EMC END-USER COMPUTING

Citrix XenDesktop 7.7 and EMC XtremIO 4.0 with VMware vSphere 6.0

EMC Solutions

Abstract

This solution guide describes the test and validation results of an end-user computing solution for Citrix XenDesktop 7.7 deployment on an EMC® XtremlO® 4.0 All-Flash Array with VMware vSphere® 6.0.

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Business case

Employees are more mobile than ever, and they expect access to business-critical data and applications from any location and from any device. They want the flexibility to bring their own device to work, which means IT departments are increasingly investigating and supporting bring your own device (BYOD) initiatives. These initiatives add layers of complexity to safeguarding sensitive information. Deploying a virtual desktop project is one way to do this.

Implementing large-scale virtual desktop environments presents many challenges. Administrators must roll out persistent, or nonpersistent, desktops rapidly for all users—task workers, knowledge workers, and power users—while offering an outstanding, better-than-local desktop user experience. In addition to performance, a virtual desktop solution must be simple to deploy, manage, and scale, with substantial cost savings over physical desktops. Storage is also a critical component of an effective virtual desktop solution.

Solution overview

The EMC end-user computing (EUC) environment described in this guide provides a modern system capable of hosting a large number of Citrix XenDesktop 7.7 virtual desktops at a consistent performance level, running on a VMware vSphere® 6.0 virtualization layer, backed by EMC® XtremIO® 4.0 for highly available storage. In this environment, an EMC VNX® system provides storage for user data. Optionally, EMC Isilon® also can be used to store user data, as validated in the EMC VSPEX with Isilon Scale-Out NAS guide.

This EUC environment is validated for up to 3,000 virtual desktops using Citrix Provisioning Services (PVS), and up to 2,000 virtual desktops using Citrix Machine Creation Services (MCS). These validated configurations are based on a reference desktop workload and form the basis for creating cost-effective, custom solutions for individual customers.

XtremIO supports scale-out clusters of up to six X-Bricks. Each additional X-Brick increases performance and virtual desktop capacity linearly. The XtremIO X-Brick has been validated to support a high number of desktops guaranteeing a given performance level for a well-defined standardized workload.

Key benefits

EMC solutions are designed to help you address the most serious IT challenges by creating solutions that are simple, efficient, and flexible and designed to take advantage of the many possibilities that XtremIO flash technology offers.
The business benefits of this EUC solution for Citrix XenDesktop include:

- A superior user experience to that of physical desktops, tablets, and laptops equipped with local SSDs
- Flexible implementation with the same user experience and economic benefits for both persistent and nonpersistent desktops across all deployment types
- Increased control and security of your global, mobile desktop environment, typically your most at-risk environment
- Better end-user productivity with a more consistent and seamless desktop experience across a wide range of end devices
- Simplified management with the solution environment contained in a centralized data center
- Better support of service-level agreements and compliance initiatives
- Lower operational and maintenance costs using consolidated management tools
- A smaller overall storage footprint due to the benefits of inline data deduplication and compression, all while delivering superior performance

**Document purpose**

This solution guide describes how to plan a simple, effective, and flexible EUC solution for Citrix XenDesktop 7.7. It provides a deployment example of virtual desktop storage on EMC XtremIO and user data storage on a VNX or optionally, an Isilon storage array.

The desktop virtualization components of the solution are hosted on the infrastructure as well. This guide illustrates how to size XenDesktop on the infrastructure, allocate resources following best practices, and capitalize on the benefits that these approaches offer.

**Audience**

This guide is intended for internal EMC personnel, qualified EMC partners, and customer EUC architects. The guide assumes that partners and customers who intend to deploy this EUC solution for Citrix XenDesktop have the necessary training and background to install and configure an EUC solution based on Citrix XenDesktop with VMware vSphere 6.0 as the hypervisor, XtremIO, VNX, and/or Isilon storage systems, and associated infrastructure components.

Readers also should be familiar with the infrastructure, networking, and security policies of any existing customer environment.

This guide provides external references where applicable. EMC recommends that partners and customers implementing this solution become familiar with these documents. For additional details, see Chapter 8: Reference Documentation.
We value your feedback!

EMC and the authors of this document welcome your feedback on the solution and the solution documentation. Contact EMC.Solution.Feedback@emc.com with your comments.

Authors: David Hartman, Ye Dai, Kathleen McCarthy
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XtremIO all-flash array

The EMC XtremIO all-flash array brings together all the necessary requirements to enable the agile data center: linear scale-out, high-availability, and rich data center services for workloads.

The basic hardware building block for these scale-out arrays is the X-Brick. Each X-Brick is made up of two active-active controller nodes and a disk array enclosure, packaged together with no single point of failure (SPOF). The Starter X-Brick, with 13 solid state drives (SSDs), can be expanded nondisruptively to a full X-Brick with 25 SSDs, without any downtime. Up to eight X-Bricks can be combined in a single scale-out cluster to increase performance and capacity in a linear manner.

The XtremIO platform is designed to maximize the use of flash storage media. Key attributes of this platform are:

- Extremely high levels of I/O performance, particularly for random I/O workloads that are typical in virtualized environments
- Consistently low (sub-millisecond) latency
- True inline data reduction—the ability to remove redundant information in the data path and write only unique data on the storage array, thus lowering the amount of physical capacity required
- A full suite of enterprise array capabilities, such as integration with VMware through vStorage APIs for Array Integration (VAAI), N-way active controllers, high availability, strong data protection, and thin provisioning

XtremIO storage includes the following components:

- **Host adapter ports**—Component that provides host connectivity through fabric into the array.
- **Storage controllers** (SCs)—Compute components of the storage array that handle all aspects of data moving into, out of, and between arrays.
- **Disk drives**—Solid state drives that contain the host/application data and their enclosures.
- **InfiniBand switches**—High throughput, low latency, scalable computer network communications link used in multi-X-Brick configurations.

**XtremIO Operating System (XIOS)**

The XtremIO storage cluster is managed by XtremIO Operating System (XIOS), which ensures that the system remains balanced and always delivers the highest levels of performance without any administrator intervention. The XIOS operating system:

- Ensures that all SSDs in the system are evenly loaded, providing both the highest possible performance, as well as endurance that supports demanding workloads for the life of the array.
- Eliminates complex configuration steps required for traditional arrays. There is no need to set RAID levels, determine drive group sizes, set stripe widths, set caching policies, build aggregates, or set other configuration parameters that require specialized storage skills.
• Automatically and optimally configures every volume at all times. I/O performance on existing volumes and data sets automatically increases with large cluster sizes. Every volume is capable of receiving the full performance potential of the entire XtremIO system.

**Standards-based enterprise storage system**

The XtremIO system interfaces with vSphere hosts using standard FC and iSCSI block interfaces. The system supports complete high-availability features, including support for native VMware multipath I/O, protection against failed SSDs, nondisruptive software and firmware upgrades, no single point of failure (SPOF), and hot-swappable components.

**Realtime, inline data reduction**

The XtremIO storage system deduplicates and compresses data in real time, including desktop images, allowing a massive number of virtual desktops to reside in a small and economical amount of flash capacity. Furthermore, data reduction on the XtremIO array does not adversely affect input/output per second (IOPS) or latency performance; rather, it enhances the performance of the end-user computing environment.

**Scale-out design**

The X-Brick is the fundamental building block of a scale out XtremIO clustered system. Using a Starter X-Brick, virtual desktop deployments can start small (up to 1,500 virtual desktops) and grow to nearly any scale required by upgrading the Starter X-Brick to an X-Brick, and then configuring a larger XtremIO cluster. The system expands capacity and performance linearly, as building blocks are added, making EUC sizing and management of future growth extremely simple.

**VAAI integration**

The XtremIO array is fully integrated with vSphere using VAAI. All API commands are supported, including ATS, Clone Blocks/Full Copy/XCOPY, Zero Blocks/Write Same, Thin Provisioning, and Block Delete. This, in combination with the array’s inline data reduction and in-memory metadata management, enables nearly instantaneous virtual machine provisioning and cloning and makes it possible to use large volume sizes for management simplicity.

**Fast provisioning**

XtremIO arrays deliver the industry’s first writeable snapshot technology that is space-efficient for both data and metadata. XtremIO snapshots are free from limitations of performance, features, topology, or capacity reservations. With their unique in-memory metadata architecture, XtremIO arrays can instantly clone desktop environments of any size.

**Ease of use**

The XtremIO storage system requires only a few basic setup steps that can be completed in minutes and with absolutely no tuning or ongoing administration to achieve and maintain high performance levels. The XtremIO system can be deployment-ready in less than one hour after delivery.
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Security with Data at Rest Encryption (D@RE)

XtremIO arrays securely encrypt all data stored on the all-flash array, delivering protection—especially for persistent virtual desktops—for regulated use cases in sensitive industries, such as healthcare, finance, and government.

VNX2 family of storage arrays

Power, efficiency, protection, and simplicity are four traits that must characterize an array in today’s high demand storage environment. Storage systems are required to provide powerful and efficient storage technologies, keep data protected, and be simple to use and manage.

The VNX multicore initiative, MCx™, is an architecture project that redesigns the core Block OE stack in the VNX2 series. Developed with many goals, the MCx platform’s most significant mission is CPU scaling. This mission is very simple: take advantage of the many CPU cores that the Intel microarchitecture offers and create a solution for further technological growth.

The VNX2 platform is a union of increased hardware performance and the extensive code changes required to support it. The optimization focuses on ensuring that cache management and back-end RAID management processes take full advantage of multicore CPUs, allowing cache and back-end processing software to scale in a linear fashion. In this way, EMC fully leverages the power of Intel’s latest multicore CPUs. The VNX2 series has a scaling factor of 97 percent, so future scaling using additional cores is guaranteed. This not only allows EMC to deliver cost efficient performance, but also to scale while delivering advanced efficiency and protection.

The VNX2 series is designed for a wide range of environments from mid-tier to enterprise. Each VNX2 model is offered in file only, block only, and unified (block and file) implementations. The VNX2 series is managed through EMC Unisphere®, a simple and intuitive user interface that completes the unified experience.

Isilon family of storage arrays (optional)

The EMC Isilon X-Series, powered by the OneFS® operating system, uses a highly versatile yet simple scale-out storage architecture to speed access to massive amounts of data, while dramatically reducing cost and complexity. The Isilon X-Series is comprised of two product lines — the Isilon X210, a 2U platform, and the Isilon X410, a 4U platform. The X410 was previously tested as a repository for user data. The Isilon X-Series is highly flexible and strikes the balance between large capacity and high-performance storage. The X-Series is an ideal solution for high-throughput and high-concurrency applications. With SSD technology for file system metadata and file-based storage workflows, the EMC Isilon X-Series also accelerates namespace-intensive operations.

- Agility: The Isilon X-Series scales from a few terabytes (TB) to over 20 petabytes (PB) and over 200 gigabytes per second (GB/s) of throughput within a single cluster. When needed, you can scale capacity and performance by adding a node in about a minute.
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- Simplicity: With its modular architecture, the Isilon X-Series makes deployment and management simple. Once racked, an X-Series cluster can be brought online in less than 10 minutes. With a single pool of storage with a global namespace, an X-Series cluster eliminates the need to support multiple volumes and simplifies management.

- Efficiency: With Isilon, you can achieve highly efficient utilization rates—over 80 percent compared to about 50 percent for traditional storage. The Isilon SmartDedupe™ data deduplication option enables you to further reduce your storage requirements by up to 30 percent. This translates into lower acquisition and operating costs.

- Security: With optional FIPS 140-2 level 2 self-encrypting drives, the X-Series platform allows you to meet regulatory and compliance needs for securing data at rest without sacrificing performance or usability.

Solution architecture

The EMC End-User Computing for Citrix XenDesktop solution provides a complete system architecture capable of supporting up to 3,000 virtual desktops for an X-Brick and up to 1,500 virtual desktops for a Starter X-Brick. The solution uses EMC XtremIO, VNX (and/or optionally Isilon), and VMware vSphere to provide the storage and virtualization platforms for a Citrix XenDesktop environment of Microsoft Windows 10 virtual desktops, provisioned by Citrix XenDesktop MCS or Citrix PVS.
Figure 1 shows the high-level architecture of the validated solution.

![Architecture of the validated solution](image)

Figure 1. Architecture of the validated solution

For the solution, we deployed the XtremIO array in a single X-Brick configuration to support up to 3,000 virtual desktops. Two different XtremIO X-Brick types were tested; a Starter X-Brick capable of hosting up to 1,500 virtual desktops, and an X-Brick capable of hosting up to 3,000 virtual desktops. We also deployed a VNX5600™ array for hosting user data. Optionally, an Isilon X410 array has been validated as a repository for user data, and may also be used.

The highly available EMC XtremIO array provides the storage for the desktop virtualization components. The existing infrastructure at the customer site can provide the infrastructure services for the solution, as shown in Figure 1. You can also deploy infrastructure services as dedicated resources as part of the solution.

Planning and designing the storage infrastructure for a Citrix XenDesktop environment is critical because the shared storage must be able to absorb large bursts of I/O that occur during daily activities. These bursts can lead to periods of erratic and unpredictable virtual desktop performance.

To provide predictable performance for end-user computing solutions, the storage system must be able to handle the peak I/O load from the clients while keeping response time to a minimum. This solution uses the EMC XtremIO array to provide the
low response times the clients require, while the real-time, inline deduplication and inline compression features of the platform reduce the amount of physical storage needed.

**Logical architecture**

The EMC EUC solution for Citrix XenDesktop supports block storage on XtremIO for the virtual desktops. Figure 2 shows the logical architecture of the solution.

