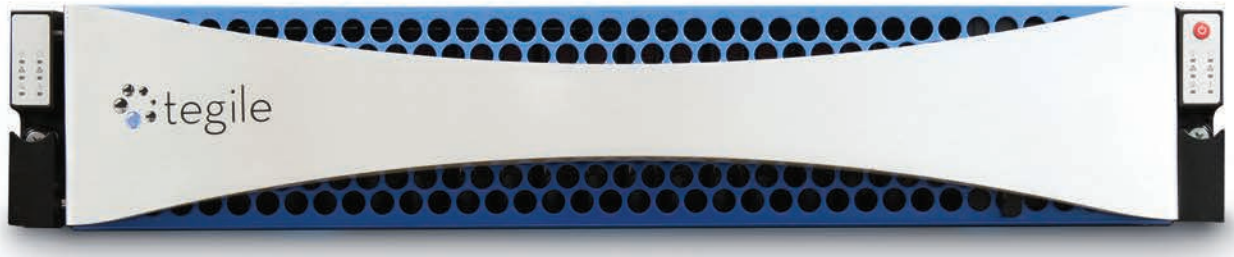
750 XenDesktop Users on Tegile Storage

Reference Architecture



Executive Summary

Tegile Systems participated in the Citrix VDI Capacity Program and conducted a joint validation certification test for deploying 750 XenDesktop users. The tests were conducted at the Citrix labs located in Santa Clara, CA. Tegile was among one of the first storage solution providers to successfully complete the certification testing.

Citrix provided the server and networking infrastructure, the Microsoft Hyper-V virtual server, the Citrix XenDesktop and the Citrix PVS infrastructure, pre-configured to host 750 desktops. Tegile provided and configured the Tegile storage array. Citrix engineers deployed the desktops on storage arrays, ran the Login VSI tests, and validated the test results.

This whitepaper documents the solution architecture, hardware and software components, configurations used in the test, best practices, test methodology and test results. It is intended to assist solution architects, sales engineers, field engineers and consultants in the planning, design, and deployment of Citrix XenDesktop solutions on Tegile storage arrays.

The solution architecture described in this guide builds a replica of a common customer virtual desktop infrastructure (VDI) environment and validates the environment for performance, scalability, and functionality.

Customers achieve:

- Increased control and security of their global, mobile desktop environment, which is typically their most at risk environment
- Better end-user productivity through a more consistent environment
- Simplified management
- Better support for service-level agreements and compliance initiatives
- Lower operation and maintenance costs

The Business Challenge

The benefits of VDI have been well documented, however, performance concerns, as well as the cost and complexity associated with storage, can become inhibitors to VDI adoption.

Customers require a scalable and highly available infrastructure on which to deploy their virtual desktop environments. There are several new technologies available to assist them in designing a virtual desktop solution, but they need to know how to use these technologies to maximize their investment, support service-level agreements, and reduce their total cost of ownership, (TCO).

Planning and designing the server, network, and storage infrastructure for Citrix XenDesktop environments is a critical step because the server infrastructure should be sized to handle the desktop workload, for both density and scale. In addition, the network infrastructure should be provisioned to handle bursts of data traffic, and finally the shared storage must be able to absorb large bursts of input/output (I/O) that occur over the course of a workday.

To provide cost-effective and predictable performance for a virtual desktop infrastructure, the storage infrastructure must be able to:

- Support a high density of virtual desktops per storage array
- Scale linearly with increase in the number of virtual desktops
- Provide low latency and high bandwidth for the clustering, provisioning, and storage interconnect networks
- Handle the peak I/O load from clients while maintaining quick response times

Overview: Citrix VDI Capacity Program for Storage Partners

In Q1, 2014, Citrix launched a new program designed specifically to address the storage needs of customers who are implementing XenDesktop using the VDI FlexCast approach. VDI presents multiple types of data, each with its own unique requirements, to the storage infrastructure tier. Storage can then respond to these requirements using a variety of hardware and software based approaches, some of which can be combined in hybrid solutions. The variety of choices and the differences between them has led to some confusion for customers and partners. To resolve this, Citrix constructed a turnkey "VDI Capacity" test rig in their Santa Clara Solutions Lab. This rig contained the necessary server capacity to generate 750 users of a reference XenDesktop workload. The VDI farm was complete and fully operational with the exception of storage. Citrix storage partners were invited to connect their storage to the VDI farm and participate in a "VDI Capacity" test that simulated "a day in the life" of a 750 user Citrix farm.

Testing Methodology

The focus of the VDI Capacity Program for Storage Partners is on provisioning the appropriate amount of storage performance and capacity with a cost-efficient design. Using a simple, binary pass/fail methodology, if a partner's provided storage solution can successfully support "a day's" run for the defined user capacity, while sustaining required performance metrics, the partner passes and the test ends. Once passed, Citrix describes the storage partner as "750 User Verified" for XenDesktop.

Citrix used Login VSI, a highly regarded and respected tool for standardized VDI performance and capacity testing, to generate VDI workloads and to measure performance. 750 desktops were created, launched and executed a workload program that simulates a typical work day. Pass/fail was determined by whether or not the storage system used could successfully handle the storage demands placed on it without reaching a latency limit called "VSI Max".

Note: More about Login VSI can be found at:

http://www.loginvsi.com/documentation/index.php?title=Main_Page.

Tegile Overview

Tegile is pioneering a new generation of affordable feature-rich storage arrays that are dramatically faster, and can store more effective data than traditional arrays.

