Reference Architecture

EMC INFRASTRUCTURE FOR CITRIX XENDESKTOP 7.1

Enabled by the EMC XtremIO All-Flash Array and Microsoft Hyper-V 2012 R2

- Simplify management and decrease total cost of ownership
- Guarantee a superior desktop experience
- Ensure a successful virtual desktop deployment

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Reference architecture overview

Document purpose

EMC's commitment to consistently maintain and improve quality is led by the Total Customer Experience (TCE) program, which is driven by Six Sigma methodologies. As a result, EMC has built its own lab to reflect real-world deployments in which TCE use cases are developed and executed. These use cases provide EMC with an insight into the challenges currently facing its customers. The solution described in this reference architecture was verified with one of these use cases.

This document describes the reference architecture of the EMC infrastructure for Citrix XenDesktop 7.1 solution, which is enabled by the EMC® XtremIO™ all-flash array and Microsoft Hyper-V 2012 R2. It also describes how the XtremIO all-flash array can benefit the end-user computing (EUC) solution.

This Reference Architecture validates the performance of the solution and provides guidelines to build similar solutions. This document is not intended to be a comprehensive guide to every aspect of this solution.

Business challenge

User experience is critical to successful EUC project rollouts. User experience expectations are increasingly set based on devices that use flash memory, such as ultrabooks and tablets. For example, the rapid application response time of a modern ultrabook computer is due in large part to its use of a solid-state drive (SSD).

Users accustomed to working with an ultrabook that easily peaks over 2,000 I/O operations per second (IOPS) may have performance problems with a virtual desktop that only delivers between 7 and 25 IOPS (the common planning assumption range in previous EUC reference architectures). This can lead to help desk calls about unacceptably slow performance.

A modern EUC deployment must deliver a better-than-local-desktop user experience and a better cost-per-desktop relative to a physical computer, and it must enable IT to use existing desktop management tools and applications.

EUC intensifies this need for higher desktop IOPS by centrally serving potentially tens of thousands of virtual operating systems and applications that are running concurrently. EUC also introduces its own unique challenges, such as boot storms and login storms, which have peak IOPS requirements that often exceed the typical operational parameters of storage arrays.

The preceding reasons combined with the requirement to build an economical solution have led to sub-par EUC infrastructures, such as those that under-size storage and downgrade desktop functionality by disabling various software components, which result in a less desirable user experience.

Solution purpose

The purpose of this solution is to highlight the potential of an XtremIO all-flash array in an EUC implementation, to build a new EUC environment, and to demonstrate performance, scalability, functionality, and user experience enabled by XtremIO 2.0, Citrix XenDesktop 7.1, and Microsoft Hyper-V 2012 R2.

This solution takes advantage of the following XtremIO capabilities:

- Absorbs peak I/O during various storm scenarios for a typical EUC infrastructure
- Enables inline deduplication for superior performance with persistent desktops and lower cost of ownership
- Makes a flash-based desktop experience available to the virtual desktop implementation

Solution benefits

This solution aids in the design and successful deployment of a high-scale EUC infrastructure with the XtremIO array. This solution shows how the XtremIO array benefits the EUC environment by providing:

- A high-quality user experience with a physical desktop equipped with a dedicated SSD
- Flexible implementation with either full-provisioned or linked-clone virtual machines
- Increased control and security of your global, mobile desktop environment, which is typically your most at-risk environment
- Increased end-user productivity with a more consistent environment
- Simplified management with the environment contained in the data center
- Better support of service-level agreements and compliance initiatives
- Lower operational and maintenance costs

Solution architecture

Overview

This section provides details of the physical and virtual architecture of this solution.

Reference architecture diagram

This midsize solution consists of an XtremIO array, a collection of servers running Hyper-V, 10 Gb Ethernet (GbE) connectivity for non-storage workloads, and 8 Gb Fibre Channel (FC) connectivity for the storage traffic. Figure 1 shows the overall physical architecture of the solution.