![Logical architecture for both block and file storage](image)

This solution uses two networks:

- One 10 GbE iSCSI (or optional 8 Gb Fibre Channel network) for carrying virtual desktop and virtual server OS data
- One 10 Gb Ethernet network for carrying all other traffic

**XenDesktop 7.7**

XenDesktop is the desktop virtualization solution from Citrix that enables virtual desktops to run on the vSphere virtualization environment. Citrix XenDesktop 7.7 integrates Citrix XenApp application delivery technologies and XenDesktop desktop virtualization technologies into a single architecture and management experience. This new architecture unifies both management and delivery components to enable a scalable, simple, efficient, and manageable solution for delivering Windows applications and desktops as secure mobile services to users anywhere on any device.
Figure 3 shows the XenDesktop 7.7 architecture components.

The XenDesktop 7.7 architecture includes the following components:

- **Citrix Director**—Enables IT support and help desk teams to monitor an environment, troubleshoot issues before they become system-critical, and perform support tasks for end users. Citrix Director is a web-based tool.

- **Citrix Receiver**—Provides users with quick, secure, self-service access to documents, applications, and desktops from any of the user's devices including smartphones, tablets, and PCs. Receiver provides on-demand access to Windows, web, and software as a service (SaaS) applications. Citrix Receiver is installed on user devices.

- **Citrix StoreFront**—Provides authentication and resource delivery services for Citrix Receiver. It enables centralized control of resources and provides users with on-demand, self-service access to their desktops and applications.

- **Citrix Studio**—Is the management console that enables you to configure and manage your deployment, eliminating the need for separate consoles for managing delivery of applications and desktops. Studio provides various wizards to guide you through the process of setting up your environment, creating your workloads to host applications and desktops, and assigning applications and desktops to users.

- **Delivery Controller**—Consists of services that communicate with the hypervisor to distribute applications and desktops, authenticate and manage user access, and broker connections between users and their virtual desktops and applications. It is installed on servers in the data center. Delivery Controller manages the state of the desktops, starting and stopping them based on demand and administrative configuration. In some editions, the controller
enables you to install profile management to manage user personalization settings in virtualized or physical Windows environments.

- **License Server**—Assigns user or device licenses to the XenDesktop environment. The license server can be installed along with other Citrix XenDesktop components or on a separate virtual or physical machine.

- **Virtual Delivery Agent (VDA)**—Enables connections for desktops and applications. The VDA is installed on server or workstation operating systems. For remote PC access, install the VDA on the office PC.

- **Server OS machines**—Deliver applications or hosted shared desktops (HSDs) to users. They can be virtual machines or physical machines, based on the Windows Server operating system.

- **Desktop OS machines**—Deliver personalized desktops to users, or applications from the desktop operating systems. They can be virtual machines or physical machines, based on the Windows Desktop operating system.

- **Remote PC Access**—Enables users to access resources on their office PCs remotely, from any device running Citrix Receiver.

**Machine Creation Services**

MCS is a provisioning mechanism that is integrated with the XenDesktop management interface, Citrix Studio, to provision, manage, and decommission desktops throughout the desktop lifecycle from a centralized point of management.

MCS enables several types of desktop experiences to be managed within a catalog in Citrix Studio. The end user logs into the same desktop for a static desktop experience and logs into a new desktop for a random desktop experience. Desktop customization is persistent for static desktops that use the Personal vDisk (PvDisk or PvD) feature or desktop local hard drives to save changes. The random desktop discards changes and refreshes the desktop when the user logs off.

**Citrix Provisioning Services**

PVS streams a single shared disk image (vDisk) instead of copying images to individual machines. PVS enables organizations to reduce the number of disk images that they manage. As the number of machines continues to grow, PVS provides the efficiency of centralized management with the benefits of distributed processing.

Because machines stream disk data dynamically, in real time from a single shared image, machine image consistency is ensured. In addition, large pools of machines can completely change their configuration, applications, and operating system during a reboot operation.

**Citrix Personal vDisk**

The Citrix PvD feature enables users to preserve customization settings and user-installed applications in a pooled desktop by redirecting the changes from the user’s pooled virtual machine to a separate Personal vDisk. During runtime, the content of the Personal vDisk is blended with the content from the base virtual machine to provide a unified experience to the end user. The Personal vDisk data is preserved during reboot and refresh operations.
**Citrix Profile Management**

Citrix Profile Management preserves user profiles and dynamically synchronizes them with a remote profile repository. Profile Management downloads a user’s remote profile dynamically when the user logs in to XenDesktop, and applies personal settings to desktops and applications regardless of the user’s login location or client device.

The combination of Profile Management and pooled desktops provides the experience of a dedicated desktop, while potentially minimizing the amount of storage required in an organization.

**VMware vSphere**

VMware vSphere is the leading virtualization platform in the industry. It provides flexibility and cost savings by enabling the consolidation of large, inefficient server farms into nimble, reliable infrastructures. The core VMware vSphere components are the VMware vSphere hypervisor and VMware vCenter Server for system management.

This solution uses VMware vSphere Enterprise Plus, which provides a wide range of features and functionality, enabling customers to achieve scalability, high availability, and optimal performance for their desktop workloads.

**VMware vCenter Server**

VMware vCenter Server is a centralized platform for managing vSphere environments. It provides administrators with a single interface for all aspects of monitoring, managing, and maintaining the virtual infrastructure and can be accessed from multiple devices.

vCenter is also responsible for managing advanced features such as vSphere High Availability (HA), vSphere Distributed Resource Scheduler (DRS), vSphere vMotion, and vSphere Update Manager.

**VMware vSphere High Availability**

VMware vSphere High Availability (HA) provides uniform, cost-effective failover protection against hardware and OS outages:

- If the virtual machine OS has an error, the virtual machine can be automatically restarted on the same hardware.
- If the physical hardware has an error, the impacted virtual machines can be automatically restarted on other servers in the cluster.

With vSphere HA, you can configure policies to determine which machines are restarted automatically and under what conditions these operations should be performed.
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Chapter 3: Configuring VDI Components

Storage

This section describes how to configure the XtremIO, VNX, and optionally, the Isilon storage arrays. In this solution, XtremIO provides VMware Virtual Machine File System (VMFS) data storage for VMware hosts running virtual desktops, while the optional VNX or Isilon arrays provide the Common Internet File System (CIFS) storage for user data.

All storage configuration examples described in this chapter are for a single X-Brick configuration validated in this solution. For larger configurations, ask your sales representative for more information.

Table 1 summarizes the tasks for storage configuration.

Table 1. Tasks for storage configuration

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparing and installing XtremIO</td>
<td>Configure XtremIO event handlers to send notifications concerning array physical space utilization.</td>
<td>[EMC XtremIO Storage Array Hardware Installation and Upgrade Guide]</td>
</tr>
<tr>
<td>Provisioning storage for VMFS datastores</td>
<td>Create XtremIO volumes that will be presented to the vSphere servers as VMFS datastores hosting the virtual desktops.</td>
<td>[Provisioning storage for VMFS datastores]</td>
</tr>
<tr>
<td>Configuring VNX Fast Cache (optional)</td>
<td>Configure FAST Cache. Optionally, configure FAST VP.</td>
<td>[Configuring VNX Fast Cache Configuring VNX FAST VP for user data (optional)]</td>
</tr>
<tr>
<td>Provisioning Isilon storage for user data (optional)</td>
<td>Create CIFS file systems that will be used to store roaming user profiles and home directories. Configure FAST Cache. Optionally, configure FAST VP.</td>
<td>[Provisioning Isilon storage]</td>
</tr>
<tr>
<td>Provision infrastructure storage for infrastructure virtual machines</td>
<td>Create additional VMFS datastores to host SQL Server, domain controller, vCenter Server, Citrix XenDesktop Desktop Delivery Controller, and Citrix Provisioning Services virtual machines.</td>
<td>[Provision infrastructure storage]</td>
</tr>
</tbody>
</table>
Perform the steps described here to configure the required volumes, as detailed in Table 2, to present to the vSphere servers as VMFS datastores. Two datastore configurations are listed for each desktop type, one that includes the space required to use the Citrix Personal vDisk (PVD) feature, and one that does not for solutions that will not use that component of Citrix XenDesktop. Note that when deploying Citrix, the following values are configured by default:

- PVS write cache disk—6 GB
- Citrix Personal vDisk (PvD)—10 GB

If either of these values is changed from the default, the datastore sizes must also be changed.

**Table 2. Volumes on XtremIO for storing virtual desktops**

<table>
<thead>
<tr>
<th>XtremIO configuration</th>
<th>Number of desktops</th>
<th>Type of desktop</th>
<th>Number of volumes</th>
<th>Volume size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter X-Brick / X-Brick</td>
<td>1,500 / 3,000</td>
<td>PVS streamed</td>
<td>6 / 12</td>
<td>2,500 GB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PVS streamed with PVD</td>
<td></td>
<td>5,000 GB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCS</td>
<td></td>
<td>2,500 GB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCS with PVD</td>
<td></td>
<td>5,000 GB</td>
</tr>
</tbody>
</table>

Complete the following steps in the EMC XtremIO Storage Management application to configure volumes on the XtremIO array for storing virtual desktops:

1. Click **Configuration**.
2. In the **Volume** pane, click **Add**.
3. In the **Add New Volumes** window, click **Add Multiple**.
4. In the **Number of Volumes** field, type the required number of datastores based on the configuration and number of virtual desktops. In the **Name** field provide a common LUN name and in the **Size** field type either 2,500 GB or 5,000 GB as required and click **OK**.

We configured a VNX5600 as a repository for user data (that is, roaming user profiles or XenDesktop Profile Management repositories and home directories). Complete the following steps in Unisphere to configure two CIFS file systems on VNX:

1. Create a block-based RAID 6 storage pool with the characteristics shown in Table 3.

   **Table 3. Create block-based RAID 6 storage pool**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Number of drives</th>
<th>Drive type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,500 virtual desktops</td>
<td>24</td>
<td>2 TB NL-SAS</td>
</tr>
<tr>
<td>3,000 virtual desktops</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

For other scale points, refer to the EMC Sizing Tool for details about the recommended array configuration.
2. Provision the required LUNs from the pool, as shown in Table 4, to present to the Data Mover as dvols for a system-defined NAS pool.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Number of LUNs</th>
<th>LUN size (TB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,500 virtual desktops</td>
<td>10</td>
<td>2.25</td>
</tr>
<tr>
<td>3,000 virtual desktops</td>
<td>20</td>
<td>2.25</td>
</tr>
</tbody>
</table>

3. Provision four file systems from the NAS pool to be exported as CIFS shares on a CIFS server.

For greater than 2,000 desktop configurations, distribute the file systems between two CIFS servers. Additionally, distribute the CIFS servers between the two active Data Movers on the VNX5600.

To configure FAST Cache on the VNX storage pool for this solution, complete the following steps in Unisphere:

1. To view FAST Cache information for the VNX array:
   a. In Unisphere, click Properties and select Manage Cache.
   b. In the Storage System Properties dialog box, as shown in Figure 4, select FAST Cache to view FAST Cache information.

   ![Figure 4. Storage System Properties dialog box](image)

2. To create FAST Cache:
   a. Click Create to open the Create FAST Cache dialog box, as shown in Figure 5.
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Figure 5. Creating FAST Cache dialog box

b. Select the required number of disks to be used for FAST Cache.

c. Select either Automatic or Manual. Automatic will create FAST Cache for the flash drives listed in the dialog box. Manual enables you to select drives manually.

d. Click OK to create FAST Cache using the selected disks.

Note: If a sufficient number of flash drives is not available, an error message appears and the FAST Cache will not be created.

e. Enable FAST Cache for the storage pool created for the solution.

After FAST Cache is created, it is enabled by default for all new pools.

f. To enable FAST Cache for an existing pool, select the FAST Cache Enabled option under Advanced in the Storage Pool Properties dialog box.

The FAST Cache feature on VNX does not cause an instant performance improvement. The system must collect data about access patterns and promote frequently used information into the cache. This process takes a few hours during which the performance of the array steadily improves.

Configuring VNX FAST VP for user data (optional)

You can configure FAST VP to automate data movement between storage tiers in the user data storage pool, which is optional. You can configure FAST VP at the pool level or at the LUN level.

This solution uses NL-SAS drives with FAST Cache for the user data storage pool. This provides acceptable performance for a wide range of use cases. However, if more performance is required, use VNX FAST VP to add automated storage tiering to the pool.
Configuring FAST VP at pool level

To view and manage FAST VP at the pool level, follow these steps:

1. To open the Storage Pool Properties window, select the storage pool for the user data and click Properties.

   Tier Status shows FAST VP relocation information specific to the pool selected. Tier Details shows the exact distribution of the data.

   Figure 6 shows the tiering information for a specific FAST VP-enabled pool.

   ![Storage Pool Properties window]

   **Figure 6.** Storage Pool Properties window

2. From the Auto-Tiering menu, select the scheduled relocation at the pool level. Set this to either Automatic or Manual.

3. Click Relocation Schedule to open the Manage Auto-Tiering window, as shown in Figure 7.

   From this window, you can control the Data Relocation Rate. The default rate is set to Medium to avoid significantly affecting host I/O.

   **Note:** FAST VP is a completely automated tool and you can schedule relocations to occur automatically. EMC recommends scheduling relocations during off-peak hours to minimize any potential performance impact.
To create a single, common Server Message Block (SMB) share on Isilon to be used by all users, follow these steps:

1. In the OneFS web administration interface, click **Protocols > Windows Sharing (SMB)**.

2. On the SMB Shares tab, click **Add a share**.

3. In the **Share Name** field, type the user name for the user (for example, Home Directory).

4. In the **Directory to Be Shared** field, type the full path of the home directory location, beginning with /ifs, or click **Browse** to locate the directory (for example, /ifs/home/).

5. Click **Create**, as shown in Figure 8.
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**Figure 8.** Create SMB share for Home Directory in Isilon

6. Repeat these steps for other CIFS shares, like the profile folder.

By default, all users have access to the common SMB share, and can access other users’ files that have a home directory in the common SMB share. If stricter access permissions are needed, enable Access-based enumeration to list only the files and folders to which each user has access when browsing content on the file server.

