



# Cisco Desktop Virtualization Solution with Nimble Storage: Reference Architecture

Validated for 1500 Pooled Virtual Desktops Using Citrix XenDesktop 5.6,  
Cisco Unified Computing System, and Nimble Storage

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## What You Will Learn

This document describes the reference architecture for the Cisco<sup>®</sup> Desktop Virtualization solution with storage for up to 1500 pooled virtual desktops based on Citrix XenDesktop 5.6 and VMware vSphere 5 Update 1. The Cisco Desktop Virtualization solution includes Cisco UCS<sup>®</sup> B-Series Blade Servers and Nimble Storage CS-Series storage appliances.

The purpose of the reference architecture is to provide a tested and modular architecture built with proven best-in-class technologies to create a complete desktop virtualization solution, including desktop management software, hypervisor, computing, networking, and storage elements. This reference architecture can accelerate your desktop transformation by enabling faster deployments, greater flexibility of choice, greater efficiency, and lower risk.

Choosing the correct computing and storage solution for virtual desktop infrastructure (VDI) is a critical step. The reference architecture described here uses the Login Virtual Session Indexer (VSI) testing tool to determine the right solution for the 1500-desktop configuration. The Login VSI tool helps you assess and plan the proper server, network, and storage configuration for a Citrix XenDesktop environment through automated workload management.

Using the Login VSI testing tool with Citrix XenDesktop pooled desktops; Nimble Storage has achieved desktop deployment levels of 1500 Microsoft Windows 7 32-bit virtual desktops on a single three-rack-unit (3RU) Nimble Storage CS440G-X4 system. This solution provides a storage architecture that is compact, easy to configure, simple to manage, and powerful enough to support demanding VDI workloads. This VDI configuration is described in this document.

This reference architecture document is not intended to be a comprehensive guide to the deployment and configuration of every aspect of this solution.

## Summary of Main Findings

- The combination of the Cisco Unified Computing System<sup>™</sup> (Cisco UCS) and Nimble Storage hardware with Citrix XenDesktop 5.6 on VMware ESXi 5 software produces a virtual desktop delivery system with a high density of more than 120 desktop virtual machines per blade all in two Cisco UCS server chassis enclosures.
- Up to 1500 virtual desktops can run on a Nimble Storage CS440G-X4 storage array, satisfactorily meeting boot and login storm service-level agreements (SLAs) and the Medium workload test requirements specified by Login VSI and Nimble Storage.
- Cisco maintains industry leadership with the new Cisco UCS Manager Release 2.0 software, which makes scaling and maintenance simple and helps ensure consistency.
- The Cisco 10-Gbps unified fabric is also validated on second-generation Cisco UCS 6200 Series Fabric Interconnects, testing more challenging workloads and maintaining exceptional user response times.

## Business Value

Proliferation of mobile devices and software-as-a-service (SaaS) cloud application offerings have added complexity to traditional IT environments. Companies big and small are seeking ways to respond to this trend without spending more budget dollars than needed for physical desktops, and without incurring additional operation management expenditures. A well-designed, thoroughly tested VDI solution can strategically empower a company to respond to the post-PC era.

Customers require a scalable and highly available infrastructure on which to deploy their virtual desktop environments. Several new technologies are available to assist them in designing a virtual desktop solution, but they need to know how to use these technologies to get the most from their investments, support SLAs, and reduce their total cost of ownership (TCO).

This solution builds an example of a common customer VDI environment and validates the environment for performance, scalability, and capability. Customers achieve:

- Increased control and security of their global, mobile desktop environment, which is typically their most at-risk environment
- Better end-user productivity with a more consistent environment
- Simplified management, with the environment contained in the data center
- Better support for SLAs and compliance initiatives
- Lower operating 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 in combination with platform modularity provides a simplified, secure, and scalable desktop virtualization platform.

- Simplified
  - Virtual desktop density per server
  - 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
  - Capability to linearly scale up 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, meaning that fewer servers are needed, reducing both capital expenditures (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 time to productivity and enhances business agility. IT staff and end users are more productive more quickly, and the business can respond to new opportunities by simply deploying virtual desktops whenever and wherever needed. The high-performance Cisco system and network deliver a near-native end-user experience, allowing users to be productive anytime and anywhere.

## Project Planning and Solution Sizing Sample Questions

You must understand user groups, applications, and data requirements to properly size computing, networking, and storage resources.

Some general project questions should be addressed at the outset:

- Has a VDI pilot plan been created based on the 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 needed to implement 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?

The following is a short, nonexhaustive list of sizing questions that should be addressed for each user subgroup:

- What is the desktop OS planned? Microsoft Windows 7 or Windows XP? 32-bit or 64-bit desktop OS?
- How many virtual desktops will be deployed in the pilot deployment? In production? Will all desktops use Microsoft Windows 7?
- How much memory is needed per target desktop group desktop?
- Are there any multimedia, Adobe Flash, or graphics-intensive workloads?
- What is the endpoint graphics processing capability?
- Are any additional 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 antivirus software a part of the image?
- Is user profile management (nonroaming profile based) part of the solution?
- What are the fault tolerance, failover, and disaster recovery plans?
- Are there any additional questions specific to any desktop subgroups that need to be addressed?

## The Solution: A Unified, Pretested, and Validated Infrastructure

Cisco's 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, extends pervasive security and policy management to each virtual desktop, and uses a new and innovative virtualization-optimized stateless server computing model (Cisco UCS).

### Base Components

- The computing platform used with the Cisco UCS reference architecture includes:
  - Cisco UCS 5108 Blade Server Chassis
  - Cisco UCS 6200 Series Fabric Interconnects
  - Cisco UCS 2200 Series Fabric Extenders
  - Cisco UCS blade servers for virtual desktop hosting and all infrastructure components: Cisco UCS B200 M3, B230 M2, and B200 M2 Blade Servers
- Hypervisor: VMware ESXi 5 update 1
- Virtual desktop management: Citrix XenDesktop 5.6
- Storage platform with Nimble CS-Series

### 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 in a single system. Innovations in the platform include a standards-based unified network fabric, Cisco virtualized interface card (VIC) support, and Cisco 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 world-record-setting performance to a wide range of workloads. Based on the 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 and 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

### 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 Enterprise Plus edition for deploying the basic virtualization infrastructure. It provides the full range of features and functions, allowing customers to achieve scalability, high availability, and optimal performance for all their desktop workloads.

### **Citrix XenDesktop 5.6**

Citrix XenDesktop is a desktop virtualization solution that simplifies IT manageability and control while delivering excellent end-user experiences for devices and networks. The Citrix XenDesktop solution helps IT departments automate desktop and application management, reduce costs, and increase data security through centralization of the desktop environment. This centralization results in greater end-user freedom and increased control for IT departments. By encapsulating the operating systems, applications, and user data, IT departments can deliver a modern desktop. IT can then deliver a more flexible desktop and application experience for real-world productivity and greater business agility.

### **Nimble Storage CS-Series**

Nimble Storage arrays are the industry's first flash-memory-optimized storage designed from the start to increase efficiency as well as reduce costs. Using the patented Cache Accelerated Sequential Layout (CASL) architecture, Nimble Storage offers scalable performance, exceptional efficiency, integrated data protection, and simple push-button management. As a result, customers can run more workloads and perform more backup operations with less storage infrastructure and empower IT to take on new projects with higher returns. CASL accelerates applications by using flash memory as a read cache in conjunction with a write-optimized data layout. It protects data by supporting instant snapshots for easy backup and restoration, along with efficient replication for disaster recovery. Nimble Storage's intuitive, automated tools greatly simplify storage and data management, reducing operations overhead.

Nimble Storage delivers:

- Accelerated performance for greater throughput and more IOPS, and latencies of less than a millisecond
- Greater storage efficiency, reducing the storage footprint needed by 30 to 75 percent
- Nondisruptive scaling to meet changing application needs through increased performance or capacity, or both
- Increased data and storage availability with integrated data protection and disaster recovery
- Simplified storage management and reduced day-to-day operation overhead

### **Login VSI**

Login VSI is the accepted industry-standard benchmarking tool to test the performance and scalability of centralized Microsoft Windows desktop environments such as server-based computing (SBC) and VDI.

Login VSI is completely vendor independent and is used to test virtual desktop environments such as Citrix XenDesktop and XenApp, Microsoft VDI and Remote Desktop Services, VMware View, and any other SBC or VDI solution based on Microsoft Windows.

Login VSI is used for testing and benchmarking by all major hardware and software vendors and is recommended by leading IT analysts and the technical community. Login VSI is vendor independent and works with standardized user workloads; therefore, results that are based on Login VSI test data are objective, verifiable, and replicable.



Because VSIMax is easy to understand and completely vendor independent, it became the industry-standard benchmark to describe the performance and scalability of virtual desktop infrastructures. VSIMax allows innovative technology vendors to demonstrate the performance and scalability gains of their solutions in an objective way. For this reason, Login VSI, with the standard Medium workload, was used in the testing described in this document.

Login VSI customers use the tool for a variety of business purposes:

- Benchmarking: To make the right decisions about different infrastructure options based on tests
- Load testing: To gain insight into the maximum capacity of the current (or future) hardware environment
- Capacity planning: To determine what infrastructure is needed to offer users an optimally performing desktop
- Change impact prediction: To test and predict the performance effect of every intended modification before its implementation

Login VSI is also the standard tool used in all tests that are run in the internationally acclaimed Project Virtual Reality Check (<http://www.projectvrc.com>).

For more information about Login VSI, visit <http://www.loginvsi.com>.

Login VSI test results are published in technical white papers (for an overview, visit <http://www.loginvsi.com/white-papers>) and presented at conferences. Login VSI is also used by end-user organizations, system integrators, hosting providers, and testing companies.

## Solution Overview and Benefits

This solution uses Cisco UCS, Nimble Storage, and VMware vSphere 5 to provide the base virtualization resources for a Citrix XenDesktop 5.6 VDI environment. The solution focuses on Microsoft Windows 7 virtual desktops provisioned by Citrix XenDesktop Machine Creation Services (MCS).

The planning and designing of the server, networking, and storage infrastructure for the Citrix XenDesktop environment is a critical step because the server infrastructure should be sized to handle the density and scale of the desktop workload, the networking infrastructure should be provisioned to handle the burst of data traffic, and the shared storage must be able to absorb the large bursts of I/O traffic that occur during a workday.

To provide cost-effective and predictable VDI performance, the infrastructure must be able to:

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

## Solution Benefits

- High performance: Nimble Storage arrays with Cisco UCS deliver the adaptive performance needed to handle the comprehensive desktop virtualization functions delivered by Citrix XenDesktop, in a compact footprint. This capability allows IT to maintain a positive user experience through boot and login storms, patch operations, and upgrades, because this joint platform is powerful enough to handle the infrastructure needs of VDI.

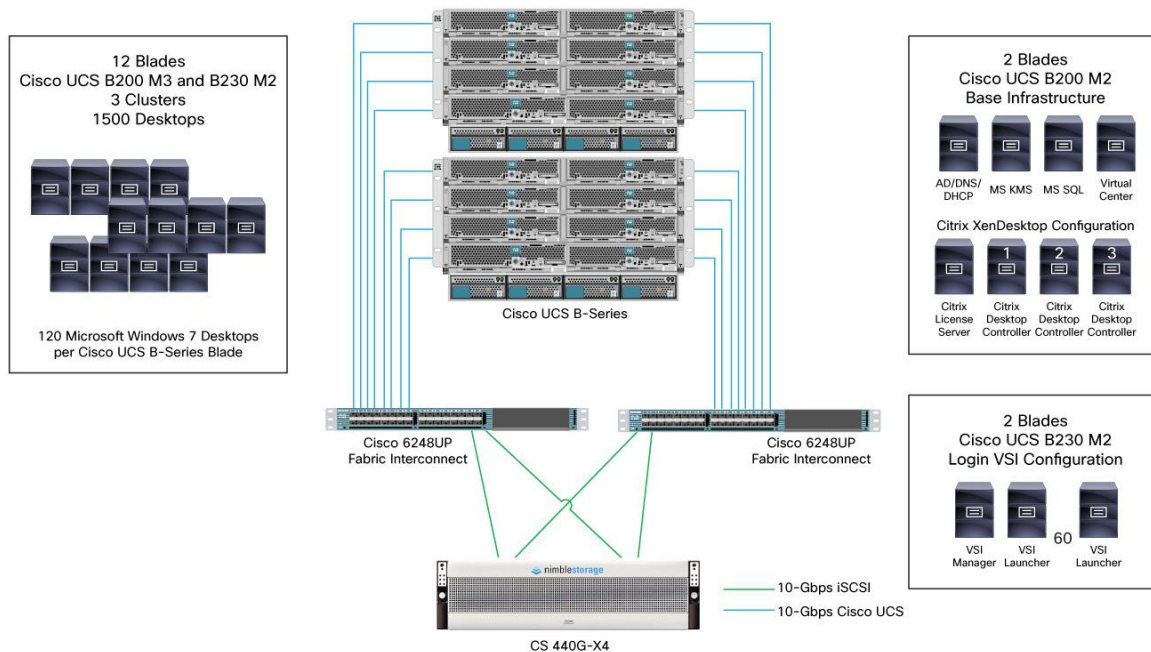


- Greater consolidation: Citrix XenDesktop frees IT departments from the chores of desktop upgrades by centralizing the creation and deployment of linked-clone pooled desktops. This feature complements Nimble Storage’s in-line compression and the dense computing and I/O capabilities of Cisco UCS. IT departments that have deployed the joint platform have seen 30 to 75 percent reduction in their storage footprint compared to traditional solutions, with no degradation of the end-user experience.
- High availability: Nimble Storage and Cisco UCS both incorporate redundant components, with no single point of failure, along with proactive monitoring and reporting. These features complement VMware vCenter’s capability to trigger efficient Nimble Storage snapshots for instant backup and fast restore operations. The result is less end-user disruption and fewer calls to the help desk.
- Expansion on demand: By integrating computing, fabric, storage, and virtualization resources in a single architecture, IT can start small and independently scale horizontally or vertically to large deployments supporting thousands of virtual desktops as needs grow.