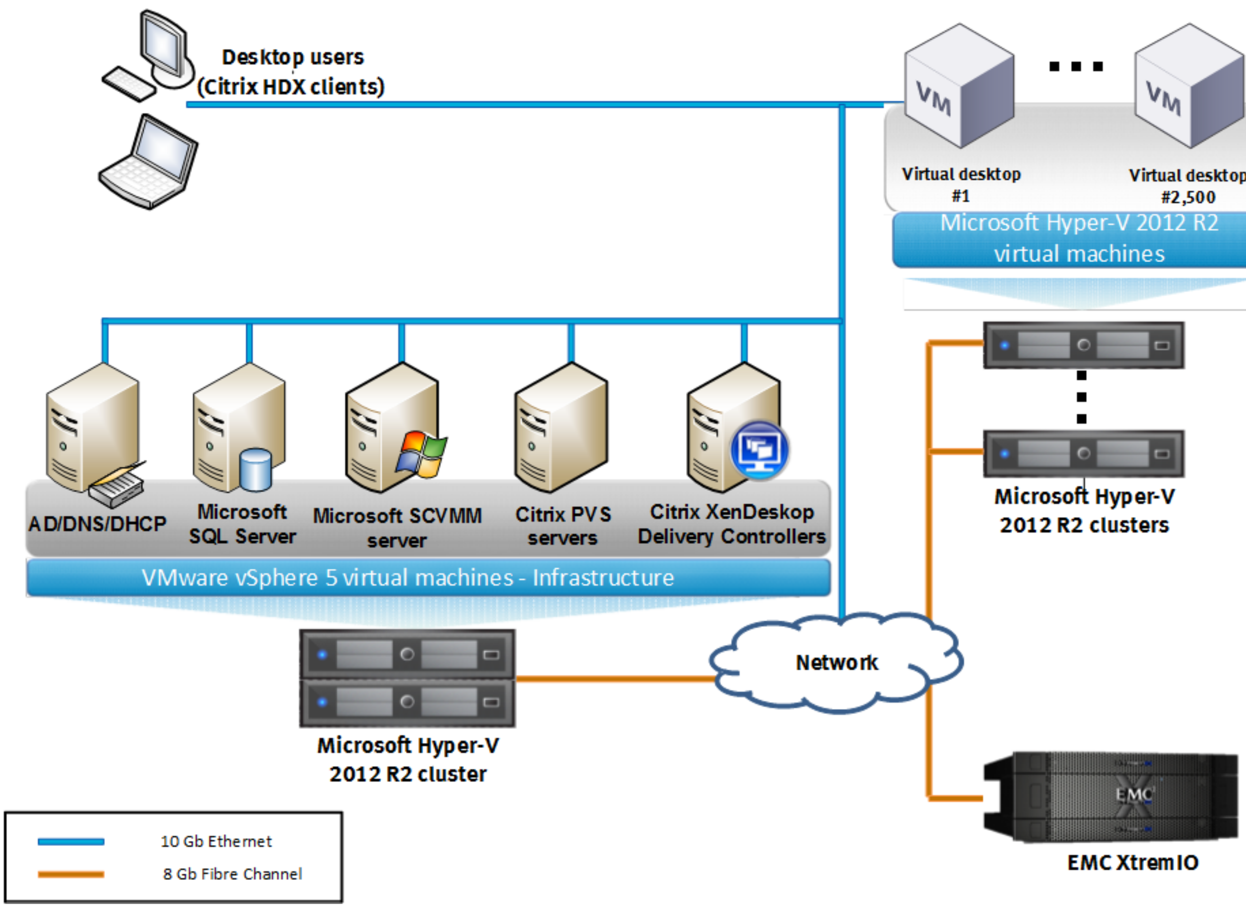

Figure 1. Citrix XenDesktop: Reference architecture

Hardware resources

Table 1 lists the hardware used to validate the solution.

Table 1. Hardware details

Hardware	Quantity	Configuration	Notes
EMC XtremIO	1	• Single managed system of 1 X-Brick • 25 x 400 GB eMLC SSD drives per X-Brick	Shared storage for virtual desktops and infrastructure servers
Intel-based servers	20	• 144 GB RAM of memory • 2 Intel Xeon E7-2870 with 2.40 GHz deca-core processors • 1 x 146 GB internal SAS internal disk storage • XtremIO (FC) for external storage • Dual-port 10 GbE NIC adapter • Dual-port 8 Gbps FC HBA adapter	• 18 Hyper-V desktop servers for clusters 1 and 2 • 2 Hyper-V servers for the clusters that host the infrastructure virtual machines
Cisco Nexus 5020	2	• 40 x 10 Gb ports • 2 Ethernet ports per server • 2 FC ports per server	Redundant FC and LAN configuration

Software resources

The following software resources were used to validate the solution:

- **EMC XtremIO**—The XtremIO array provides storage for Microsoft Windows 7 virtual desktops by using FC connections to Hyper-V hosts. This solution uses a single XtremIO X-Brick.
- **Microsoft Hyper-V 2012 R2**—Hyper-V 2012 R2 hosts infrastructure virtual machines as a two-node Microsoft Hyper-V 2012 R2 cluster. Two additional Hyper-V 2012 R2 clusters are used to host 2,500 virtual desktops.
- **Microsoft System Center Virtual Machine Manager (SCVMM) 2012 R2**—SCVMM provides a scalable and extensible environment that forms the foundation for virtualization management for the Microsoft Hyper-V 2012 R2 clusters. One SCVMM Server was used in this solution.
- **Citrix XenDesktop 7.1**—XenDesktop provides virtual desktop delivery, authenticates users, manages the assembly of users' virtual desktop environments, and brokers connections between users and their virtual desktops. In this reference architecture, Citrix XenDesktop 7.1 is installed on Microsoft Windows Server 2012 R2 and hosted as a virtual machine on a Microsoft Hyper-V 2012 R2 server. Four Delivery Controller Servers were used in this solution.
- **Citrix Machine Creation Services (MCS)**—MCS provisions, manages, and decommissions desktops throughout the desktop lifecycle from a centralized point of management as a provisioning mechanism integrated with the XenDesktop management interface, Citrix Studio.
- **Citrix Provisioning Services (PVS)**—PVS hosts a single shared disk image of desktops. PVS streams disk data dynamically in real time with the PVS servers to ensure that the virtual machine image consistency is maintained.

- **Citrix Personal vDisk (PvD)**—PvD allows users to preserve customization settings and user-installed applications in a pooled desktop.
- **Virtual desktops**—This solution deployed 2,500 virtual desktops running Windows 7. The solution was validated with both MCS linked clone virtual desktops and PVS streamed virtual desktops.
- **Cisco Nexus 5020 switches**—Two Nexus switches provide redundant high-performance, low-latency 10 GbE and 8 Gbps FC networking. The Ethernet connections are delivered by a cut-through switching architecture for 10 GbE server access in next-generation data centers.
- **Microsoft Windows Server 2012 R2 domain controllers and Domain Name System (DNS) Servers**—Two Windows Server 2012 R2 domain controllers provide Active Directory services to manage the identities and relationships that constitute the Windows environment for the virtual desktops. The DNS component of the Windows network infrastructure is also installed on these servers. These servers are hosted as virtual machines on Microsoft Hyper-V 2012 R2.
- **Microsoft Windows Server 2012 R2 Dynamic Host Configuration Protocol (DHCP) server**—The DHCP server manages the IP address scheme centrally for virtual desktops. This service is hosted on one of the domain controller virtual machines.
- **Microsoft SQL Server 2012**—SQL Server 2012 stores the configuration details for the database service as required by Citrix XenDesktop, Citrix PVS, and Microsoft SCVMM. This SQL Server is hosted as a virtual machine on a Microsoft Hyper-V 2012 R2 server.
- **10 Gb IP network**—This network provides multi-Gb connectivity between all the XenDesktop infrastructure components, including the virtual desktop users and Windows server infrastructure.
- **8 Gbps FC network**—This network provides 8 Gbps FC connectivity for XtremIO storage, which allows Hyper-V servers to access FC LUNs on the XtremIO cluster with high bandwidth and low latency.

XtremIO storage layout

The XtremIO cluster is configured with the following LUNs for desktop and infrastructure storage:

- Ten 4 TB LUNs for the MCS linked clone and PVS streamed desktops
- One 2 TB LUN for the infrastructure server storage

Table 2 lists the storage requirements for each type of virtual desktop.

Table 2. Storage requirements

Type	Capacity	Number	Total capacity
MCS linked-clone virtual desktop	3 GB (average)	2,500	7.5 TB
PVS-streamed virtual desktop with a write-cache disk	6 GB	2,500	15 TB
PvD for MCS and PVS desktops	5 GB	2,500	12.5 TB

Storage network layout

Figure 2 shows the 10 GbE and 8 Gb FC connectivity between the Cisco Nexus 5020 switches and the XtremIO storage. Uplink Ethernet ports coming off the Nexus switches can be used to connect to a 10 Gb or 1 Gb external LAN. In this solution, the 10 Gb LAN through Cisco Nexus switches is used to extend Ethernet connectivity to the desktop clients, Citrix XenDesktop components, and Windows Server infrastructure.