For information about other ways of configuring Isilon as the home directory, refer to *Managing SMB Shares and User Home Directories in EMC Isilon OneFS 6.5 and Later.*

**Infrastructure requirements**

This EUC solution requires multiple application servers to support the various components required for the solution. Unless otherwise specified, all servers use Microsoft Windows Server 2012 R2 as the base OS. Table 5 summarizes the minimum requirements of each infrastructure server required.

**Table 5.** Infrastructure server minimum requirements

<table>
<thead>
<tr>
<th>Server</th>
<th>CPU</th>
<th>RAM</th>
<th>IOPS</th>
<th>Storage capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain controllers (each)</td>
<td>2 vCPUs</td>
<td>4 GB</td>
<td>25</td>
<td>32 GB</td>
</tr>
<tr>
<td>SQL Server</td>
<td>2 vCPUs</td>
<td>6 GB</td>
<td>100</td>
<td>200 GB</td>
</tr>
<tr>
<td>vCenter Server</td>
<td>4 vCPUs</td>
<td>8 GB</td>
<td>100</td>
<td>80 GB</td>
</tr>
<tr>
<td>Citrix XenDesktop Controllers (each)</td>
<td>2 vCPUs</td>
<td>8 GB</td>
<td>50</td>
<td>32 GB</td>
</tr>
<tr>
<td>Citrix PVS Server s (each)</td>
<td>4 vCPUs</td>
<td>20 GB</td>
<td>75</td>
<td>150 GB</td>
</tr>
</tbody>
</table>
Infrastructure storage layout
This solution requires a 1.5 TB volume to host the infrastructure virtual machines, which can include the VMware vCenter Server, Citrix XenDesktop Controllers, Citrix PVS servers, optional Citrix ShareFile servers, Microsoft Active Directory Server, and Microsoft SQL Server.

Server configuration and path management
This section provides information about installing and configuring the vSphere hosts and infrastructure servers required to support the architecture. Table 6 summarizes the tasks.

Table 6. Tasks for server installation

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add vSphere hosts</td>
<td>Add the vSphere hosts to the XtremIO initiator groups.</td>
<td>Creating XtremIO initiator groups</td>
</tr>
<tr>
<td>to the XtremIO initiator groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connect VMware datastores</td>
<td>Connect the VMware datastores to the vSphere hosts deployed for the solution.</td>
<td>vSphere Storage Guide Connecting vSphere datastores</td>
</tr>
<tr>
<td>Optimize vSphere</td>
<td>Perform the configuration changes needed to ensure optimal performance of the XtremIO array</td>
<td>Introduction to the EMC XtremIO Storage Array Optimizing vSphere for XtremIO</td>
</tr>
</tbody>
</table>

Connecting vSphere datastores
Connect the datastores configured in Provisioning storage for VMFS datastores to the appropriate vSphere servers. These include the datastores configured for:

- Virtual desktop storage
- Infrastructure virtual machine storage (if required)
- SQL Server storage (if required)

To enable vSphere servers to access the XtremIO volumes, configure XtremIO initiator groups and add the appropriate vSphere hosts to each using the following steps in the XtremIO Storage Management Application:

1. Click **Configuration**.
2. In the **Initiator Group** pane, click **Add**.
3. In the **Add New Initiator Group** window, type a name in the **Initiator Group Name** field, and then click **Add**.
4. In the **Add Initiator** window, type a name in the **Initiator Name** field, and then use the **Initiator Port Address** list to select the initiator port of a vSphere server that should be in the target initiator group. Click **Ok** to return to the **Add Initiator** window.
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5. In the Add Initiator window, repeat step 4 as needed to add all target initiator ports to the initiator group. When you have added all initiators, click Finish.

6. In the Configuration menu,
   a. Select the target volumes from the Volumes pane, and
   b. Select the target initiator group from the Initiator Groups pane,
   c. Click the Map All button, and then click Apply to complete the process and grant the vSphere servers access to the selected volumes.
   d. Repeat as needed to grant the remaining initiator groups access to the remaining volumes.

7. Perform a Rescan for Datastores operation on the vSphere hosts so that they will immediately detect the XtremIO volumes to which they have access.

8. Repeat this process as needed, creating an initiator group for each vSphere cluster.

The VMware vSphere Storage guide provides instructions on how to format the vSphere datastores when XtremIO initiator groups have been configured. Refer to the list of documents in the Reference Documentation section for more information.

Optimizing vSphere for XtremIO

Multiple changes are required to ensure optimal performance of the XtremIO array when used with vSphere. These changes are outlined in the Introduction to the EMC XtremIO Storage Array, and include:

- Change the vSphere storage device path selection setting to Round Robin (VMware) for each vSphere datastore. Use the following vSphere PowerCLI command, replacing cluster with the name of the vSphere cluster where the target vSphere hosts reside. Repeat as needed for each cluster:

  Get-VMHost -location cluster | get-scsilun -luntype "disk" | where {$_ .MultipathPolicy -ne "RoundRobin"} | Set-ScsiLun -MultipathPolicy "RoundRobin"

- Change vSphere Disk.SchedQuantum setting to 64 and Disk.DiskMaxIOSize setting to 4096. Use the following vSphere PowerCLI commands, replacing cluster with the name of the vSphere cluster where the target vSphere hosts reside. Repeat as needed for each cluster:

  Get-VMhost -location cluster | Set-VMhostAdvancedConfiguration Disk.SchedQuantum -Value 64
  Get-VMhost -location cluster | Set-VMhostAdvancedConfiguration Disk.DiskMaxIOSize -Value 4096

- Change the vSphere Disk.SchedNumReqOutstanding setting to 256 for each vSphere datastore. Use the following vSphere PowerCLI script. Repeat as needed for each vSphere cluster, updating the script with the target ClusterName:

  $vmhosts = get-vmhost -location ClusterName
  foreach ($vmhost in $vmhosts) {
    $esxcli = get-esxcli -vmhost $vmhost
    $AllLUNs = get-scsilun -vmhost $vmhost | where {$_ .vendor -eq "XtremIO"}
foreach ($lun in $AllLUNs) {
    $CN = $lun.canonicalname
    $EsxCli.storage.core.device.set($null, $cn, $null, $null, $null, $null, $null, 256, $on)
}

The settings described in this section apply only to vSphere hosts connected to EMC XtremIO arrays, and must not be applied to block datastores hosted on other arrays, including other EMC arrays. It is acceptable to use these settings on vSphere hosts that are connected to NFS datastores as well as an XtremIO, as the settings will have no effect on the communication with those NFS datastores.

The EMC VSI plug-in enables administrators to perform most common XtremIO administrative tasks from the vSphere Web Client, instead of the XtremIO management console. Furthermore, administrators can use the plug-in to perform key vSphere host optimizations for XtremIO, instead of the vSphere PowerCLI. If a VNX array is deployed as part of this solution, administrators can use the VSI plug-in to manage this storage also.

If your solution uses the VSI plug-in, refer to the [EMC VSI for VMware vSphere Web Client](#) for installation, configuration, and operation instructions.

Figure 9 shows an EMC VSI installation that has been successfully integrated with the vSphere Web Client, as displayed on the **vCenter Home** page.

![vSphere Web Client: EMC VSI integration](image)

**Figure 9. vSphere Web Client: EMC VSI integration**

The **vCenter Home > Storage Systems** option lists all EMC storage systems after you have added them to the VSI plug-in. Figure 10 shows that the XtremIO array has been successfully added and is available for management in the vSphere Web Client.
After you have added an array to the VSI plug-in, the vSphere Web Client lists all of the array’s datastores. Right-click a datastore and select **All EMC VSI Plugin Actions** to access all actions you can apply to that datastore, as shown in Figure 11.
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Networking

This section describes the requirements for preparing the network infrastructure required to support this solution. Table 7 summarizes the tasks.

Table 7. Tasks for switch and network configuration

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configure the infrastructure network</td>
<td>Configure the storage array and vSphere host infrastructure networking.</td>
<td>Configuring the infrastructure network</td>
</tr>
<tr>
<td>Configure the VLANs</td>
<td>Configure private and public VLANs as required.</td>
<td>Vendor's switch configuration guide</td>
</tr>
<tr>
<td>Configure the storage network</td>
<td>Configure FC/FCoE switch ports and zoning for vSphere hosts and the storage array if implementing these protocols.</td>
<td>Configuring the storage network Vendor's switch configuration guide</td>
</tr>
</tbody>
</table>

The infrastructure network requires redundant network links for each vSphere host, the storage array, switch interconnect ports, and switch uplink ports. This configuration provides both redundancy and additional network bandwidth.

This configuration is required whether the network infrastructure for the solution already exists or is being deployed with other components of the solution.

Figure 12 shows a sample redundant Ethernet infrastructure for the VNX used in this solution. This solution uses redundant switches and links to ensure that no single point of failure exists within the network connectivity. The same principal applies to an Isilon configuration.
Ensure that there are adequate switch ports for the storage array and vSphere hosts. EMC recommends that you configure the vSphere hosts with a minimum of two VLANs:

- **Client access network**: Virtual machine networking and CIFS traffic (these are customer-facing networks, which can be separated if needed)
- **Management network**: vSphere management and VMware vMotion (private network)

This solution requires a dedicated storage network. If iSCSI is used to connect vSphere hosts to the XtremIO array, a dedicated VLAN for the storage network is also required. If Fibre Channel (FC) or a combination of FC for the XtremIO array and FCoE for vSphere hosts will be used, no additional VLANs are required for the storage network.
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For the solution tests, we used an iSCSI network. The infrastructure iSCSI network requires redundant iSCSI switches and links for each vSphere host and the storage array. This configuration provides both redundancy and additional storage network bandwidth. We connected each vSphere host to both iSCSI switches, and each switch to each storage processor on the storage array.

Figure 13 shows the network architecture used for testing this solution.

![Sample iSCSI network architecture]

**Figure 13.** Sample iSCSI network architecture
Table 8 summarizes the tasks for setting up and configuring a Microsoft SQL Server database for the solution. When the tasks are complete, SQL Server is set up on a virtual machine, with all of the databases required by vCenter, Update Manager, XenDesktop, and Citrix Provisioning Services.

Table 8. Tasks for SQL Server database setup

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a virtual machine for SQL Server</td>
<td>Create a virtual machine to host SQL Server on one of the vSphere servers designated for infrastructure virtual machines, and use the datastore designated for the shared infrastructure. Verify that the virtual server meets the hardware and software requirements.</td>
<td>vsphere Virtual Machine Administration</td>
</tr>
<tr>
<td>Install SQL Server</td>
<td>Install SQL Server 2012 on the virtual machine.</td>
<td>SQL Server Installation (SQL Server 2012)</td>
</tr>
<tr>
<td>Configure the database for VMware vCenter Server</td>
<td>Create the database required for vCenter Server on the appropriate datastore.</td>
<td>Preparing vCenter Server Databases</td>
</tr>
<tr>
<td>Configure the database for VMware Update Manager</td>
<td>Create the database required for Update Manager on the appropriate datastore.</td>
<td>Preparing the Update Manager Database</td>
</tr>
<tr>
<td>Configure VMware vCenter database permissions</td>
<td>Configure the database server with appropriate permissions for vCenter.</td>
<td>Preparing vCenter Server Databases</td>
</tr>
<tr>
<td>Configure VMware Update Manager database permissions</td>
<td>Configure the database server with appropriate permissions for Update Manager.</td>
<td>Preparing the Update Manager Database</td>
</tr>
</tbody>
</table>
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Deploying the VMware vCenter Server

Table 9 summarizes the tasks to be completed to configure VMware vCenter Server for the solution.

Table 9. Tasks for vCenter configuration

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create the vCenter host virtual machine</td>
<td>Create a virtual machine for vCenter Server.</td>
<td>vSphere Virtual Machine Administration</td>
</tr>
<tr>
<td>Install the vCenter guest OS</td>
<td>Install Windows Server 2012 R2 Standard Edition on the vCenter host virtual machine.</td>
<td>Install and Deploy Windows Server 2012 R2</td>
</tr>
<tr>
<td>Update the virtual machine</td>
<td>Install VMware Tools, enable hardware acceleration, and allow remote console access.</td>
<td>vSphere Virtual Machine Administration</td>
</tr>
<tr>
<td>Create vCenter ODBC connections</td>
<td>Create the 64-bit vCenter and 32-bit vCenter Update Manager ODBC connections.</td>
<td>vSphere Installation and Setup Installing and Administering VMware vSphere Update Manager</td>
</tr>
<tr>
<td>Install vCenter Server software</td>
<td>Install the vCenter Server software.</td>
<td>vSphere Installation and Setup</td>
</tr>
<tr>
<td>Install vCenter Update Manager software</td>
<td>Install the vCenter Update Manager software.</td>
<td>Installing and Administering VMware vSphere Update Manager</td>
</tr>
<tr>
<td>Create a virtual datacenter</td>
<td>Create a virtual datacenter.</td>
<td>vCenter Server and Host Management</td>
</tr>
<tr>
<td>Apply vSphere license keys</td>
<td>Type the vSphere license keys in the vCenter licensing menu.</td>
<td>vSphere Installation and Setup</td>
</tr>
<tr>
<td>Add vSphere Hosts</td>
<td>Connect the vCenter server to the vSphere hosts.</td>
<td>vCenter Server and Host Management</td>
</tr>
<tr>
<td>Configure vSphere clustering</td>
<td>Create a vSphere cluster and move the vSphere hosts into it.</td>
<td>vSphere Resource Management</td>
</tr>
<tr>
<td>Install the vCenter Update Manager plug-in</td>
<td>Install the vCenter Update Manager plug-in from the administration console.</td>
<td>Installing and Administering VMware vSphere Update Manager</td>
</tr>
<tr>
<td>Deploy EMC PowerPath/VE</td>
<td>Use Update Manager to deploy the PowerPath/VE plug-in to all vSphere hosts.</td>
<td>EMC PowerPath/VE for VMware vSphere Installation and Administration Guide</td>
</tr>
<tr>
<td>Install EMC VSI for VMware vSphere plug-in</td>
<td>Install VSI for VMware vSphere plug-in on the administration console.</td>
<td>EMC VSI for VMware vSphere: Unified Storage Management—Product Guide</td>
</tr>
<tr>
<td>Install EMC PowerPath Viewer</td>
<td>Install PowerPath Viewer on the administration console.</td>
<td>EMC PowerPath Viewer Installation and Administration Guide</td>
</tr>
</tbody>
</table>
This section provides information on how to set up and configure XenDesktop Delivery Controllers for the solution. For a new installation of XenDesktop, Citrix recommends that you complete the tasks in Table 10 in the order shown.