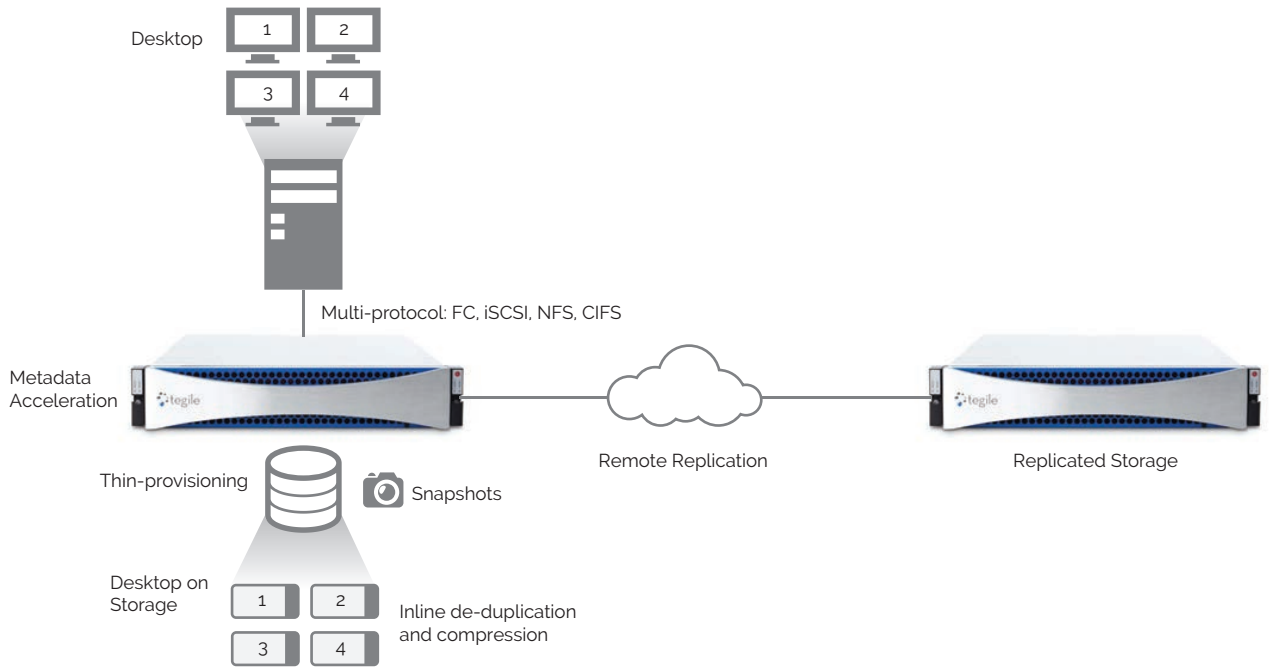


Figure 1: Solution Overview

The new generation Tegile storage array is purpose-built to address VDI needs:

High Performance

Tegile storage arrays are architected from the ground-up to use flash storage in an intelligent and optimal manner. The patented Tegile IIntelliFlash™ technology accelerates performance to solid-state speeds without sacrificing the capacity or cost advantage of hard disk storage. Tegile arrays are significantly faster than legacy arrays and considerably less expensive than traditional storage arrays.

Storage Efficiency

Inline deduplication and compression enhance usable capacity well beyond raw capacity, reducing storage capacity requirements by as much as 90 percent according to Tegile VDI deployments in the field.

Availability

Tegile storage arrays are designed for redundancy, with no single point of failure. The rich set of availability features includes multiple RAID options, snapshots, cloning, and remote replication, with proactive monitoring and alerts for timely notification when issues arise, and they are included at no extra cost.

Single Platform for Multiple Workloads

Tegile storage arrays support both SAN and NAS protocols for storage access. Desktop images can be deployed using NFS, iSCSI or Fibre Channel protocols, while data folders for the Microsoft Windows virtual desktops can be provisioned using CIFS on the same storage array.

Scalability

Tegile offers several different hybrid and all-flash storage arrays within its portfolio. The product line also includes storage expansion shelves to add capacity to the storage arrays. The expansion shelves include all flash or a mix of flash and hard disk drives.

The Tegile storage array is a balance of performance, capacity, features, and price that can satisfy the needs of the most demanding VDI users.

Tegile Storage Solution

This section describes the solution architecture for the validation of 750 virtual desktop users using Tegile storage arrays and Citrix XenDesktop. The solution has been validated using Login VSI. The test configuration consists of 750 Windows 8 (64-bit) desktop virtual machines using Citrix PVS PXE. The solution processed a steady state workload around 10 IOPS per VM. The solution successfully passed the Login VSI test criteria and met the application response time requirements for virtual desktop deployments. The $/desktop of the certified Tegile storage solution is approximately $40.5.

The following table highlights the VDI Capacity Program Matrix of the certified Tegile storage array:

VDI Capacity Program Results Matrix

Storage Vendor Name	Storage Solution Name/Model	Solution Type	Login VSImax Pass/Fail	Physical Storage Used	Logical Storage Provisioned	Total Available IOPS Based on 4K Read/Writes (90% writes)
Tegile	T3300	Hybrid	Pass	16TB	32TB	25,000

Solution Components/ Architecture Design

Hardware and Software Used

The following hardware and software was used in the testing environment:

Hardware

Component	Description
Servers	
Blade Server Chassis	HP C7000
Blade Servers	HP BL460c G7 Blade Server
Networking	
Switches Inside Blade Server Chassis	HP Virtual Connect FlexFabric switch
External Switch	HP H3C 5820 switch
Storage	
Storage Array	Tegile T3300

Software

Component	Description
Virtual Desktop Broker	Citrix XenDesktop 7
VDI Desktop Provisioning	Citrix Provisioning Services 7.0
Endpoint Client	Citrix REceiver for Windows 14.0.0.91
User Profile Management	Citrix User Profile Manager 4.1.1
VDI Personalization	Citrix Personal vDisk 7.0.0.46
Licensing	Citrix License Server 11.11
Workload Generator	Login VSI 3.7
Office	Microsoft Office 2010 SP1
Virtual Desktop OS	Microsoft Windows 8 (64-bit)
Desktop Client OS	Microsoft Windows 7 (32-bit)
Database Server	Microsoft SQL Server 2008 R2
Hypervisor Management	Microsoft SCVMM 2012
Infrastructure Host Hypervisor	Windows Server 2012 Hyper-V
Virtual Desktop Host Hypervisor	Windows Server 2012 Hyper-V
Client Host Hypervisor	Windows Server 2012 Hyper-V
Storage Controller	Tegile IntelliFlash OS 2.0.8

Additional details can be found in the Addendum.