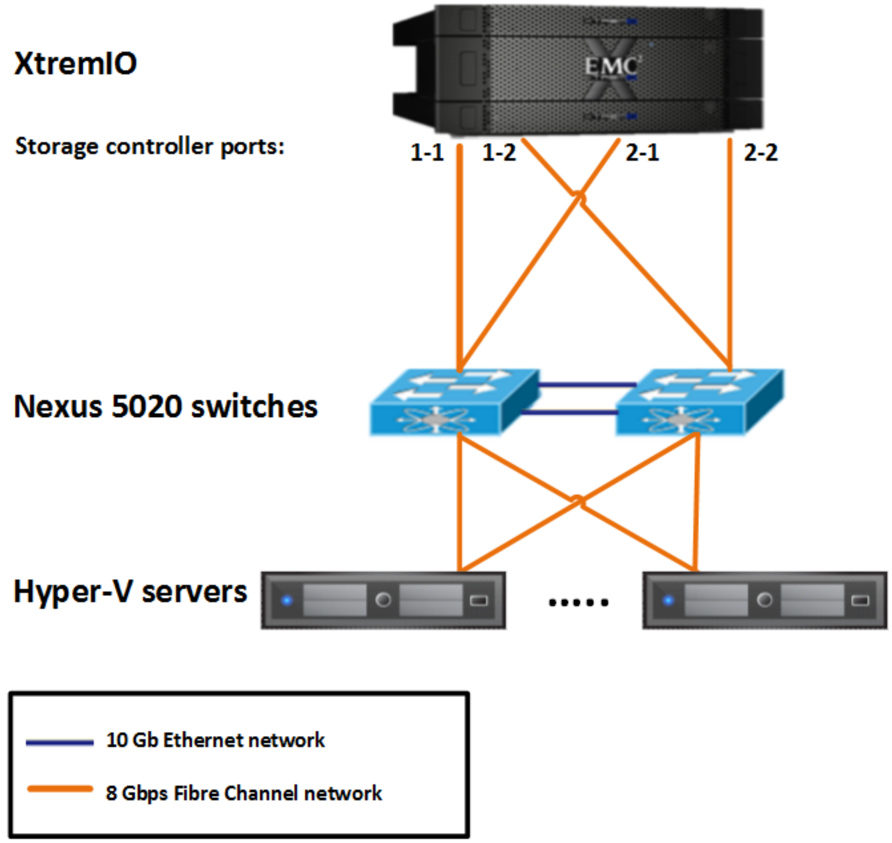

Figure 2. Network layout diagram

Host network configuration

All network interfaces on the Hyper-V servers in this solution use 10 GbE connections. All virtual desktops are assigned an IP address by using a DHCP server. The Intel-based servers use two on-board Broadcom GbE controllers for the network connections.

The Hyper-V NIC team connections use the Teaming Mode set to **SwitchIndependent** and the Load Balancing Algorithm set to **HyperVPort**.

vSwitch configuration

The Hyper-V vSwitch uses the Allow Management OS set to **$false** and the Minimum Bandwidth Mode set to **Weight**.

Virtual management network adapters

Individual virtual network adapters (vNICs) were created on the virtual switch (VDINET vSwitch) for the Hyper-V Management, LiveMigration, CSVNetwork (Cluster Shared Volume), and CSVHeartbeat services.

Table 3 lists the port groups configured on the VDINET vSwitch.

Table 3. Port groups configured on VDINET vSwitch

Configured vNICs on VDINET	Used for
Management	Hyper-V host management
LiveMigration	Virtual machine live migration
CSVNetwork	Cluster shared volume networking
CSVHeartbeat	Cluster shared volume heartbeats

Key components

Introduction

The following key components were used to validate the solution:

- EMC XtremIO array
- Microsoft Hyper-V 2012 R2
- Microsoft SCVMM 2012 R2
- Citrix XenDesktop 7.1
- Citrix PVS 7.1
- Citrix MCS
- Citrix PvD
- Citrix Profile Management

Hardware resources and Software resources provide more information on the components used in the solution.

XtremIO

The XtremIO all-flash array is designed to maximize the use of flash storage media, providing high performance with low latency. Each cluster building block is a high-availability, high-performance, fully active/active storage system with no single point of failure (SPOF). With multiple building blocks forming a cluster, the XtremIO array automatically stays in balance and all desktops benefit from the entire performance potential of the cluster at all times.

