests that it would take about 14 SAS drives to achieve the same level of performance.

Figure 70 shows the Data Mover CPU utilization during the recompose test.

Figure 70. Recompose — Data Mover CPU utilization

The Data Mover briefly achieved a CPU utilization of approximately 14 percent during peak load in this test.
**Data Mover NFS load**

Figure 71 shows the NFS operations per second from the Data Mover during the recompose test.

Figure 71. Recompose — Data Mover NFS load

At peak load, the NFS operations per second were above 12,000.

**ESX CPU load**

Figure 72 shows the CPU load from the ESX servers in the VMware clusters. A single server is reported because each server had similar results.

Figure 72. Recompose — ESX CPU load

The CPU load on the ESX server was never more than 25 percent utilized during the peak load. It is important to note that hyperthreading was enabled to double the number of logical CPUs.
Figure 73 shows the Average Guest Millisecond/Command counter, which is shown as GAVG in esxtop. This counter represents the response time for I/O operations initiated to the storage array. The average of both datastores hosting the replica storage is shown as Replica LUN- GAVG, and the average of all the datastores hosting the linked clone storage is shown as Linked Clone LUN- GAVG in the graph.

The peak replica GAVG value was approximately 3 ms whereas the peak GAVG of linked clone was less than 6 ms.
Refresh results

Test methodology  This test was conducted by selecting a refresh operation for all desktops in both pools from the View Manager administration console. A refresh for all desktops in one pool was started and was followed immediately by a refresh for all desktops in the other pool with only a few seconds of delay. No users were logged in during the test. Overlays are added to the graphs to show when the last power-on task completed and when the IOPS to the pool LUNs achieved a steady state.

Pool individual disk load  Figure 74 shows the disk IOPS for a single SAS drive that is part of the storage pool. Because the statistics from each drive in the pool were similar, the statistics of a single drive are shown for clarity and readability of the graph.

Figure 74. Refresh — Disk IOPS for a single SAS drive

During peak load, the SAS disk serviced 140 IOPS and the disk response time was 7 ms.
Figure 75 shows the Replica LUN IOPS and response time from one of the storage pool LUNs. Because the statistics from each LUN were similar, only a single LUN is reported for clarity and readability of the graph.

During peak load, the LUN response time was approximately 14 ms and the datastore serviced 325 IOPS.

Figure 76 shows the linked clone LUN IOPS and response time from one of the storage pool LUNs. Because the statistics from each LUN were similar, only a single LUN is reported for clarity and readability of the graph.

During peak load, the LUN response time remained under 4 ms and the datastore serviced over 1,400 IOPS.
Figure 77 shows the total IOPS serviced by the storage processor during the test.

Figure 77. Refresh — Storage processor IOPS

During peak load, the storage processors serviced over 16,900 IOPS.

Figure 78 shows the storage processor utilization during the test.

Figure 78. Refresh — Storage processor utilization

The storage processor peak utilization was below 30 percent during the refresh test. The load is shared between two storage processors during the test.
FAST Cache IOPS

Figure 79 shows the IOPS serviced from FAST Cache during the test.

![Figure 79. Refresh — FAST Cache IOPS](image)

At peak load, FAST Cache serviced over 10,000 IOPS from the datastores. The FAST Cache hits included IOPS serviced by Flash drives and storage processor memory cache. If memory cache hits are excluded, the pair of Flash drives alone serviced nearly 2,842 IOPS at peak load. A sizing exercise using EMC’s standard performance estimate (180 IOPS) for 15k rpm SAS drives suggests that it would take roughly 16 SAS drives to achieve the same level of performance.
Figure 80 shows the Data Mover CPU utilization during the Refresh test. The Data Mover briefly achieved a CPU utilization of approximately 23 percent during peak load in this test.

Figure 80. Refresh — Data Mover CPU utilization

Figure 81 shows the NFS operations per second from the Data Mover during the Refresh test.