Solution Architecture

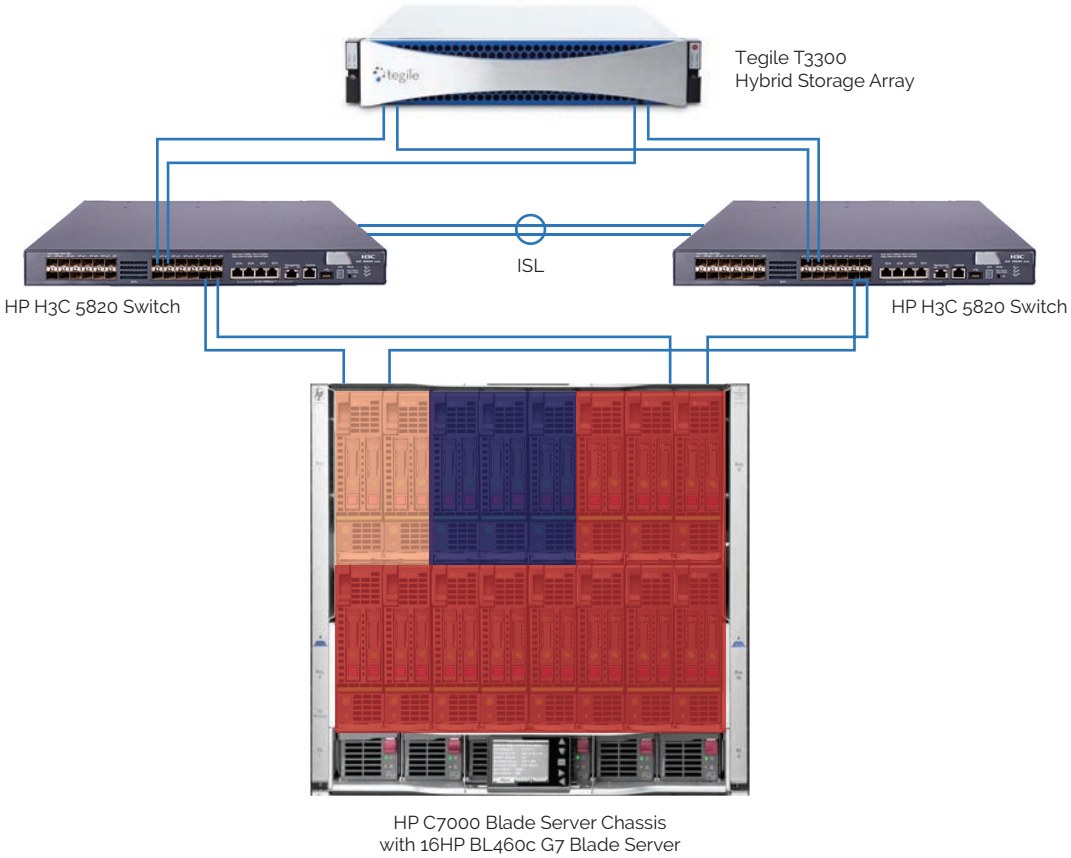


Figure 2: Solution Topology

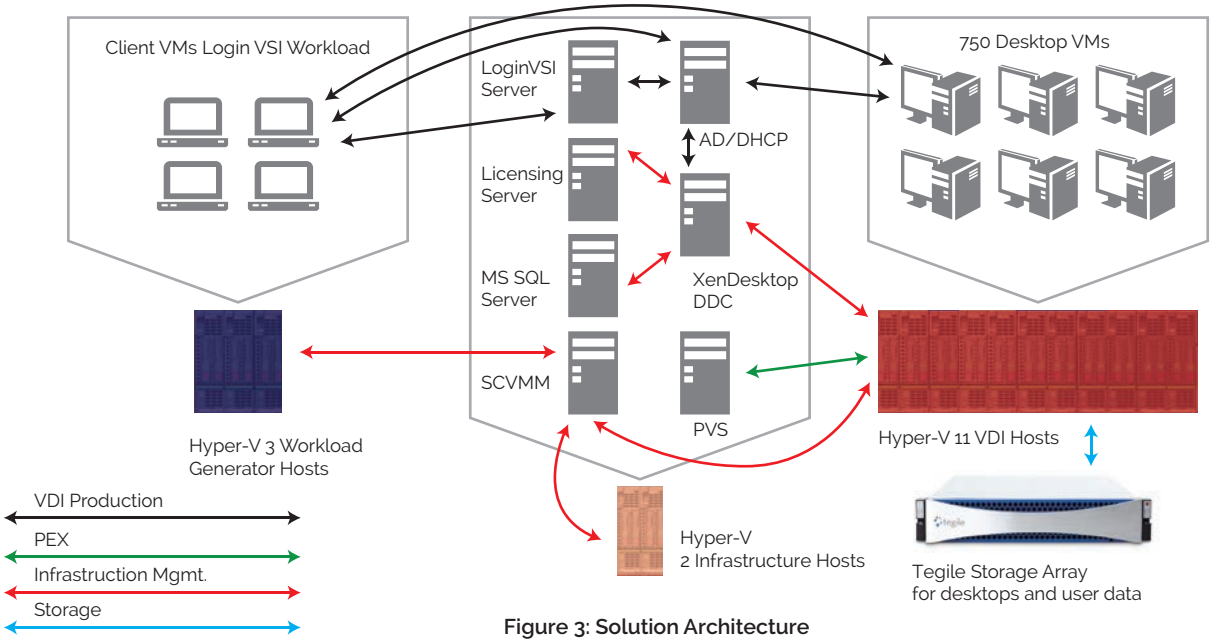


Figure 3: Solution Architecture

The above diagram shows the solution topology and architecture for implementing the Citrix XenDesktop VDI solution on Tegile storage array. The lists below describe the components:

Server

- One HP C7000 blade server chassis with 16 HP blade servers
- Each blade server installed with Windows Server 2012 Hyper-V
- 11 blade servers configured to host 750 desktops, at approximately 70 - 80 desk tops per server. Note that during the test, only 10 VDI hosts were actually used.
- The following infrastructure servers were deployed as virtual servers installed with Windows Server 2012 on two physical blade servers:
  - Active Directory and DHCP
  - SCVMM
  - MS SQL Server
  - XenDesktop DDC (Desktop Delivery Controller)
  - License Server
  - PVS (Provisioning Server)
  - Login VSI Server
  - 3 blade servers configured to host 50 client VMs for workload generation. Each client VM was responsible for launching the workload on 15 desktop VMs.

Network

- Four networks were used during the test for:
  - VDI Production
  - PXE boot
  - Infrastructure Management
  - Storage
- The Tegile storage array was connected to the HP blade server chassis through HP H3C 5820 10GbE switches. During the test, only one switch was used.

Storage

- One Tegile T3300 hybrid storage array with active-active storage controllers
- The Tegile T3300 hybrid storage array was connected to the HP blade servers through 4x 10GbE links using the HP H3C 5820 switch
- Used iSCSI storage protocol for storage connectivity
- Tegile storage array hosted both the write cache and user data for all 750 desktops

Virtual Desktop

- All 750 virtual desktops shared one OS image vDisk on the PVS server through PXE boot
- The write cache of each virtual desktop was redirected to the Tegile storage array
- The user data of each virtual desktop also resided on the Tegile storage array Workload
- Used Login VSI v3.7 to generate the workload on all 750 VMs
- "Medium" workload selected

Additional details can be found in the Addendum.

Users

The following table describes the VDI users tested in the solution.

#of users	OS Image vDisk	Write Cache/User	User Data/User
750	Shared 1 x 40GB vDisk	6GB	30GB

Storage Architecture Design

We recommend that you choose the PVS write cache destination to be "Cache on device hard drive" to achieve higher scalability and to allow for better manageability and agility in a large PVS development.

While the PVS servers absorb most of the read IOPS, the write cache storage is I/O intensive, as all writes on the desktops are redirected to the write cache storage. The test results indicated that the read/write ratio was around 90% write and 10% read for the write cache.

Storage Configuration

For the 750 VDI user test, we used one single Tegile T3300 hybrid storage array. The following table describes the technical specifications of the Tegile T3300.