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

The XtremIO system provides the following benefits:

- **Standards-based enterprise storage system**—Uses standard FC and iSCSI block interfaces to interact with Hyper-V hosts. The system supports complete high-availability features, including support for native Hyper-V multipath I/O, protection against failed SSDs, nondisruptive software and firmware upgrades, no SPOF, and hot-swappable components.
- **Real-time, inline data reduction**—Deduplicates desktop images in real time, enabling a massive number of virtual desktops to reside in a small and economical amount of flash capacity. Data reduction on XtremIO does not adversely affect IOPS or latency performance; instead, it enhances the performance of the EUC environment.

- **Scale-out design**—Enables you to start with a small virtual desktop deployment (about 1,000 desktops) and grow to nearly any scale by configuring a larger XtremIO cluster. A single XtremIO X-Brick is the building block of a scaled-out XtremIO clustered system. The system expands capacity and performance linearly as building blocks are added, making EUC sizing and management of future growth simple.
- **ODX integration**—Integrates fully with Hyper-V through Offloaded Data Transfer (ODX). This, in combination with the inline data reduction and in-memory metadata management on the array, enables nearly instantaneous virtual machine provisioning and cloning, and the ability to use large volume sizes for management simplicity.
- **Massive performance**—Handles very high, sustained levels of small, random, mixed read and write I/O by design, which is typically expected for virtual desktops, with consistently low latency.
- **Ease of use**—Requires only a few basic setup steps, which can be completed in minutes, and absolutely no tuning or ongoing administration to achieve and maintain high performance levels. In fact, you can take XtremIO from the shipping box to deployment readiness in less than an hour.
- **Data center economics**—Supports 2,000 or more desktops easily on a single X-Brick, which requires only a few rack units of space and approximately 750 watts of power.

Microsoft Hyper-V 2012 R2

Microsoft Hyper-V is a Windows Server role that was introduced in Windows Server 2008 but is now available as a dedicated product for use in a virtualization environment only. Hyper-V virtualizes computer hardware resources such as CPU, memory, storage, and networking. This transformation creates fully functional virtual machines that run their own operating systems and applications like physical computers.

Hyper-V works with the Failover Clustering feature and Cluster Shared Volumes (CSVs) to provide high availability in a virtualized infrastructure. Live migration and live storage migration enable seamless movement of virtual machines or virtual machines files between Hyper-V servers or storage systems with minimal performance impact.

Microsoft SCVMM 2012 R2

Microsoft SCVMM is management software for the virtualized data center. SCVMM enables you to configure and manage your virtualization hosts, networking, and storage resources for creating and deploying virtual machines and services to your private clouds.

You can use Citrix XenDesktop and PVS with SCVMM to deploy and manage both the MCS linked-clone and PVS-streamed virtual desktops.

Citrix XenDesktop 7.1

The Citrix XenDesktop 7.1 architecture, management, and delivery components are shared between XenDesktop and XenApp to provide a unified management experience. Figure 3 shows the XenDesktop architecture components.

