Reference Architecture

# A Cisco Integrated Desktop Virtualization Solution with Tegile IntelliFlash Storage

Deploying 1000 Virtual Desktops using VMware Horizon 6 with View powered by Cisco UCS, Cisco Nexus Switching, and Tegile IntelliFlash Storage

# Table of Contents

# What You Will Learn

This document describes the reference architecture of the Cisco® Desktop Virtualization solution with shared storage for 1000 virtual desktops based on VMware Horizon View 6 and VMware vSphere 5.5. The Cisco Desktop Virtualization solution includes Cisco UCS® B-Series Blade Servers, the Cisco Nexus® Switching 5500 Series platform, and the Tegile IntelliFlash™ T3700 storage array. This reference architecture is based on Cisco's "scalable architecture" deployment model for desktop virtualization.

## Cisco Desktop Virtualization Solutions

Cisco Desktop Virtualization solutions transform user desktops into workspaces while lowering operating costs and reducing initial capital outlay. They also offer rapid provisioning and simplified management. Built with an ecosystem of industry-leading technology partners like Tegile, IT environments of all sizes can benefit. With a portfolio of scalable architectural approaches that deliver consistently high-performance with an uncompromised user experience, Cisco Desktop Virtualization solutions scale as business demand grows.

The purpose of the reference architecture is to provide a tested modular architecture for a complete desktop virtualization solution. It features proven, best-in-class technologies including the desktop software, hypervisor, compute, networking, and storage elements. This reference architecture accelerates your desktop transformation by enabling faster deployments and offering flexibility, efficiency, and lower risk.

Storage is a critical element in the deployment of virtual desktop infrastructure (VDI). VMware provides the VMware View Planner tool to enable its partners to help assess and plan the appropriate compute, network, and storage configuration for VMware View environments.

With VMware vSphere 5.5 and View 6, along with a Cisco UCS B-Series server platform connected to a single 2 rack unit (2RU) multiprotocol Tegile IntelliFlash 3700 storage array, the system could deploy 1000 Microsoft Windows 7 virtual desktops. Details of the configuration are described in this document.
This reference architecture is not intended to be a comprehensive deployment and configuration guide and does not cover every aspect of this solution.

# Summary of Findings

- The combination of the Cisco Unified Computing System™ (Cisco UCS), Cisco Nexus switching, and Tegile IntelliFlash storage hardware with VMware ESXi 5.5, VMware Horizon 6 with View software produces a virtual desktop delivery system with high density per blade and per chassis.
- Cisco maintains its industry leadership with the new Cisco UCS Manager 2.2 software, which makes scaling and maintenance simple while helping to ensure consistency. The advanced networking and storage functionality provide various configuration options to deploy desktop workloads.

- The Cisco 10-Gbps unified fabric architecture has also been validated on second-generation Cisco UCS 6200 Series Fabric Interconnects and second-generation Cisco Nexus 5500 Series switches, processing more challenging workloads and maintaining unsurpassed user response times.
- The all-flash, multiprotocol Tegile IntelliFlash 3700 storage array can easily run 1000 virtual desktops, with in-line de-duplication and compression enabled to significantly reduce the amount of storage required to host the virtual desktops. The test meets boot, login, and steady-state requirements specified by LoginVSI, while providing an ~85 percent reduction in storage capacity as a result of the integrated in-line de-duplication and compression functionality of the storage array.

# Business Value

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, tiered, 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).

The reference 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, with the environment contained in the data center
- Better support for service-level agreements and compliance initiatives
- Lower operation and maintenance costs

# Modular Virtual Desktop Infrastructure Overview

## Cisco Data Center Infrastructure for Desktop Virtualization

Cisco focuses on three main elements to deliver the best desktop virtualization data center infrastructure: simplification, security, and scalability. The software, combined with platform modularity, provides a simplified, secure, and scalable desktop virtualization platform.

- Simplified
  - Highest virtual desktop density per server in the industry
  - Unified management, providing a common view of the platform
  - Predefined, validated infrastructure
- Secure
  - Virtual, desktop-aware access and control policies

  - Virtual, desktop-aware networking and on-demand provisioning
  - Segmentation and network security policies across LAN and WAN
- Scalable
  - Ability to linearly scale to thousands of desktops in a single domain
  - Rapid desktop provisioning through service profiles
  - Low-latency, high-bandwidth network for virtual desktop and multimedia delivery

The simplified, secure, scalable Cisco data center infrastructure solution for desktop virtualization saves time and money. It provides faster payback and ongoing savings (better ROI and lower TCO) with the industry's highest virtual desktop density per server. This means that fewer servers are needed, reducing both capital expenditure (CapEx) and operating expenses (OpEx). The solution also has much lower network infrastructure costs, with fewer cables per server and fewer ports required, through the use of the Cisco UCS architecture and unified fabric.

The simplified deployment of Cisco UCS for desktop virtualization accelerates the time to productivity and enhances business agility. IT staff and end users can be more productive in less time. When new opportunities arise, the business can react by deploying virtual desktops whenever and wherever needed. The high-performance Cisco UCS system and network deliver a near-native end-user experience, allowing users to be productive anytime and anywhere.

## Sample Questions for Project Planning and Solution Sizing

Some general project questions should be addressed at the outset:

- Has a VDI pilot plan been created based on a business analysis of the desktop groups, applications, and data?
- Is the infrastructure and budget in place to run the pilot program?
- Are the skill sets required to execute the VDI project available? Can these be acquired through hiring or contract?
- Have end-user experience performance metrics been identified for each desktop subgroup?
- How will success or failure be measured?
- What are the future implications of success or failure?

Here is a short list of sizing questions that should be addressed for each user subgroup:

- What desktop OS do they plan to use? Microsoft Windows 7 or Windows XP? 32-bit or 64-bit desktop OS?
- How many virtual desktops will be deployed in the pilot? How many in production? Will all virtual desktops use Microsoft Windows 7?
- How much memory will be needed per desktop in the target desktop group?
- Are there any multimedia, Adobe Flash, or graphics-intensive workloads?
- What is the end point graphics processing capability?
- Are any VMware ThinApp applications planned? Will they be packaged or installed?
- What is the storage configuration in the existing environment?
- Are sufficient I/O operations per second (IOPS) available for the write-intensive VDI workload?
- Will storage be dedicated and tuned for VDI service?
- Does the desktop have a voice component?
- Is anti-virus software a part of the image?
- Is user profile management (non-roaming-profile-based management) part of the solution?

- What are the fault tolerance, failover, and disaster recovery plans?
- Are there additional desktop subgroup-specific questions that need to be addressed?

## The Solution: A Unified, Pretested, and Validated Infrastructure for Desktop Virtualization

The Cisco Desktop Virtualization solution binds together the three critical elements of an end-to-end deployment: the end user, the network, and the data center. It draws on Cisco's architectural advantage to provide a solution that supports a diversity of endpoint devices and extends pervasive security and policy management to each virtual desktop. It's all powered by a new, virtualization-optimized, stateless server computing model – Cisco UCS.

### Base Components

The Cisco UCS computing platform includes:

- UCS 6200 Series Fabric Interconnects
- UCS 2200 Series IO Modules
- UCS 5108 Blade Chassis
- 7 UCS B200 M4 Blade Servers for virtual desktop hosting
- 1 UCS B200 M4 Blade server for virtual infrastructure management

The solution also includes:

- Cisco Nexus 5500 Series Switches
- Hypervisor: VMware ESXi 5.5 booted from local drives
- Virtual Desktop Connection Broker: VMware Horizon 6 with View
- Tegile IntelliFlash T3700 all flash storage array

### Cisco Unified Computing System

Cisco UCS is the first truly unified data center platform that combines industry-standard, x86-architecture blade and rack servers with networking and storage access to form a single system. Innovations in the platform include a standards-based unified network fabric, Cisco virtualized interface card (VIC), and Cisco UCS Extended Memory technology. The system uses a wire-once architecture with a self-aware, self-integrating, intelligent infrastructure that eliminates the time-consuming, manual, error-prone assembly of components into systems.

Cisco UCS B-Series Blade Servers provide a comprehensive line of 2- and 4-socket servers to deliver record-setting performance to a wide range of workloads. Based on Intel® Xeon® processor E7 and E5 product families, these servers are excellent for virtualized and nonvirtualized applications. These servers:

- Reduce CapEx and OpEx with converged network fabrics and integrated systems management
- Deliver performance, versatility, and density without compromise
- Address a broad set of workloads, including IT infrastructure, web infrastructure, and distributed databases for both virtualized and nonvirtualized environments
- Increase IT staff productivity and business agility through just-in-time provisioning and mobility support for both virtualized and nonvirtualized environments

## Cisco Nexus 5500 Series

Cisco Nexus 5500 Series switches deliver an innovative architecture to simplify data center transformation by enabling a high-performance, standards-based, multiprotocol, multipurpose, Ethernet-based fabric. They help consolidate separate LAN, SAN, and server cluster network environments into a single 10 Gigabit Ethernet fabric. This unification enables network consolidation and greater utilization of previously separate infrastructure and cabling, reducing by up to 50 percent the number of adapters and cables required and eliminating redundant switches. This infrastructure displacement also lowers power and cooling costs significantly.

## VMware vSphere 5

VMware vSphere 5 is the market-leading virtualization platform that is used in thousands of IT environments around the world. VMware vSphere 5 transforms a computer's physical resources by virtualizing the CPU, RAM, hard disk, and network controller. This transformation creates fully functional virtual desktops that run isolated and encapsulated operating systems and applications just like physical computers.

The high-availability features of VMware vSphere 5 are coupled with VMware Distributed Resources Scheduler (DRS) and vMotion, which enables the transparent migration of virtual desktops from one VMware vSphere server to another with little or no impact on the customer's use.

This reference architecture uses VMware vSphere Desktop edition for deploying desktop virtualization. It provides the full range of features and functions of the VMware vSphere Enterprise Plus edition, allowing customers to achieve scalability, high availability, and optimal performance for all their desktop workloads. Also, VMware vSphere Desktop comes with unlimited virtual RAM (vRAM). VMware vSphere Desktop edition is intended for customers who want to purchase VMware vSphere licenses to deploy desktop virtualization.

## VMware Horizon 6 with View

VMware Horizon® is a family of desktop and application virtualization solutions designed to deliver Windows and online services from any cloud. With Horizon, VMware extends the power of virtualization—from data centers to devices—to deliver desktops and applications with great user experiences, closed-loop manageability, and hybrid- cloud flexibility.

Horizon 6 allows IT to deliver virtual or RDSH hosted desktops and applications through a single platform to end users. These desktop and application services—including RDS hosted apps, packaged apps with VMware ThinApp®, SaaS apps, and even virtualized apps from Citrix—can all be accessed from one unified workspace to provide end users with all of the resources they want, at the speed they expect, with the efficiency business demands. Horizon 6 is available in three editions:

- Horizon View Standard – Simple, powerful VDI with a great user experience
- Horizon Advanced – Cost-effective delivery of desktops and applications through a unified workspace
- Horizon Enterprise – Desktops and applications delivered with cloud automation and management

Horizon 6 allows organizations to extend the power of desktop and application virtualization to support workplace mobility while driving greater levels of operational efficiency at lower costs.

Key feature highlights include:

***Desktops and Applications Delivered Through a Single Platform***

Deliver virtual or remote desktops and applications through a single platform to streamline management, easily entitle end users, and quickly deliver Windows desktops and applications to end users across devices and locations.

Horizon 6 now supports a single platform for delivering hosted Windows applications and shared desktop sessions from Windows Server instances using Microsoft Remote Desktop Services (RDS), virtual desktops, and ThinApp packaged applications.