Figure 81. Refresh — Data Mover NFS load

At peak load, the NFS operations per second were 19,300.
Figure 82 shows the CPU load from the ESX servers in the VMware clusters. A single server is reported because each server had similar results.

Figure 82. Refresh — ESX CPU load

The CPU load on the ESX server was never more than 25 percent utilization during peak load. It is important to note that hyperthreading was enabled to double the number of logical CPUs.
**ESX disk response time**

Figure 83 shows the Average Guest Millisecond/Command counter, which is shown as GAVG in esxtop. This counter represents the response time for I/O operations initiated to the storage array. The average of both datastores hosting the replica storage is shown as **Replica LUN - GAVG**, and the average of all the datastores hosting the linked clone storage is shown as **Linked Clone LUN - GAVG** in the graph.

![Graph showing ESX disk response time](image)

**Figure 83. Refresh — Average Guest Millisecond/Command counter**

The peak replica and linked clone LUN GAVG was below 9 ms.

**FAST Cache benefits**

**Case study**

To illustrate the benefits of enabling FAST Cache in a desktop virtualization environment, a test was conducted to compare the performance of the storage array with and without FAST Cache. The non-FAST Cache configuration consisted of 30 SAS drives in a storage pool. The FAST Cache configuration consisted of 15 SAS drives backed by FAST Cache with two Flash drives, displacing 15 SAS drives from the non-FAST Cache configuration for a 15:2 ratio of drive savings. Figure 84, Figure 85, and Figure 86 show how FAST Cache benefits are realized in each use case.

Figure 84 shows that with FAST Cache, the peak host response time during boot storm reduced by 84 percent when compared to the non-FAST Cache configuration.
Chapter 7: Testing and Validation

EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series (NFS), VMware vSphere 4.1, VMware View 4.6, and VMware View Composer 2.6—Proven Solutions Guide

Figure 84. Boot storm — Average latency comparison
Figure 85 shows that the antivirus scan completed in 59 minutes with FAST Cache enabled as compared to 78 minutes without FAST Cache. With FAST Cache enabled, the overall scan time was reduced by around 24 percent, and the peak response time was reduced by 35 percent.

![Antivirus Scan Comparison](chart)

**Figure 85.** Antivirus scan — Scan time comparison

Figure 86 shows that with FAST Cache, the peak host response time during patch storm reduced by 48 percent when compared to the non-FAST Cache configuration.

![Patch Storm Comparison](chart)

**Figure 86.** Patch storm — Average latency comparison
Chapter 8: Conclusion

This chapter includes the following sections:

- Summary
- References

Summary

As shown in Chapter 7: Testing and Validation, EMC VNX FAST Cache provides measurable benefits in a desktop virtualization environment. It not only reduces the response time for both read and write workloads, but also effectively supports more users on fewer drives, and greater IOPS density with a lower drive requirement.

References

The following documents, located on the EMC Powerlink website, provide additional and relevant information. Access to these documents depends on your login credentials. If you do not have access to a document, contact your EMC representative:

- **EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series, VMware vSphere 4.1, VMware View 4.5, and VMware View Composer 2.5—Reference Architecture**
- **EMC Infrastructure for Virtual Desktops Enabled by EMC VNX Series, VMware vSphere 4.1, VMware View 4.5, and VMware View Composer 2.5—Proven Solution Guide**
- **EMC Performance Optimization for Microsoft Windows XP for the Virtual Desktop Infrastructure—Applied Best Practices**
- **Deploying Microsoft Windows 7 Virtual Desktops with VMware View—Applied Best Practices Guide**

The following documents, located on the VMware website, also provide useful information:

- **Introduction to VMware View Manager**
- **VMware View Manager Administrator Guide**
- **VMware View Architecture Planning Guide**
- **VMware View Installation Guide**
- **VMware View Integration Guide**
- **VMware View Reference Architecture**
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- Storage Deployment Guide for VMware View
- VMware View Windows XP Deployment Guide
- VMware View Guide to Profile Virtualization
- ESX Installable and vCenter Server Setup Guide