Component	Description
# of storage controllers	2 Active-Active controllers (Only one controller used during the test.)
Storage Processors	Each controller is equipped with dual intel Xeon E5645 quad-core processors at 2.40 GHz
Storage RAM Cache	Total 192GB, 96GB per controller. (Only 96GB on one controller used during the test.)
Storage Flash Cache	Total 1200GB; 6SSDs; 200GB per SSD
#of 10GbE ports	Total 4; 2 per controller. Jumbo Frame was enabled, with MTU set to 9000. (Only 2 ports on one controller used during the test.)
# of FC8G ports	Total 4; 2 per controller. (Not used during the test.)
# of GbE ports	Total 4; 2 per controller. (Only 1 port per controller used for management during the test.)
Physical Storage Capacity	Total 16TB; 16 2.5" Near Line SAS HDDs; 1 TB per drive

Storage Provisioning

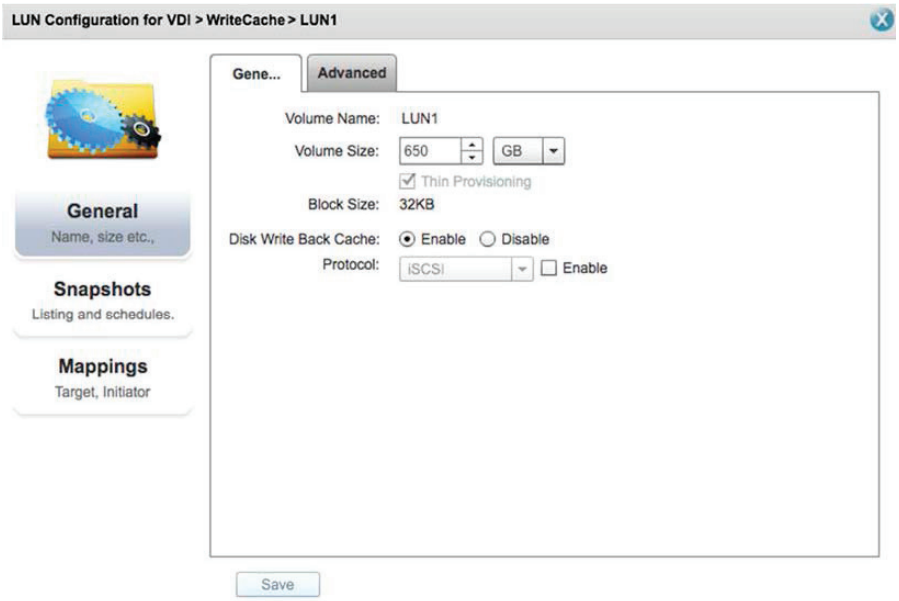
During the test, one storage pool was created to host both write cache and user data. On this storage pool, 11 iSCSI LUNs were provisioned for write cache; another 11 iSCSI LUNs were provisioned for user data. For simplicity, one write cache LUN and one user data LUN were allocated for each VDI host.

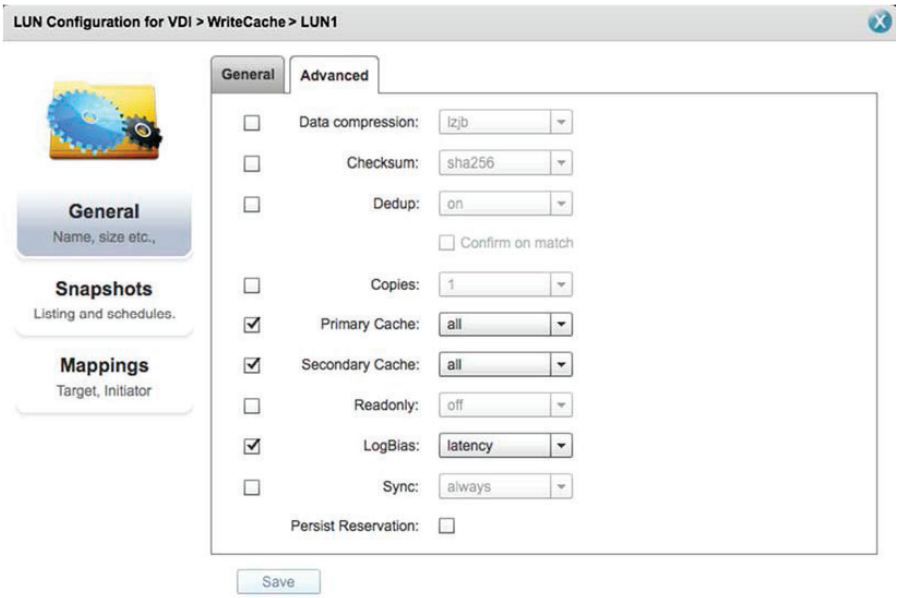
The following table describes the configuration of the storage pool.

Pool Type	Meta SSD	Cache SSD	Data HDD	Spare HDD	RAID Level
Hybrid	2x 200GB	4x 200GB	14x 1TB NL SAS	2x 1TB NL SAS	RAID10

Write Cache LUN Configuration

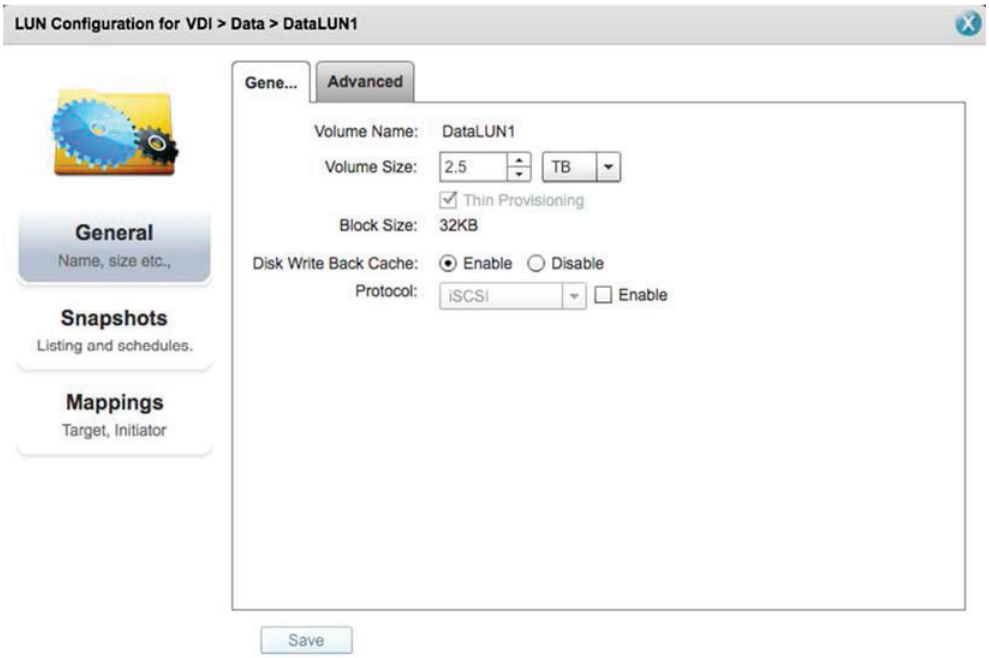
Each write cache LUN was configured as follows:

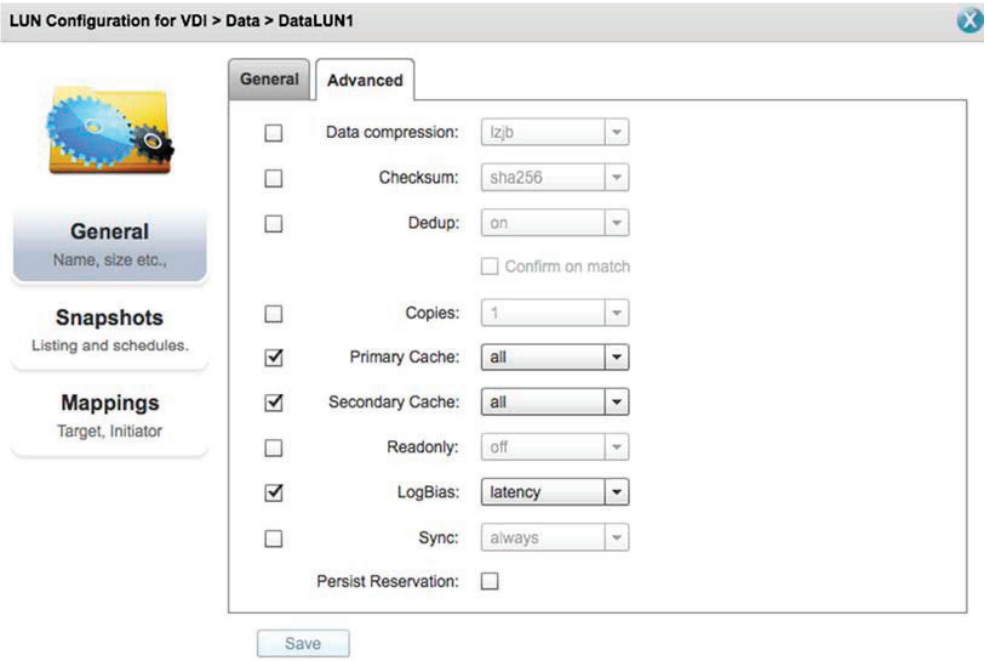




User Data LUN Configuration

Each user data LUN was configured as follows:





Network Configuration

Jumbo Frames were enabled on all of the 10Gb ports on the storage network, from the HP blade servers and the HP H3C 10Gb switches, to the 10Gb iSCSI ports on the Tegile storage controllers.

Host Configuration

On each of the 11 HP blade server VDI hosts, the Windows Server 2012 iSCSI initiator was configured with multipathing enabled, and the load balancing policy was set to "Round Robin with Subset" for all Tegile iSCSI LUNs.

Desktop NTFS Partition Block Alignment

Even though the OS image and write cache settings were pre-designed and pre-configured for this project, we recommend that you align the NTFS partition with the Tegile LUN block size. Block alignment generally increases IO performance by 10% to 50%. It helps lower the VDI application response time and allows for a higher density of VDI users on the storage array.

The following table lists the recommended partition offset and NTFS allocation unit size for the NTFS partitions used in the Hyper-V hosted XenDesktop VDI solution on the Tegile storage array.

Component	Partition	Partition Offset	NTFS Allocation Unit Size
Hyper-V	Write Cache Partition	1MB	32KB
Hyper-V	User Data Partition	1MB	32KB
Desktop VM	OS system Partition on the OS Image vDisk	1MB	32KB
Desktop VM	User Data Partition	1MB	32KB
Desktop VM	Write Cache Partition	1MB	32KB

Test Workflow

The following steps describe the test workflow:

1. Boot all 750 VMs.
2. Wait for all VMs to complete booting, and wait for the VMs to achieve steady-state.
3. Start batches of Login VSI workload tests on all VMs.
   Note: The tests ran for approximately 45 minutes on each VM.
4. Wait for the Login VSI workload tests to complete on all VMs.
5. Login VSI reports the test results.

Test Results

Login VSI Results

Based on the Login VSI test results, the Tegile storage array and Citrix XenDesktop solution successfully passed the 750 VDI user test.

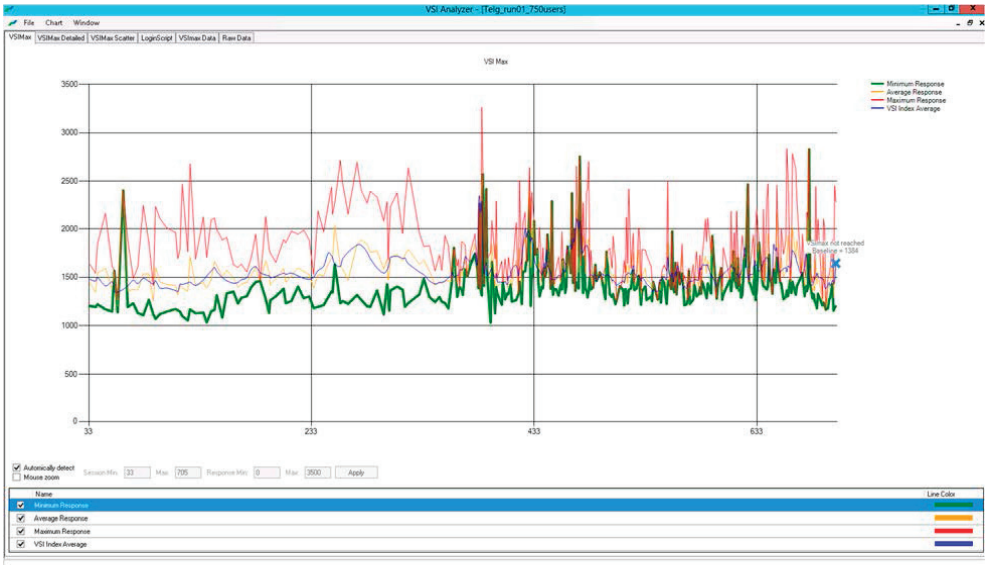


Figure 4: Tegile 750 VDI user Login VSI VSImax chart

The above Login VSI VSImax chart shows the VSImax baseline at 1384. The 750 VDI users did not saturate the overall system resources and the infrastructure can support more virtual desktop users. Since the scope was restricted to 750 VDI users for the Citrix VDI Capacity Program, this test did not go beyond 750 users.