***Unified Workspace with Secure and Trusted Access***

With Horizon 6, end users can simply and securely access desktops and applications (including RDS hosted apps, packaged ThinApps, SaaS apps, and even virtualized apps from Citrix) through a unified workspace. IT organizations can similarly secure desktops and apps based on even the most stringent regulations, streamlining the management of multiple identity sources like active directory and LDAP to efficiently manage end-user access. End users can also use single sign-on (SSO) from their Unified Workspace Web app portal to sign in to AirWatch® Web Secure Content Locker™ and to enroll their devices if they are also using AirWatch Mobile Device Management.

***Comprehensive Workspace Environment Management***

Horizon 6 ensures that IT can consolidate control, delivery, and monitoring while protecting user compute resources. Horizon 6 now includes support for:

*User Environment Management*

VMware User Environment Manager™ offers personalization and dynamic policy configuration across any virtual, physical, and cloud-based environment.

- Simplify end-user profile management by providing organizations with a single and scalable solution that leverages existing infrastructure.
- Provide end users with quick access to a Windows workspace and applications, with a personalized and consistent experience across devices and locations.

*Real-time Application Delivery and Management*

- Instantly provision applications at scale.
- Dynamically attach applications to users, groups, or devices, even when users are logged onto their desktop.
- Provision, deliver, update, and retire applications in real time.

*Policy and Image Management*

- Support for desktop and application provisioning and entitlement through View.
- Support for Mirage unified image management for streamlined management across virtual datacenters as well as physical and full-clone virtual machines.
- A cloud pod architecture that allows IT to easily move and locate View pods across datacenters and sites.

*Analytics and Automation*

- Cloud analytics with VMware vRealize™ Operations for Desktops and Applications provides comprehensive visibility across a VMware and Citrix desktop and application environment, allowing IT to optimize the health and performance of desktop and application services.

*Orchestration and Self-Service*

- vCenter provides a centralized platform to manage your desktop workloads.
- A plug in to VMware vRealize™ Orchestrator™ that allows IT organizations to leverage VMware vRealize™ Automation™ for automated desktop and application provisioning.

Support for VMware vSphere 5.5 allows one to leverage the latest functions of the leading cloud infrastructure platform for highly available, scalable, and reliable desktop services.

### Tegile IntelliFlash™ Storage

Tegile IntelliFlash storage arrays make flash storage easy and affordable. With the ability to run flash and hard disk on the same system, along with NAS and SAN file protocols, Tegile offers you one flash platform for any workloads. Manage all of your storage from a single user interface and save on maintenance and labor. Use all-flash arrays for mission-critical applications, and hybrid arrays for purposes like disaster recovery, saving money without compromising performance. With multiprotocol network attached storage (NAS) and storage area network (SAN) connectivity, these virtual data storage systems are easy-to-use, fully redundant, and highly scalable. Additionally, they come complete with built-in snapshot, replication, near-instant recovery, and virtualization management features.

Tegile's patented MASS technology accelerates performance to solid-state speeds without sacrificing the capacity or cost advantage of hard disk storage. Additionally, this technology enables on-the-fly de-duplication and compression, shrinking your storage footprint as much as 80%.

The portfolio of Tegile IntelliFlash storage arrays scale to accommodate the various capacity and performance requirements of customers. The IntelliFlash product line includes the all-flash T3600, T3700, and T3800 storage arrays, with the T3800 providing the most capacity. The product line also includes the hybrid T3100, T3200, and T3300 storage arrays, with the T3300 providing the most performance. In addition, the product line includes storage expansion shelves to add capacity. The expansion shelves include a mix of solid-state and hard disk drives (SSDs and HDDs).

The benefits of Tegile IntelliFlash's balanced approach to storage include:

- Performance acceleration through intelligent use of DRAM, SSD, and metadata acceleration
- Reduced costs through efficient use of storage capacity with in-line, variable-block de-duplication, compression, and thin provisioning
- Flexibility resulting from integrated multiprotocol support, including Fibre Channel, iSCSI, Network File System (NFS), and Common Internet File System (CIFS)
- Enhanced data protection and availability through silent data corruption detection and correction along with snapshots, cloning, remote replication, and a rich set of RAID options.
- Ease of use through application and VM-aware provisioning and reporting, as well as customizable dashboards

## Solution Overview and Benefits

This solution uses Cisco UCS, Cisco Nexus 5548UP switches, Tegile IntelliFlash storage, and VMware vSphere 5.5 to provide resources for a VMware View 6 environment of Windows 7 32-bit virtual desktops provisioned by VMware View Composer.

Planning and designing the server, networking, and storage infrastructure for VMware View environment is a critical step because the server infrastructure should be sized to handle the desktop workload, both in terms of density and scale. In addition, the networking infrastructure should be provisioned to handle bursts of data traffic. 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 infrastructure must be able to:

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

## Solution Benefits

Cisco UCS with Tegile IntelliFlash storage delivers:

- High performance: The success of VDI deployments is largely determined by end-user satisfaction. Users expect response times in a VDI environment to be on par with dedicated desktop and laptop computers. The Cisco Nexus 5500 Series and Cisco UCS B200 M4 Blade Servers, along with the virtual interface card (VIC), provide a high-performance, low-latency network and compute platform. Tegile IntelliFlash storage is architected to deliver high I/O throughput and IOPS for virtualized environments through the intelligent use of flash storage and hard disk drives. The joint Cisco and Tegile solution provides a high-performance compute, network, and storage platform that can deploy the rich set of virtual desktop features and functions delivered by VMware View.
- Storage capacity reduction: The integrated, in-line de-duplication, compression, and thin provisioning technologies in Tegile IntelliFlash storage arrays dramatically reduce physical storage consumption. Customers using Tegile IntelliFlash storage have reported up to 83 percent storage capacity reduction with the use of in-line de-duplication and compression. These data reduction features are provided at no extra cost and are included in the price of the array.
- Reduced server and storage footprint: Both Cisco UCS and Tegile IntelliFlash storage have been designed with virtualization in mind. The high compute, memory, and network capacity provided by Cisco UCS enables a high density of virtual desktops in a compact footprint with fewer physical components. The reduced number of components enabled by Cisco UCS, combined with efficient storage use through data reduction enabled by Tegile IntelliFlash storage, directly result in lower CapEx and OpEx for the VMware View virtual desktop deployment.
- Availability: Cisco UCS and Tegile IntelliFlash storage arrays are both designed with redundant components and no single point of failure. Both systems also provide proactive monitoring and alerts. Tegile IntelliFlash storage arrays come integrated with a rich set of RAID options along with features like snapshots, cloning, and remote replication for increased data availability. The overall solution enables a VMware View deployment with fewer disruptions to end users.
- Single platform for multiple workloads: Cisco UCS and Tegile IntelliFlash storage support multiple protocols for storage access. Both support NAS and SAN protocols. While this particular solution has been tested with NFS for storage access, the integrated multiprotocol support in Cisco UCS and Tegile IntelliFlash storage provides customers with flexibility and protocol choice. Desktop images can be deployed using NFS, iSCSI, or Fibre Channel protocol, while data folders for the Microsoft Windows virtual desktops can be provisioned using CIFS on the same Tegile IntelliFlash storage array and Cisco UCS system.

# Architecture of VMware Horizon 6 with View on Cisco UCS and Tegile Storage Solution

This section describes the topology and reference architecture for the deployment of 1000 virtual desktop users using Cisco UCS, Tegile IntelliFlash storage, and VMware View.

## Solution Components

The solution has been validated using LoginVSI 4.0, following the VMware recommended test guidelines. The test configuration consists of 1000 linked clone Windows 7 32-bit desktop virtual machines using Remote Desktop Protocol (RDP). The solution processes a steady state workload of 7 to 10 IOPS per VM, simulating a Windows 7 task user profile. The solution passed the LoginVSI test criteria and met the VMware requirements to deliver the application response times required for virtual desktop deployments.

Figure 1 shows the server, storage, and network topology. The solution was configured for high availability:

- One Cisco UCS 5108 Blade Chassis with four redundant power supplies, four redundant fans and two redundant Cisco IO Modules
- Eight UCS B200 M4 Blade Servers providing server-based N+1 fault tolerance
- Two Cisco UCS 6248UP fabric Interconnects
- Two Cisco Nexus 5548UP 10 Gigabit Ethernet, Fibre Channel, and FCoE switches
- One Tegile IntelliFlash T3700 all-flash storage array with active-active storage controllers
- The eight blade servers shared eight 10 Gigabit Ethernet ports, with four links connected to Fabric Interconnect A and the other four links connected to Fabric Interconnect B
- Each Cisco fabric interconnect was connected to both Cisco Nexus 5548UP switches
- The Tegile T3700 storage array was connected to both Cisco Nexus 5548UP switches with fully redundant 10 Gigabit Ethernet links from both storage controllers
- The two Cisco Nexus switches were also connected together with redundant 10 Gigabit Ethernet interswitch links
- The Tegile IntelliFlash T3700 storage array was shared among all the blade servers using NFS over 10 Gigabit Ethernet
- NFS shares from the IntelliFlash storage array are accessed across dual ports on both controllers using virtual IP addresses
- In the event of a single path failure on a controller, or a single controller failure, the NFS shares will continue to be accessible in a transparent manner to the hosts

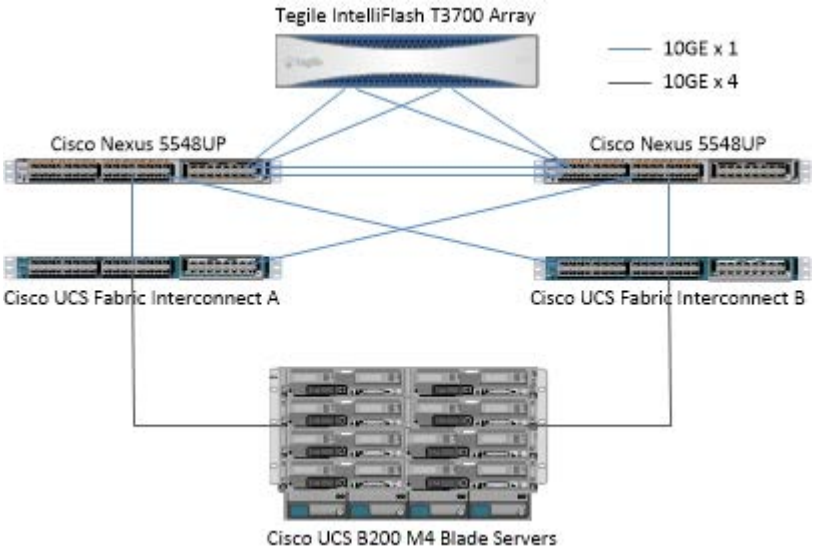



**Figure 1 - Solution Topology**

Figure 2 shows a high-level architecture of the 1000 VMware View virtual desktop solution using Cisco UCS blade servers and the Tegile IntellliFlash T3700 storage array.