## Architecture and Design of Citrix XenDesktop 5.6 Solution

The basic components and connectivity used for the server, storage, and network are shown in Figure 1. A single Nimble Storage array was connected to two Cisco UCS chassis through a pair of Cisco UCS fabric interconnects using appliance ports with 10-Gbps connectivity. The Infrastructure components (VMware, Citrix, Microsoft, and Login VSI components) and the Citrix XenDesktop virtual machine desktops were all run on the blades in the two Cisco UCS chassis enclosures.

**Figure 1:** Solution Topology



The solution components include:

- Cisco UCS B-Series Chassis (2)
- Cisco UCS 2204XP Fabric Extenders (2 per chassis)
- Cisco UCS 6248UP Fabric Interconnects (2)
- Cisco UCS B200 M3 (10-Gbps Cisco UCS) (2)

- Cisco UCS B230 M2 (10-Gbps Cisco UCS) (12)
- Cisco UCS B200 M2 (10-Gbps Cisco UCS) (2)
- Nimble Storage CS440G-X4 (10-Gbps [iSCSI]) (1)
- Infrastructure (2 blades: Cisco UCS B200 M2)
  - Microsoft Windows Active Directory, Domain Name System (DNS), and Dynamic Host Configuration Protocol (DHCP)
  - Microsoft Windows Key Management Server (KMS)
  - Microsoft SQL Server
  - VMware vCenter
  - Citrix XenDesktop
- 1500 desktops (12 blades: 2 Cisco UCS B200 M3 and 10 Cisco UCS B230 M2)
  - Approximately 120 Microsoft Windows 7 desktops per Cisco UCS B230 M2 blade (10): Density was scaled for a maximum number of desktop virtual machines per server for the Cisco UCS B230 M2 at 135 in the event that one of the 10 clustered hosts fails
  - 145 Microsoft Windows 7 desktops per Cisco UCS B200 M3 blade (2): These were in separate cluster for measurement purposes only; no additional high availability was included in the sizing for the Cisco UCS B200 M3 servers
- Login VSI (2 blades: Cisco UCS B230 M2)
  - Login VSI management server
  - Microsoft Common Internet File System (CIFS) share
  - Login VSI Launchers (60 virtual machines with 25 desktops sessions per launcher)

### Cisco UCS B-Series Blade Servers

The Citrix XenDesktop reference architecture testing was performed on a Cisco UCS blade system designed to host approximately 120 desktops per Cisco UCS B230 M2 blade and 145 desktops per Cisco UCS B200 M3 blade. For the targeted 1500-desktop test, 12 blades were configured into three sets of VMware ESXi clusters.

Each Cisco UCS B230 M2 blade was configured as follows:

- Two Intel Xeon E7-2870 2.4-GHz processors (20 cores total)
- 256 GB of RAM

Each Cisco UCS B200 M3 blade was configured as follows:

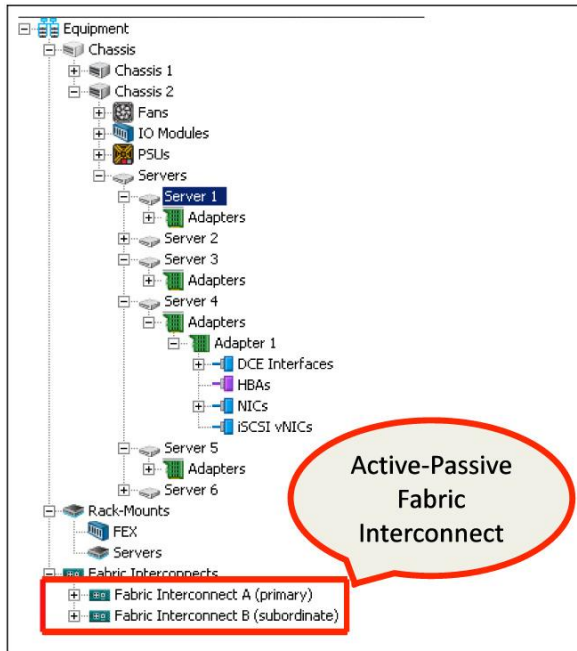
- Two Intel Xeon E5-2690 2.9-GHz processors (16 cores total)
- 256 GB of RAM

The Cisco UCS configuration was connected to Nimble Storage as an iSCSI array directly with the Cisco fabric interconnect with dual, redundant 10-Gbps connections. This architecture provides the most efficient use of hardware and lowers the total cost per desktop of the server, network, and storage solution.

Each Cisco UCS chassis was connected to each fabric interconnect with four 10-Gbps network connections.

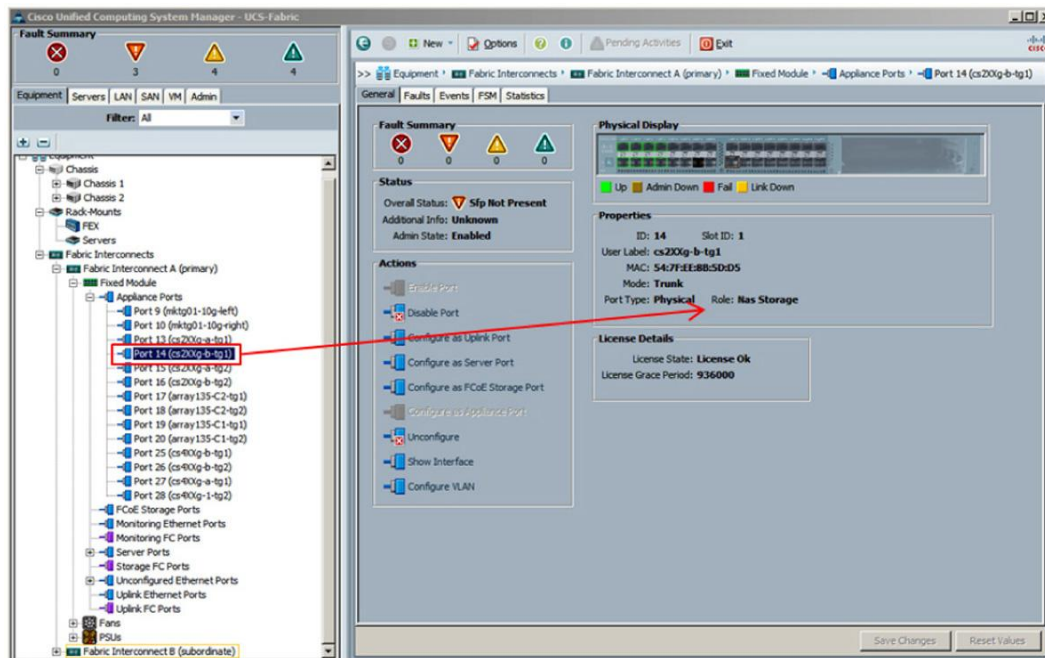
The dual fabric interconnect pairs have primary and subordinate roles in this configuration (Figure 2). For more information about Nimble Storage connectivity with Cisco UCS, please refer to Appendix E.

**Figure 2:** Cisco UCS Fabric Interconnect Configuration



For a configuration without an access-layer switch (Cisco Nexus<sup>®</sup> 5500 platform switches), the fabric interconnect ports connected to the Nimble Storage array must be configured to operate in Appliance Port mode (Figure 3).

**Figure 3:** Cisco UCS Appliance Port Mode: Nimble Storage Data Ports



Twelve of the Cisco UCS blades in this chassis were used to host the Microsoft Windows 7 desktop virtual machines. These were configured into three VMware ESXi clusters. Four blades were clustered and used to provide the core virtualization infrastructure services as described in the following paragraphs. Additionally, two blades of this cluster were used to provide the Citrix XenDesktop web client-side access and test framework services (Login VSI Launchers) for the Login VSI toolkit.

## VMware vSphere 5

For this test configuration, the VMware vSphere 5.0 Update 1 ESXi hypervisor was deployed. The Cisco UCS blades were configured as either local boot (internal SSD) or iSCSI boot from SAN, all using the same Nimble Storage array. The goal was to make the environment as robust as possible and also to demonstrate the capability to support the iSCSI boot from SAN function.

The virtualization infrastructure was constructed on virtual machines and running on a cluster of two Cisco UCS B200 M2 blades. To support the VDI environment, this infrastructure included the following Microsoft Windows Server 2008 R2 virtual machines:

- Microsoft Windows Active Directory, DNS, and DHCP
- Microsoft KMS
- VMware vCenter Server
- Microsoft SQL Server (to support the VMware and Citrix database infrastructure)
- Microsoft CIFS share (to support Login VSI)

The desktop virtual machines were run on three different virtual desktop clusters composed of 10 dedicated Cisco UCS B230 M2 and 2 newer-model Cisco UCS B200 M3 blades. Although the Cisco server, Nimble Storage, and VMware and Citrix virtualization configuration had no inherent need for these three distinct clusters, the servers were separated into this configuration to facilitate other peripheral testing measurements and observations outside the scope of this reference architecture. One cluster (UCS-1000) was created as a baseline configuration similar to a previous desktop reference architecture configuration, one cluster (UCS-NEW) was created with the new Cisco UCS B200 M3 blades only, and the final cluster (UCS-NEW) was created to hold the additional blades to get the total desktop count to 1500 virtual machines. The results of the server and storage configuration and performance could have easily been based on a single cluster. Customer environments are not restricted to either approach and should use the approach that best fits the overall resource management needs.

The desktop configuration used for this test was a Microsoft Windows 7 Professional SP1 (x86 32-bit) virtual machine with 1.5 GB of RAM, one virtual CPU (vCPU), and a 24-GB disk. The configuration of the desktop application environment consisted of:

- Microsoft Office 2007 (Microsoft Word, Excel, and PowerPoint)
- Internet Explorer 9
- Microsoft Outlook 2007
- Adobe Acrobat Reader 9
- 7-Zip tools
- BullZip PDF Printer 7.2

Also configured in the Microsoft Windows 7 golden image in addition to the Microsoft OS and Microsoft Office 2007 suite were the Citrix XenDesktop and Login VSI agents and additional Login VSI workload tools as identified previously. The configuration of the golden image followed best practices for Microsoft Windows 7 VDI optimizations from VMware, Citrix, and Login VSI.

## Citrix XenDesktop 5.6

Citrix XenDesktop 5.6 MCS was used to construct and manage the desktop virtual machines. This test used a static pool of desktop virtual machines. The details of the specific virtual machine site configuration are included at the end of this document (see Appendix D). The configuration of the Citrix environment consisted of:

- Citrix License Server (1)
- Citrix XenDesktop Studio
- Citrix XenDesktop Desktop Controller (3)

## Login VSI 3.6.1

To perform the workload test, the Login VSI desktop workload testing tool was used to run a sample Medium workload on each of the 1500 active Microsoft Windows 7 desktops. The Login VSI tool can be configured in many ways for configuration testing. This test followed the guidelines for the Medium workload and VSIMax calculation techniques. The result of the Login VSI workload is close to that for a typical Microsoft Windows-based task worker with a steady-state IOPS rate of about 10 IOPS per desktop. The configuration of the Citrix environment consisted of:

- Login VSI management server (1)
- Login VSI CIFS share server (1)
- Login VSI Launchers with Citrix Receiver (60: 30 Login VSI Launchers on two Cisco UCS B230 M2 hosts in the UCS-MGT cluster; each launcher was to handle 25 desktop session logins)

## Nimble Storage CS-Series

This testing used the Nimble Storage CS440G-X4 model, which has 24 terabytes (TB) of raw capacity (12 x 2-TB 7200-rpm SATA HDDs), 2.4 TB of SSD-based flash memory, and dual 10 Gigabit Ethernet data network interface card (NIC) connections per controller. The Nimble Storage CS440G-X4 has two controllers operating in an active-standby redundant configuration.

For the 1500-desktop virtual machines solution, the storage volumes were configured with approximately 75 desktop virtual machines in each VMware Virtual Machine File System (VMFS) data store. Each data-store volume was configured with 2 TB, using thin provisioning at the storage level and providing plenty of room at the pooled machine catalog configuration for conservative desktop provisioning methods. The Nimble Storage appliance was then configured with 20 x 2-TB iSCSI volumes presenting 20 individual data stores at the VMware level to various VMware ESXi host clusters.

The Cisco UCS blades were configured into three separate clusters to control access to the VMFS volumes. The clusters were configured as follows:

- UCS-1000: 7 Cisco UCS B230 M2 blades (10 volumes)
- UCS-EXTRA: 3 Cisco UCS B230 M2 blades (6 volumes)
- UCS-NEW: 2 Cisco B200 M3 blades (4 volumes)

Through the Citrix XenDesktop balanced machine allocation, each volume contained approximately 75 desktop linked-clone virtual machines and the base master image. Current best practice reviews suggest the test could have run as many as 100 desktops per data store, or more. The volumes are thin provisioned by default, and 75 desktops of approximately 24-GB logical full footprint per 2-TB data store is a good conservative approach.