Table 10. Tasks for XenDesktop controller setup

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating virtual machines for XenDesktop Delivery Controllers</td>
<td>Create two virtual machines in vSphere Client. These virtual machines are used as XenDesktop Delivery Controllers.</td>
<td>vSphere Virtual Machine Administration</td>
</tr>
<tr>
<td>Installing the guest operating system for the XenDesktop Delivery Controllers</td>
<td>Install the Windows Server 2012 R2 guest operating system on the virtual machines.</td>
<td>Install and Deploy Windows Server 2012 R2</td>
</tr>
<tr>
<td>Installing the XenDesktop server-side components</td>
<td>Install the required XenDesktop server components on the first Delivery Controller.</td>
<td>Citrix website</td>
</tr>
<tr>
<td>Installing Citrix Studio</td>
<td>Install Citrix Studio to manage XenDesktop deployment remotely.</td>
<td></td>
</tr>
<tr>
<td>Configuring a site</td>
<td>Configure a site in Citrix Studio.</td>
<td></td>
</tr>
<tr>
<td>Adding a second XenDesktop Delivery Controller</td>
<td>Install an additional Delivery Controller for high availability.</td>
<td></td>
</tr>
<tr>
<td>Preparing a master virtual machine</td>
<td>Create a master virtual machine as the base image for the virtual desktops.</td>
<td></td>
</tr>
<tr>
<td>Provisioning the virtual desktops</td>
<td>Provision the virtual desktops using PVS or MCS.</td>
<td></td>
</tr>
</tbody>
</table>

Installing server-side components of XenDesktop

After creating the VMs, install the following XenDesktop server-side components on the first Delivery Controller:

- **Delivery Controller**: Distributes applications and desktops, manages user access, and optimizes connections
- **Citrix Studio**: Creates, configures and manages infrastructure components, applications, and desktops
- **Citrix Director**: Monitors performance and troubleshoots problems
• **License server**: Manages product licenses
• **Citrix StoreFront**: Provides authentication and resource delivery services for Citrix Receiver

**Note**: Citrix supports installation of XenDesktop components only through the procedures described in Citrix documentation.

**Installing Citrix Studio**
Install Citrix Studio on the appropriate administrator consoles to manage your XenDesktop deployment remotely.

**Configuring a site**
Start Citrix Studio and configure a site as follows:

1. License the site and specify which edition of XenDesktop to use.
2. Setup the site database using a designated login credential for SQL Server.
3. Provide information about your virtual infrastructure, including the vCenter SDK path that the controller will use to establish a connection to the VMware infrastructure.

**Adding a second controller**
After you have configured a site, you can add a second Delivery Controller to provide high availability. The XenDesktop server-side components required for the second controller are:

• Delivery Controller
• Citrix Studio
• Citrix Director
• Citrix StoreFront

Do not install the license-server component on the second controller because it is centrally managed on the first controller.

**Preparing the master virtual machine**
Complete the following steps to prepare the master virtual machine:

1. Install the Windows 10 guest OS.
2. Install the appropriate integration tools such as VMware Tools.
3. Optimize the OS settings to prevent unnecessary background services from generating nonessential I/O operations that adversely affect the overall performance of the storage array. Refer to the following White Paper for details: Optimizing Microsoft Windows Virtual Desktops.
4. Install the Virtual Delivery Agent.
5. Install the third-party tools or applications, such as Microsoft Office, relevant to your environment.
6. The same procedure applies to Windows Server 2012 R2 guest OS for Hosted Shared Desktops (HSD) as well, except for the optimization process.
**Provisioning the virtual desktops**
Provision the virtual desktops with either:

- Citrix Studio
- Or
- EMC VSI for VMware vSphere Web client

**Provisioning virtual desktops with Citrix Studio**
Complete the following steps in Citrix Studio to deploy MCS-based virtual desktops:

1. Create a machine catalog using the master virtual machine as the base image.
   
   MCS allows the creation of a machine catalog that contains various types of desktops. We tested the following desktop types for this solution:
   
   - **Windows Desktop OS**:
     - Random: Users connect to a new (random) desktop each time they log on.
     - PvD: Users connect to the same (static) desktop each time they log on. Changes are saved on a separate PvD.
   
   2. Add the machines created in the catalog to a delivery group so that the virtual desktops are available to the end users.

**Provisioning virtual desktops with VSI**
Use the EMC VSI for VMware vSphere Web Client to deploy dedicated full clone virtual desktops that are integrated with XenDesktop, which leverages XtremIO snapshot technology.

1. Log in to **VMware vSphere Web Client**.
2. Select virtual machine of master image, right click and then select **All EMC VSI Plugin Actions > EMC Clone...**
3. For **Select base name and folder**, type a name for the clone, select the destination folder, and then click **Next**.
4. For **Select a compute resource**, select a cluster, host, vApp, or resource pool to run the virtual machine clones, and then click **Next**.
5. For **Select clone options**, complete the following information:
   a. **Clone count**—Type the number of clones you want to create.
   b. **Generated clone name**:
      i. **Add leading zeros to index used to generate names**—Select to add leading zeroes to the index numbers in the file names.
      ii. **Number of digits in index**—Specify the total number of digits to append to the end of the clone name.
   c. **Customization specification**—List of all customized definitions from the customization specifications manager.
d. **Select destination datastore**—The target to store the clones. Select an existing XtremIO datastore or select **New** to create a new datastore.

e. **Power on virtual machines after creation**—Select to automatically power on the virtual machine clone.

6. Under **Connection Broker Information**, select **Integrate with XenDesktop**, and click **Next**.

- **XenDesktop Controller**—Select the appropriate IP address from the list.
- **New/Existing Machine Catalog**:
  - **Add VMs to a New Machine Catalog**—Opens the **Set up a New Machine Catalog** dialog box. Type a name and description for the new machine catalog.
  - **Add VMs to an Existing Machine Catalog**—Select from the list.
- **New/Existing Desktop Group**:
  - **Add VMs to a New Desktop Group**—Opens the **Set up a New Desktop Group** dialog box. Type a name, display name, and description for the new desktop group.
  - **Add VMs to an Existing Desktop Group**—Select from the list.

7. For **Ready to Complete**, review your selections, and then click **Finish**.

Refer [EMC VSI for VMware vSphere Web Client Product Guide](#) for more information.

### Installing and configuring Citrix Provisioning Services

This section provides information about how to set up and configure Citrix PVS for the solution. This section does not apply to a Citrix MCS only implementation.

For a new installation of PVS, Citrix recommends that you complete the tasks in Table 11 in the order shown.

#### Table 11. Tasks for XenDesktop controller setup

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating virtual machines for PVS servers</td>
<td>Create two virtual machines in vSphere Client. These virtual machines are used as PVS servers.</td>
<td><a href="#">vSphere Virtual Machine Administration</a></td>
</tr>
<tr>
<td>Installing the guest operating system for the PVS servers</td>
<td>Install the Windows Server 2012 R2 guest operating system for the PVS servers.</td>
<td></td>
</tr>
<tr>
<td>Installing the PVS server-side components</td>
<td>Install the PVS server components and console on the PVS server.</td>
<td></td>
</tr>
<tr>
<td>Configuring a PVS server farm</td>
<td>Run the Provisioning Services Configuration Wizard to create a PVS server farm.</td>
<td><a href="#">Citrix website</a></td>
</tr>
<tr>
<td>Adding a second PVS server</td>
<td>Install the PVS server components and console on the second server and join it to the existing server farm.</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating a PVS store</td>
<td>Specify the store path where the vDisks will reside.</td>
<td></td>
</tr>
<tr>
<td>Configuring inbound communication</td>
<td>Adjust the total number of threads to be used to communicate with each virtual desktop.</td>
<td></td>
</tr>
<tr>
<td>Configuring a bootstrap file</td>
<td>Update the bootstrap image to use both PVS servers to provide streaming services.</td>
<td></td>
</tr>
<tr>
<td>Configuring boot options 66 and 67 on the DHCP server</td>
<td>Specify the TFTP server IP and the name of the bootstrap image used for the Preboot eXecution Environment (PXE) boot.</td>
<td></td>
</tr>
<tr>
<td>Preparing a master virtual machine</td>
<td>Create a master virtual machine as the base image for the virtual desktops.</td>
<td></td>
</tr>
<tr>
<td>Provisioning the virtual desktops</td>
<td>Provision the virtual desktops using PVS.</td>
<td></td>
</tr>
</tbody>
</table>

**Configuring a PVS server farm**

After creating the VMs, the PVS server components are installed on the PVS server. Once complete, start the Provisioning Services Configuration Wizard and configure a new server farm using the following options:

1. Specify the DHCP service to be run on another computer.
2. Specify the PXE service to be run on this computer.
3. Select **Create farm** to create a new PVS server farm using a designated SQL Server database instance.
4. When creating a new server farm, you need to create a site. Provide an appropriate name for the new site and target device collection.
5. Select the license server that is running on the XenDesktop controller.
6. Select **Use the Provisioning Services TFTP service**.

**Adding a second PVS server**

After you have configured a PVS server farm, you can add a second PVS server to provide high availability. Install the PVS server components and console on the second PVS server and run the Provisioning Services Configuration Wizard to join the second server to the existing server farm.

**Creating a PVS store**

A PVS store is a logical container for vDisks. When deploying PVS servers on datastores located on an XtremIO array, configure the PVS stores using virtual hard disks assigned to each PVS server.
Chapter 3: Configuring VDI Components

Configuring inbound communication

Each PVS server maintains a range of User Datagram Protocol (UDP) ports to manage all inbound communications from virtual desktops. Ideally, one thread is dedicated to each desktop session. The total number of threads supported by a PVS server is calculated as:

\[
\text{Total threads} = (\text{Number of UDP ports} \times \text{Threads per port} \times \text{Number of network adapters})
\]

Adjust the thread count accordingly to match the number of deployed virtual desktops.

Configuring a bootstrap file

To update the bootstrap file required for the virtual desktops to PXE boot, complete the following steps:

1. In the Provisioning Services console, select Farm > Sites > Site-name > Servers.
2. Right-click a server and select Configure Bootstrap.
   The Configure Bootstrap dialog box appears, as shown in Figure 14.

![Configure Bootstrap dialog box](image)

3. Update the bootstrap image to reflect the IP addresses used for all PVS servers that provide streaming services in a round-robin fashion. Select Read Servers from Database to obtain a list of PVS servers automatically or select Add to manually add the server information.
4. After modifying the configuration, click OK to update the ARDBP32.BIN bootstrap file, which is located at C:\ProgramData\Citrix\Provisioning Services\Tftpboot.
5. Navigate to the folder and examine the timestamp of the bootstrap file to ensure that it is updated on the intended PVS server.
Chapter 3: Configuring VDI Components

Configuring boot options 66 and 67 on DHCP server

To PXE boot the virtual desktops successfully from the bootstrap image supplied by the PVS servers, set the boot options 66 and 67 on the Microsoft DHCP server. Options 066 and 067 specify the boot server host name and the boot file name respectively; collectively they are referred to as a network boot referral.

Complete the following steps to configure the boot options on the DHCP server:

1. From the DHCP management interface of the DHCP server, right-click Scope Options and select Configure Options.
2. Select 066 Boot Server Host Name. In String value, type the IP address of the PVS server configured as the TFTP server.
3. Select 067 Bootfile Name. In String value, type ARDBP32.BIN.

The ARDBP32.BIN bootstrap image is loaded on a virtual desktop before the vDisk image is streamed from the PVS servers.

Preparing the master virtual machine

Complete the following steps to prepare the master virtual machine:

1. Install the Windows 10 guest OS.
2. Install appropriate integration tools such as VMware Tools.
3. Optimize the OS settings to prevent unnecessary background services from generating nonessential I/O operations that adversely affect the overall performance of the storage array. Refer to the following White Paper for details: Optimizing Microsoft Windows Virtual Desktops.
4. Install the Virtual Delivery Agent.
5. Install any third-party tools or applications, such as Microsoft Office.
6. Install the PVS target device software on the master virtual machine.
7. Modify the BIOS of the master virtual machine so that the network adapter is at the top of the boot order to ensure PXE boot of the PVS bootstrap image.

Provisioning the virtual desktops

Complete the following steps to deploy the PVS-based virtual desktops:

1. Run the PVS imaging wizard to clone the master image onto a vDisk.
2. When the cloning is complete, shut down the master virtual machine and modify the following vDisk properties:
   - **Access mode**: Standard Image
   - **Cache type**: Cache on device hard drive
3. Prepare a virtual machine template for the XenDesktop Setup Wizard.
4. Run the XenDesktop Setup Wizard in the PVS console to create a machine catalog that contains the specified number of virtual desktops.
5. Add the virtual desktops created in the catalog to a delivery group so that the virtual desktops are available to the end users.
This section provides information about how to implement Citrix MCS for the solution. For a new installation of MCS, Citrix recommends that you complete the tasks in Table 12 in the order shown.