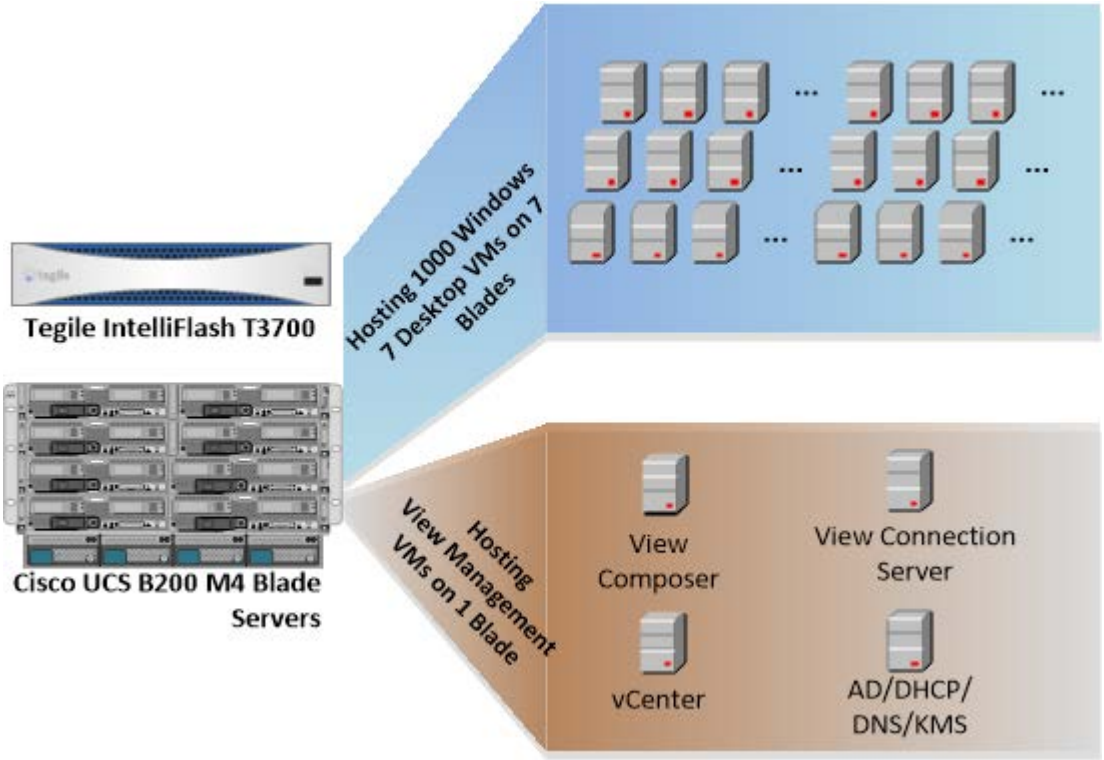



**Figure 2 - VMware View Virtual Desktop Architecture**

The components of the virtual desktop architecture are:

- 1000 Windows 7 32-bit virtual desktops were configured.
- Each virtual desktop was configured with:
  - 1 vCPU
  - 1.5-GB vMemory
  - 25-GB provisioned virtual disk space
  - 1 vNIC
  - Max display resolution: 1920 x 1200
  - Each Windows 7 desktop was installed with several desktop applications such as Microsoft Office 2007 Word, Excel, Power Point and Outlook, Internet Explorer, Firefox, Adobe Reader, 7Zip, and Windows Media Player.
- The 1000 virtual desktops were hosted on seven Cisco UCS B200 M4 Blade Servers.
- 143 virtual desktops were hosted on each blade server.
- VMware ESXi 5.5 was installed on the blade servers.
- One Tegile IntelliFlash storage array was used to store all 1000 virtual desktops.
- One Cisco UCS 200 M4 Blade Server was used to host the following infrastructure virtual machines:
  - VMware vCenter 5.5
  - VMware View Connection Server 6.0
  - VMware View Composer 6.0
  - LoginVSI 4.0
  - Microsoft Active Directory Domain Controller hosting DHCP, DNS and KMS licensing

## Solution Validation

This section details the configuration and tuning that was performed on the individual components to produce a complete, validated solution.

### Server Configuration: Cisco UCS B200 M4 Blade Server

This section provides the detailed configuration of the Cisco UCS Blade Servers.

Each UCS B200 M4 blade server was configured with:

- Two Intel Xeon E5-2660 v3 10-core processors (20 total cores)
- 256 GB of RAM
- Cisco Virtual Interface Card 1340 Converged Network Adapter
- Two 300-GB 10K RPM 2.5-inch SAS HDD local drives

Figure 3 shows the equipment view of the Cisco UCS B-Series chassis. It contains eight blade servers and two Cisco UCS Fabric Interconnect modules (A and B). Fabric Interconnect A serves as the primary interconnect and B serves as the subordinate interconnect. Figure 4 shows the UCS Fabric Interconnects and highlights the port status of one of the ports used to interface with the uplink switch.

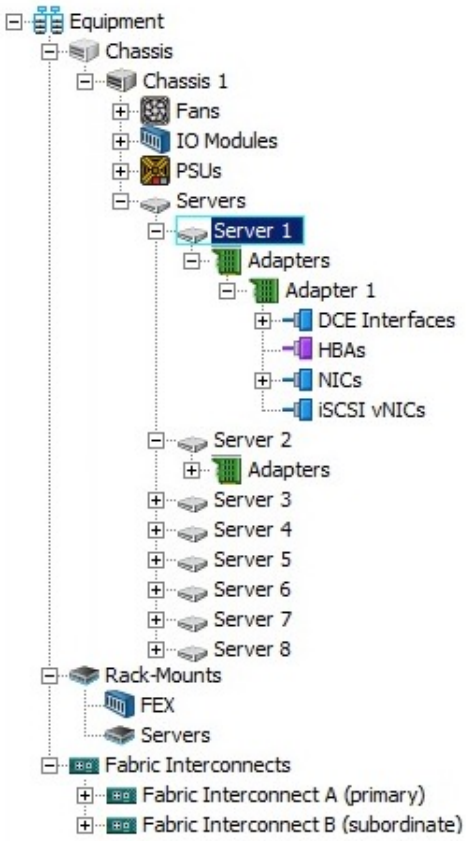



**Figure 3 - Cisco UCS Manager: Equipment View**

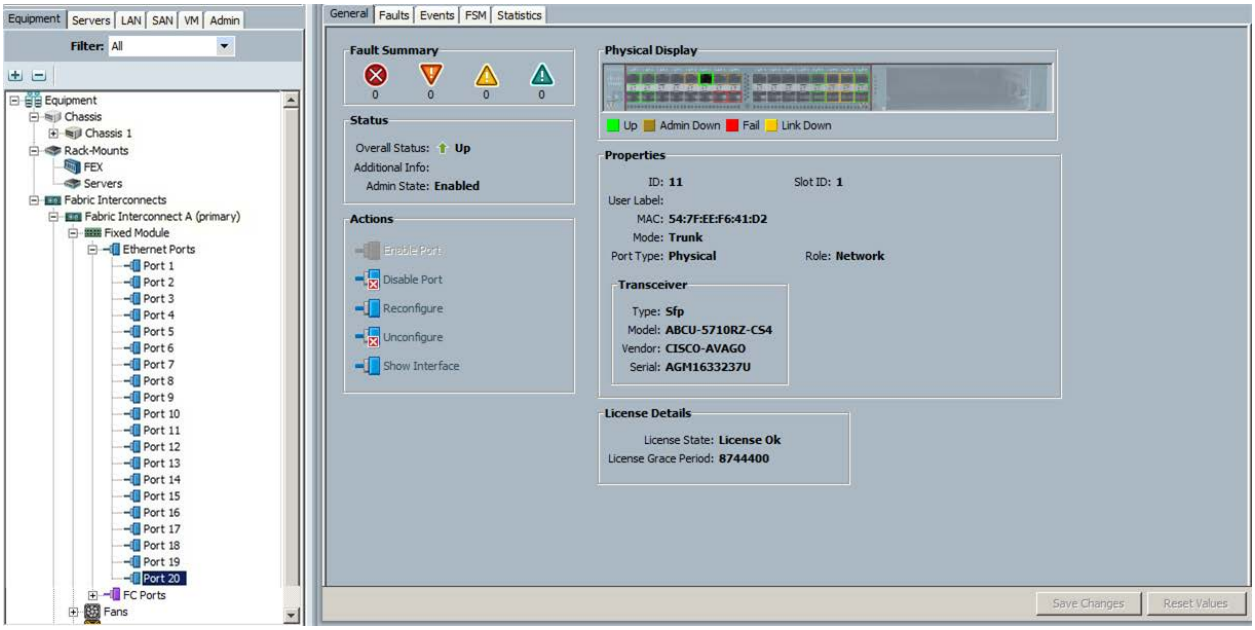



**Figure 4 - Cisco UCS Manager: Fabric Interconnects**

Figure 5, below, shows vNIC configuration on the Cisco UCS blade server.

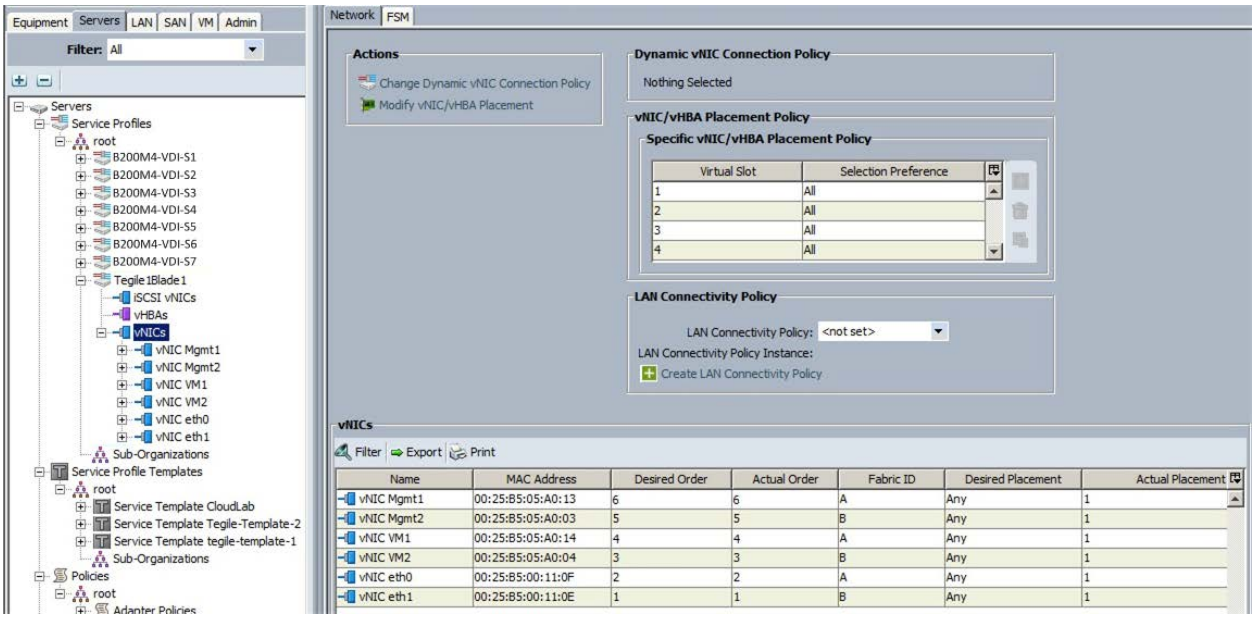



**Figure 5 - UCS Manager: Blade vNIC Configuration**

Each blade server is configured with six vNICs in three groups:

- Group 1: vNIC Mgmt1 and vNIC Mgmt2 were used for virtual infrastructure management and vMotion.
- Group 2: vNIC VM1 and vNIC VM2 were used for the desktop virtual machines.
- Group 3: vNIC eth0 and vNIC eth1 were used for NFS.
- In each group, one vNIC was connected to Fabric A and the other to Fabric B, providing dual-redundant network paths for all three functions.

## Server Configuration: VMware vSphere 5.5

Figure 6 shows the network configuration on the ESX host.