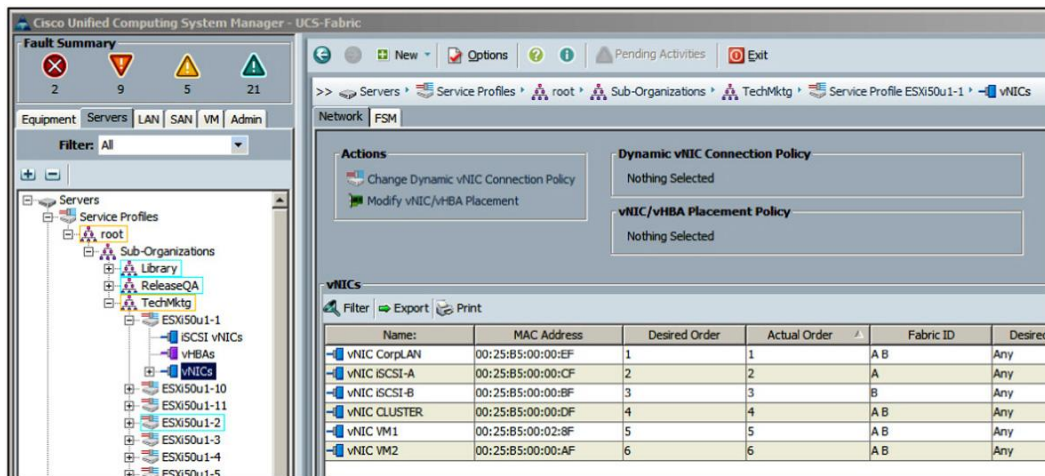
The Citrix XenDesktop storage component that mapped to the Nimble Storage solution used a simple and easy-to-manage approach: everything for the desktop was in the same data store. With Nimble Storage capabilities, it is not necessary to separate the various desktop storage artifacts into different storage tiers or locations. The CASL file system is optimized to handle VDI workloads, including boot storms. During a boot storm, the virtual desktop shared base image is automatically cached in the built-in SSDs, thereby accelerating the access times. As a result, boot times are greatly reduced, even when large numbers of virtual desktops boot at the same time. During steady-state operations, in which end users access applications in a random fashion, random write I/O is also optimized with the CASL write-coalescing technology.

## Solution Validation

### Server: Cisco UCS

The Cisco UCS blade servers were configured with multiple virtual NIC (vNIC) interfaces to allow separation of management (and optional internal cluster) traffic (two vNICs), VDI desktop traffic (two vNICs), and iSCSI data traffic (two vNICs). Figure 4 shows a typical server service profile.

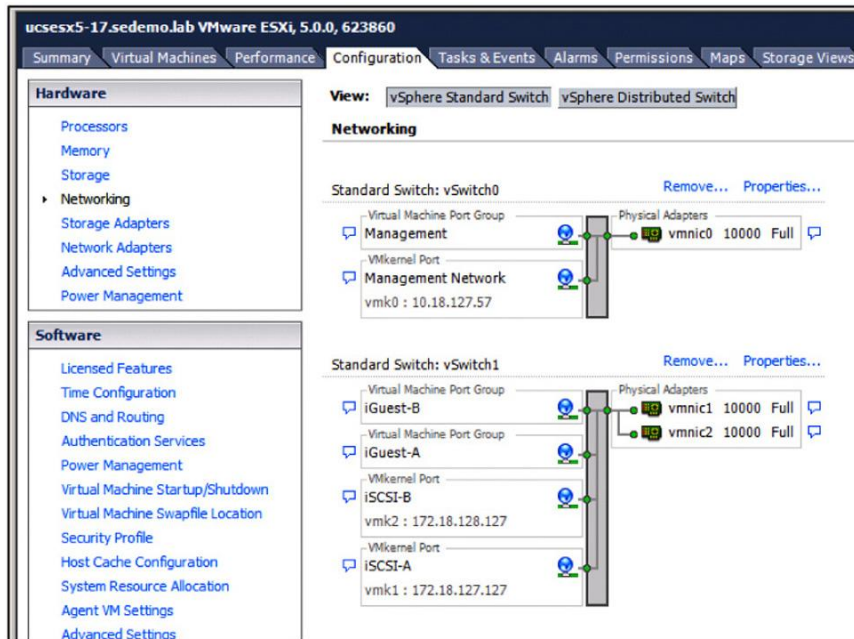
**Figure 4:** Cisco UCS Blade Server vNIC Configuration



Each Cisco UCS blade server is configured with six vNIC interfaces, with the VMware ESX vSwitch network configuration shown here (Figures 5 through 9):

- vSwitch0 (management network)
  - vmnic0
- vSwitch1 (iSCSI data traffic)
  - vmnic1 and vmnic2 (no teaming; VMware ESX software iSCSI multipathing is enabled with the Path Selection Policy [PSP] Round Robin algorithm), and note that iGuest-A and iGuest-B port groups are defined for guest attached iSCSI presentation to the Nimble Storage array but are not used in this particular VDI reference architecture)

Figure 5: VMware Network Configuration (Part 1)



- vSwitch2 (optional internal and clustering network)
  - vmnic3
- vSwitch3 (virtual desktop traffic)
  - vmnic4 and vmnic5 (teamed for load distribution and failover)

Figure 6: VMware Network Configuration (Part 2)

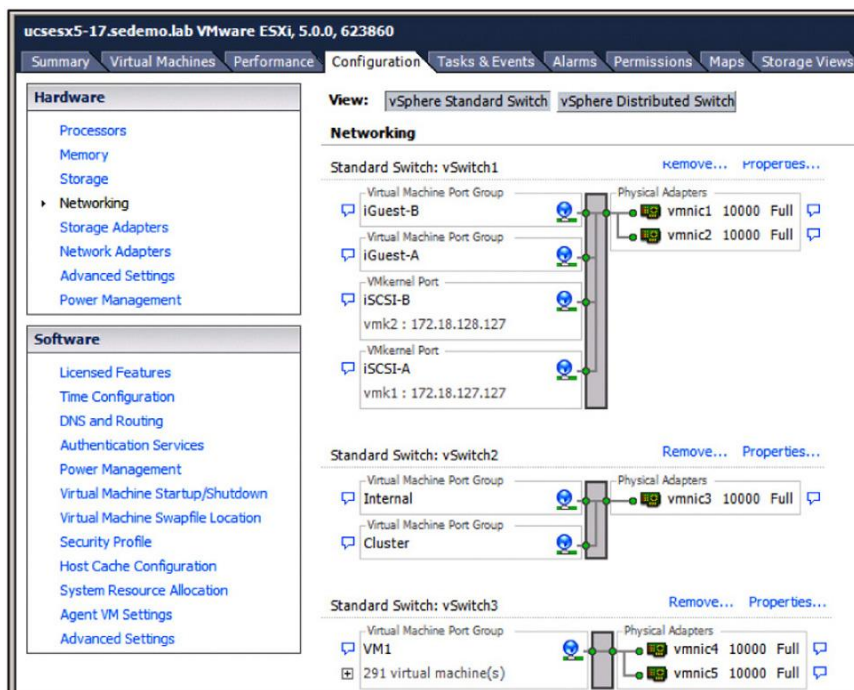


Figure 7: VMware iSCSI Port 1 Configuration Details

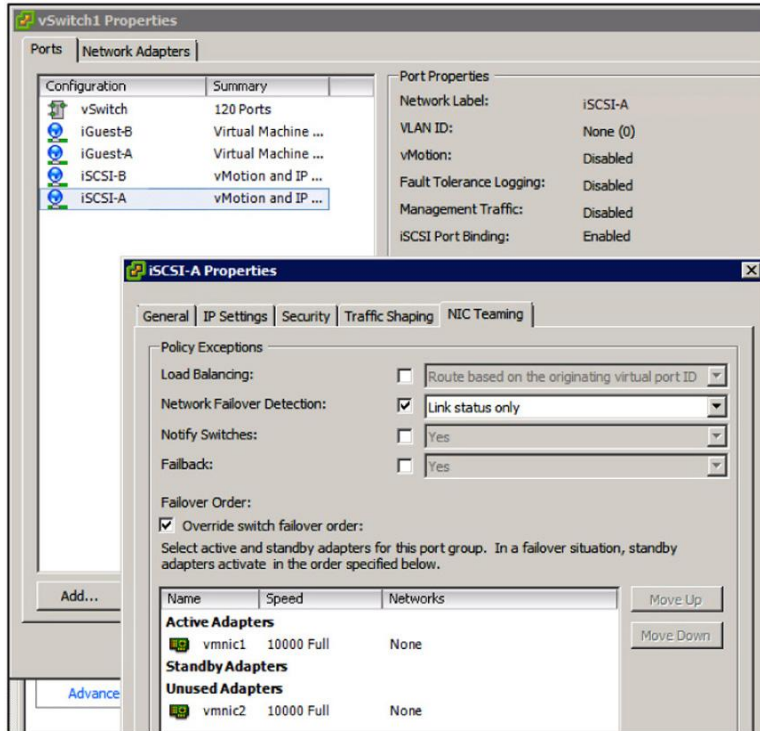
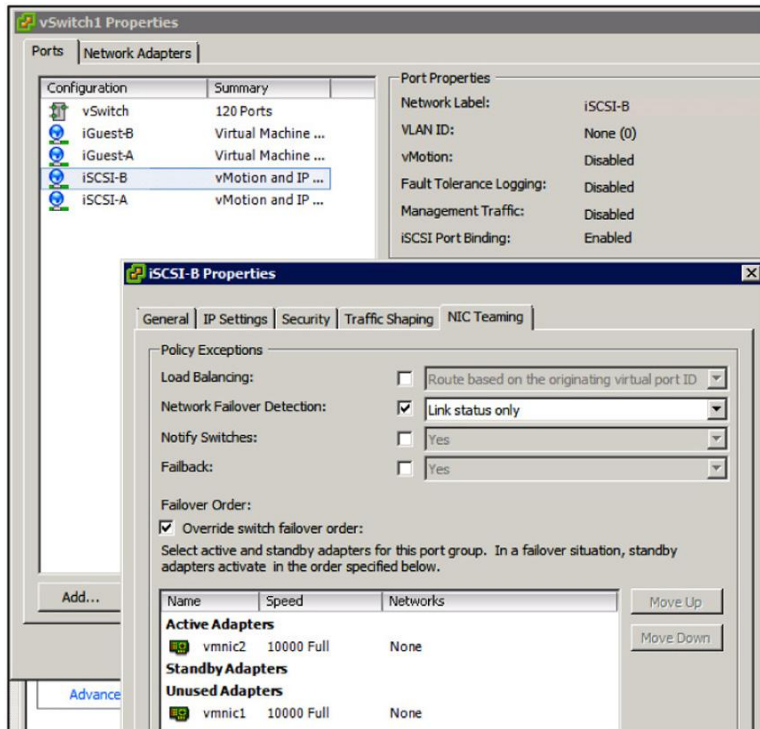
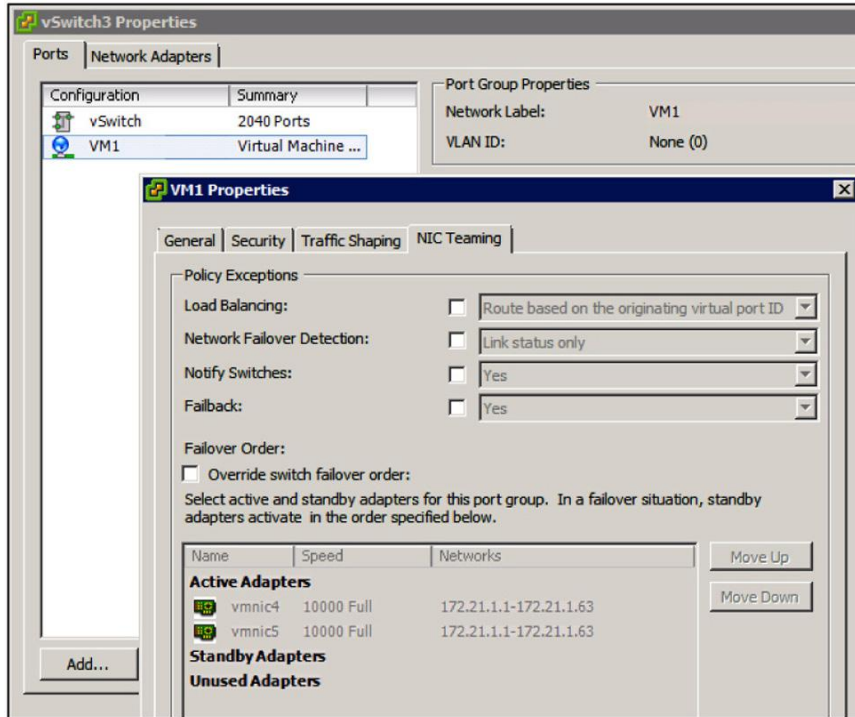


Figure 8: VMware iSCSI Port 2 Configuration Details





**Figure 9:** VMware Desktop Virtual Machine Network Configuration Details

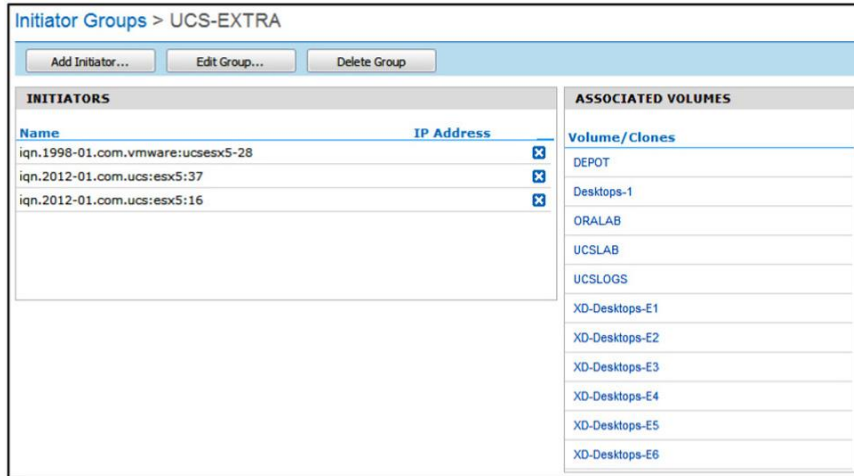


### Storage: Nimble Storage CS-Series

The Nimble Storage CS440G-X4 was configured with multiple volumes presented to the Cisco UCS VDI clusters as shown in the figures that follow. Each of the 20 volumes was configured as 2 TB of thin-provisioned iSCSI SAN storage VMFS data store.