### Table 12. Tasks for XenDesktop controller setup

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparing a master virtual machine</td>
<td>Create a master virtual machine as the base image for the virtual desktops.</td>
</tr>
<tr>
<td>Provisioning the virtual desktops</td>
<td>Provision the virtual desktops using MCS.</td>
</tr>
</tbody>
</table>

### Preparing the master virtual machine

Complete the following steps to prepare the master virtual machine:

1. Install the Windows 10 guest OS.
2. Install appropriate integration tools such as VMware Tools.
3. Optimize the OS settings to prevent unnecessary background services from generating nonessential I/O operations that adversely affect the overall performance of the storage array. Refer to the following White Paper for details: [Optimizing Microsoft Windows Virtual Desktops](#).
4. Install the Virtual Delivery Agent.
5. Install third-party tools or applications, such as Microsoft Office.
6. Shut down the master virtual machine and take a snapshot.

### Provisioning the virtual desktops

Complete the following steps to deploy the MCS-based virtual desktops:

1. Create a new machine catalog in the XenDesktop desktop delivery controller.
2. In the machine catalog creation wizard, choose Citrix Machine Creation Services (MCS) as deploy machine type.
3. Choose the snapshot from Master Image to create the number of virtual desktops.
Chapter 4: Testing and Monitoring Tools

This chapter presents the following topics:

Login VSI 4 ............................................................................................................... 45

XtremIO dashboard .................................................................................................. 45
Login VSI 4

Login VSI provides proactive performance management solutions for virtualized desktop and server environments. Enterprise IT departments use Login VSI products in all phases of their virtual desktop deployment—from planning to deployment to change management—for more predictable performance, higher availability, and a more consistent end user experience. The world’s leading virtualization vendors use the flagship product, Login VSI, to benchmark performance. With minimal configuration, Login VSI products work in VMware vSphere Horizon for View, Citrix XenDesktop and XenApp, Microsoft Remote Desktop Services (Terminal Services), and any other Windows-based virtual desktop solution.

For more information, visit www.loginvsi.com.

XtremIO dashboard

The system dashboard enables users to monitor the systems’ storage usage, performance, alerts and hardware states related to the XtremIO storage system.

![XtremIO dashboard](image)

**Figure 15.** XtremIO dashboard

**Monitoring servers**

Monitor the storage, performance, alerts, and hardware areas from both a physical host level (the hypervisor host level) and from a virtual level (from within the guest virtual machine). VMware has tools to monitor and capture this data. For example, you can use the esxtop utility to monitor and log these metrics. Windows Server 2012 R2 guests can use the perfmon utility. Follow your vendor’s guidance to determine performance thresholds for specific deployment scenarios, which can vary greatly depending on the application.
Chapter 4: Testing and Monitoring Tools

Detailed information about these tools is available from:

This chapter presents the following topics:

Overview .................................................................................................................. 48

PVS and MCS: large scale validation ...................................................................... 49
Overview

This section outlines the test results obtained for this solution. While this solution is intended to provide results that are applicable to real-world environments, the results presented are from benchmark testing and, as performance benchmark results, must be considered within that context.

Note: Benchmark results are highly dependent upon workload, specific application requirements, and system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, do not use this workload as a substitute for a specific customer application benchmark when critical capacity planning or product evaluation decisions are considered.

Test environment

The test environment was based on Citrix XenDesktop 7.7 running on virtual machines built on VMware vSphere 6.0. Desktops were hosted on the EMC XtremIO X-Brick with user data and profiles stored on an EMC VNX. Virtual desktops were running Windows 10.

User load was applied to the desktops using Login VSI, a highly-recognized tool for standardized VDI performance and capacity testing. The “knowledge worker” test profile, which consumes two vCPUs per virtual desktop, simulated typical workday tasks such as web browsing, video viewing, email, and document manipulation with Microsoft Office 2013 and other tools. Test pass/fail was determined by whether the storage system used successfully handled the storage demands placed on it without reaching a latency limit called “VSImax.”

Table 13 describes the hardware components on which the test environment was built.

Table 13. Solution hardware components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server model</td>
<td>Desktop cluster: Cisco UCS C260-BASE-2646</td>
<td>20</td>
<td>62 servers</td>
</tr>
<tr>
<td></td>
<td>Desktop cluster: Cisco UCS B230-BASE-M2</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infrastructure cluster: Cisco UCS C260-BASE-2646</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Processor(s)</td>
<td>Cisco UCS C260-BASE-2646 @ 2.393 GHz</td>
<td>2</td>
<td>124 CPU sockets</td>
</tr>
<tr>
<td></td>
<td>Cisco UCS B230-BASE-M2 @ 2.263 GHz</td>
<td>2</td>
<td>10 cores per socket</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,240 cores total</td>
</tr>
<tr>
<td>Memory</td>
<td>Cisco UCS C260-BASE-2646</td>
<td>144 GB per server</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco UCS B230-BASE-M2</td>
<td>256 GB per server</td>
<td></td>
</tr>
<tr>
<td>Network adapter</td>
<td>Cisco UCS VIC Ethernet NIC 10 Gb</td>
<td>2/server</td>
<td>124 adapters</td>
</tr>
</tbody>
</table>
Chapter 5: Testing, Results and Summary

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage arrays</td>
<td>EMC XtremIO X-Brick: 256 GB cache</td>
<td>1</td>
<td>1 XtremIO X-Brick with 2 controllers for the virtual machine data of the entire desktop solution</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600: 24 GB cache</td>
<td>1</td>
<td>1 VNX5600 with 2 controllers for the user data of the entire desktop solution</td>
</tr>
<tr>
<td>Storage array disks</td>
<td>EMC XtremIO X-Brick: 400 GB SSDs</td>
<td>25</td>
<td>10 TB (raw)</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600: 200 GB SSD</td>
<td>10</td>
<td>130 TB (raw)</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600: 2 TB NL-SAS 7200 RPM</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

Configuration

We configured the environment as follows:

- The XtremIO X-Brick was connected to the VMware vCenter cluster by using iSCSI block protocol over 10 Gb Ethernet. An 8 Gb FC network can be used with no change in function.

- Windows 10 desktops were provisioned by using Citrix XenDesktop 7.7 Provisioning Services (PVS) and Machine Creation Services (MCS), placing operating-system virtual disks on the XtremIO array and user data and profiles on low-cost, high-capacity near-line Serial Attached SCSI (NL-SAS) drives on an EMC VNX5600 array.

- Desktops were hosted on two different server types due to equipment availability. Any similar combination of servers providing the same number and type of processor cores along with the same amount of memory per core is acceptable to implement the solution.

- Infrastructure services (Domain Controller, SQL Server, XenDesktop controllers, PVS servers, and so on) were configured on virtual machines hosted on two Cisco UCS C260 servers with storage hosted by the VNX used in the solution. These services can be hosted on existing hardware or the solution can use existing services as long as the product sizing best practices are observed.

PVS and MCS: large scale validation

PVS random test results with client disk cache option

Login storm results

The primary test objective was to demonstrate the ability of the XtremIO X-Brick to comfortably support 3,000 Windows 10 virtual desktops deployed by using XenDesktop 7.7 PVS in a vSphere 6.0 environment.

Test success was determined by running the Login VSI “knowledge worker” workload on the desktops without reaching the VSImax threshold.
Login VSI test results

Login VSI ([http://www.loginvsi.com](http://www.loginvsi.com)) is a virtual desktop benchmarking tool that simulates real-world workloads applied by Microsoft Office (Word, PowerPoint, Excel, Outlook), web browsing, video viewing, and others. The tool can apply a variety of workloads tailored to VDI configuration and user “productivity,” and determines the maximum system capacity based on measured response time to the various tasks. The performance limit, “VSImax,” denotes the maximum number of desktops supported by the infrastructure.

The “knowledge worker” workload, which consumes 2-vCPU desktops, was used for this test.

As shown in Figure 16, VSImax was not reached at the target number of 3,000 desktops, which validates that the infrastructure is capable of hosting that number of desktops and delivering an excellent end-user experience. We launched 3,120 desktop sessions to ensure that any issues with the testing platform itself would not cause the number of active tests to fall below the target of 3,000 desktops. The 3,033 desktops that completed the test exceeded our target.

![Figure 16. VSImax–3,000 PVS desktops](image)

Login VSI uses scripting and automation tools to simulate the actions of end users, and on occasion due to Login VSI software limitations, some of the test sessions stop running for reasons unrelated to infrastructure performance. By initiating more test sessions than we actually need, we ensure that our targeted number of sessions successfully complete the testing process.
Login storm IOPS

Figure 17 shows the I/O rate across the login storm test. Notice the predominance of write operations.
Chapter 5: Testing, Results and Summary

**Login storm CPU utilization**

Figure 18 shows how the array used four CPUs over the duration of the test.

![Login storm CPU utilization](image)

**Login storm data reduction ratio**

Figure 19 shows the XtremIO Dashboard view that provides the data reduction ratio during the login storm, demonstrating the efficiency of the array's in-line deduplication and compression functionality.
At steady state, the XtremIO array reduces all data before writing to SSDs. No post-process garbage collection or post-process data reduction is needed.

**Login storm summary**

The login storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 3,000 PVS random with client disk cache desktops performing a nearly simultaneous login operation. The threshold metrics for determining this scale point was a combination of resource utilization percentages, duration of task execution, and overall latency encountered, with resource utilization being the primary factor. For example, testing of PVS random with client disk cache nearly exhausted the XtremIO CPU resources.

Scenarios of this type have several mitigating factors in real-world environments, but this test serves as a reasonable worst-case scenario to ensure that real-world results are more favorable than those realized in the lab. The low capacity utilization noted in Figure 19 is the result of this benchmark test with limited variability in the desktop data. In a nonlab environment, capacity utilization will be somewhat higher depending on the specifics of the environment. These results show that the configuration used has ample capacity to deal with additional data storage in the desktop.

---

**Figure 19. Login storm data reduction ratio**

<table>
<thead>
<tr>
<th>Storage</th>
<th>Overall Efficiency</th>
<th>54.1:1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data Reduction Ratio</td>
<td>3.9:1</td>
</tr>
<tr>
<td></td>
<td>Duplication</td>
<td>1.9:1</td>
</tr>
<tr>
<td></td>
<td>Compression</td>
<td>2.1:1</td>
</tr>
<tr>
<td>Thin Provisioning Saving</td>
<td>93%</td>
<td></td>
</tr>
<tr>
<td>Volume Capacity</td>
<td>30TB</td>
<td></td>
</tr>
<tr>
<td>Physical Capacity</td>
<td>7.587TB</td>
<td></td>
</tr>
</tbody>
</table>

At steady state, the XtremIO array reduces all data before writing to SSDs. No post-process garbage collection or post-process data reduction is needed.
Chapter 5: Testing, Results and Summary

PVS random test results using RAM cache with overflow to disk option

Login storm results
The primary test objective was to demonstrate the ability of the XtremIO X-Brick to comfortably support 3,000 Windows 10 virtual desktops deployed by using XenDesktop 7.7 PVS in a vSphere 6.0 environment.

Test success was determined by running the Login VSI “knowledge worker” workload on the desktops without reaching the VSImax threshold.

Login VSI test results
As shown in Figure 20, VSImax was not reached at the target number of 3,000 PVS desktops, which validates that the infrastructure is capable of hosting that number of desktops and delivering an excellent end-user experience. We launched 3,120 desktop sessions to ensure that any issues with the testing platform itself would not cause the number of active tests to fall below the target of 3,000 desktops. The 3,080 desktops that completed the test exceeded our target.

Figure 20. VSImax–3,000 desktops
Login storm IOPS

Figure 21 shows the I/O rate across the login storm test. Notice the predominance of write operations.

Figure 21. Login storm IOPS

Login storm latency

In this test, new users were logged in at an average rate of one every 1.46 seconds, with the “knowledge worker” workload starting immediately upon login.

Figure 22 shows that the array latency averaged around 0.9 milliseconds throughout the testing.
Figure 22. Login storm latency

Login storm array CPU utilization

Figure 23 shows how the array used four CPUs over the duration of the test.
Chapter 5: Testing, Results and Summary

Login storm data reduction ratio

Figure 24 shows the XtremIO Dashboard view that provides the data reduction ratio during the login storm, demonstrating the efficiency of the array’s in-line deduplication and compression functionality.

<table>
<thead>
<tr>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Efficiency</strong></td>
</tr>
<tr>
<td><strong>Data Reduction Ratio</strong></td>
</tr>
<tr>
<td>Deduplication</td>
</tr>
<tr>
<td>Compression</td>
</tr>
<tr>
<td><strong>Thin Provisioning Saving</strong></td>
</tr>
<tr>
<td><strong>Volume Capacity</strong></td>
</tr>
<tr>
<td>2.18TB Physical Space Used</td>
</tr>
<tr>
<td>5.793TB (33%) used</td>
</tr>
<tr>
<td><strong>Physical Capacity</strong></td>
</tr>
<tr>
<td>2.18TB (29%) used</td>
</tr>
</tbody>
</table>

Figure 24. Login storm data reduction ratio

Login storm summary

The login storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 3,000 PVS random desktops performing a nearly simultaneous login operation. These results show that the configuration used has ample capacity to deal with additional data storage in the desktop.

Boot storm results

This test demonstrated the ability of the XtremIO array to service I/O as 3,000 PVS desktops were booted over a period of 16 minutes. The period started when the first desktop was booted by using the XenDesktop Studio console and ended when the last desktop was shown as being registered on the console.

PVS static (PvD) test results with RAM cache with overflow to disk option
Chapter 5: Testing, Results and Summary

Boot storm IOPS

Figure 25 shows the I/O rate across the boot storm test. Notice the predominance of read operations.

Boot storm latency

Figure 26 shows the latency in microseconds across the boot storm test duration. The average array latency peaked at just over 700 microseconds.
Boot storm array CPU utilization
Figure 27 shows how the array used four CPUs over the duration of the test.

![Graph showing CPU utilization over time](image)

Figure 27. PVS static boot storm array CPU utilization

Boot storm data reduction ratio
Figure 28 shows the XtremIO Dashboard view that provides the data reduction ratio during the boot storm, demonstrating the efficiency of the array’s in-line deduplication and compression functionality.
Boot storm summary

The boot storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 3,000 PVS static desktops performing a nearly simultaneous boot operation. These results show that the configuration used has the necessary resources to support this environment with outstanding responsiveness.