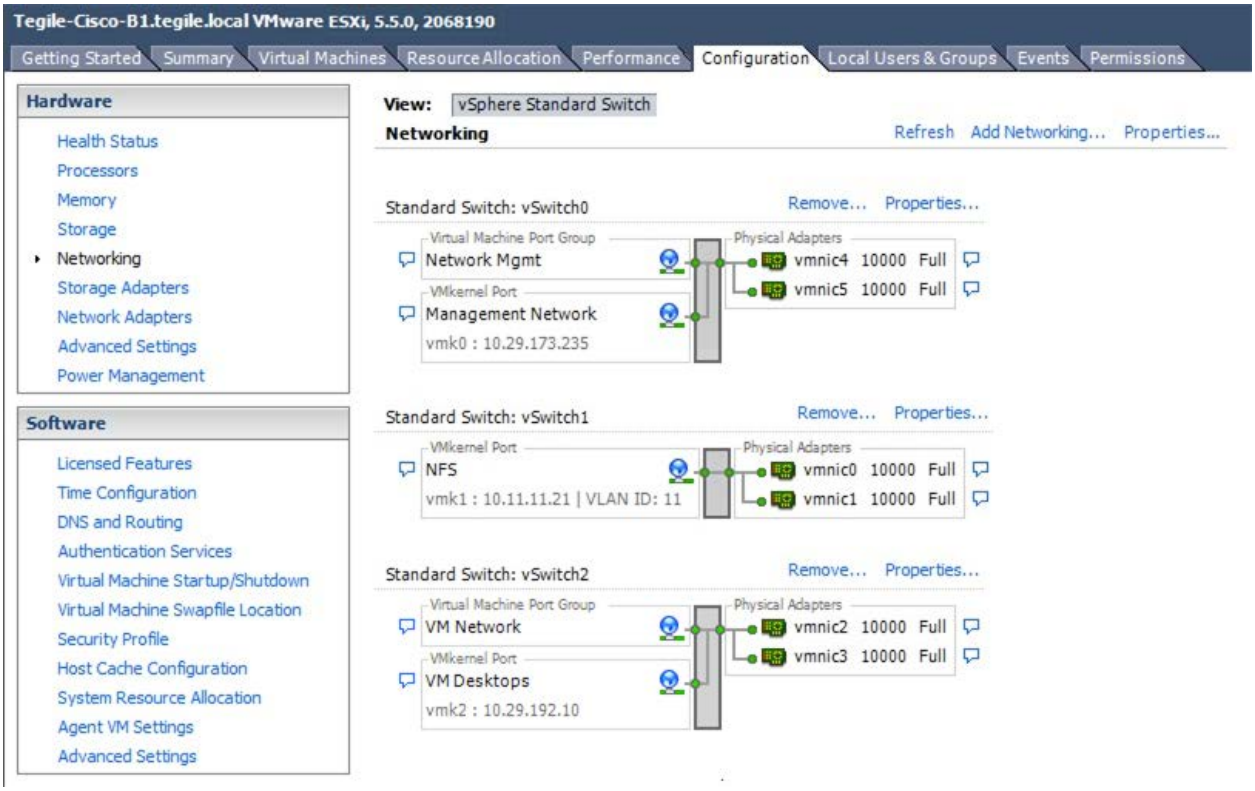



**Figure 6 - ESX Networking Configuration**

Corresponding to the three groups of vNICs configured on each Cisco UCS blade, three virtual switches were configured on each ESX host:

- vSwitch0 for virtual infrastructure management
  - The vmnic4 and vmnic5 physical adapters were configured to provide dual-redundant paths.
- vSwitch1 for NFS storage access
  - The vmnic0 and vmnic1 physical adapters were configured to provide dual-redundant paths.
- vSwitch2 for virtual desktop VMs
  - The vmnic2 and vmnic3 physical adapters were configured to provide dual-redundant paths.

Figure 7 shows the vSwitch network configuration. The “Number of Ports” parameter was increased from 120 to 248 to support 150 virtual desktops on a single ESX host.

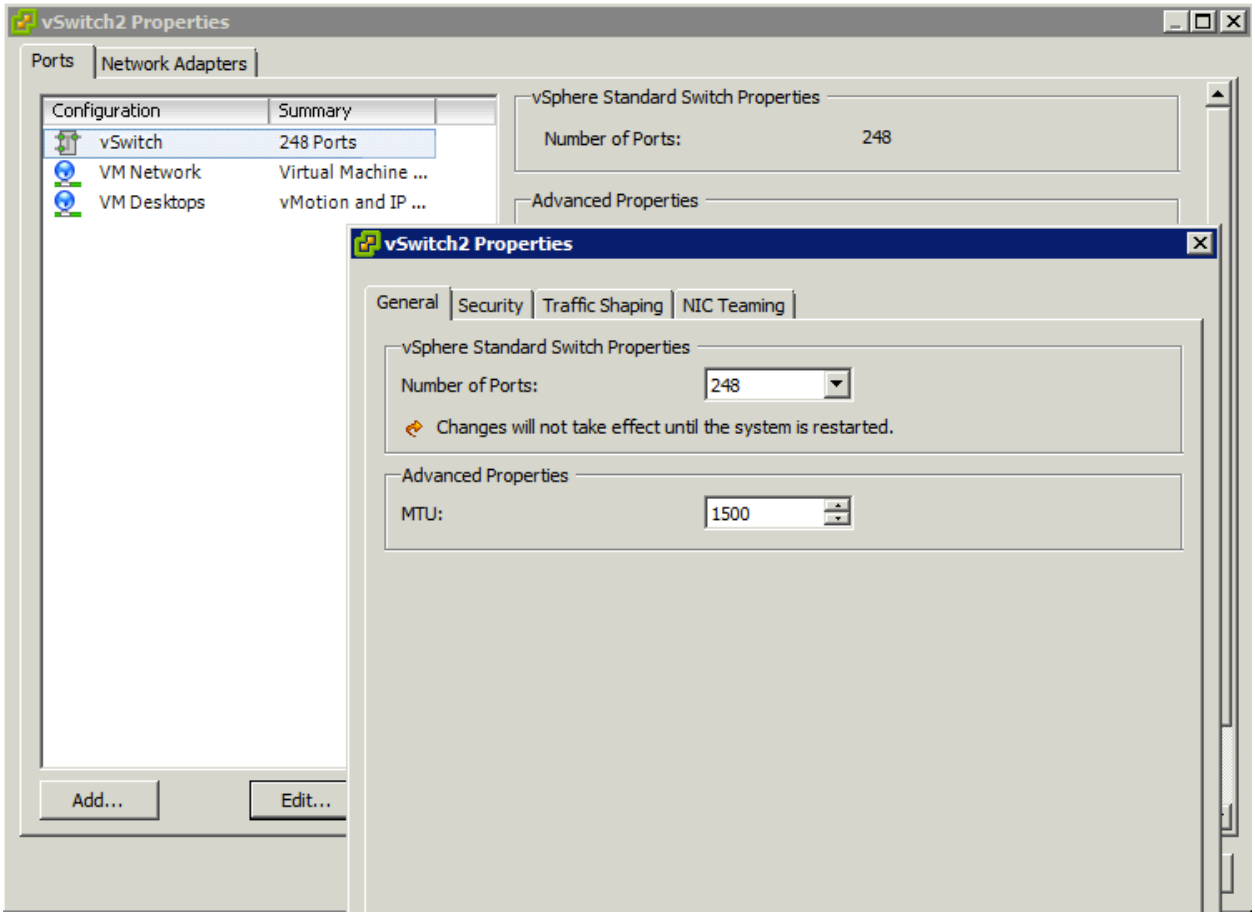



Figure 7 - ESX vSwitch Configuration

Figure 8 shows the storage configuration on the ESX hosts. Seven NFS datastores, tegile1 through tegile7, were configured on each ESX host. The corresponding NFS shares were exported by the Tegile IntelliFlash T3700 storage array, configured with floating IP addresses 10.11.11.10 and 10.11.11.11, and shared by Ethernet ports on both storage controllers for redundancy and load balancing.

The NFS MaxQueueDepth parameter was set to 16 on each ESX host.

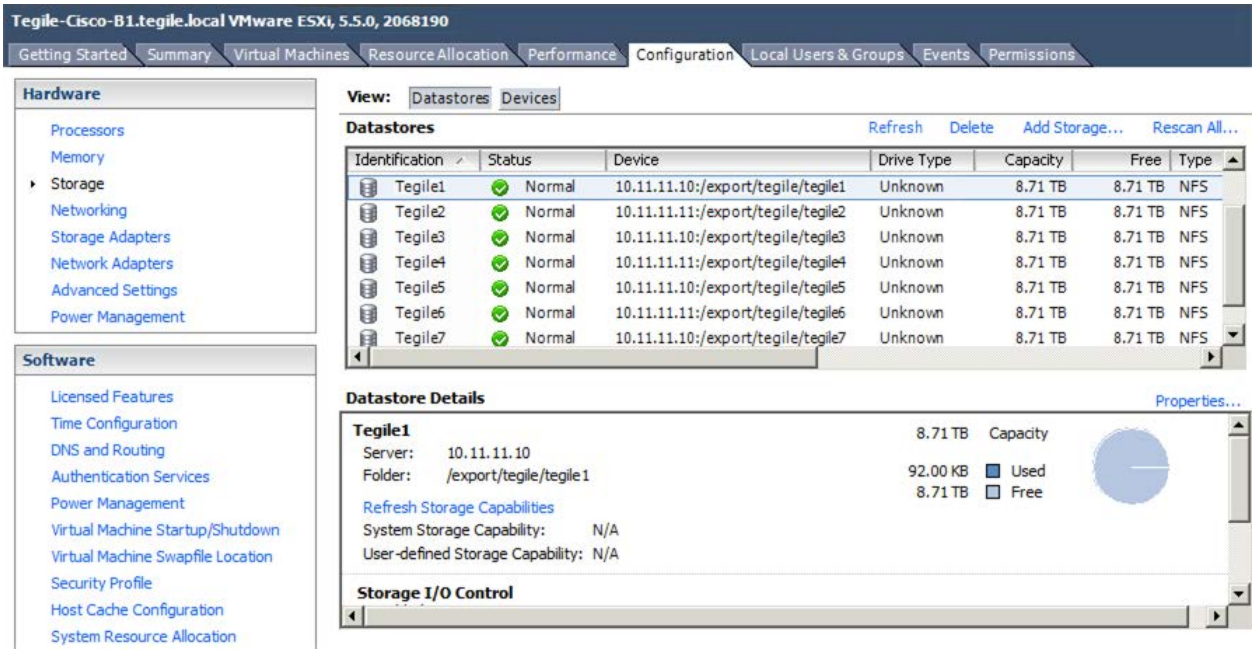



Figure 8 - ESX Storage Configuration

## Switch Configuration: Cisco Nexus 5500 Series

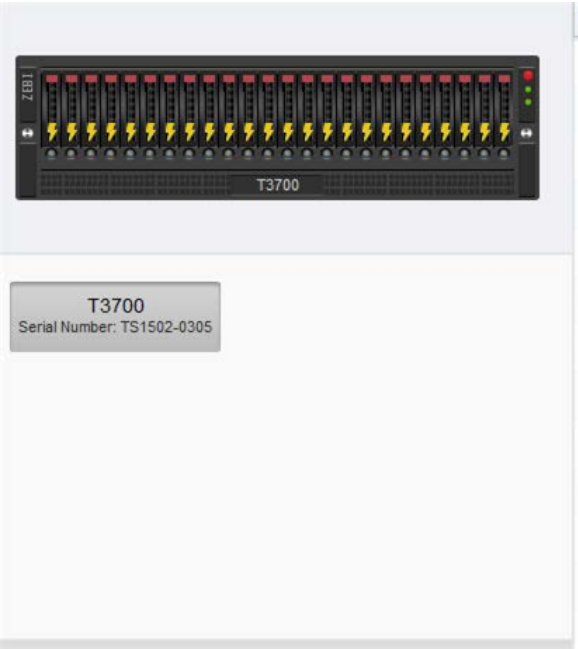
The Cisco Nexus 5500 Series Switch was configured as follows:

- The inter-switch link ports, and the ports connected to the Cisco UCS Fabric interconnects, were configured as trunk ports.
- The ports connected to the Tegile IntelliFlash T3700 storage array were configured as access ports.
- VLAN 11 was used for NFS.