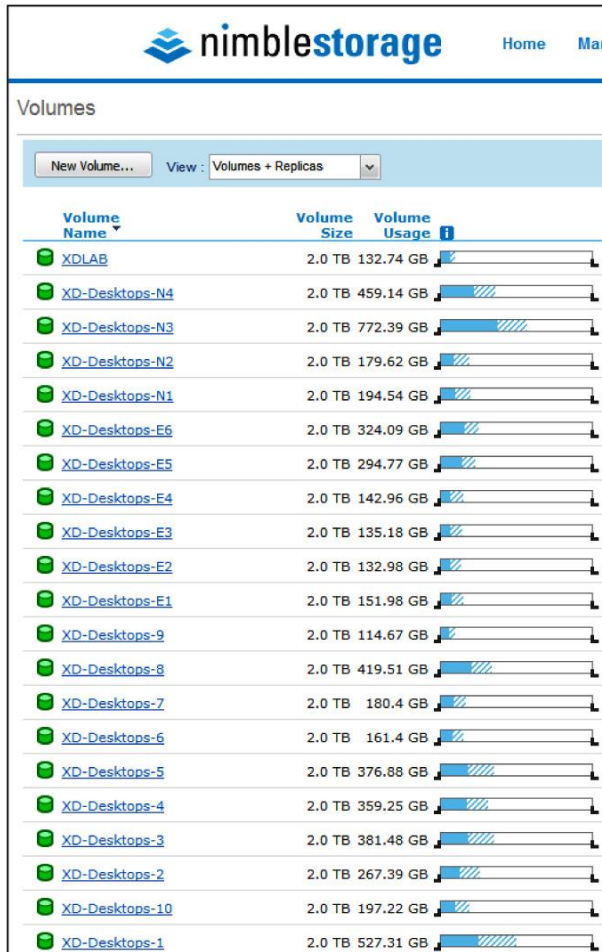
The VMware ESXi iSCSI initiators for each Cisco UCS blade were grouped to match the cluster membership and defined in a single initiator group for ease of management and presentation. Nimble Storage allows all host initiator iSCSI qualified names (IQNs) to be grouped into a single group, which eases the need to provision storage for multiple groups of VMware ESX host initiators. This approach is a best-practice recommendation for VMware vSphere environments, because it prevents inconsistent performance policy settings and volume presentations to a VMware ESX host cluster that shares the same group of volumes. Figure 10 shows an example of the grouping of all VMware ESX hosts in the VDI environment sharing a single initiator group. The initiator group is constructed by adding the IQN information for each blade's iSCSI initiator in a single combined group representing the VMware ESX cluster formed by the blades.

**Figure 10:** Nimble Storage iSCSI Initiator Setup



The 20 VMFS data stores were then configured into the same Citrix desktop group for each associated host cluster in the Citrix XenDesktop Studio management interface. The example in Figure 10 shows six of the XD-Desktops-En volumes presented to the UCS-EXTRA VMware ESXi host cluster of three servers: with IQNs ending in 28, 37, and 16. Figure 11 shows all the Nimble Storage volumes provisioned for this configuration.

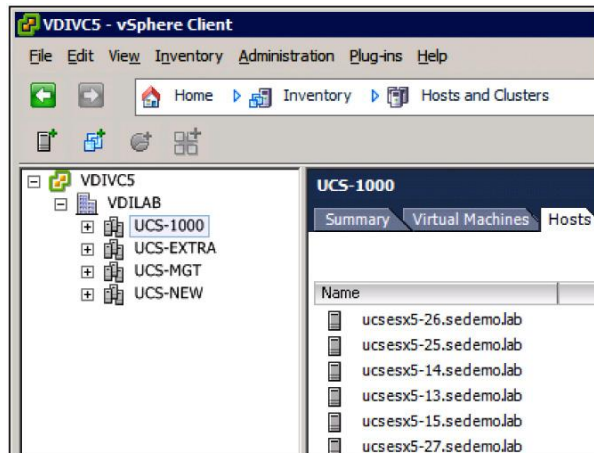
**Figure 11:** Nimble Storage Volume Management



## Virtualization and Hypervisor: VMware

The VMware vSphere 5 environment was set up with four clusters of VMware ESXi hosts for the VDI configuration (Figure 12). Three of the four clusters were purely for virtual desktops, and the fourth cluster was for infrastructure components described elsewhere in this document.

**Figure 12:** VDI Cluster Configuration



## Testing Methodology and Results

To validate the capability to run up to 1500 desktop virtual machines on the Nimble Storage CS440G-X4 array, the Login VSI desktop testing tool was used to run sample tests for a variety of configurations. The goal was to exercise and measure the storage infrastructure under a defined Medium user reference workload. The workload consisted of the following:

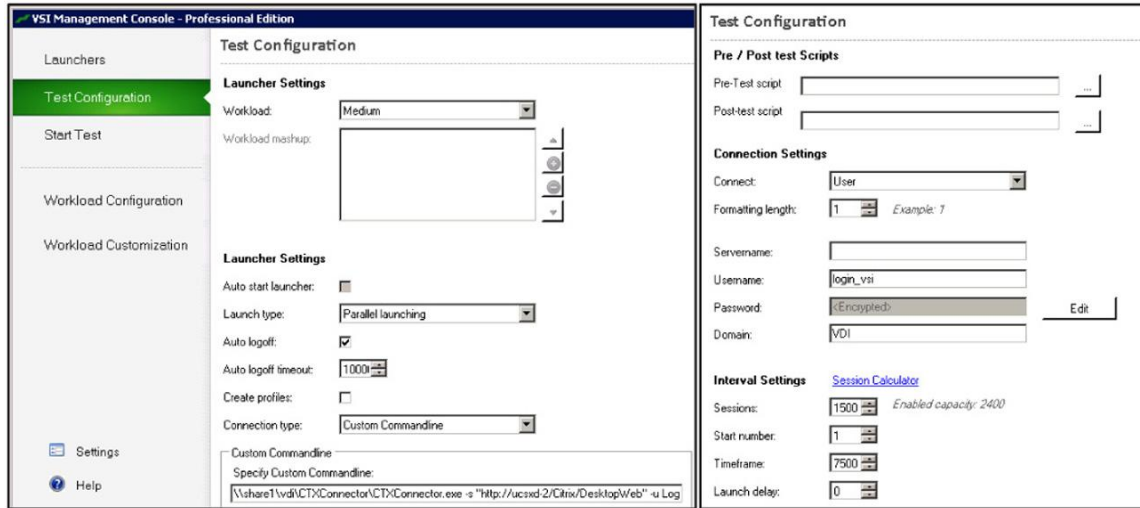
- Fifteen-hundred desktop virtual machines configured into one desktop group (UCS-XD) that consisted of four machine catalogs of 300 to 400 desktops each
- Twelve blade servers in a Cisco UCS and VMware ESXi cluster, each running approximately 125 virtual machines based on Citrix XenDesktop allocations for the cluster resources
- All 1500 virtual desktops configured in a single static assigned pool (they represent persistent desktops used by task workers, with random workloads throughout the day)

The Login VSI tool has an extensive set of customizations and configuration choices possible. For this reference architecture testing, the basic Medium user workload was used.

As shown in the workload profile in Figure 13, the test configuration was run with the predefined Medium workload using the parallel launching method across 60 Login VSI Launchers. The 1500 desktops were given 7500 seconds to start (5 seconds per user start cycle) and then run at steady state for another 10,000 seconds (about 3 hours).

For more information about what is represented in the predefined Medium workload, please refer to the Login VSI information here: <http://www.loginvsi.com/documentation/v3/performing-tests/workloads>.

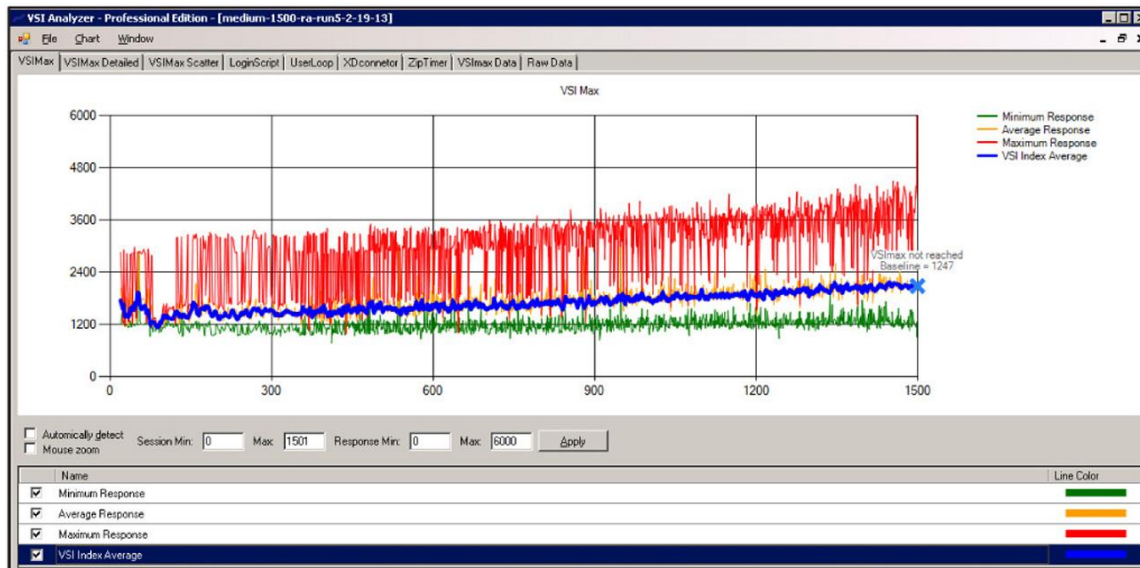
**Figure 13: Login VSI Medium Workload Test Configuration**



The primary goal of the testing of this particular reference architecture was to establish a simple, manageable, and scalable configuration that would be able to run the Medium user profile workload and not reach the VSIMax threshold. The testing did not attempt to benchmark the upper limits of the configuration because this would have required pushing one or all components (server, network, or storage) to levels above the 85 to 90 percent desired operation thresholds. The 1500-desktop solution constructed was able to run the Login VSI Medium workload on multiple occasions and stay below the VSIMax threshold, as shown in Figure 14. More information about interpreting the Login VSI VSIMax calculation can be found here:

<http://www.loginvsi.com/documentation/v3/analyzing-results/determining-vsimumax>

**Figure 14: VSIMax Calculation**



## Boot and Login Scenarios

The Login VSI testing tool allows control of an orderly user login sequence when performing a test run. Because the testing involves making a client connection to the desktop, the desktop virtual machine should already be powered on and receiving connections. To test the boot, reboot, and shutdown scenarios, Citrix XenDesktop Studio and scripts were used to manipulate the power-state characteristics of large sets of desktop virtual machines.

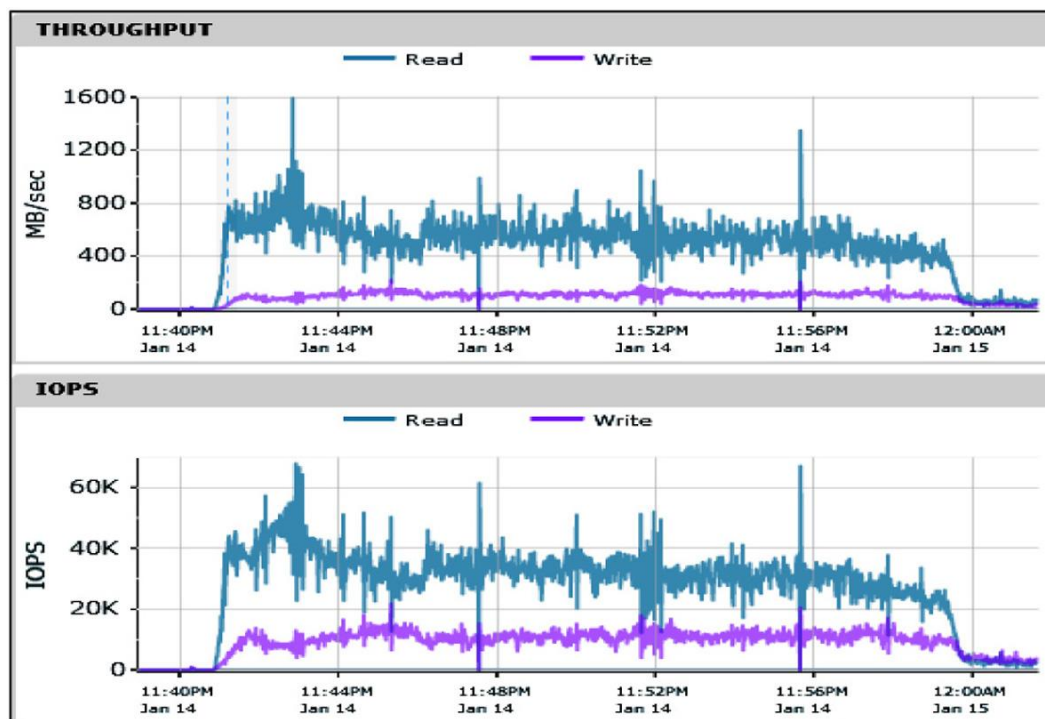
The total time to boot 1500 desktops and have the desktops ready for Citrix XenDesktop client access was approximately 20 minutes. This time is measured by the registration of the desktop virtual machine with the Citrix XenDesktop Studio management user interface and its move to the ready state.