Login storm results

The primary test objective was to demonstrate the ability of the XtremIO X-Brick to comfortably support 3,000 Windows 10 virtual desktops deployed by using XenDesktop 7.7 PVS in a vSphere 6.0 environment.

Test success was determined by running the Login VSI “knowledge worker” workload on the desktops without reaching the VSImax threshold.

Login VSI test results

The “knowledge worker” workload which consumes 2-vCPU desktops was used for this test.

As shown in Figure 29, VSImax was not reached at the target number of 3,000 desktops, which validates that the infrastructure is capable of hosting that number of desktops and delivering an excellent end-user experience.

We launched 3,120 desktop sessions to ensure that any issues with the testing platform itself would not cause the number of active tests to fall below the target of 3,000 desktops. The 3,040 desktops that completed the test exceeded our target.
Figure 29. VSImax–3,000 desktops

Login storm IOPS

Figure 30 shows the I/O rate across the login storm test. Notice the predominance of write operations.

Figure 30. Login storm IOPS
**Login storm latency**

In this test, new users were logged in at an average rate of one every 1.62 seconds, with the “knowledge worker” workload starting immediately upon login.

Figure 31 shows that the array latency averaged below 1 millisecond throughout the testing.
Chapter 5: Testing, Results and Summary

**Login storm CPU utilization**

Figure 32 shows how the array used four CPUs over the duration of the test.

![Login storm array CPU utilization](image)

**Login storm data reduction ratio**

Figure 33 shows the XtremIO Dashboard view that provides the data reduction ratio during the login storm, demonstrating the efficiency of the array's in-line deduplication and compression functionality.
Login storm summary

The login storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 3,000 PVS desktops performing a nearly simultaneous login operation. These results show that the configuration used has ample capacity to deal with additional data storage in the desktop.

Login storm results

The primary test objective was to demonstrate the ability of the XtremIO X-Brick to comfortably support 2,000 MCS random Windows 10 virtual desktops deployed by using XenDesktop 7.7 in a vSphere 6.0 environment.

Login VSI test results

As shown in Figure 34, VSImax was not reached at the target number of 2,000 MCS random desktops, which validates that the infrastructure is capable of hosting that number of desktops and delivering an excellent end-user experience. We launched 2,120 desktop sessions to ensure that any issues with the testing platform itself would not cause the number of active tests to fall below the target of 2,000 desktops. The 2,065 desktops that completed the test exceeded our target.
Chapter 5: Testing, Results and Summary

Figure 34. VSImax – 2,000 MCS random desktops

MCS random login storm IOPS

Figure 35 shows the I/O rate across the login storm test. Notice the predominance of read operations.

Figure 35. MCS random login storm IOPS
Chapter 5: Testing, Results and Summary

**MCS random login storm CPU utilization**

Figure 36 shows how the array used four CPUs over the duration of the test.

![MCS random login storm array CPU utilization](image)

**MCS random login storm data reduction ratio**

Figure 37 shows the XtremIO Dashboard view that provides the data reduction ratio during the login storm, demonstrating the efficiency of the array's in-line deduplication and compression functionality.
Chapter 5: Testing, Results and Summary

Figure 37. Login storm data reduction ratio

**MCS random login storm summary**

The login storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 2,000 MCS random desktops performing a nearly simultaneous login operation. These results show that the configuration used has ample capacity to deal with additional data storage in the desktops.

**Login storm results**

The primary test objective was to demonstrate the ability of the XtremIO X-Brick to comfortably support 2,000 MCS (PvD) Windows 10 virtual desktops deployed by using XenDesktop 7.7 in a vSphere 6.0 environment.

**Login VSI test results**

As shown in Figure 38, VSImax was not reached at the target number of 2,000 MCS (PvD) desktops, which validates that the infrastructure is capable of hosting that number of desktops while delivering an excellent end-user experience. We launched 2,120 desktop sessions to ensure that any issues with the testing platform itself would not cause the number of active tests to fall below the target of 2,000 desktops. The 2,091 desktops that completed the test exceeded our target.
Figure 38. VSImax–2,000 MCS (PvD) desktops

**MCS (PvD) login storm IOPS**

Figure 39 shows the I/O rate across the login storm test. Notice the predominance of write operations.

Figure 39. MCS (PvD) login storm IOPS
**MCS (PvD) login storm latency**

In this test, new users were logged in at an average rate of one every 1.38 seconds, with the “knowledge worker” workload starting immediately upon login.

Figure 40 shows that the array latency averaged below 0.7 milliseconds throughout the testing.

![Figure 40. MCS (PvD) login storm latency](image-url)
**MCS (PvD) login storm CPU utilization**

Figure 41 shows the utilization of the array’s four CPUs across the test duration.

![Figure 41. MCS (PvD) login storm array CPU utilization](image-url)
**MCS (PvD) login storm data reduction ratio**

Figure 42 shows the XtremIO Dashboard view that provides the data reduction ratio during the login storm, demonstrating the efficiency of the array’s in-line deduplication and compression functionality.

<table>
<thead>
<tr>
<th>Storage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Efficiency</strong></td>
<td>163.6:1</td>
</tr>
<tr>
<td><strong>Data Reduction Ratio</strong></td>
<td>8.9:1</td>
</tr>
<tr>
<td>Deduplication</td>
<td>4.5:1</td>
</tr>
<tr>
<td>Compression</td>
<td>2.0:1</td>
</tr>
<tr>
<td><strong>Thin Provisioning Saving</strong></td>
<td>95%</td>
</tr>
</tbody>
</table>

**MCS (PvD) login storm summary**

The login storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 2,000 MCS (PvD) desktops performing a nearly simultaneous login operation. These results show that the configuration used has ample capacity to deal with additional data storage in the desktop.

**Summary findings**

The various provisioning types affected the testing scenarios as follows.

**Boot storm results**

Figure 43 summarizes the differences between PVS and MCS provisioning types during boot storm testing, and how the metric *simultaneous actions per minute* affects the duration of the test. Using a setting that is too aggressive causes boot failures in virtual machines. The key point is that MCS provisioning takes significantly longer.
Figure 43. Comparison of PVS and MCS boot storms

We also examined data transfer sizes during the boot storm and created a histogram during a PVS boot storm test. The majority of sizes fall in the 16 KB, 32 KB, and 128 KB sizes, as shown in Figure 44.

<table>
<thead>
<tr>
<th>Block Size</th>
<th>I/O</th>
<th>Actual IOPS</th>
<th>Normalized IOPS (8kB)</th>
<th>MB/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>4kB</td>
<td>Read</td>
<td>10000</td>
<td>10000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td>8000</td>
<td>8000</td>
<td>32</td>
</tr>
<tr>
<td>8kB</td>
<td>Read</td>
<td>5000</td>
<td>5000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td>2250</td>
<td>2250</td>
<td>18</td>
</tr>
<tr>
<td>16kB</td>
<td>Read</td>
<td>9500</td>
<td>19000</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td>9000</td>
<td>18000</td>
<td>144</td>
</tr>
<tr>
<td>32kB</td>
<td>Read</td>
<td>7750</td>
<td>31000</td>
<td>248</td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td>500</td>
<td>2000</td>
<td>16</td>
</tr>
<tr>
<td>64kB</td>
<td>Read</td>
<td>1000</td>
<td>8000</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td>500</td>
<td>4000</td>
<td>32</td>
</tr>
<tr>
<td>128kB</td>
<td>Read</td>
<td>3500</td>
<td>56000</td>
<td>448</td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td>1500</td>
<td>24000</td>
<td>192</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Read</td>
<td><strong>129,000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Write</td>
<td><strong>58,250</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 44. PVS boot storm data size histogram

Different PVS caching methods affected latency and XtremIO CPU resource utilization. The “PVS static using RAM cache with overflow to disk” method provided the best results, as shown in Figure 45.
Figure 45. Comparison of PVS cache type configurations during boot storm testing

The “MCS random” and “MSC static” methods resulted in noticeable differences in IOPS during boot storm testing. “MCS static” resulted in lower backend IOPS, as shown in Figure 46.

Figure 46. MCS static versus MCS random backend IOPS during boot storm testing
MCS static provisioning resulted in lower latency and XtremIO CPU consumption compared to MCS random provisioning, as shown in Figure 47.

![MCS Boot Storm Comparison](image)

**Figure 47.** MCS static versus MCS random effects on latency and XtremIO CPU utilization during boot storm testing

**Login storm results**

The results show the differences between PVS and MCS provisioning types during login storm testing.

The PVS cache type dramatically affects IOPS being sent to XtremIO. The “PVS random with RAM cache overflow to disk” type provides the largest reduction in backend IOPS, as shown in Figure 48.

![PVS Login Storm Comparison](image)

**Figure 48.** Comparison of PVS cache type during login storm testing
Here we can see the effects of PVS cache type on latency and XtremIO CPU utilization during login storm testing. The “PVS static with RAM cache overflow to disk” type resulted in the lowest latency and resource utilization, as shown in Figure 49.

Figure 49. Effects of PVS cache type on latency and XtremIO CPU resources during login storm testing

“MCS static” resulted in fewer backend IOPS compared to “MCS random” during login storm testing, as shown in Figure 50.

Figure 50. MCS static compared to MCS random effect on backend IOPS during login storm testing
“MCS static” resulted in lower latency and XtremIO CPU utilization compared to “MCS random” during login storm testing, as shown in Figure 51.

![MCS Login Storm Comparison](image)

**Figure 51. Comparison of MCS random versus MCS static effects on latency and XtremIO CPU utilization during login storm testing**

This solution validates the following two Citrix XenDesktop scale points: PVS (3,000 desktops) and MCS (2,000 desktops).

- For PVS scenarios, the random client cache type (RAM Cache with Overflow to Disk) provided almost 50 percent superior performance due to the majority of write IOPS being cached on the server side. The PVS static type shows slightly better performance than the random.

- For MCS scenarios, all read and write IOPS were serviced by the XtremIO, resulting in a higher storage load than PVS. As a result, it can support fewer desktops than PVS scenarios. Boot, login storm, and login VSI tests passed with excellent XtremIO performance.
Chapter 6 Solution Design Considerations and Best Practices

This chapter presents the following topics:

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Chapter 6: Solution Design Considerations and Best Practices

Overview

This chapter describes best practices and considerations for designing the EUC solution. For more information on deployment best practices of various components of the solution, refer to the vendor-specific documentation.

Server design considerations

The server infrastructure must meet the following minimum requirements:

- Sufficient CPU cores and memory to support the required number and types of virtual machines
- Sufficient network connections to enable redundant connectivity to the system switches
- Sufficient excess capacity to enable the environment to withstand a server failure and failover

EMC recommends that you monitor resource utilization and adapt as needed. For example, the reference virtual desktop and required hardware resources in this solution assume that there are no more than five virtual CPUs for each physical processor core (5:1 ratio). In most cases, this provides an appropriate level of resources for the hosted virtual desktops; however, this ratio may not be appropriate in all cases. EMC recommends monitoring CPU utilization at the hypervisor layer to determine if more resources are required and adding them as needed.

Table 14 identifies the server hardware and the configurations validated in this solution.

Table 14. Server hardware

<table>
<thead>
<tr>
<th>Servers for virtual desktops</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>2 vCPUs per desktop (5 desktops per core)</td>
</tr>
<tr>
<td></td>
<td>300 cores across all servers for 1,500 virtual desktops</td>
</tr>
<tr>
<td></td>
<td>600 cores across all servers for 3,000 virtual desktops</td>
</tr>
<tr>
<td>Memory</td>
<td>2 GB RAM per virtual machine</td>
</tr>
<tr>
<td></td>
<td>3 TB RAM across all servers for 1,500 virtual desktops</td>
</tr>
<tr>
<td></td>
<td>6 TB RAM across all servers for 3,000 virtual machines</td>
</tr>
<tr>
<td></td>
<td>2 GB RAM reservation per vSphere host</td>
</tr>
<tr>
<td>Network</td>
<td>3 x 10 GbE NICs per blade chassis</td>
</tr>
</tbody>
</table>

Note: The 5:1 vCPU to physical core ratio applies to the reference workload defined in this solution guide.
Chapter 6: Solution Design Considerations and Best Practices

Proper sizing and configuration of the solution requires care when configuring server memory. The guideline for allocating memory to virtual machines considers vSphere overhead and virtual machine memory settings.

Adequate server capacity is required for two purposes in the solution:

- To support the required infrastructure services such as authentication, authorization, DNS, and databases
- To support the virtualized desktop infrastructure

In this solution, 2 GB of memory is assigned to each virtual machine, as defined in Table 19. The solution was validated with statically assigned memory and no over-commitment of memory resources. If memory over-commitment is used in a real-world environment, regularly monitor the system memory utilization and associated page file I/O activity to ensure that a memory shortfall does not cause unexpected results.

Network design considerations

This solution defines minimum network requirements and provide general guidance on network architecture while allowing the customer to choose any network hardware that meets the requirements. If additional bandwidth is needed, it is important to add capability at both the storage array and the hypervisor host to meet the requirements.

For reference purposes in the validated environment, EMC assumes that each virtual desktop generates 9 IOPS per second with an average size of 4 KB. This means that each virtual desktop generates at least 36 KB/s of traffic on the storage network. For an environment rated for 1,500 virtual desktops, this means a minimum of approximately 70 MB/sec, which is well within the bounds of modern networks.

However, this does not consider other operations. For example, additional bandwidth is needed for:

- User network traffic
- Virtual desktop migration
- Administrative and management operations

The requirements for each of these operations depend on how the environment is used. It is not practical to provide concrete numbers in this context. However, the networks described for the reference architectures in this solution must be sufficient to handle average workloads for these operations.