## Storage Configuration: Tegile IntelliFlash T3700

This section provides details of the Tegile IntelliFlash T3700 storage array configuration. The 2RU Tegile IntelliFlash T3700 all-flash storage array used for this test had 24 TB of raw capacity, with two redundant active-active controllers and with two 10 Gigabit Ethernet ports on each controller. The array was configured with seven NFS shares. These shares were available over the 10 Gigabit Ethernet ports across the two redundant controllers. The integrated, in-line de-duplication and compression functionality were enabled for this test.

Figure 9 shows storage configuration for the Tegile IntelliFlash T3700 storage array.




| Disk Number | Size | Pool Name | Disk Type |
|---|---|---|---|
| 0 | 931.51G | VDIPool | Data SSD |
| 1 | 931.51G | VDIPool | Data SSD |
| 2 | 931.51G | VDIPool | Data SSD |
| 3 | 931.51G | VDIPool | Data SSD |
| 4 | 931.51G | VDIPool | Data SSD |
| 5 | 931.51G | VDIPool | Data SSD |
| 6 | 931.51G | VDIPool | Data SSD |
| 7 | 931.51G | VDIPool | Data SSD |
| 8 | 931.51G | VDIPool | Data SSD |
| 9 | 931.51G | VDIPool | Data SSD |
| 10 | 931.51G | VDIPool | Hot-Spare SSD |
| 11 | 931.51G | VDIPool | Hot-Spare SSD |
| 12 | 931.51G | Peer:VDIPool-b | Data SSD |

**Figure 9 - Tegile IntelliFlash Storage Configuration**

Note the following about the storage configuration:

- One storage pool, called VDIPool, was configured on the Tegile IntelliFlash T3700 storage array.
- The storage pool consisted of 9 1-TB eMLC SSDs in a RAID10 configuration.
- Two additional eMLC SSD were configured as hot spares for the storage pool.
- The storage pool was configured with thin provisioning, with in-line compression and de-duplication enabled, and with the file share block size set to 32 KB.
- Seven 9-TB thin-provisioned NFS shares were configured as part of VDIPool for virtual desktop storage.

Seven total NFS shares were created, tegile1 through tegile7. Figure 10 shows the Tegile IntelliFlash NFS share configuration.

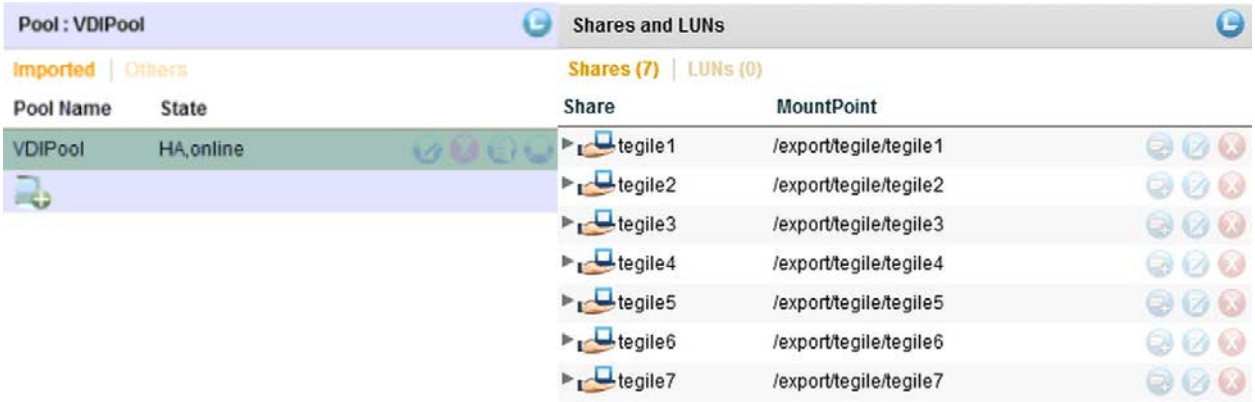



**Figure 10 - Tegile IntelliFlash: NFS Configuration**

Figure 11 shows storage space utilization and storage capacity reduction resulting from the integrated, in-line de-duplication and compression features of the Tegile IntelliFlash storage array after 1000 Windows 7 virtual desktop linked clones were provisioned.

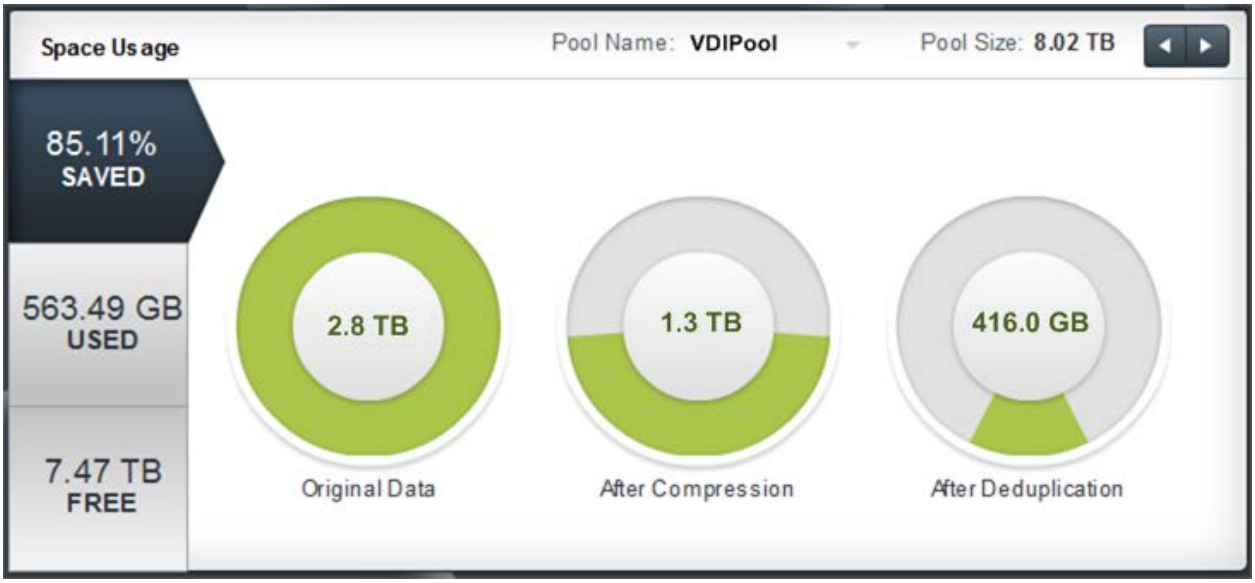



**Figure 11 - Dashboard Space Usage**

The original data for 1000 virtual desktops and infrastructure was ~2.8 TB per controller, but the actual storage capacity used was only 416.0 GB per controller. Storage capacity reduction was ~85 percent, with a ~31 percent reduction from in-line de-duplication and a 48 percent reduction from compression.

The NFS queue depth on the Tegile IntelliFlash storage appliance was set to 1024 to enable concurrent I/O requests from all seven VDI blades with an NFS queue depth of 16 on each host.

## VDI Configuration: Server and Storage

Figure 12 shows the vCenter cluster configuration for the VDI infrastructure. The cluster contains seven ESXi hosts on seven UCS B200 M4 Blade Servers. The 1000 Windows 7 32-bit virtual desktops were evenly spread across the seven ESXi hosts. Storage for the 1000 virtual desktops was evenly spread across the seven NFS shares configured on the Tegile IntelliFlash T3700 storage array. The server and storage configuration resulted in an even distribution of ~150 virtual desktops per ESXi host and ~150 virtual desktop linked clones per NFS share.

Each Windows 7 32-bit virtual desktop was configured with 1 vCPU, 1.5 GB vMemory, and 25 GB of provisioned virtual disk space.

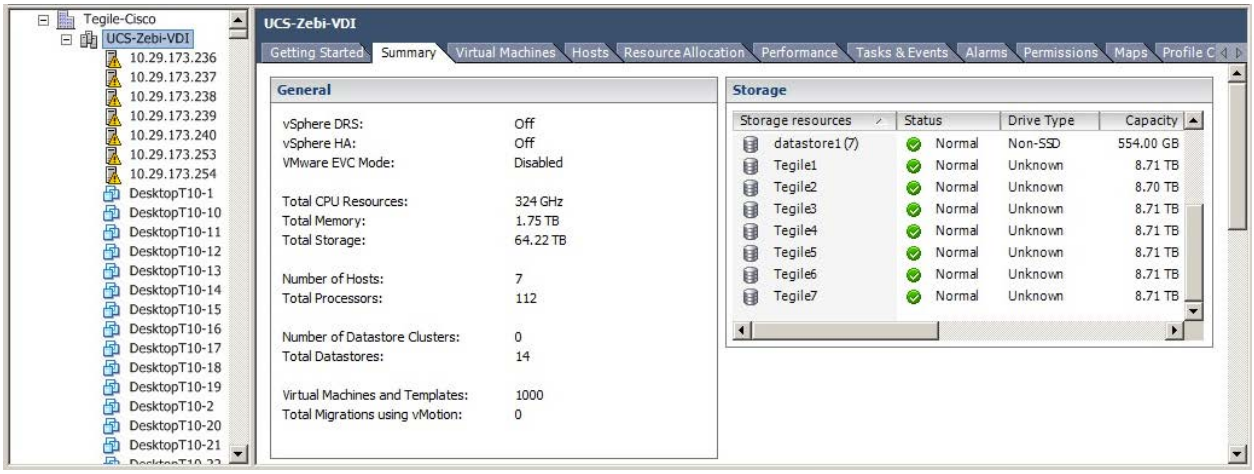



Figure 12 - VMware vCenter Cluster Configuration for VDI (UCS-IntelliFlash-VDI)

Figure 13 shows a sample of the aggregate storage array level and per-VM real time analytics displayed on the Tegile IntelliFlash web-based management interface.


Figure 13 - Tegile IntelliFlash: Virtual Machine Analytics

# Testing Methodology and Results

To perform the test, the LoginVSI 4.0 tool was used to run a representative workload on each of the 1000 Windows 7 virtual desktops. The test was performed according to the guidelines provided in the VMware Horizon Fast Track 2.0 Proven Storage test criteria.

## Testing Methodology and Success Criteria

Login VSI performs benchmarks for Virtual Desktop Infrastructure (VDI) workloads through system saturation. It loads the system with simulated user workloads using well-known desktop applications, such as Microsoft Office, Internet Explorer, and Adobe Reader. By gradually increasing the amount of simulated users, the system is eventually saturated. After the system is saturated, the response time of the applications increases significantly. This latency in application response times indicates whether the system is almost overloaded. By nearly overloading a system, it is possible to find out what the maximum user capacity is.

After a test is performed, the response times are analyzed to calculate the maximum active session and desktop capacity, called VSImax.

## VSImax Operations

The simulated desktop workload is scripted in a 48-minute loop when a simulated Login VSI user is logged on performing generic office worker activities. After the loop is finished, it restarts. Within each loop, the response times of the six operations shown in Table 34 are measured in a regular interval. The response times are used to determine VSImax.