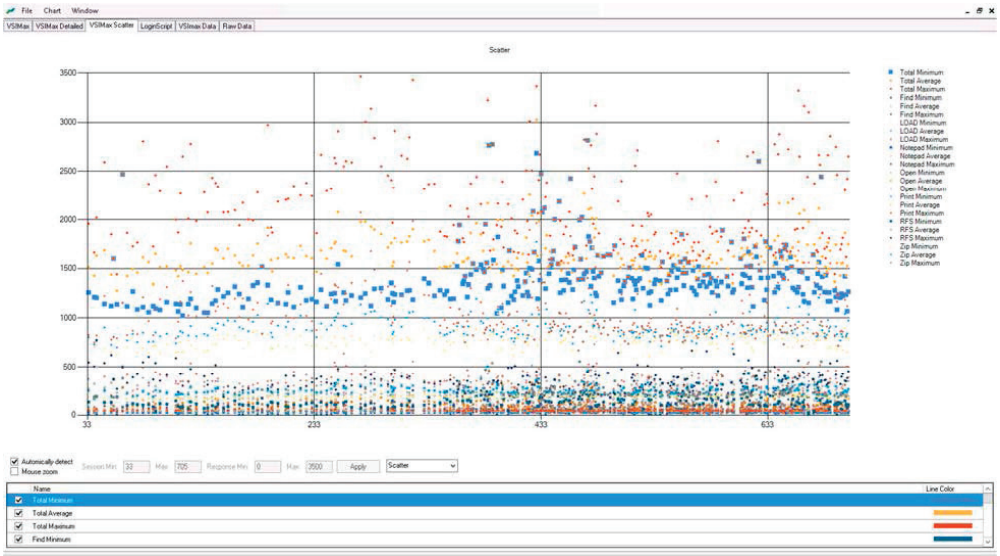
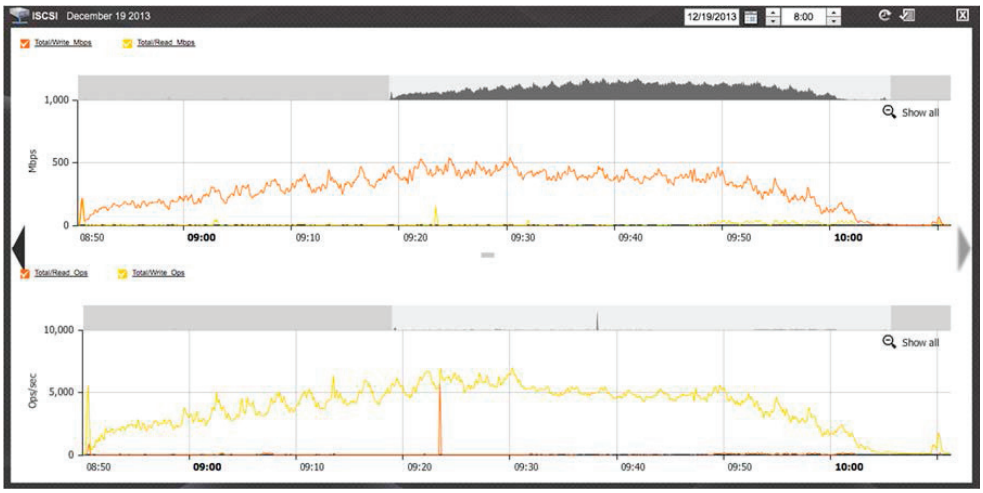


Figure 5: Tegile 750 VDI user Login VSI VSImax Scatter chart

The above VSImax Scatter chart shows the minimum and maximum values for the various workloads running on the virtual desktops after the login process completed.

Tegile Storage Analytics

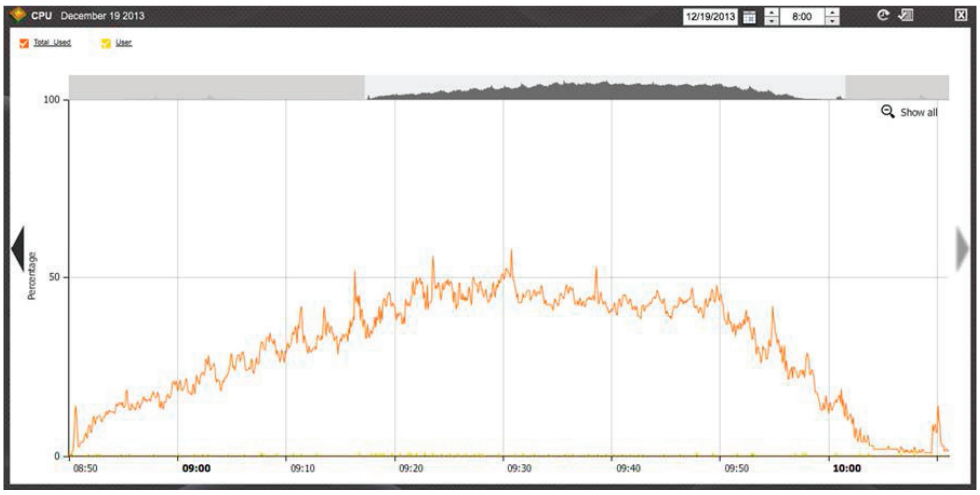
The Tegile storage analytics show that the T3300 array was only utilized for approximately 50% of its performance capability. The array would have been able to host hundreds of additional VDI users.



The above iSCSI analytics screenshot shows that the Login VSI VDI test workload generated over 90% write IOs to Tegile storage, with the average request size around 10KB.

The transfer rate peaked around 500 Mbps, which is far below the bandwidth of the 2x 10Gbps links on the storage controller.

The IOPS peaked around 7000, which is approximately half the capability of the T3300 for this IO profile.



The above CPU analytics screenshot shows that the peak CPU utilization was around 50% on the Tegile storage controller during the test.

Inline Compression and Deduplication

Inline compression and deduplication in the Tegile array reduce the capacity requirements by 75% to 90% in VDI environments.

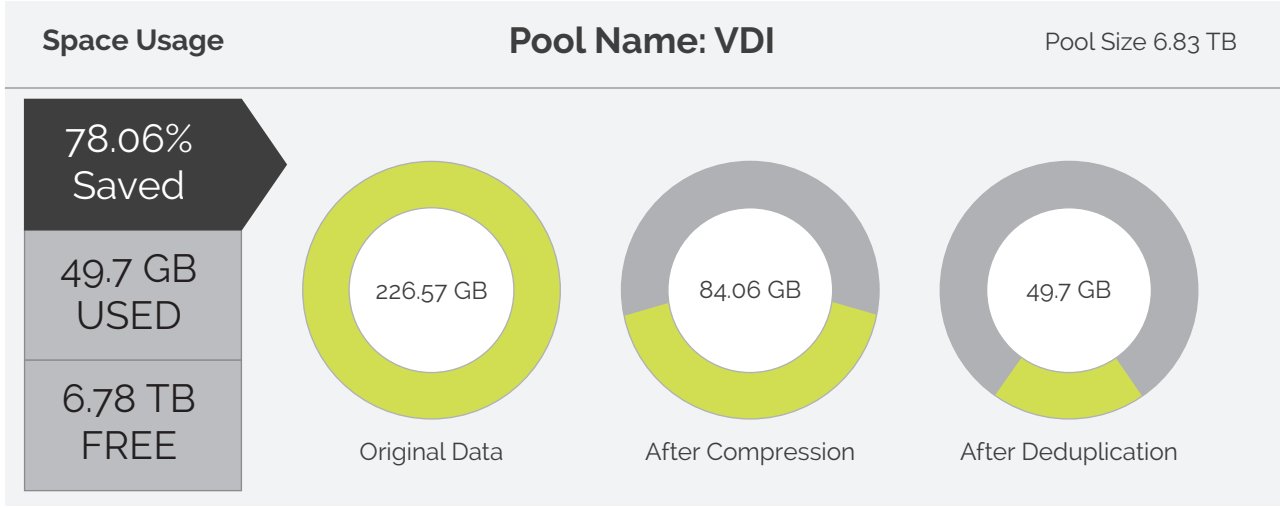
In VDI deployments, typically there are 4 types of data:

- OS images (e.g., Windows 8)
- Application software (e.g., MS Office, Adobe Reader etc.)

- OS and application temp data (e.g., temporary cache files generated by the OS or by the applications)
- User data (e.g., emails, word documents, images, videos etc.)

Most of this data is compressible. Tegile inline compression usually provides 30% — 70% capacity saving for VDI data.

In VDI environments, there is usually a large amount of duplicate data. For example, there could be well over 90% of duplicate data in OS images when most of the desktops are running the same versions of Windows OS. There could also be a large amount of duplication in the application software, since the same versions of Microsoft Office, Adobe Reader etc are usually installed on the desktops. While Citrix PVS allows multiple desktops to boot from one, or a small number of base OS image vDisks, which reduces the data duplication and also simplifies desktop provisioning and maintenance, there can still be significant duplicated data in the OS and application data in the write cache as well as the user data.



Tegile block data deduplication removes the duplication of all of the OS, application and user data, and only stores a single instance of the data, dramatically reducing the storage footprint for VDI.

The above screenshot from the Tegile GUI shows approximately 78% capacity savings through inline compression and deduplication on the Tegile array for this test. This translates to significant savings in storage acquisition and maintenance costs, and ongoing power and cooling costs.

Better yet, Tegile inline compression and deduplication help improve the I/O performance by allowing more effective data to be cached in RAM and SSD. This helps improve the overall I/O performance by delivering lower latency to meet VDI response time requirements, and by providing more IOPS to support more VDI users.

Additional Solution Data

The following sections discuss other beneficial features of Tegile hybrid storage arrays.

Tegile IntelliFlash

Tegile hybrid storage arrays are powered by IntelliFlash technology to realize the holy grail of storage – high performance, high capacity and high reliability at low cost.

Traditional disk array storage systems store data and metadata together, with metadata combined and interspersed with data on disks. Over time, with data being modified, deleted, and rewritten, metadata becomes fragmented on the disk. Additionally, certain storage system features, such as deduplication, can cause metadata to multiply and grow rapidly. Inordinate growth of metadata causes significant deterioration in a system's behavior over time. This was the key driver behind IntelliFlash. With IntelliFlash, the Tegile storage array system organizes and stores metadata, independent of the data, on high-speed devices with optimized retrieval paths. This accelerates every storage function within the system, raising the performance of near-line SAS hard disk drives to the level of extremely expensive high-RPM SAS or Fibre Channel drives.

In short, with Tegile hybrid storage arrays, you get the performance of SSDs with the capacity and price benefits of HDD drives.

Thin Provisioning

Thin provisioning is a method for logically presenting more storage to hosts than physically available. With thin provisioning, the storage administrator is able to utilize a pool of physical disks and create logical volumes for different applications to use, while not pre-allocating space to those volumes. The space gets allocated only when the host needs it.

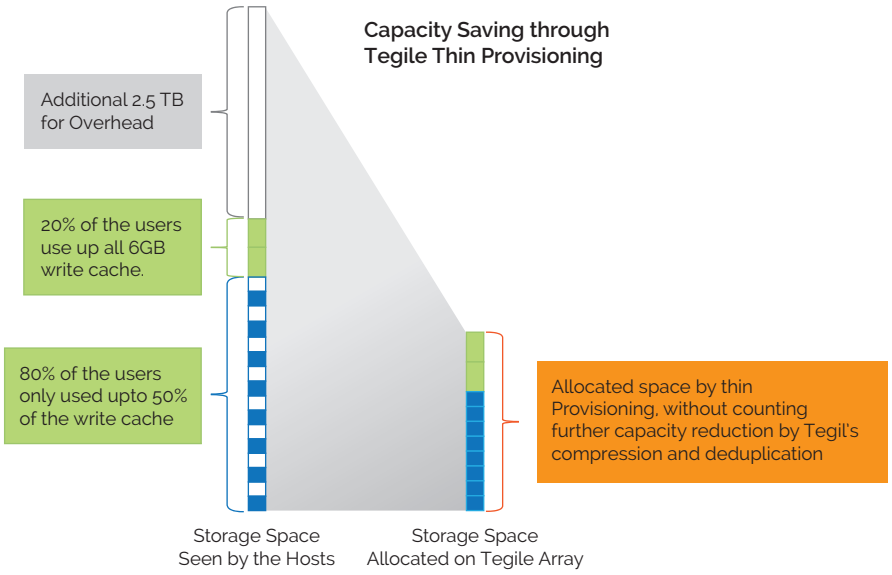


Figure 6: Savings with Thin Provisioning

The above diagram shows an example of savings through the use of thin provisioning on Tegile storage arrays.

Conclusion and Call to Action

Citrix and Tegile collaboratively validated and certified the Citrix XenDesktop 750 User VDI solution on the Tegile T3300 storage array. While the scope of this test was confined to 750 desktop users, the T3300 array is capable of supporting several hundred more desktop users for this I/O profile.

The new generation of Tegile storage arrays are purpose-built to address VDI needs. Tegile hybrid storage arrays are architected from the ground up to use flash storage in an intelligent and optimal manner. The patented Tegile IntelliFlash™ technology accelerates performance to solid-state speeds without sacrificing the capacity or cost advantage of hard disk storage. Inline deduplication and compression enhance usable capacity well beyond raw capacity, reducing storage capacity requirements by as much as 90 percent.

- For more information about Citrix XenDesktop, visit http://www.citrix.com/XenDesktop
- For more information about Tegile VDI storage solutions, visit http://www.tegile.com/solutions/desktop-virtualization-solutions, or call 1-855-5-TEGILE.

Addendum

The information below was provided by Citrix to describe the details of the storage requirements and the VDI Capacity Program certification test setup environment in the Citrix lab.