The effect of the boot storm period on the Nimble Storage appliance can be seen in Figure 15, which contains two graphs:

- MBps throughput
- IOPS

These graphs show that the storage infrastructure is delivering data well within the operational specifications expected. The system under test is capable of approximately 42,000 mixed-workload IOPS.

**Figure 15:** Nimble Storage Boot Storm



## Steady-State Scenarios

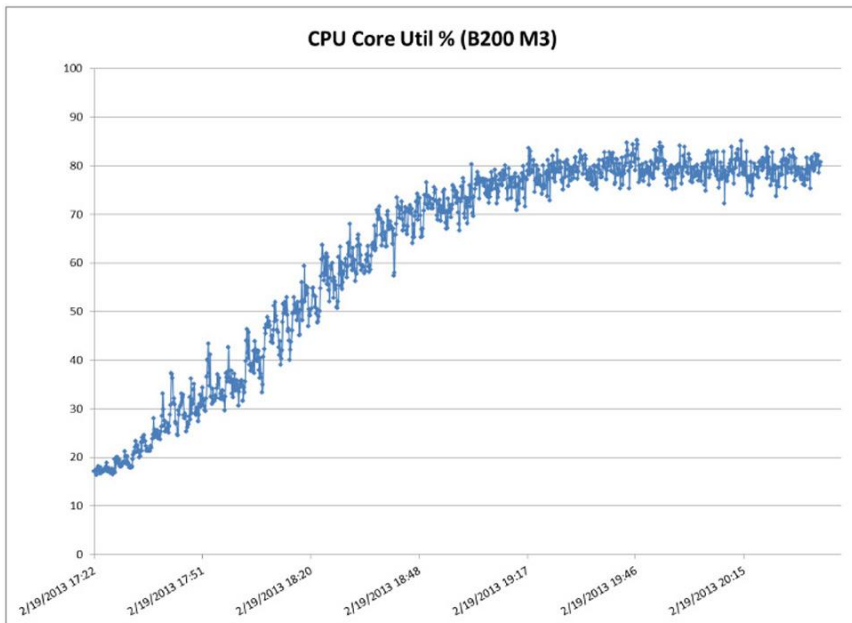
After the system is booted to a powered-on and ready state, the transition to steady state causes a dramatic shift in the number and type of random I/O operations required to support the desktop workload. As the desktop virtual machines shift through login to running specified workload profile tasks defined by Login VSI, the random write operations become the dominant factor, reaching levels of three to four times the number of random read I/O operations. The details of these different-state workloads are shown in Appendixes B and C.

Figure 16 shows that as the workload approaches steady state, the CPU utilization on a single server blade is within the performance bounds desired for each blade in the Cisco UCS solution. Figure 17 shows a high-level view of server resource utilization from the VMware vCenter.

**Note:** The server allocation and related utilization shown in Figure 17 can be categorized as follows:

- Infrastructure services (2 Cisco UCS B200 M2 servers)
  - Low CPU and memory use
  - ucsesx5-11 and ucsesx5-12
- Login VSI components (2 Cisco UCS B230 M2 servers)
  - High CPU and medium memory use
  - ucsesx5-18 and ucsesx5-21
- VDI desktops (2 Cisco UCS B200 M3 servers)
  - High CPU and medium memory use
  - ucsesx5-23 and ucsesx5-24
- VDI desktops (10 Cisco UCS B230 M2 servers)
  - High CPU and high memory use
  - ucsesx5-13 through ucsesx5-17, ucsesx5-22, and ucsesx5-25 through ucsesx5-28

**Figure 16:** Cisco UCS B200 M3 Blade: Steady-State Workload



**Figure 17: VMware vCenter Server Sample Resource Use**

Name	% Memory	% CPU
ucsesx5-21.sedemo.lab	51	88
ucsesx5-17.sedemo.lab	74	84
ucsesx5-23.sedemo.lab	88	84
ucsesx5-18.sedemo.lab	51	83
ucsesx5-15.sedemo.lab	76	78
ucsesx5-22.sedemo.lab	75	78
ucsesx5-28.sedemo.lab	72	78
ucsesx5-13.sedemo.lab	76	76
ucsesx5-16.sedemo.lab	74	74
ucsesx5-25.sedemo.lab	73	73
ucsesx5-26.sedemo.lab	73	72
ucsesx5-14.sedemo.lab	74	71
ucsesx5-24.sedemo.lab	87	66
ucsesx5-11.sedemo.lab	57	59
ucsesx5-27.sedemo.lab	72	22
ucsesx5-12.sedemo.lab	40	4

## Conclusion

The VDI solution test conducted with the Cisco UCS B-Series Servers, Nimble Storage CS440G-X4 array, and Citrix XenDesktop 5.6 showed that a robust yet simple configuration is possible for VDI scenarios with up to 1500 average worker desktops.

## For More Information

Nimble Storage VDI Solutions: <http://www.nimblestorage.com/solutions/VDI/overview.php>

Nimble Storage Alliances: <http://www.nimblestorage.com/solutions/alliances/index.php>

Cisco VXI: Desktop Virtualization with Citrix: <http://www.cisco.com/en/US/netsol/ns1135/index.html>

## Appendix A: Bill of Materials

Table 1 shows the bill of materials (BOM) for the test.

**Table 1:** Bill of Materials

Vendor	Component Model (Quantity)	Software or OS Version
<b>Servers and Network</b> Cisco	Cisco UCS 5108 Blade Server Chassis (2)	Release 2.0(3c)
	Cisco UCS 2204XP Fabric Extender	
	Cisco UCS 6248UP 48-Port Fabric Interconnects (2)	
	Cisco UCS B200 M3 Blade Server (2)	
	Cisco UCS B230 M2 Blade Server (12)	
	Cisco UCS B200 M2 Blade Server (2)	
<b>Storage</b> Nimble Storage	Nimble Storage CS440G-X4 (1)	Release 1.4.4.0
<b>Hypervisor</b> VMware	VMware vSphere ESXi	VMware ESXi 5.0 Update 1
	VMware vSphere vCenter Server Standard	VMware vCenter 5.0 Update 1
<b>Desktop Management</b> Citrix	Citrix XenDesktop (up to 2000 desktops)	XenDesktop 5.6 MCS
<b>Workload Testing</b> Login VSI	Login VSI (up to 2000 desktops)	3.6.1

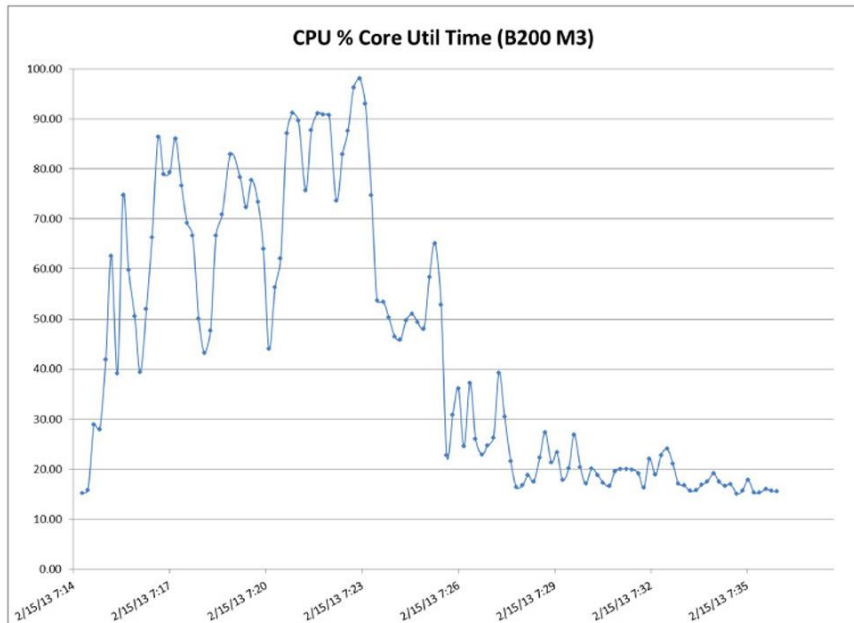


## Appendix B: VMware esxtop Graphs

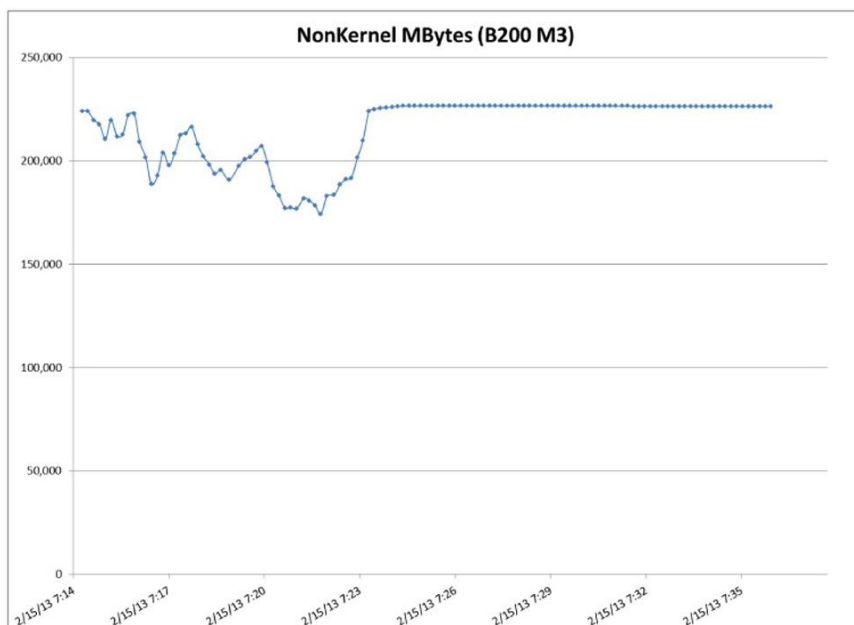
### Boot Storm Cisco UCS Performance Graphs

Approximately 20 minutes was required to reboot and log in all 1500 desktops. The operations were staggered across the environment of 12 VMware ESXi hosts and sampled with VMware esxtop for one Cisco UCS B200 M3 Blade Server (Figures 18 through 23) and one Cisco UCS B230 M2 Blade Server (Figures 24 through 29).

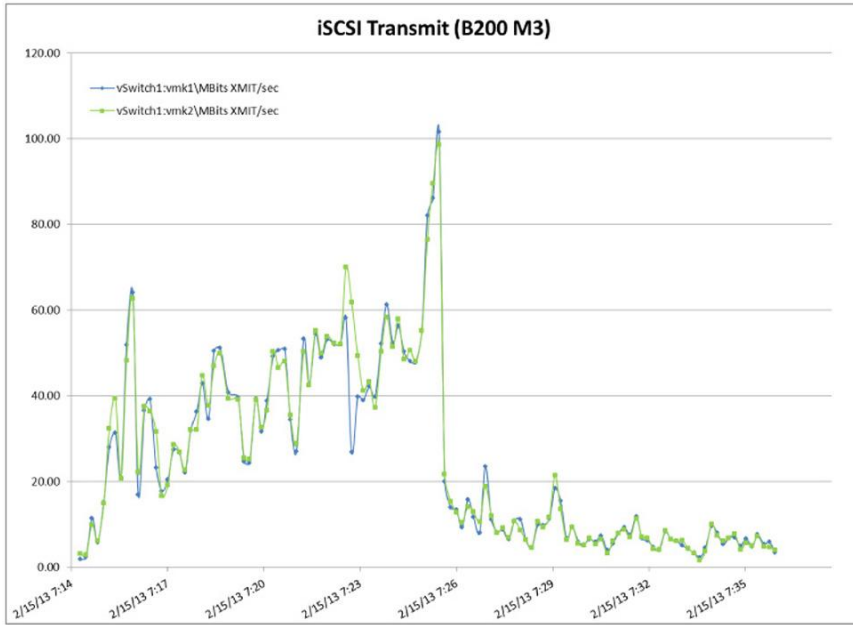
**Figure 18:** Boot Storm Cisco UCS CPU Utilization: Percentage of Core Used (Total)



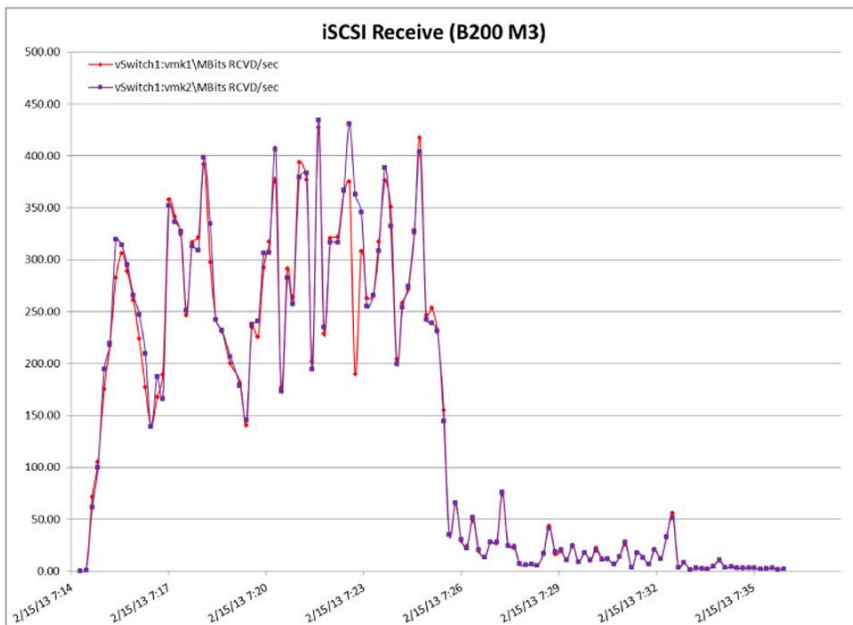
**Figure 19:** Boot Storm Cisco UCS Nonkernel Memory Use