These measured operations hit different subsystems, such as CPU (user and kernel), memory, disk, the OS, the application, print, and so on. The operations are short by nature. When such operations are consistently long, the system is saturated because of excessive queuing. As a result, the average response times escalate. This effect is visible to end users. If such operations consistently consume multiple seconds, the user regards the system as slow and unresponsive.

| MEASUREMENT ID | MEASUREMENT ACTION | MEASUREMENT ACTION DETAILED | MEASURES RELATED RESOURCE |
|---|---|---|---|
| WSLD | Start Microsoft Word and load a random document | Start and load a local random document file from the content pool | CPU, RAM, and I/O |
| NSLD | Start VSI Notepad and load a document. | Start and load a local random text file from the content pool | CPU and I/O |
| WFO | Open a file in VSI-Notepad | Ctrl+O | CPU, RAM, and I/O |
| NFP | Open Print in VSI-Notepad | Ctrl+P | CPU |
| ZHC | Compress files with high compression | Compress a local random PST file from the content pool (5MB) | CPU |
| ZNC | Compress files with no compression | Compress a local random PST file from the content pool (5MB) | I/O |

## Login VSI Test Configuration

The Login VSI test suite comes with several types of workloads to simulate various types of users. The workload used in this test was the “Office worker” simulation. This workload simulates what a real office employee would do and mimics how resources are used in deployed VDI environments that use only 1vCPU in their VM’s. The following applications are included into the Office worker workload:

- Microsoft Outlook
- Microsoft Internet Explorer
- Microsoft Word
- Adobe Reader
- Microsoft PowerPoint
- Microsoft Excel
- Login VSI photo viewer
- Doro PDF Writer

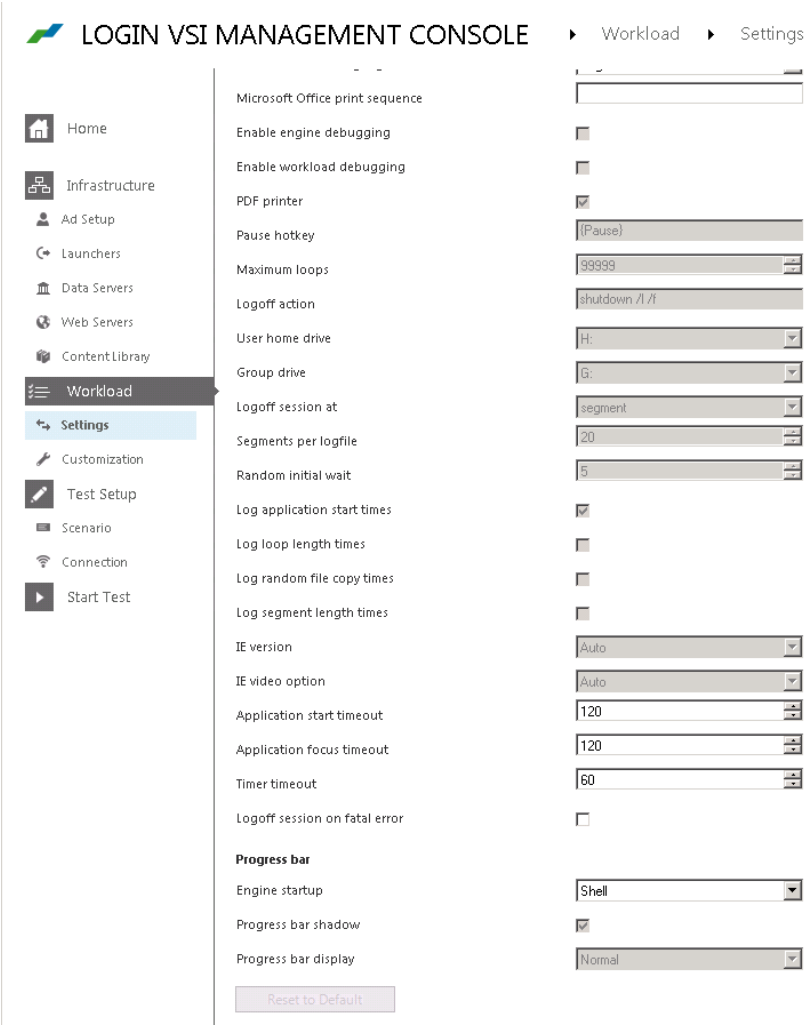



**Figure 14 - Login VSI Office Worker Workload Profile**

LoginVSI has a Benchmark mode which predefines and constrains the launch window to 2880 seconds (48 minutes). This gives a normalized baseline to compare all tests and allows for the workload to complete a full 48 minute cycle. There is only a single phase to this profile. A user starts a remote desktop session on a VM and begins the workload. Additional users login and begin the workload at a rate of one user every 2.9 seconds. This rate of login is maintained for the full 48 minutes until all 1000 users have logged in and begun the simulated workload.

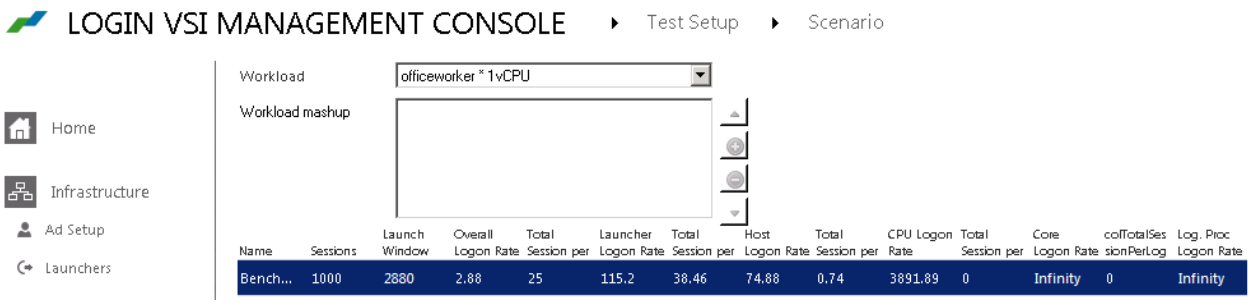



Figure 15 - Login VSI Test Profile

## Test Results

The goal of the test was to validate that the solution architecture can provide the required application QoS for the targeted 1000 Windows 7 virtual desktop users based on VMware View 6, Cisco UCS B200 M4 Blade Servers, and the Tegile IntelliFlash T3700 storage array under the test guidelines of Horizon Fast Track Prove Storage and Login VSI.

Two different login VSI tests were performed using the architecture shown in Figure 1:

- The first test was performed to verify that a single UCS B200 M4 blade server could support 150 virtual desktops.
- The next test was performed with seven UCS B200 M4 blade servers to validate the reference solution for 1000 virtual desktops.

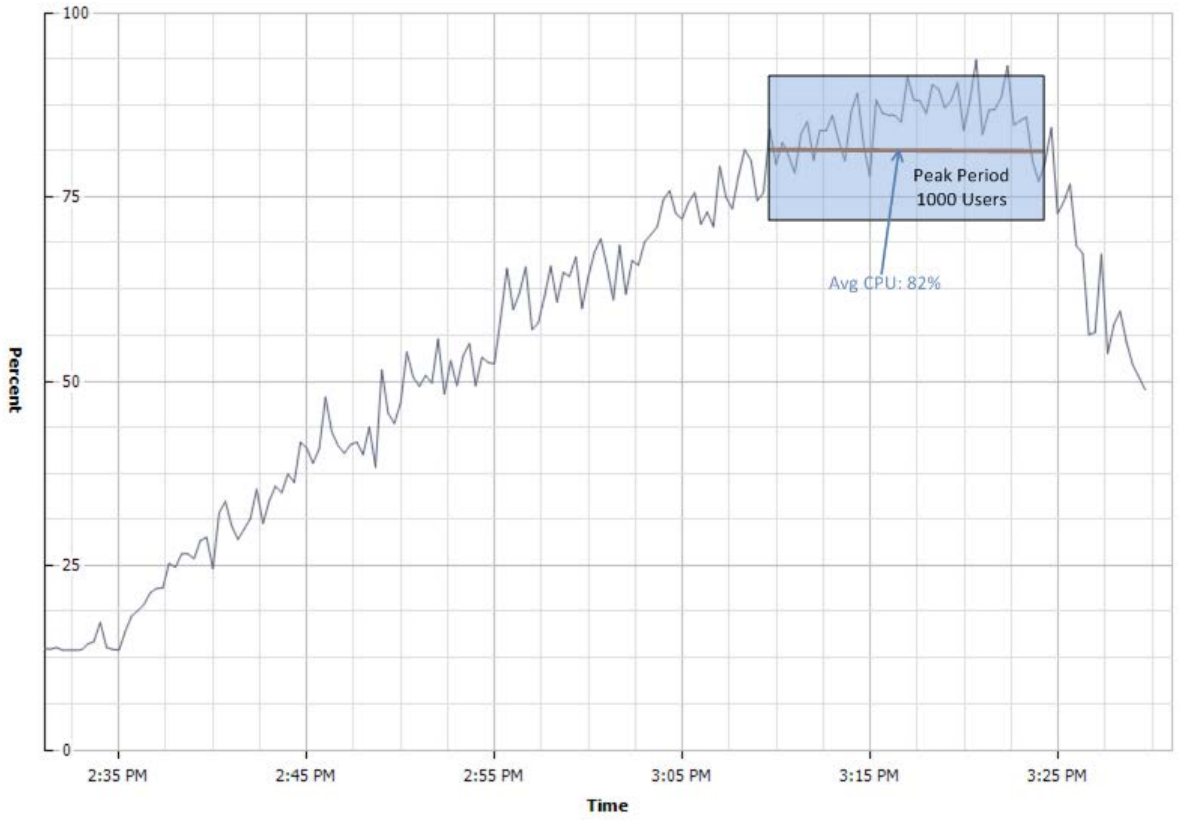
Both tests completed successfully.

## Single Server 150 VDI Users Test Results

The purpose of this test was to verify that each blade server was capable of handling 150 VDI users of the targeted profile.

In this test, a single Cisco UCS B200 M4 blade was used to host 150 Windows 7 32-bit virtual desktops on the configuration shown in Figure 1. The test was performed using the Login VSI Office Worker workload and test profiles described in the previous section.

Figure 16 shows the CPU utilization, with 150 virtual desktops on a single Cisco UCS B200 M4 blade server. The CPU utilization peaked around 85 percent with an average CPU utilization of ~82 percent, showing that a single UCS B200 M4 blade server was able to support 150 virtual desktops.




**Performance Chart Legend**

| Key | Object | Measurement | Rollup | Units |
|---|---|---|---|---|
| ■ | 10.64.80.28 | CoreUtilization | average | Percent |

**Figure 16 - Single Server 150 VDI Users: CPU Usage**

## 1000 VDI Users Test Results

The purpose of this test was to show that the reference solution was able to support 1000 VDI users of the targeted profile. The validation test bed was provisioned with seven VMware View pools, with approximately 150 linked clones per pool, as non-persistent desktops. The desktops were evenly distributed across seven NFS shares from the Tegile IntelliFlash storage array. The 1000 desktops were also evenly distributed on the seven ESXi hosts on seven UCS B200 M4 blade servers, with an average of 143 virtual desktops per blade server.

Figure 17 illustrates the LoginVSI response times which shows the acceptable range, VSI Index Average being between the maximum response and minimum response times. For the entirety of the test, VSI index average response time was far below the maximum response threshold of 2.078 seconds.