Regardless of the network traffic requirements, always have at least two physical network connections that are shared by a logical network to ensure a single link failure does not affect the availability of the system. Design the network so that in the event of a failure, the aggregate bandwidth is sufficient to accommodate the full workload.
The network infrastructure must meet the following minimum requirements:

- Redundant network links for the hosts, switches, and storage
- Support for link aggregation
- Traffic isolation based on industry best practices

Table 15 lists the hardware resources for the network infrastructure that is validated in this solution.

<table>
<thead>
<tr>
<th>Storage type</th>
<th>Configuration</th>
</tr>
</thead>
</table>
| XtremIO for virtual desktop storage | • 2 physical switches  
• 2 x FC (8 Gb)/FCoE or 2 x 10 GbE ports per VMware vSphere server, for storage network  
• 2 x FC or 2 x 10 GbE ports per SC, for desktop data                                           |
| VNX for optional user data storage | • 2 physical switches (can be shared w/XtremIO)  
• 2 x 10 GbE ports per VMware vSphere server  
• 1 x 1 GbE port per Control Station for management  
• 2 x 10 GbE ports per Data Mover for data                                                  |
| Isilon for optional user data storage| • 2 physical switches (can be shared w/XtremIO)  
• 2 x 10 GbE ports per VMware vSphere server  
• 1 x 1 GbE port per node for management  
• 2 x 10 GbE ports per controller for data                                                  |

Notes: The solution can use a 1 GbE network infrastructure provided that the underlying bandwidth and redundancy requirements are fulfilled.

This section provides guidelines for setting up a redundant, highly available network configuration. The guidelines take into account network redundancy, link aggregation, traffic isolation, and jumbo frames.

The configuration examples are for IP-based networks, but similar best practices and design principles apply for the Fibre Channel storage network option.

Network redundancy

The infrastructure network requires redundant network links for each vSphere host, the storage array, the switch interconnect ports, and the switch uplink ports. This configuration provides both redundancy and additional network bandwidth. This configuration is also required regardless of whether the network infrastructure for the solution already exists or is deployed with other solution components.
Figure 52 provides an example of highly available XtremIO FC network topology.

![Diagram of highly available XtremIO FC network topology]

**Figure 52.** Highly-available XtremIO FC network design example

Figure 53 shows a highly available network setup example for user data with a VNX family storage array. The same high-availability principles apply to an Isilon configuration as well. In either case, each node has two links to the switches.
Link aggregation

EMC VNX and Isilon provide network high availability or redundancy by using link aggregation. Link aggregation enables multiple active Ethernet connections to appear as a single link with a single MAC address and, potentially, multiple IP addresses.¹

In this solution, we configured the Link Aggregation Control Protocol (LACP) on the VNX or Isilon array to combine multiple Ethernet ports into a single virtual device. If a link is lost in the Ethernet port, the link fails over to another port. We distributed all network traffic across the active links.

Traffic isolation

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

¹ A link aggregation resembles an Ethernet channel but uses the LACP IEEE 802.3ad standard. This standard supports link aggregations with two or more ports. All ports in the aggregation must have the same speed and be full duplex.
VLANs segregate network traffic to enable traffic of different types to move over isolated networks. In some cases, physical isolation is required for regulatory or policy compliance reasons, but in most cases logical isolation using VLANs is sufficient.

This solution requires a minimum of two VLANs:

- Client access
- Management

Figure 54 shows the design of these VLANs with VNX. An Isilon-based configuration would share the same design principles.

![Figure 54. Required networks](image)

The client access network is for users of the system (clients) to communicate with the infrastructure, including the virtual machines and the CIFS shares hosted by the VNX or Isilon array. The management network provides administrators with dedicated access to the management connections on the storage array, network switches, and hosts.

Some best practices call for additional network isolation for cluster traffic, virtualization layer communication, and other features. These additional networks can be implemented, but they are not required.
Storage design considerations

Overview

XtremIO offers inline de-duplication, inline compression, inline security-at-rest features, and native thin provisioning. Storage planning requires that you determine:

- Volume size
- Number of volumes
- Performance requirements

Each volume must be greater than the logical space required by the server. An XtremIO cluster can fulfill the solution’s capacity and performance requirements.

Validated storage hardware and configuration

vSphere supports more than one method of using storage when hosting virtual machines. We tested the configurations described in Table 16 using iSCSI. The storage layouts described adhere to all current best practices. If required, a customer or architect with the necessary training and background can make modifications based on their understanding of the system’s usage and load.

Table 16. Storage hardware

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Configuration</th>
</tr>
</thead>
</table>
| XtremIO shared storage                       | Common:
|                                              |   - 2 x FC or 2 x 10 GbE interfaces per storage controller                   |
|                                              |   - 1 x 1 GbE interface per storage controller for management               |
| For 1,500 virtual desktops:                  |   - Starter X-Brick configuration with 13 x 400 GB flash drives              |
| For 3,000 virtual desktops:                  |   - X-Brick configuration with 25 x 400 GB flash drives                      |
| Optional: Isilon shared storage disk capacity | Only required if deploying an Isilon cluster to host user data.              |
|                                              |   - 4 x X410 node                                                            |
|                                              |   - 2 x 800 GB EFD each node                                                 |
|                                              |   - 34 x 1 TB SATA each node                                                 |
| Optional: VNX shared storage disk capacity    | For 1,500 virtual desktops:                                                  |
|                                              |   - 2 x 200 GB EFD                                                           |
|                                              |   - 32 x 2 TB NL-SAS                                                         |
|                                              | For 3,000 virtual desktops:                                                  |
|                                              |   - 4 x 200 GB EFD                                                           |
|                                              |   - 48 x 2 TB NL-SAS                                                         |

Note: For VNX arrays, EMC recommends configuring at least one hot spare for every 30 drives of a given type. The recommendations in Table 16 include hot spares.
Validation test profile

Table 17 shows the desktop definition and storage configuration parameters that we validated with the environment profile.

**Table 17. Validated environment profile**

<table>
<thead>
<tr>
<th>Profile characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC XtremIO</td>
<td>4.0.2</td>
</tr>
<tr>
<td>Hypervisor</td>
<td>vSphere 6.0, Update 2</td>
</tr>
<tr>
<td>Desktop OS (VDI) OS type</td>
<td>Windows 10 Enterprise Edition (64-bit)</td>
</tr>
<tr>
<td>Server OS(HSD) OS type</td>
<td>Windows Server 2012 R2</td>
</tr>
<tr>
<td>vCPU per virtual desktop</td>
<td>2</td>
</tr>
<tr>
<td>Number of virtual desktops per CPU core</td>
<td>5</td>
</tr>
<tr>
<td>RAM per virtual desktop</td>
<td>2 GB</td>
</tr>
<tr>
<td>Desktop provisioning method</td>
<td>MCS or PVS</td>
</tr>
<tr>
<td>Average IOPS per virtual desktop at steady state</td>
<td>9 IOPS</td>
</tr>
<tr>
<td>Internet Explorer</td>
<td>11</td>
</tr>
<tr>
<td>Office</td>
<td>2013</td>
</tr>
<tr>
<td>Adobe Reader</td>
<td>11</td>
</tr>
<tr>
<td>Adobe Flash Player</td>
<td>11 ActiveX</td>
</tr>
<tr>
<td>Doro PDF printer</td>
<td>1.8</td>
</tr>
<tr>
<td>Workload generator</td>
<td>Login VSI 4.1.5</td>
</tr>
<tr>
<td>Workload type</td>
<td>Knowledge Worker</td>
</tr>
<tr>
<td>Number of datastores to store virtual desktops</td>
<td>14 for 1,500 virtual desktops</td>
</tr>
<tr>
<td></td>
<td>28 for 3,000 virtual desktops</td>
</tr>
<tr>
<td>Number of virtual desktops per datastore</td>
<td>125</td>
</tr>
<tr>
<td>Disk and RAID type for XtremIO virtual desktop datastores</td>
<td>400 GB eMLC SSD drives</td>
</tr>
<tr>
<td></td>
<td>EMC XtremIO proprietary data protection</td>
</tr>
<tr>
<td></td>
<td>XDP that delivers RAID 6-like data protection</td>
</tr>
<tr>
<td></td>
<td>yet better performance than RAID 10</td>
</tr>
</tbody>
</table>
This chapter presents the following topics:

- **Overview** .................................................................................................................. 87
- **Reference workload** .................................................................................................. 87
- **Infrastructure requirements** ..................................................................................... 88
- **XtremIO array configurations** ................................................................................... 88
- **Isilon configuration** .................................................................................................. 89
- **VNX array configurations** .......................................................................................... 90
- **Sizing the architecture** ............................................................................................. 91
Overview

This chapter describes how to design an EUC for Citrix XenDesktop solution and how to size it to fit the customer’s needs. It introduces the concepts of a reference workload, building blocks, and validated end-user computing maximums, and describes how to use these to design your solution. Table 18 summarizes the high-level steps you need to complete when sizing the solution.

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Collect the detailed customer requirements for the end-user computing environment.</td>
</tr>
</tbody>
</table>
| 2    | Use the **EMC Business Value Portal Sizing Tool** to determine the recommended sizing for your end-user computing solution, based on the customer requirements collected in Step 1.  
**Note:** If the Sizing Tool is not available, you can manually size the end-user computing solution using the guidelines in this chapter. |

Reference workload

EMC defines a reference workload to represent a unit of measure for quantifying the resources in the solution reference architectures. By comparing the customer’s actual usage to this reference workload, you can determine which reference architecture to choose as the basis for the customer’s EUC deployment.

For EMC end-user computing solutions, the reference workload is defined as a single virtual desktop—the reference virtual desktop—with the workload characteristics listed in Table 19.

To determine the equivalent number of reference virtual desktops for a particular resource requirement, convert the total actual resources required for all desktops into the reference virtual desktop format.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop OS (VDI) OS type</td>
<td>Windows 10 Enterprise Edition (64-bit)</td>
</tr>
<tr>
<td>Server OS (HSD) OS type</td>
<td>Windows Server 2012 R2</td>
</tr>
<tr>
<td>Virtual processors per virtual desktop</td>
<td>2</td>
</tr>
<tr>
<td>RAM per virtual desktop</td>
<td>2 GB</td>
</tr>
<tr>
<td>Average IOPS per virtual desktop at steady state</td>
<td>9</td>
</tr>
<tr>
<td>Internet Explorer</td>
<td>11</td>
</tr>
<tr>
<td>Microsoft Office</td>
<td>2013</td>
</tr>
<tr>
<td>Adobe Reader</td>
<td>XI</td>
</tr>
</tbody>
</table>
Chapter 7: Sizing the Solution

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adobe Flash Player</td>
<td>11 ActiveX</td>
</tr>
<tr>
<td>Doro PDF printer</td>
<td>1.82</td>
</tr>
<tr>
<td>Workload generator</td>
<td>Login VSI 4.1.5</td>
</tr>
<tr>
<td>Workload type</td>
<td>Knowledge Worker</td>
</tr>
</tbody>
</table>

This desktop definition is based on user data that resides on shared storage. The I/O profile is defined by using a test framework that runs all desktops concurrently with a steady load generated by the constant use of office-based applications such as browsers and office productivity software.

This solution is verified with performance testing conducted using Login VSI, which is the industry-standard load testing solution for virtualized desktop environments.

### Infrastructure requirements

This EUC solution requires multiple application servers to support the environment. Unless otherwise specified, all servers use Microsoft Windows Server 2012 R2 as the base OS. Table 20 lists the minimum requirements of each infrastructure server required.

**Table 20. Infrastructure server minimum requirements**

<table>
<thead>
<tr>
<th>Server</th>
<th>CPU</th>
<th>RAM</th>
<th>IOPS</th>
<th>Storage capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain controllers (each)</td>
<td>2 vCPUs</td>
<td>4 GB</td>
<td>25</td>
<td>32 GB</td>
</tr>
<tr>
<td>SQL Server</td>
<td>2 vCPUs</td>
<td>6 GB</td>
<td>100</td>
<td>200 GB</td>
</tr>
<tr>
<td>vCenter Server</td>
<td>4 vCPUs</td>
<td>8 GB</td>
<td>100</td>
<td>80 GB</td>
</tr>
<tr>
<td>Citrix XenDesktop Controllers (each)</td>
<td>2 vCPUs</td>
<td>8 GB</td>
<td>50</td>
<td>32 GB</td>
</tr>
<tr>
<td>Citrix PVS Servers (each)</td>
<td>4 vCPUs</td>
<td>20 GB</td>
<td>75</td>
<td>150 GB</td>
</tr>
</tbody>
</table>

**Storage layout**

This solution requires a 1.5 TB volume to host the infrastructure virtual machines, which can include the VMware vCenter Server, Citrix XenDesktop Controllers, Citrix PVS servers, optional Citrix ShareFile servers, Microsoft Active Directory Server, and Microsoft SQL Server.

**XtremIO array configurations**

We validated the XtremIO EUC configurations on the two types of XtremIO X-Bricks, Starter X-Brick and X-Brick, which vary according to the number of SSDs they include, and their total available capacity. For each array, EMC recommends a maximum EUC configuration as outlined in this section.
Chapter 7: Sizing the Solution

Validated XtremIO configurations

The following XtremIO validated disk layouts provide support for a specified number of virtual desktops at a defined performance level. This solution supports two XtremIO X-Brick configurations, which are selected based on the number of desktops being deployed:

- XtremIO Starter X-Brick—The XtremIO Starter X-Brick includes 13 SSD drives, and is validated to support up to 1,500 virtual desktops.
- XtremIO X-Brick—The XtremIO X-Brick includes 25 SSD drives, and is validated to support up to 3,000 virtual desktops.

The XtremIO storage configuration required for this solution is in addition to the storage required by the components that support the solution’s infrastructure services.