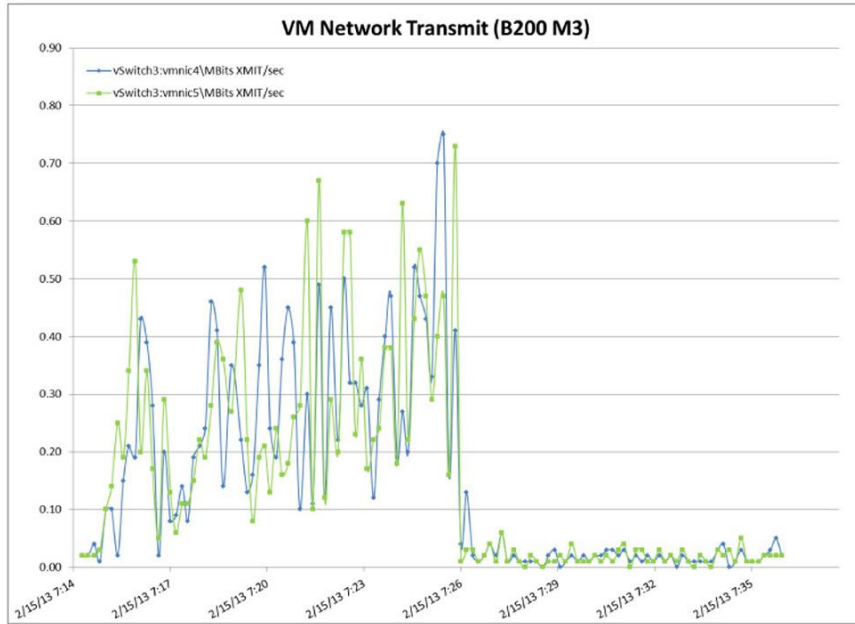
**Figure 20: Boot Storm iSCSI Transmit (MBps) Multipath I/O (MPIO)**



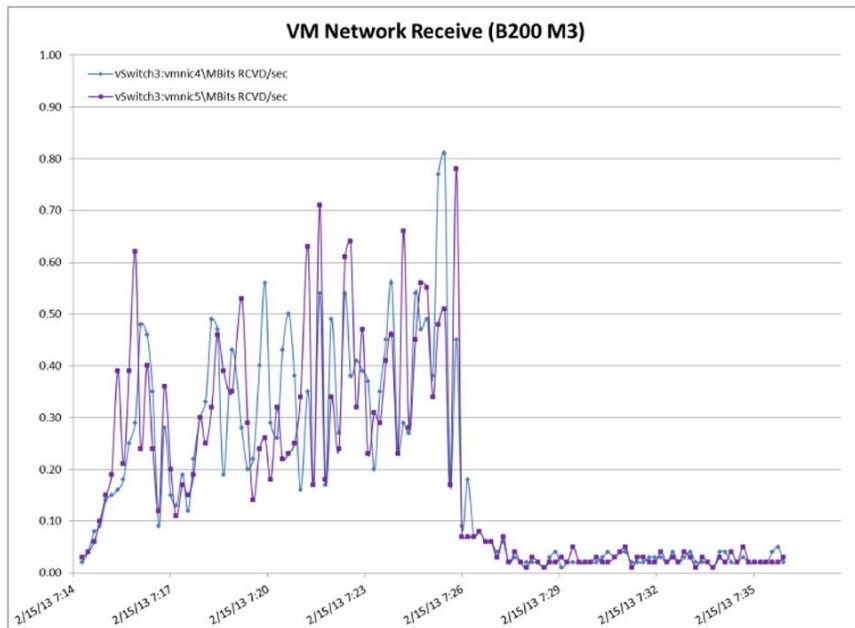
**Figure 21: Boot Storm iSCSI Receive (MBps) MPIO**



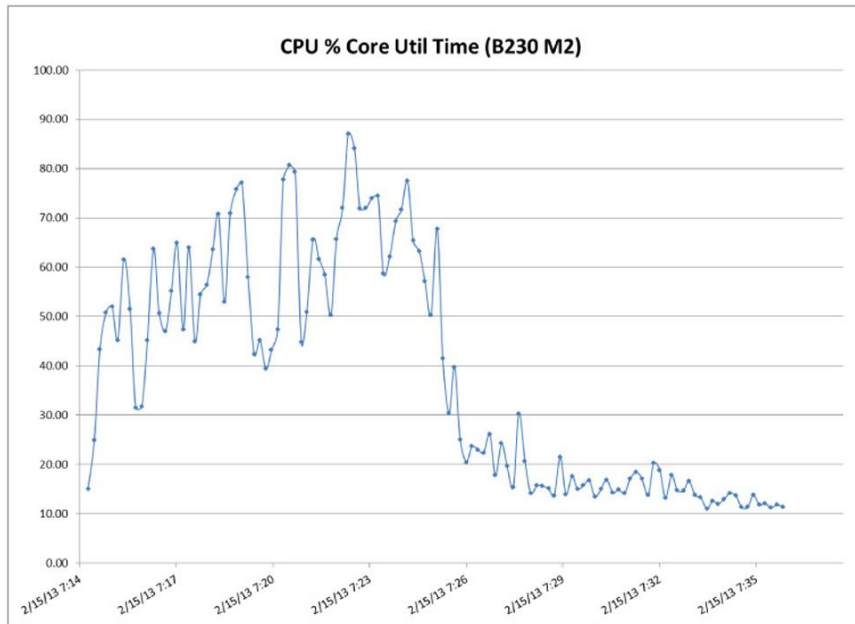
**Figure 22: Boot Storm Virtual Machine Network Transmit Operation (MBps)**



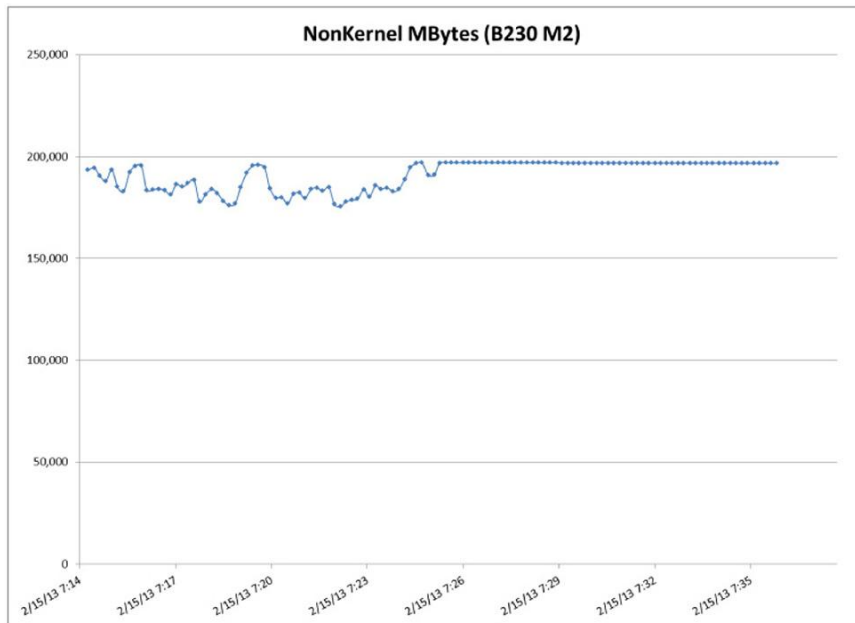
**Figure 23: Boot Storm Virtual Machine Network Receive Operation (MBps)**



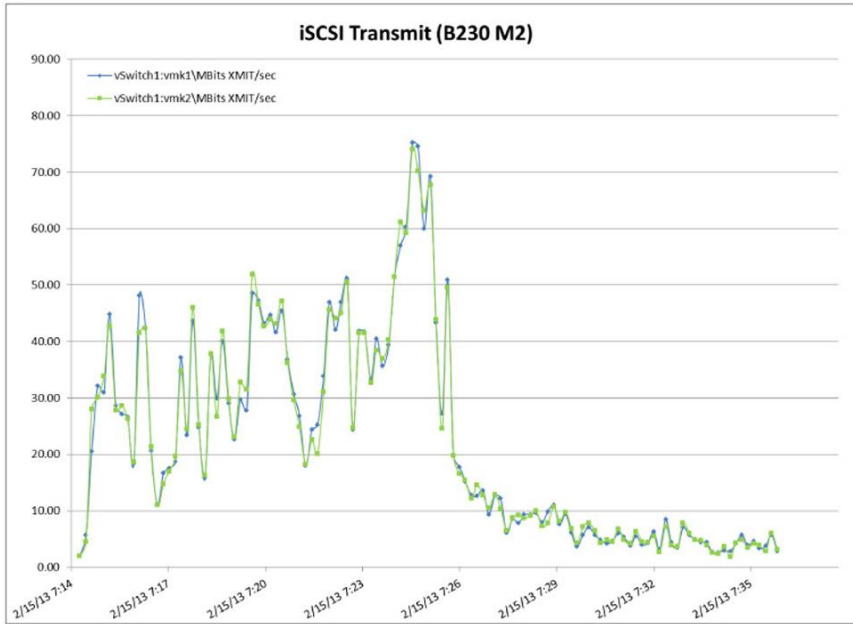
**Figure 24:** Boot Storm Cisco UCS CPU Utilization: Percentage of Core Used (Total)



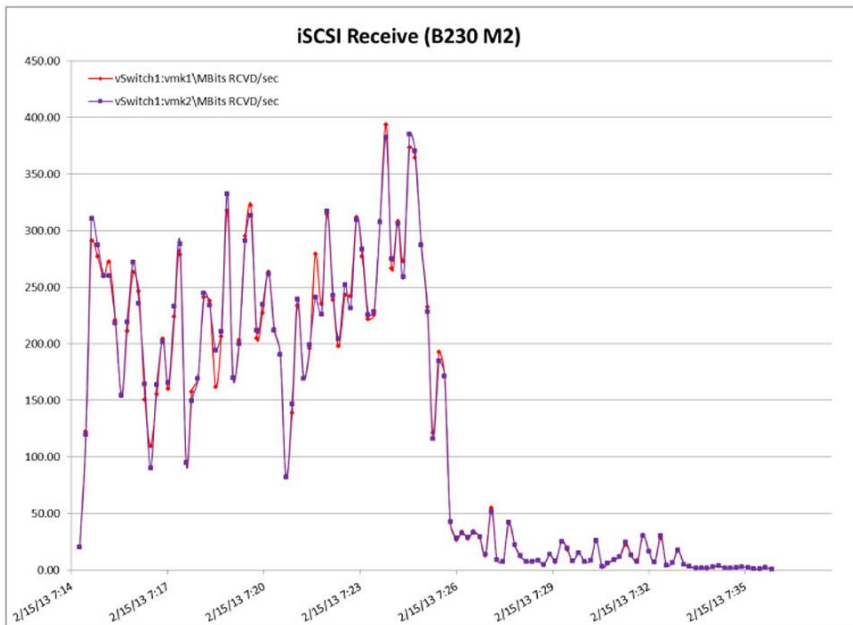
**Figure 25:** Boot Storm Cisco UCS Nonkernel Memory Use



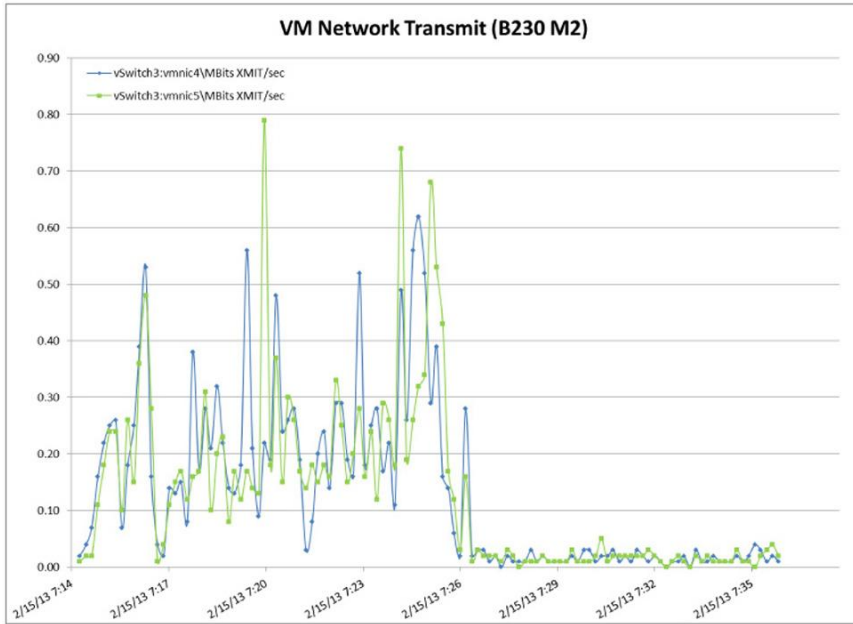
**Figure 26:** Boot Storm iSCSI Transmit (MBps) MPIO