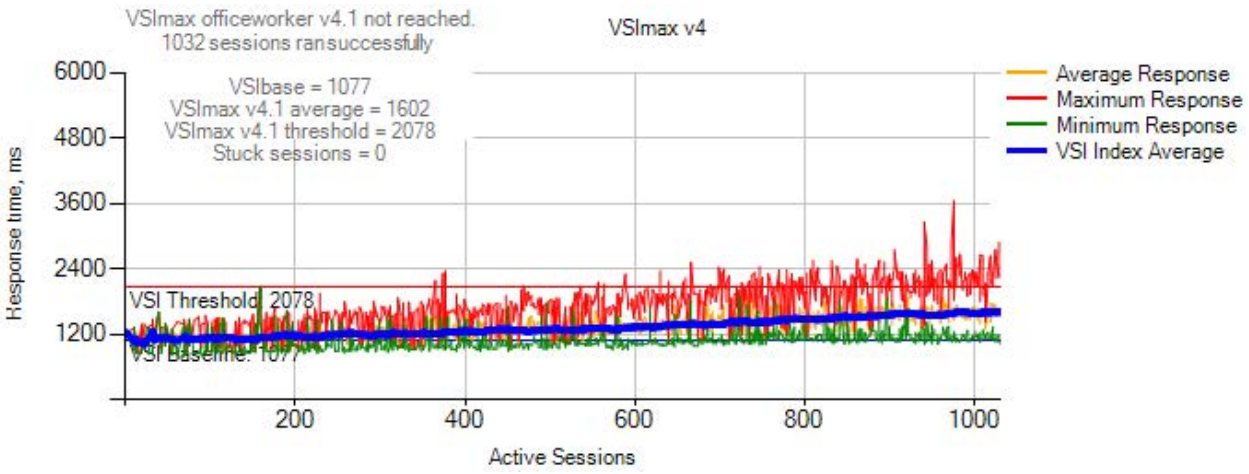



**Figure 17 - Login VSI Session Response Time**

## Boot and Login Scenarios

The total time to boot 1000 desktops, and for the Login VSI agent to log in, was approximately 3 minutes 30 seconds. Distributing the 1000 desktops across the seven ESXi hosts inside one ESX cluster, as well as across the seven NFS shares from the Tegile IntelliFlash storage array, ensured that the load was balanced across the server, storage, and network resources during the boot and login process.

Figure 18 shows the average CPU utilization of the ESXi cluster over the entire test period.

Read operations were dominant during the boot and login process, with a storage cache hit ratio of around 90 percent (For detailed analytics from the Tegile IntelliFlash storage array for the duration of the test, see Figures 23-25 at the end of this document.)

## Server CPU

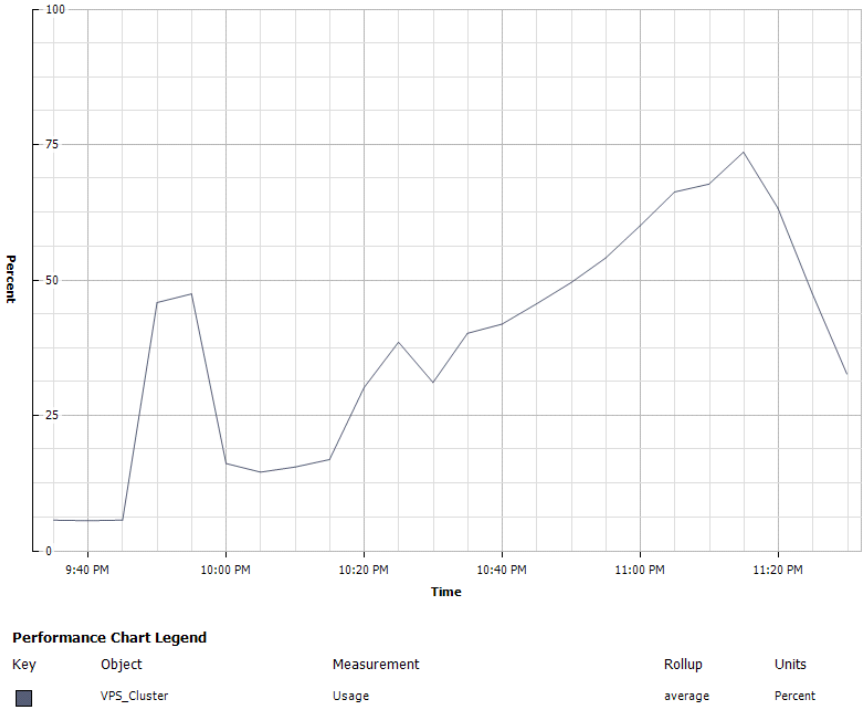



Figure 18 - ESX Cluster Overall CPU Usage of 1000 VDI Users Test

## Server Memory

Figure 19 shows a steady increase in memory consumption during the boot and login process along with a continued increase throughout. After the completion of the test, memory consumption began to decrease as the VMs were shutting down.

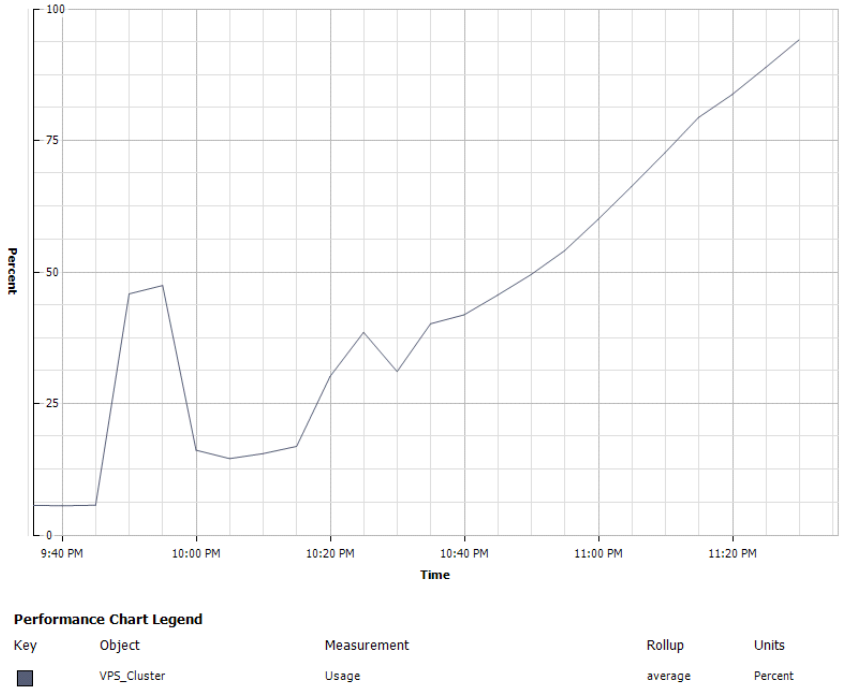



Figure 19 - Memory Usage on ESX Cluster for 1000 VDI Users Test

## Network

The network load for storage access appeared to be much higher during the boot storm when compared with the load during steady-state operations. Figure 20 shows that the storage network load during the boot and login process was well below the allocated bandwidth, confirming that the reference architecture provides adequate bandwidth to support 1000 virtual desktop users.

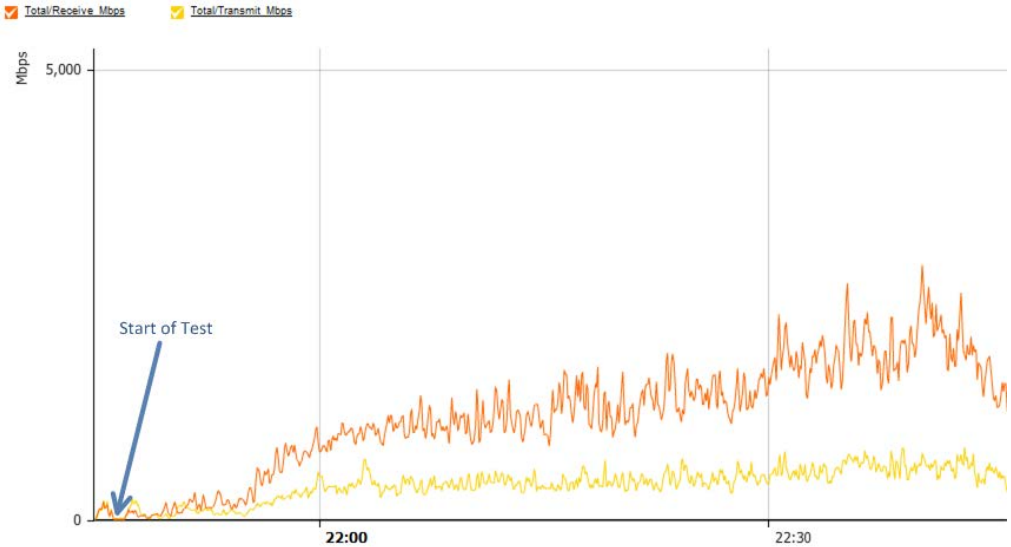



Figure 20 - Tegile IntelliFlash Network Load during Boot Storm and Ramp Up

**Storage**

Figure 21 and Figure 22 show the datastore performance on a virtual desktop host. The IntelliFlash NFS share average read latency is around 9ms and the average write latency is below 20ms.