XtremIO storage layout

Table 2 shows the number and size of the XtremIO volumes the solution uses to present to the vSphere servers as a VMFS datastore for virtual desktop storage. Two datastore configurations are listed for each desktop type: one that includes the space required to use the Citrix Personal vDisk (PvD) feature, and one that does not for solutions that will not use that component of Citrix XenDesktop. Please note that when deploying Citrix desktops with PVS or PvD, the following values are configured by default:

- PVS write cache disk—6 GB
- Citrix Personal vDisk (PvD)—10 GB

If either of these values is changed from the default, the datastore sizes must also be changed as a result.

Expanding existing EUC environments

The EMC EUC solution supports a flexible implementation model where it is easy to expand your environment as the needs of the business change.

To support future expansion, the XtremIO Starter X-Brick can be nondisruptively upgraded to an X-Brick by installing the XtremIO expansion kit, which adds an additional twelve 400 GB SSD drives. The resulting X-Brick supports up to 3,000 desktops.

To support more than 3,000 reference virtual desktops, XtremIO supports scaling out by adding more X-Bricks. Each additional X-Brick increases performance and virtual desktop capacity linearly. Two, four, six, and eight X-Brick XtremIO clusters are all valid configurations.

Isilon configuration

This solution can optionally use the EMC Isilon system for storing user data, home directories, and profiles. A four-node Isilon cluster can be used to support 3,000 users’ data with the reference workload validated in this solution. Each node has 36 drives (two EFD and 34 SATA) and two 10 GbE Ethernet ports. Table 21 provides detailed information.
Chapter 7: Sizing the Solution

Table 21. User data resource requirements on Isilon

<table>
<thead>
<tr>
<th>Number of reference virtual desktops</th>
<th>Isilon configuration</th>
<th>Max capacity/User (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of nodes</td>
<td>Node type</td>
</tr>
<tr>
<td>1~2,500</td>
<td>3</td>
<td>X410</td>
</tr>
<tr>
<td>2,501~3,500</td>
<td>4</td>
<td>X410</td>
</tr>
<tr>
<td>3,501~5,000</td>
<td>5</td>
<td>X410</td>
</tr>
</tbody>
</table>

Table 21 shows the recommendation for Isilon configuration with the total number of CIFS calls used as the primary sizing threshold. Each X410 node used in this solution can provide 30 TB of usable capacity. If more capacity per user is needed, additional nodes can be added.

VNX array configurations

This solution also supports using VNX series storage arrays for user data storage, with FAST Cache enabled for the related storage pools. The VNX5400™ can support up to 1,500 users with the reference workload. The VNX5600 can support up to 3,000 users with the reference workload validated in this solution. Table 22 summarizes the detailed requirements for 1,250–3,000 users.

Table 22. User data resource requirement on VNX

<table>
<thead>
<tr>
<th>Number of users</th>
<th>VNX model</th>
<th>SSD for FAST Cache</th>
<th>Number of 2 TB NL-SAS drives</th>
<th>Max capacity/User (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,250</td>
<td>5400</td>
<td>2</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>1,500</td>
<td>5400</td>
<td>2</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>2,500</td>
<td>5600</td>
<td>4</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td>3,500</td>
<td>5600</td>
<td>4</td>
<td>48</td>
<td>17</td>
</tr>
</tbody>
</table>

If multiple drive types have been implemented, FAST VP can be enabled to automatically tier data to balance differences in performance and capacity.

Note: FAST VP can provide performance improvements when implemented for user data and roaming profiles.
VNX shared file systems

The virtual desktops use four shared file systems—two for the Citrix XenDesktop Profile Management repositories and two to redirect user storage that resides in home directories. In general, redirecting users’ data out of the base image to VNX for File enables centralized administration and data protection and makes the desktops more stateless. Each file system is exported to the environment through a CIFS share. Each Personal Management repository share and home directory share serves an equal number of users.

Sizing the architecture

To choose the appropriate architecture for a customer environment, you must determine the resource requirements of the environment and then translate these requirements to an equivalent number of reference virtual desktops that have the characteristics defined in Table 23. This section describes how to use the Customer Sizing Worksheet to simplify the sizing calculations as well as additional factors you must take into consideration when deciding which architecture to deploy.

Using the Customer Sizing Worksheet

The Customer Sizing Worksheet helps you to assess the customer environment and calculate the sizing requirements of the environment. Table 23 summarizes a completed worksheet for a sample customer environment.

Table 23. Example Customer Sizing Worksheet

<table>
<thead>
<tr>
<th>User type</th>
<th>vCPUs</th>
<th>Memory</th>
<th>IOPS</th>
<th>Equivalent reference virtual desktops</th>
<th>No. of users</th>
<th>Total reference desktops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy users</td>
<td>2</td>
<td>8 GB</td>
<td>12</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Equivalent reference virtual desktops</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>200</td>
<td>800</td>
</tr>
<tr>
<td>Moderate users</td>
<td>2</td>
<td>4 GB</td>
<td>8</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Equivalent reference virtual desktops</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Typical users</td>
<td>1</td>
<td>2 GB</td>
<td>8</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Equivalent reference virtual desktops</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1,200</td>
<td>1,200</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2,400</td>
<td></td>
</tr>
</tbody>
</table>

To complete the Customer Sizing Worksheet:

1. Identify the user types planned for deployment into the end-user computing environment and the number of users of each type.

2. For each user type, determine the compute resource requirements in terms of vCPUs, memory (GB), storage performance (IOPS), and storage capacity.
3. For each resource type and user type, determine the equivalent reference virtual desktops requirements, that is, the number of reference virtual desktops required to meet the specified resource requirements.

4. Determine the total number of reference desktops needed from the resource pool for the customer environment.

**Determining the resource requirements**

**CPU**

The reference virtual desktop outlined in Table 19 assumes that most desktop applications are optimized for two virtual CPUs. If one type of user requires a desktop with a different number of virtual CPUs, modify the proposed virtual desktop count to account for the additional resources. For example, if you virtualize 100 desktops, but 20 users require a single CPU instead of two, consider that your pool needs to provide 180 virtual desktops of capability.

**Memory**

Each group of desktops will have different targets for the available memory that is considered acceptable. Like the CPU calculation, if a group of users requires additional memory resources, adjust the number of planned desktops to accommodate the additional resource requirements.

For example, if there are 200 desktops to be virtualized, but each one needs 4 GB of memory instead of the 2 GB that the reference virtual desktop provides, plan for 400 reference virtual desktops worth of server resources.

**IOPS**

The storage performance requirements for desktops are usually the least understood aspect of performance. The reference virtual desktop uses a workload generated by an industry-recognized tool to execute a wide variety of office productivity applications that should be representative of the majority of virtual desktop implementations.

**Storage capacity**

The storage capacity requirement for a desktop can vary widely depending on the types of applications in use and specific customer policies. The virtual desktops in this solution rely on shared storage for user profile data and user documents. This requirement can also be met by using existing file shares in the environment.
Determining the equivalent reference virtual desktops

With all of the resources defined, you determine the number of equivalent reference virtual desktops by using the relationships indicated in Table 24. Round up all values to the closest whole number.

Table 24. Reference virtual desktop resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Value for reference virtual desktop</th>
<th>Relationship between requirements and equivalent reference virtual desktops</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>2</td>
<td>Equivalent reference virtual desktops = (resource requirements)/2</td>
</tr>
<tr>
<td>Memory</td>
<td>2</td>
<td>Equivalent reference virtual desktops = (resource requirements)/2</td>
</tr>
<tr>
<td>IOPS</td>
<td>9</td>
<td>Equivalent reference virtual desktops = (resource requirements)/9</td>
</tr>
</tbody>
</table>

For example, the heavy user type in Table 23 requires two virtual CPUs, 12 IOPS, and 8 GB of memory for each desktop. This translates to one reference virtual desktop of CPU, four reference virtual desktops of memory, and two reference virtual desktops of IOPS.

The number of reference virtual desktops required for each user type then equals the maximum required for an individual resource. For example, the number of equivalent reference virtual desktops for the heavy user type in Table 23 is four, as this number will meet the all resource requirements—IOPS, vCPU, and memory.

To calculate the total number of reference desktops for a user type, you multiply the number of equivalent reference virtual desktops for that user type by the number of users.

Determining the total reference virtual desktops

After the worksheet is completed for each user type that the customer wants to deploy into the virtual infrastructure, compute the total number of reference virtual desktops required in the resource pool by calculating the sum of the total reference virtual desktops for all user types. In the example in Table 23, the total is 2,400 virtual desktops.

This EUC reference architecture supports two separate points of scale, a Starter X-Brick capable of supporting up to 1,500 reference desktops, and an X-Brick capable of hosting up to 3,000 reference desktops. The total reference virtual desktops value from the completed Customer Sizing Worksheet can be used to verify that this reference architecture would be adequate for the customer requirements. In the example in Table 23, the customer requires 2,400 virtual desktops of capability. Therefore, this architecture provides sufficient resources for current needs as well as room for growth.
However, other factors can verify that this architecture will perform as intended. For example:

- **Concurrency**
  
The reference workload used to validate this solution assumes that all desktop users will be active at all times. We tested this 3,000-desktop architecture with 3,000 desktops, all generating workload in parallel and all booted at the same time. If the customer expects to have 3,000 users, but only 50 percent of them are logged on at any given time due to time zone differences or alternate shifts, the reference architecture might be able to support additional desktops in this case.

- **Heavier desktop workloads**
  
The reference workload is considered a typical office worker load. However, some customers’ users might have a more active profile.

  If a company has 3,000 users and, due to custom corporate applications, each user generates 50 predominantly write IOPS, as compared to the 9 IOPS used in the reference workload, this customer will need 150,000 IOPS (3,000 users x 50 IOPS per desktop). In this case, the proposed I/O load is greater than the array maximum of 100,000 write IOPS so the configuration would be underpowered. The company would need to deploy an additional X-Brick, reduce the current I/O load, or reduce the total number of desktops to ensure that the storage array performs as required.

**Fine tuning hardware resources**

In most cases, the Customer Sizing Worksheet suggests an architecture adequate for the customer’s needs. However, in some cases you might want to further customize the hardware resources available to the system. In that case, this document serves as a starting point for the sizing exercise instead of the final result.

**Storage resources**

The XtremIO array is deployed in a specialized configuration known as an X-Brick. While additional X-Bricks can be added to increase the capacity or performance capabilities of the XtremIO cluster, this solution is based on a single X-Brick. The XtremIO array requires no tuning, and the number of SSDs available in the array are fixed. The EMC Business Value Portal Sizing Tool or Customer Sizing Worksheet should be used to verify that the EMC XtremIO array can provided the necessary levels of capacity and performance.
Server resources

For the server resources in the solution, it is possible to customize the hardware resources more effectively. First, total the resource requirements for the server components, as shown in Table 25. Note the addition of the Total CPU resources and Total memory resources columns to the worksheet.

Table 25. Server resource component totals

<table>
<thead>
<tr>
<th>User types</th>
<th>vCPUs</th>
<th>Memory (GB)</th>
<th>Number of users</th>
<th>Total CPU resources</th>
<th>Total memory resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy users</td>
<td>2</td>
<td>8</td>
<td>200</td>
<td>400</td>
<td>1,600</td>
</tr>
<tr>
<td>Moderate users</td>
<td>2</td>
<td>4</td>
<td>200</td>
<td>400</td>
<td>800</td>
</tr>
<tr>
<td>Typical users</td>
<td>1</td>
<td>2</td>
<td>1,200</td>
<td>1,200</td>
<td>2,400</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>2,000</td>
<td>4,800</td>
</tr>
</tbody>
</table>

The example in Table 25 requires 2,000 virtual vCPUs and 4,800 GB of memory. The reference architectures assume five desktops per physical processor core and no memory over-provisioning. This converts to 400 processor cores and 4,800 GB of memory for this example. Use these calculations to more accurately determine the total server resources required.

Note: Keep high availability requirements in mind when customizing the server hardware.

Summary

EMC considers the requirements stated in this solution to be the minimum set of resources needed to handle the workloads defined for 3,000 reference virtual desktops. In any customer implementation, the load of a system can vary over time as users interact with the system. If the type of customer virtual desktops differs significantly from the reference definition and varies in the same resource group (that is, CPU resources), you might need to add more of that resource to the configuration.
This chapter presents the following topics:

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**Other documentation** .................................................................................................................. 97
EMC documentation

The following documents, located on EMC Online Support provide additional information. Access to these documents depends on your login credentials. If you do not have access to a document, contact your EMC representative.

- EMC XtremIO Storage Array User Guide
- EMC XtremIO Storage Array Software Installation and Upgrade Guide
- EMC XtremIO Storage Array Hardware Installation and Upgrade Guide
- EMC XtremIO Storage Array Security Configuration Guide
- EMC XtremIO Storage Array Pre-Installation Checklist
- EMC XtremIO Storage Array Site Preparation Guide
- EMC VNX5600 Unified Installation Guide
- VNX Installation Assistant for File/Unified Worksheet
- VNX2 Multicore FAST Cache: A Detailed Review
- VSI for VMware vSphere Web Client 6.9 Product Guide
- Optimizing Microsoft Windows Virtual Desktops – EMC Deployment Best Practices
- EMC PowerPath/VE for VMware vSphere Installation and Administration Guide

Other documentation

The following documents, available on the VMware website, provide additional information:

- VMware vSphere Installation and Setup Guide
- VMware vSphere Networking
- vSphere Storage
- VMware vSphere Virtual Machine Administration
- VMware vCenter Server and Host Management
- Installing and Administering VMware vSphere Update Manager
- Preparing vCenter Server Databases
- vSphere Resource Management
Chapter 8: Reference Documentation

The following documents, available on the Citrix website, provide additional information:

- XenApp 7.7 and XenDesktop 7.7 Documentation Center
- Windows 10 and 8.1 Virtual Desktop Optimization Guide
- Storage Center system requirements

The following documents, available on the Microsoft website, provide additional information:

- Installing Windows Server 2012 R2
- SQL Server Installation (SQL Server 2012)