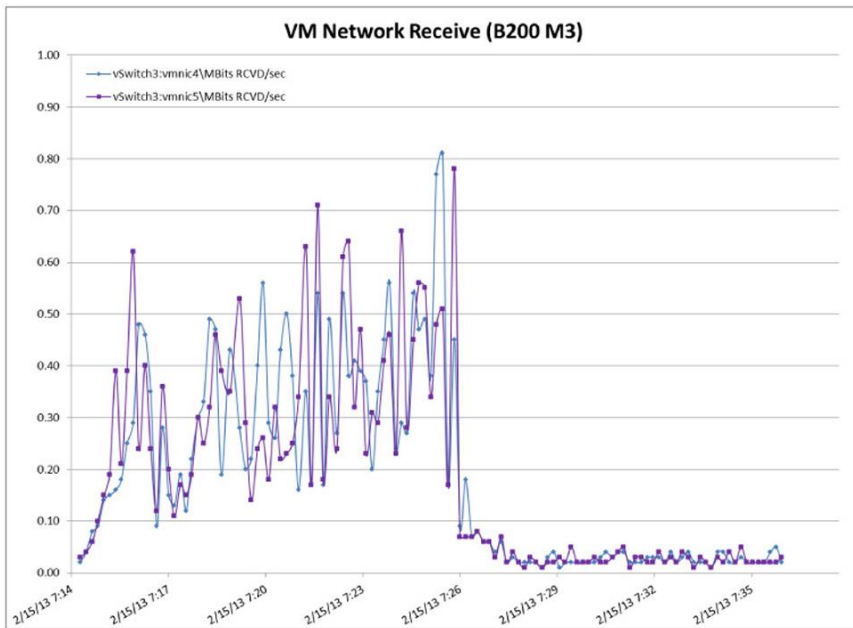
**Figure 27:** Boot Storm iSCSI Receive (MBps) MPIO



**Figure 28: Boot Storm Virtual Machine Network Transmit Operation (MBps)**



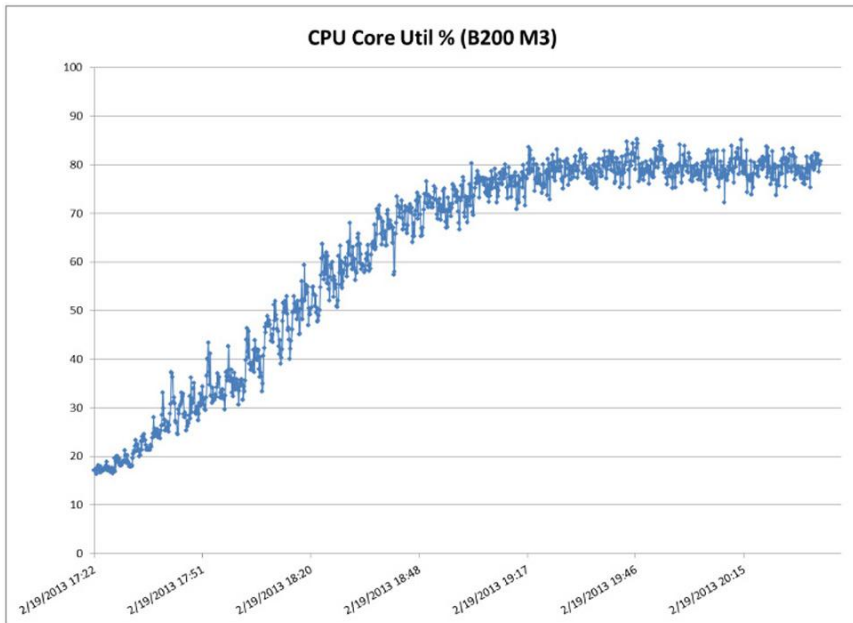
**Figure 29: Boot Storm Virtual Machine Network Receive Operation (MBps)**



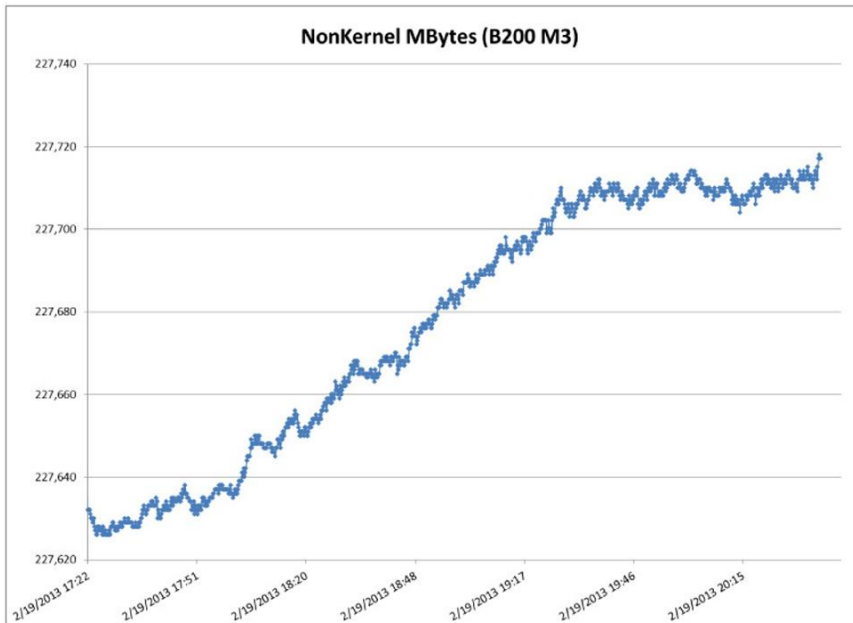
### Steady-State Cisco UCS Performance Graphs

Approximately 3 hours, including rollout of the test work load on 1500 desktops, were sampled with VMware esxtop on one Cisco UCS B200 M3 Blade Server (Figures 30 through 35) and one Cisco UCS B230 M2 Blade Server (Figures 36 through 41).

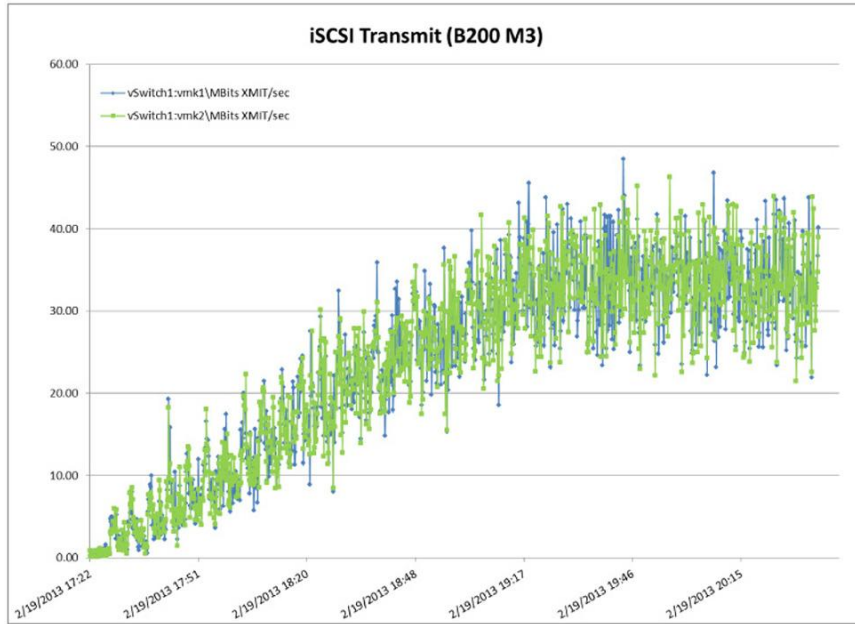
**Figure 30:** Steady-State Cisco UCS CPU Utilization: Percentage of Core Used (Total)



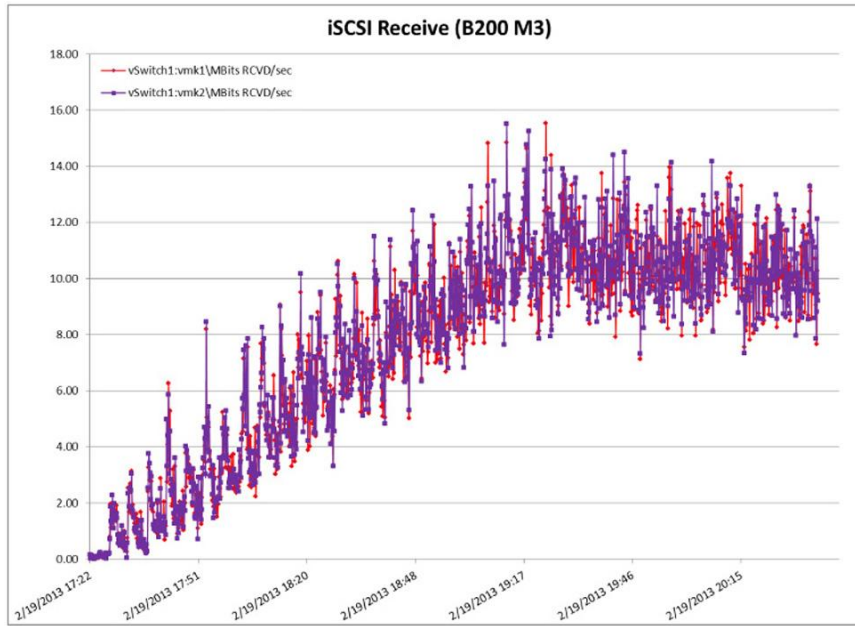
**Figure 31:** Steady-State Cisco UCS Nonkernel Memory Use



**Figure 32: Steady-State iSCSI Transmit Operations (MBps): MPIO**

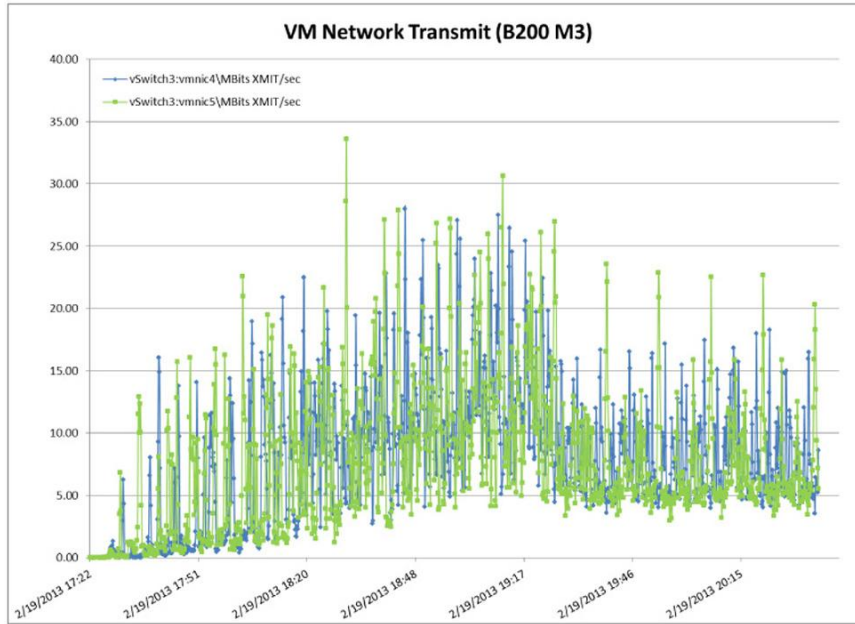


**Figure 33: Steady-State iSCSI Receive Operations (MBps): MPIO**

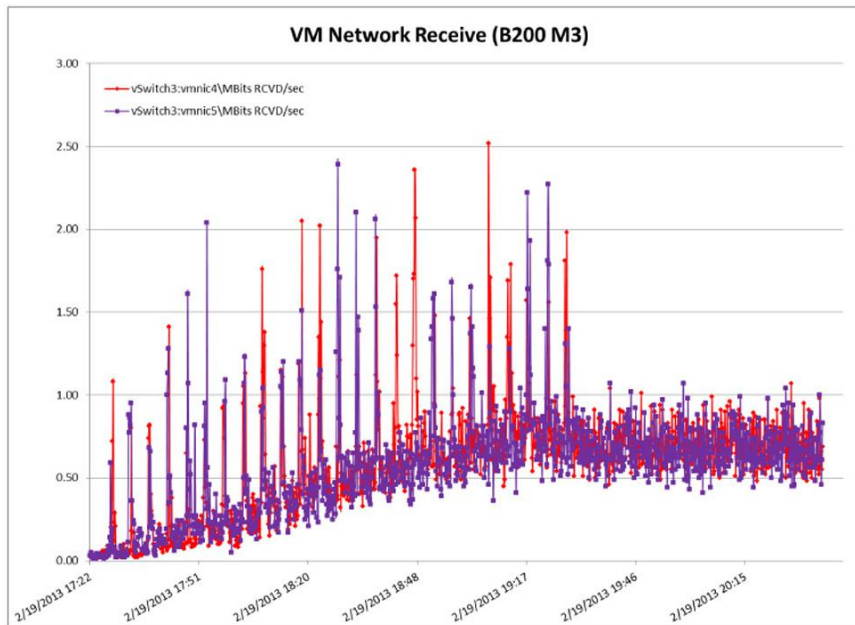




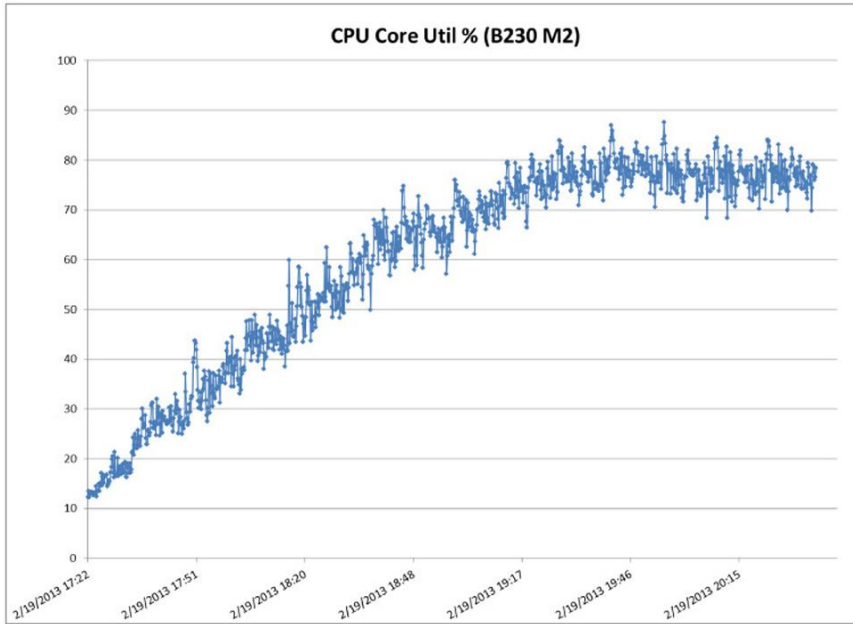
**Figure 34:** Steady-State Virtual Machine Network Transmit Operations (MBps)