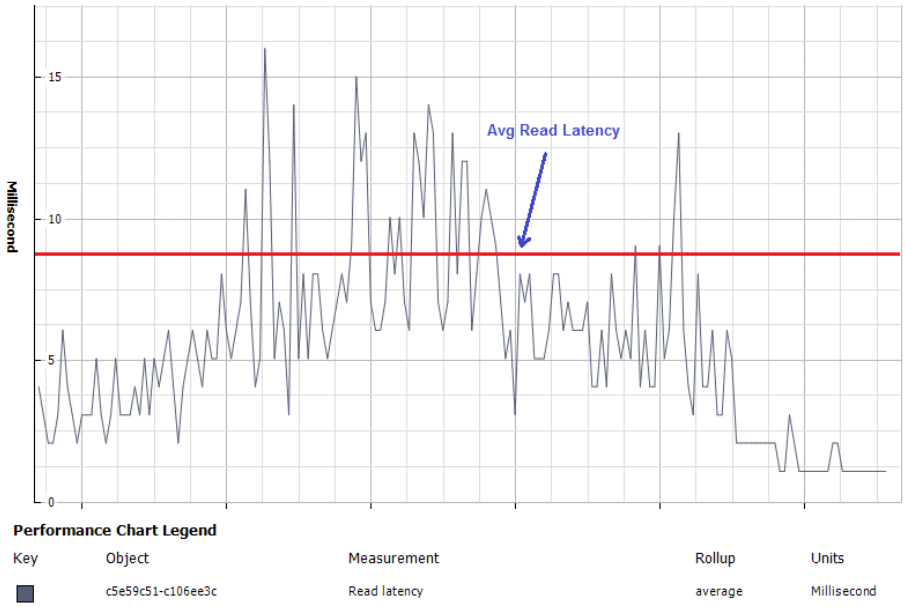



Figure 21 - ESXi Datastore Read Latency

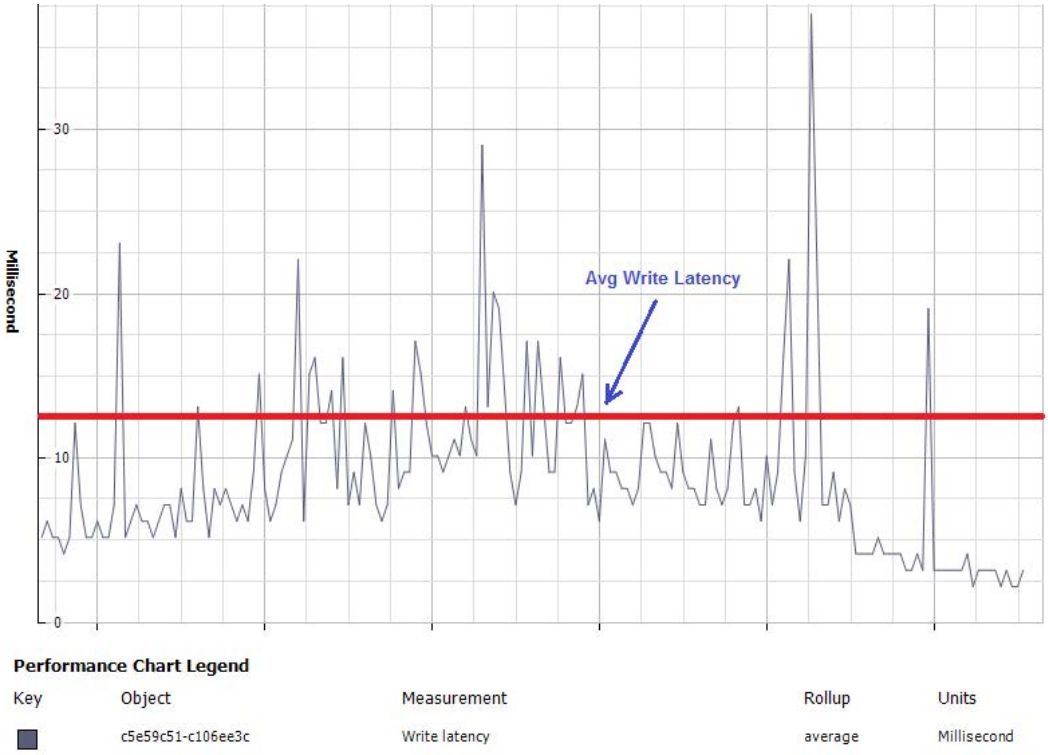



**Figure 22 - ESXi Datastore Write Latency**

Results showed that the I/O load generated by the test was well within the capabilities of the Tegile IntelliFlash T3700 storage array.

Figures 23-25 shows analytics from the Tegile IntelliFlash storage array for the duration of the test from boot and login, through ramp up, and at steady state. In Figure 23, the NFS R/W IOPS chart shows that the IOPS peaked at 12,000, and that the I/O was somewhat balanced during the boot and login process. During steady state, the overall I/O load went up and was dominated by write operations. The test workload for 1000 virtual desktops is well within the performance and capacity capabilities of the Tegile IntelliFlash T3700, which is capable of providing up to 80,000 IOPS for mixed I/O workloads.

The Cache Hit Chart shows that the storage cache hits were consistently above 90 percent over the duration of the test.

Utilization for the CPUs in the storage array were under 50 percent, well below the 80 percent threshold. This shows the array has much more to give.

**NFS R/W IOPs**

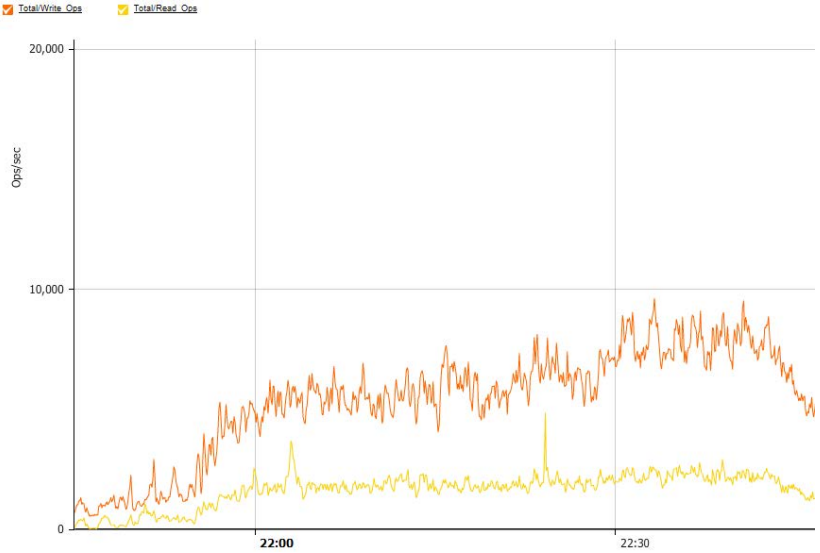



**Figure 23 - Tegile IntelliFlash R/W IOPs during entirety of test cycle**

**Cache Hits**

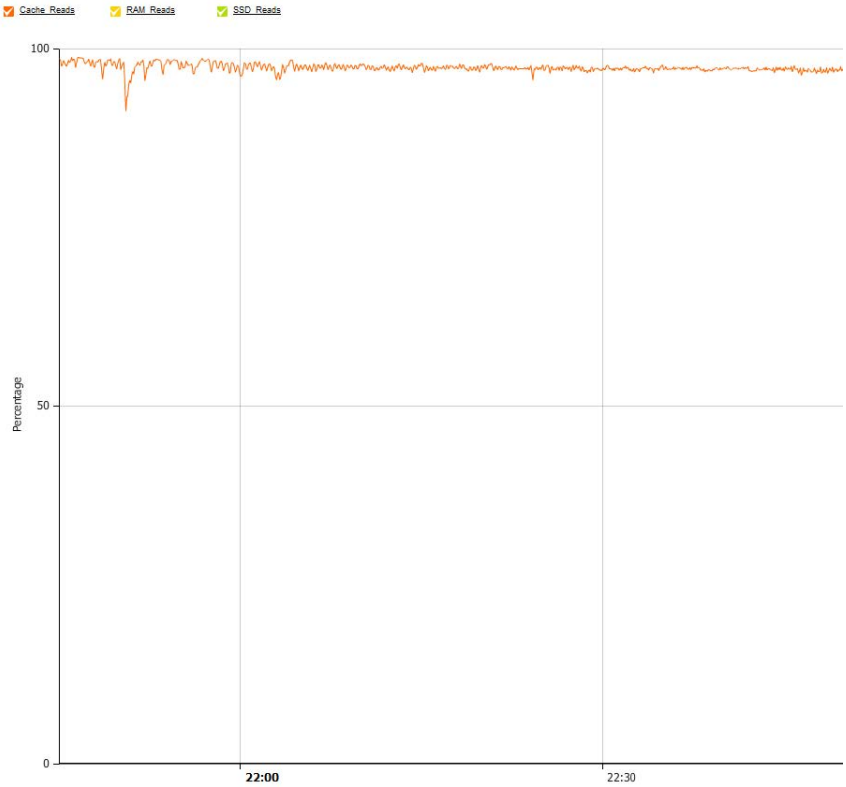



**Figure 24 - Tegile IntelliFlash Cache Hits during entirety of test cycle**

**CPU Usage**

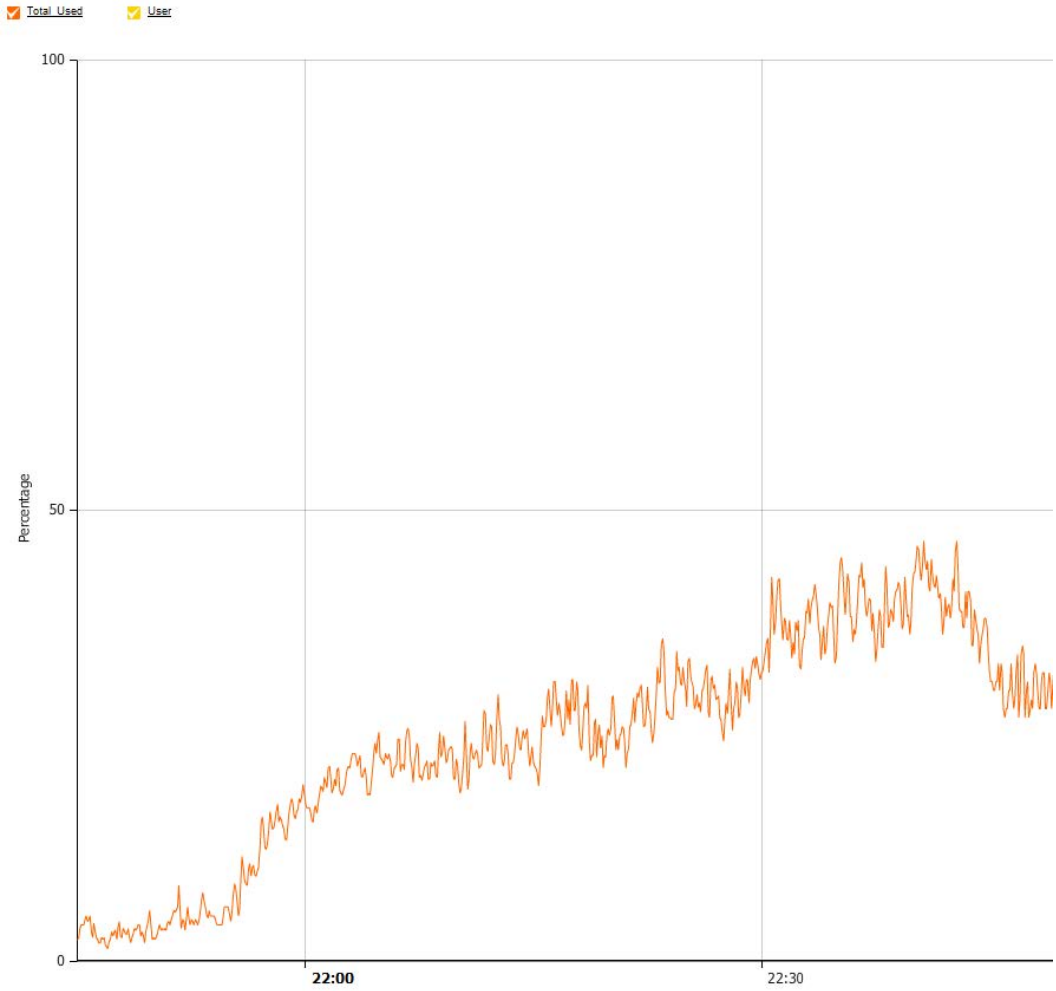



Figure 25 - Tegile IntelliFlash CPU Usage during entirety of test cycle

# Conclusion

The VDI test performed with the Cisco UCS B200 M4 blade servers, Tegile T3700 storage array, and VMware View 6.0 showed that the reference architecture detailed in this document is easily capable of supporting 1000 virtual desktops running average desktop user workloads.

# Acknowledgements


- Mike Brennan, Cisco
- Ashok Rajagopalan, Cisco
- Syed Ghayur, Cisco
- TJ Singh Bamrah, Cisco
- David Nguyen, Cisco

- Dr. Ashish (Ash) Godbole, VMware
- Marilyn Basanta, VMware
- Rajiev Rajavasireddy, Tegile Systems
- Alok Agrawal, Tegile Systems
- Wen Yang, Tegile Systems
- Rajesh Nair, Tegile Systems
- Jackie Cheng, Tegile Systems
- Harrison Waller, Tegile Systems

# References

VMware Horizon - FAQs: https://www.vmware.com/files/pdf/products/horizon/VMware-Horizon-FAQ.pdf

VMware Server and Storage Sizing Guide for Windows 7

http://www.cisco.com/en/US/docs/unified_computing/ucs/hw/chassis/install/blade.html

Cisco Validated Designs: http://www.cisco.com/go/vdidesigns

Cisco Desktop Virtualization Solutions: http://www.cisco.com/go/vdi



Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883