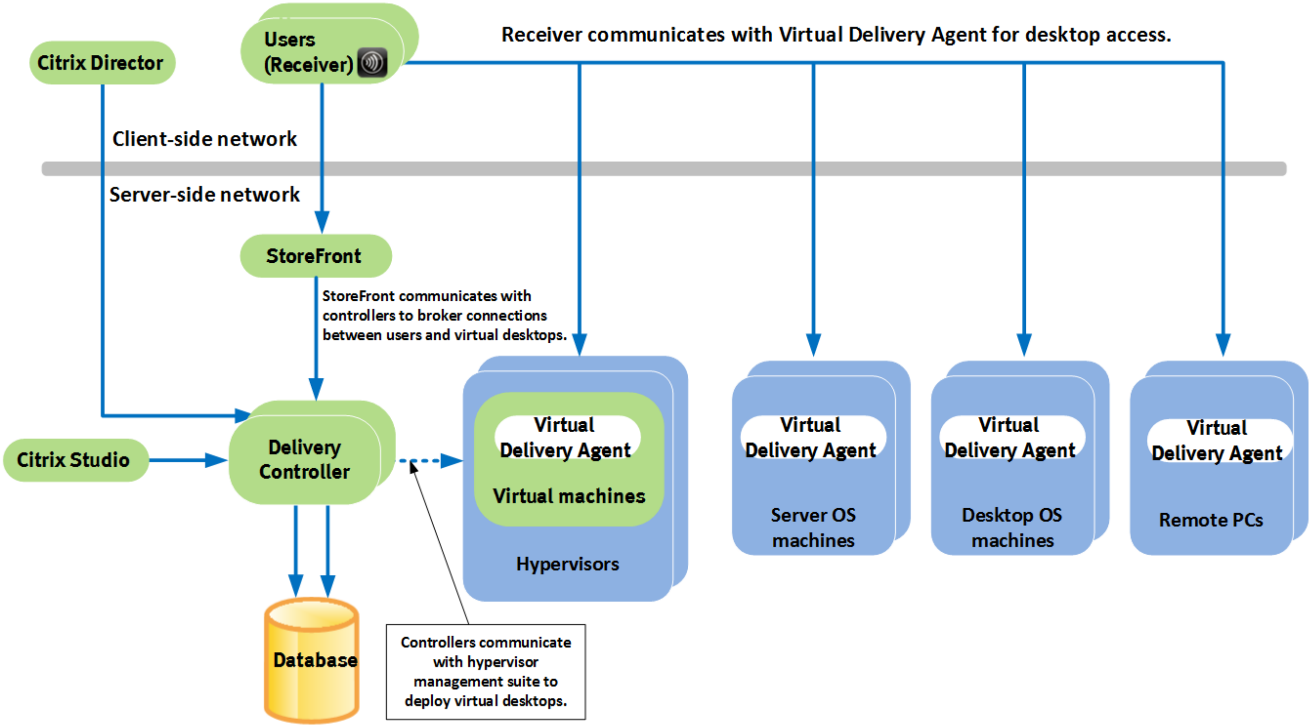

Figure 3. XenDesktop 7.1 architecture components

The key XenDesktop architecture components are as follows:

- **Receiver**—Provides you with quick, secure, self-service access to documents, applications, and desktops from any user devices with Citrix Receiver installed, including smart phones, tablets, and PCs. Receiver provides on-demand access to Windows, the web, and software-as-a-service (SaaS) applications.
- **StoreFront**—Authenticates user access to sites that host resources and manage stores of desktops and applications.
- **Studio**—Enables you to configure and manage your deployment through the Studio management console, which eliminates separate management consoles for managing delivery of applications and desktops. Studio has various wizards that guide you through setting up your environment, creating 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 on servers in the data center installed with the Delivery Controller. The controller manages the state of the desktops and administrative configuration, and starts and stops the desktops on demand. In some editions, the controller enables you to install Profile Management for managing user personalization settings in virtualized or physical Windows environments. Each site in the solution has one or more delivery controllers.
- **Virtual Delivery Agent (VDA)**—Enables connections for desktops and applications when installed on server or desktop operating systems. For remote PC access, you must install the VDA on the office PC.
- **Server OS**—Uses physical or virtual machines, based on the Windows Server OS, to deliver applications or hosted shared desktops (HSDs) to users.

- **Desktop OS**—Uses physical or virtual machines, based on the Windows desktop OS, to deliver personalized desktops to users or applications from desktop operating systems.
- **Remote PC access**—Enables you to access resources on your office PCs remotely from any device running Citrix Receiver.

Citrix PVS

Citrix PVS takes a different approach from traditional desktop imaging solutions by fundamentally changing the relationship between hardware and the software that runs on it. By streaming a single shared disk image (vDisk) instead of copying images to individual virtual machines, PVS enables organizations to reduce the number of disk images to manage. As the number of virtual machines continues to grow, PVS provides the efficiency of centralized management with the benefits of distributed processing.

As machines stream the disk data dynamically in real time from a single shared image, the virtual machine image consistency is ensured. In addition, the configuration, applications, and OS for large virtual machine pools can change completely during the restart operation.

In this solution, PVS provisions 2,500 virtual desktops running Windows 7. The desktops are deployed from a single vDisk image. The PvD feature was used during testing, although this feature is not explicitly required and similar results are obtainable without that feature enabled.

Citrix MCS

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

You can manage several types of physical and virtual machines within a catalog in Citrix Studio with MCS. Desktop customization is persistent for these machines that use PvD, while machines with no PvD are appropriate if desktop changes are discarded when the user logs off.

This solution uses MCS to deploy 2,500 static linked-clone virtual desktops running Windows 7. The PvD feature was used during testing. However, this solution does not explicitly require this feature and you can achieve similar results without PvD enabled.