Minimum storage requirements

Note: Determined by Citrix for 750 concurrent VDI desktop users:

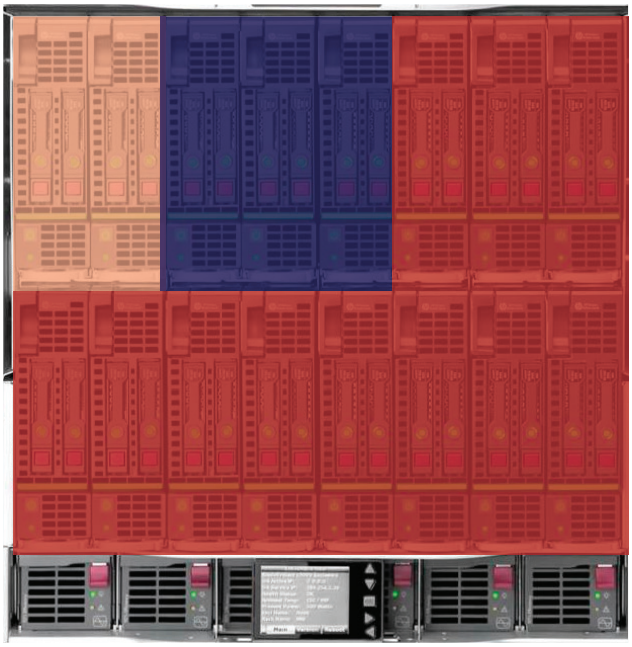
- Write Cache Files:
  – 6 GB write cache file per user
  – 4.5 TB minimum required
  – Additional 2.5 TB added to LUN for overhead
- User Data:
  – 30 GB allowed for each user
  – 750 * 30 = 22 TB of required space
  – 3 TB added for overhead
- Total storage capacity required:
  – 7 TB for write cache + 25 TB for user data = 32 TB required

Citrix Provided Server Configuration

- A single HP C7000 enclosure was used to hold the servers
- The enclosure was in a separate isolated environment
- Servers were BL460c G7 with 2 Processors and 192 GB of memory
  – 1 server contained the necessary infrastructure VMs
  – 4 servers contained client VMs necessary to drive work load
  • A separate Login VSI v3.7 license was obtained to provide further isolation
- VM Configuration: Win7 (32-bit), 1.5GB memory, 1 vCPU

  – 11 servers containing XD7 desktops
- VM Configuration: Win7 (64-bit), 1.5 GB memory, 1 vCPU
  – Servers contain Windows 2012 Hyper-V

Server Layout



Infrastructure Server - XD and VSI Hosts

Clients

VDI

Figure 7: Citrix Provided Configuration

Network Configuration

- FlexFabric was configured to allow for either Ethernet or Fibre connectivity from the blades. They were connected to a 4 Gb Brocade switch.
  Four networks were created:
  – Network 1 – Internal to HP Virtual Connect for PXE boot of VMs, 5 Gb
  – Network 2 – Connection to lab storage and management, 1Gb
  – Network 3 – Production network for connection between clients and XD VMs, 5 Gb
  – Network 4 – Connection to vendor storage for using 10Gb iSCSI
- There was no HA or redundancy across the NICs

Network Layout

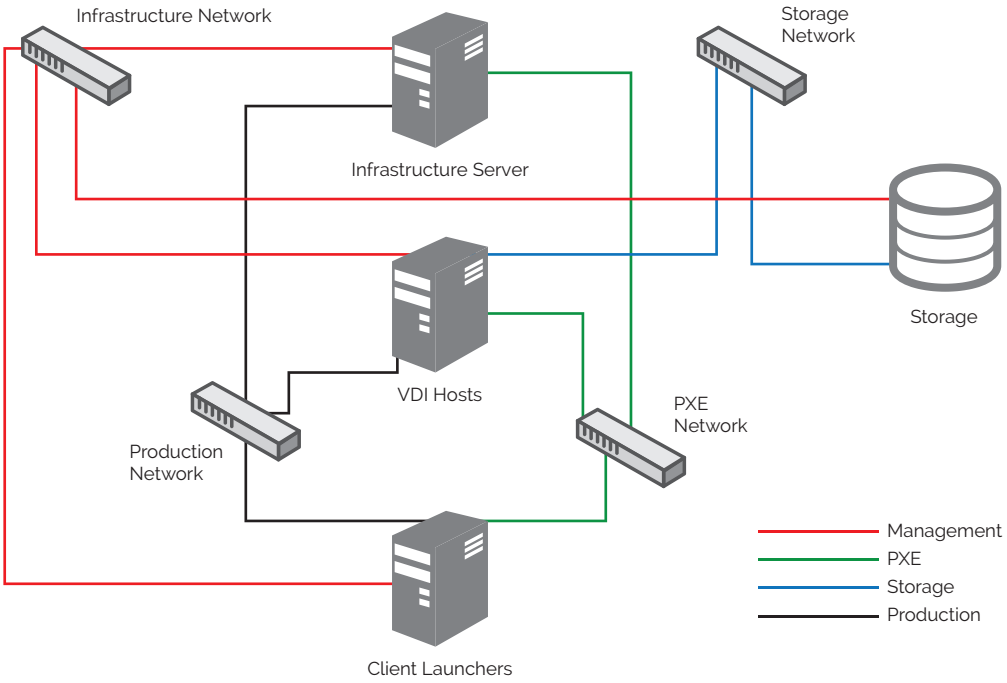


Figure 8: Network Layout

XenDesktop Configuration

- Used XenDesktop 7
- Provisioned with PVS version 7.0.0.46. Due to MCS working best with file-based storage and not all vendors supporting file-based storage (NFS), used PVS to provision the desktop VMs. This created a write-intensive environment
- Created one each broker (DDC) and PVS VM to support the infrastructure

Storage Configuration Completed by Tegile

- Tegile controlled the setup of their storage:
  – Number of LUNs, Cache Usage, iSCSI vs Fibre, etc.
- Citrix provided necessary configuration information prior to Tegile going on-site (IP addresses, etc)
- Tegile provided full disclosure of configuration. Citrix signed-off on configuration.
- Configurations contain best practices as would be recommended to customers in productivity environment
- Tegile disclosed street price of storage configuration, that number was used to determine cost per user for 750 users

Definitions

VM Definitions

- Infrastructure VMs:
  – 64-Bit Windows 2012
  – AD VM – 4GB memory, 1 vCPU
  – DDC VM – 8 GB memory, 2 vCPU – locally configured SQL
  – PVS VM – 4 GB memory, 2 vCPU – locally configured SQL
- Client VMs
  – Win7 (32-bit), 1.5 GB memory, 1 vCPU
- XD VMs
  – Win8 (64-bit), 1.5 GB memory, 1 vCPU

Login VSI

- Used Login VSI v3.7
- VSIShare used inside the chassis
- Used IOPs medium work load

Acknowledgements

This work would not have been possible without contribution and support of the following people from Citrix and Tegile:

- Bernie Hannon, Citrix
- Eliseo Alvarez, Citrix
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About Tegile

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