Citrix PvD

Citrix PvD was introduced in Citrix XenDesktop 5.6. With PvD, you can preserve customization settings and user-installed applications in a pooled desktop. During runtime, the content of the PvD is blended with the content from the base virtual machine to provide a unified experience to the user. PvD data is preserved during the reboot and refresh operations.

Citrix Profile Management

Citrix Profile Management preserves user profiles and dynamically synchronizes them with a remote profile repository. Citrix Profile Management ensures that personal settings are applied to desktops and applications regardless of the user's login location or client device.

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

With Citrix Profile Management, a user's remote profile is downloaded dynamically when the user logs in to a Citrix XenDesktop. Profile Management downloads user profile information only when the user needs it.

Validated environment profile

Overview

This section provides an environment profile for the solution and a summary of the tests performed to validate the EMC infrastructure for Citrix XenDesktop 7.1.

Profile components

Table 4 provides the environment profile used to validate the solution.

Table 4. Solution environment profile

Profile component	Specification
Number of virtual desktops	2,500
Virtual desktop OS	Windows 7 Enterprise SP1 (32-bit)
CPU per virtual desktop	1 vCPU
Number of virtual desktops per CPU core	6.94 (as tested)
RAM per virtual desktop	2 GB
Average storage available for each MCS linked clone or PVS streamed desktop	16 GB
Average storage used in the virtual desktop master image (used by Windows and applications)	14 GB
Average physical storage used for each desktop	• Linked clone: 8 MB • PVS streamed: 182.9 MB
Deduplication ratio of desktops **Note:** All desktops were thinly provisioned, so the deduplication ratio is calculated based only on actual space that was in use.	• Linked clone: 6.6:1 • PVS streamed: 2.0:1 (includes PVS servers)
Average IOPS per virtual desktop at Login VSI steady state	• Linked clone: 11.6 • PVS streamed: 5.2
Peak IOPS observed per virtual desktop during Login VSI testing	• Linked clone: 282.3 • PVS streamed: 136.2
Peak IOPS observed per virtual desktop during boot storm	• Linked clone: 130.9 • PVS streamed: 41.3
Average IOPS observed per virtual desktop throughout boot storm	• Linked clone: 36.2 • PVS streamed: 15.1
Time required to deploy 2,500 desktops	• Linked clone: 2 hours 56 minutes • PVS streamed: Varies based on number of PVS consoles used to execute deployment tasks
Average time required to deploy a single desktop	• Linked clone: 4 minutes • PVS streamed: 10 minutes

Profile component	Specification
Number of data stores used to store virtual desktops	10
Number of virtual desktops per data store	250
Disk and RAID type for data stores	• 400 GB eMLC SSD drives • XtremIO proprietary data protection (XDP) that delivers RAID 6-like data protection but better than the performance of RAID 10
Number of Hyper-V clusters used for desktops	2
Number of Hyper-V servers in each cluster	9
Number of virtual desktops in each cluster	1,250

In Table 4, you can calculate the amount of physical space required for each desktop by dividing the physical space used by the desktops (after being deployed and powered on) by the total number of desktops. For PVS desktops, this calculation also accounts for the storage required for the PVS servers.

Desktop provisioning services

Overview

This solution was validated by using MCS linked clone desktops and PVS streamed desktops to ensure that similar performance can be obtained regardless of the deployment method used. The PvD feature was used during testing, although this feature is not explicitly required and similar results are obtainable without that feature enabled.

MCS linked clones

Citrix XenDesktop 7.1 with MCS supports the use of linked clones to quickly provision virtual desktops.

In a linked clone desktop, the OS reads all common data from the read-only base disk and creates the unique data on the linked clone. Figure 5 shows a logical representation of this relationship.

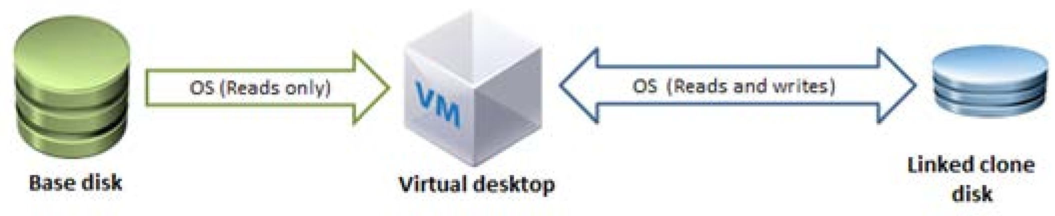

Figure 4. Logical representation of base disk and linked clone

The deduplication capabilities of the XtremIO array, combined with the architectural advantages of a linked-clone desktop, result in physical storage utilization of only 220 MB per MCS linked clone desktop at the time of deployment.

PVS streamed desktops

Citrix PVS integrates with XenDesktop and Microsoft SCVMM to provision and deliver streamed virtual desktops.

A streamed desktop streams the disk data dynamically in real time from a single shared image hosted on the PVS servers. This enables the configuration, applications, and even the operating system (OS) of large pools of machines to change completely during a restart operation if required.

The deduplication capabilities of the XtremIO array resulted in physical storage utilization of only 182 MB per PVS streamed desktop at the time of deployment.

Static pools configuration

Twenty-five hundred desktops with two static desktop pools were deployed using a common Microsoft Windows 7 master image. Ten data stores were used to store the virtual desktops, five for each Hyper-V cluster.

High availability and failover

Overview

This solution provides a virtual desktop infrastructure with high availability. Each component is configured to provide a robust and scalable solution for the host, connectivity, and storage layers.

Host layer

The application hosts have redundant power supplies and network connections to reduce the impact of component failures in the Hyper-V servers. Additionally, Hyper-V utilizes Microsoft clustering services to enable virtual desktops to migrate to alternative Hyper-V hosts in the event of a host failure or maintenance event.

Storage layer

The XtremIO array is available with completely redundant components and can tolerate any component failure without a service downgrade. Fault protection includes (but is not limited to):

- Dual power supplies in controllers and drive array enclosures (DAEs) to support the loss of a power supply while keeping the controller/DAE in service
- Redundant active/active controllers to support controller failures
- Redundant SAS interconnect modules in the DAEs
- Redundant inter-controller communication links
- Multiple host connections with multipath capabilities to survive path failures
- XtremIO Data Protection (XDP) to tolerate SSD failures
- Multiple techniques to ensure initial and ongoing data integrity

Conclusion

The testing of this solution revealed the following conclusions:

- The XtremIO array can deliver outstanding user experience to each virtual desktop user by servicing I/O at sub-millisecond latency at high I/O levels for 4,000 MCS linked-clone or PVS desktops across a wide variety of desktop workloads. These desktops can be PVS, PVS with Personal vDisk, MCS linked clones, MCS linked clones with Personal vDisk, or a combination of these. Based on utilization statistics recorded during testing, an XtremIO cluster with two X-Bricks can scale up to 8,000 PVS streamed or MCS linked-clone desktops, or 4,000 desktops per X-Brick.
- As the IOPS read/write ratio changes, the responsiveness of the XtremIO array remains virtually unchanged. The array does not require any system-level post-process garbage collection, nor does it exclusively lock SSDs being written to—both commonly implemented in all-flash arrays. As a result, the XtremIO array can provide consistent performance for any mix of read/write IOPS.
- The user experience of the virtual desktops as they fill up and must overwrite existing capacity in the array is not degraded over time. Citrix XenDesktop stakeholders (including end users, storage administrators, virtualization administrators, and desktop administrators) benefit from the predictable, consistent performance of the XtremIO array.

This proven solution provides a blueprint for a validated Citrix XenDesktop 7.1 virtualization solution enabled by EMC XtremIO storage and the Microsoft Hyper-V 2012 R2 virtualization platform. The solution can support and scale to thousands of virtual desktops.

Refer to the *Proven Solution Guide: EMC Infrastructure for Citrix XenDesktop 7.1—Enabled by the EMC XtremIO All-Flash Array and Microsoft Hyper-V 2012 R2* for more details about the solution and to review the test results.

References

EMC documentation

The following documents, located on the EMC website, provide additional and relevant information:

- *EMC Infrastructure for Citrix XenDesktop 7.1 Proven Solution Guide*
- *Flash Implications in Enterprise Storage Array Designs*

Citrix documentation

The following Citrix document, located on the Citrix website, provides relevant information:

Citrix XenDesktop Design & Deployment Handbook

Microsoft documentation

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

- *Microsoft Windows Server 2012 R2 Evaluation Guide*
- *Technical Documentation Download for System Center 2012–Virtual Machine Manager*

Note: The provided links were working correctly at the time of publication.