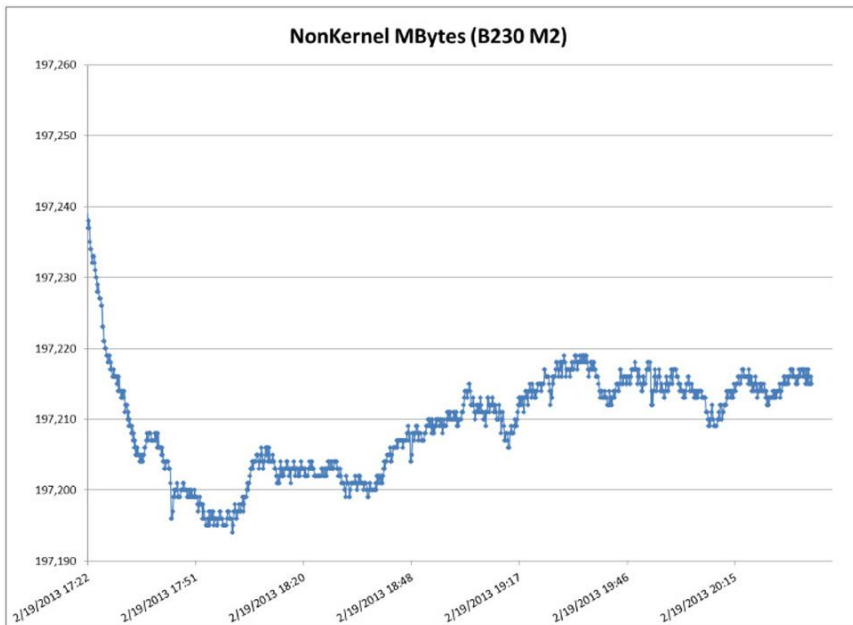
**Figure 35:** Steady-State Virtual Machine Network Receive Operations (MBps)



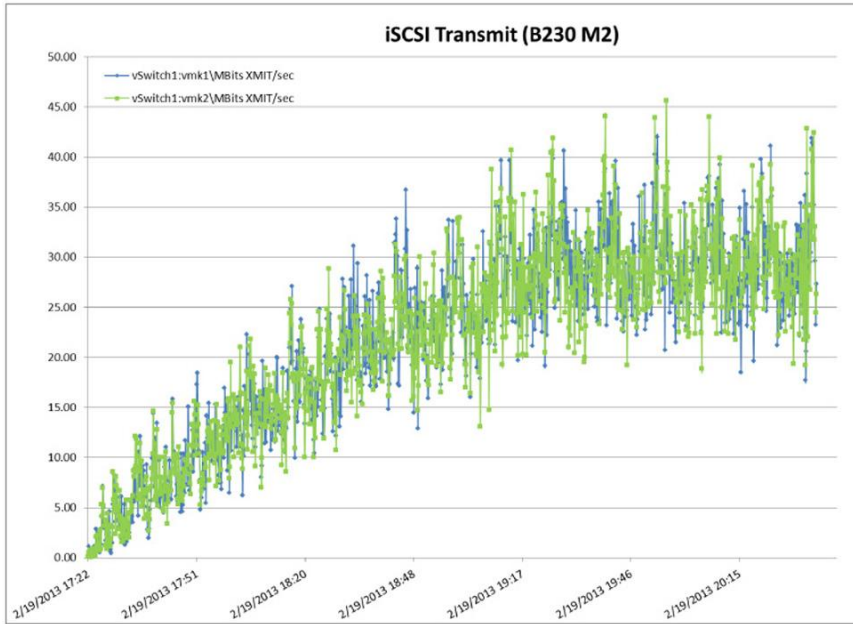
**Figure 36:** Steady-State Cisco UCS CPU Utilization: Percentage of Core Used (Total)



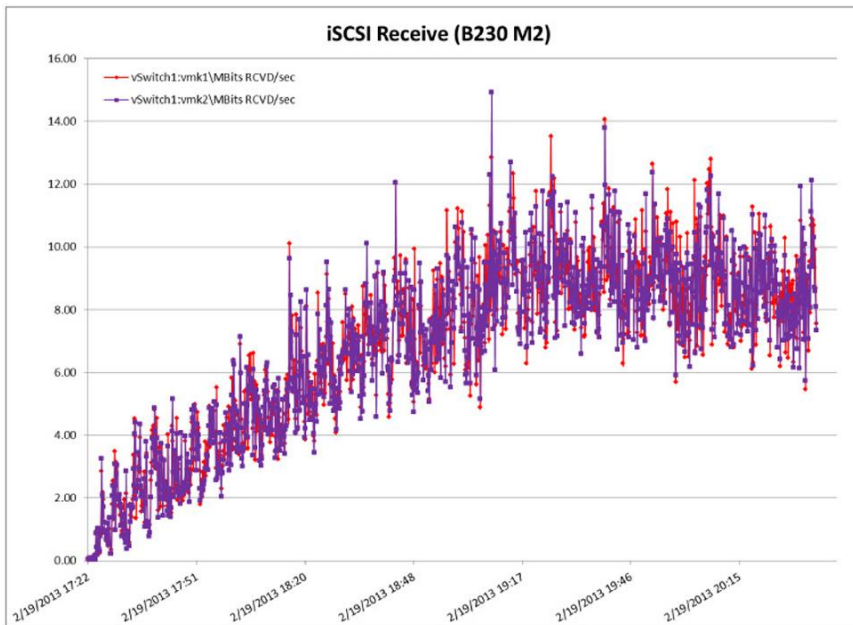
**Figure 37:** Steady-State Cisco UCS Nonkernel Memory Use



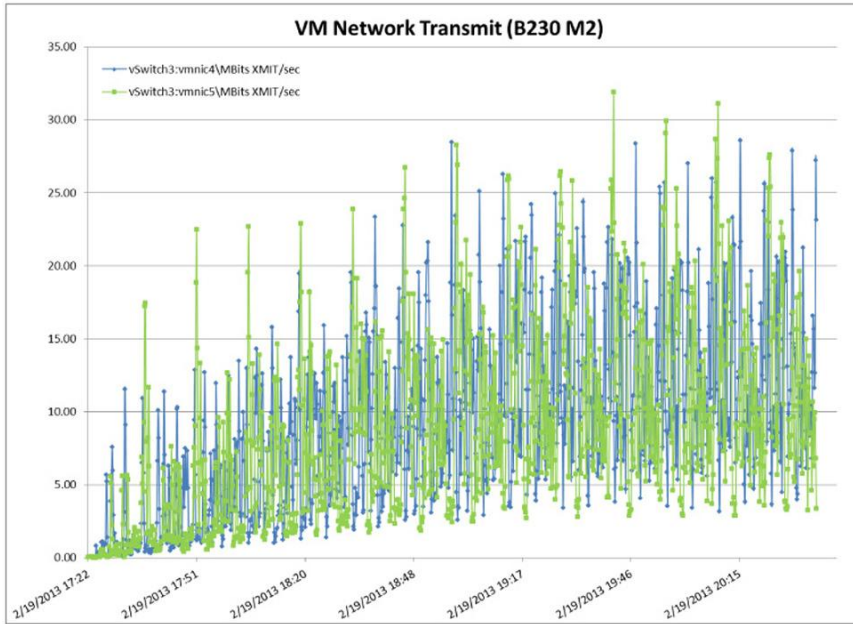
**Figure 38:** Steady-State iSCSI Transmit Operations (MBps): MPIO



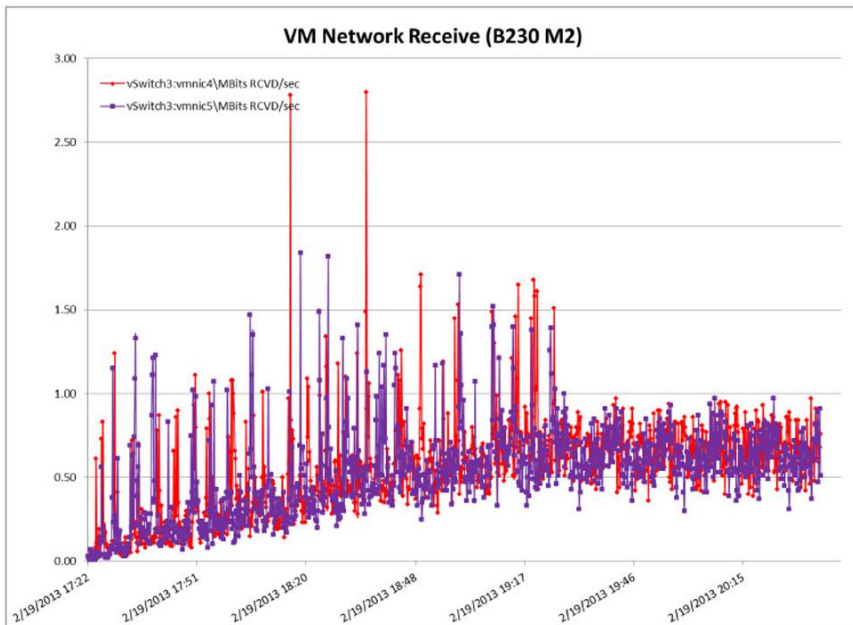
**Figure 39:** Steady-State iSCSI Receive Operations (MBps): MPIO



**Figure 40:** Steady-State Virtual Machine Network Transmit Operations (MBps)



**Figure 41:** Steady-State Virtual Machine Network Receive Operations (MBps)

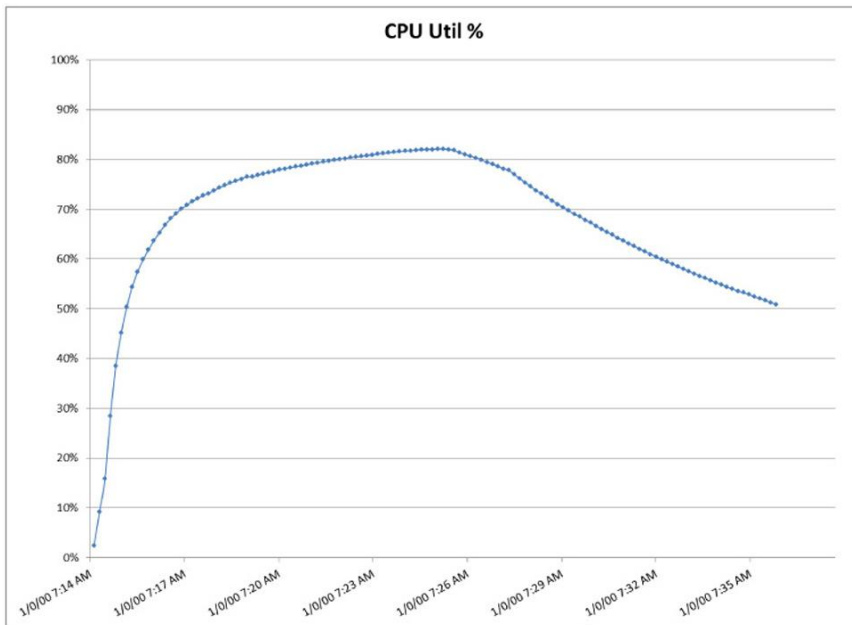


## Appendix C: Nimble Storage Performance Graphs

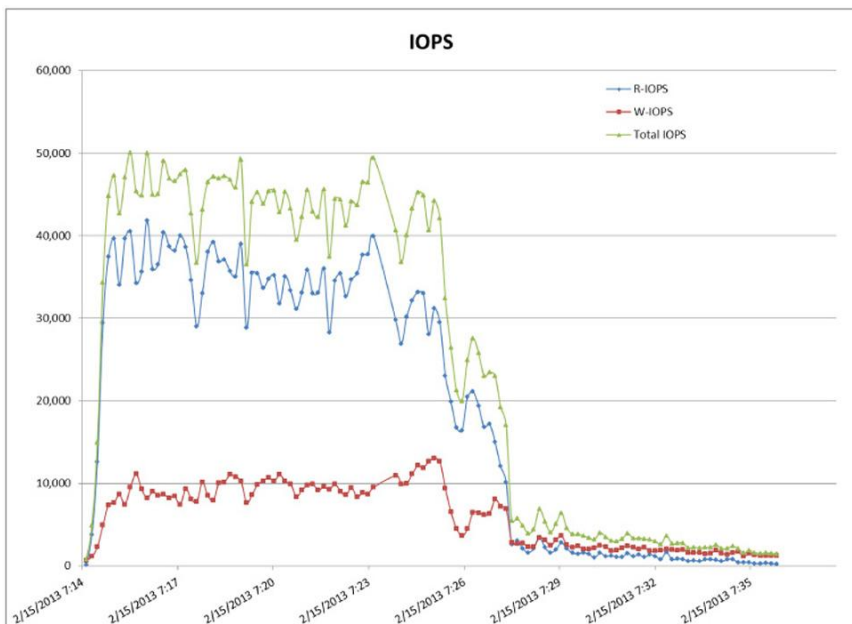
### Boot Storm Storage Performance Graphs

Approximately 20 minutes were needed to boot and log in 1500 desktops (Figures 42 through 45).

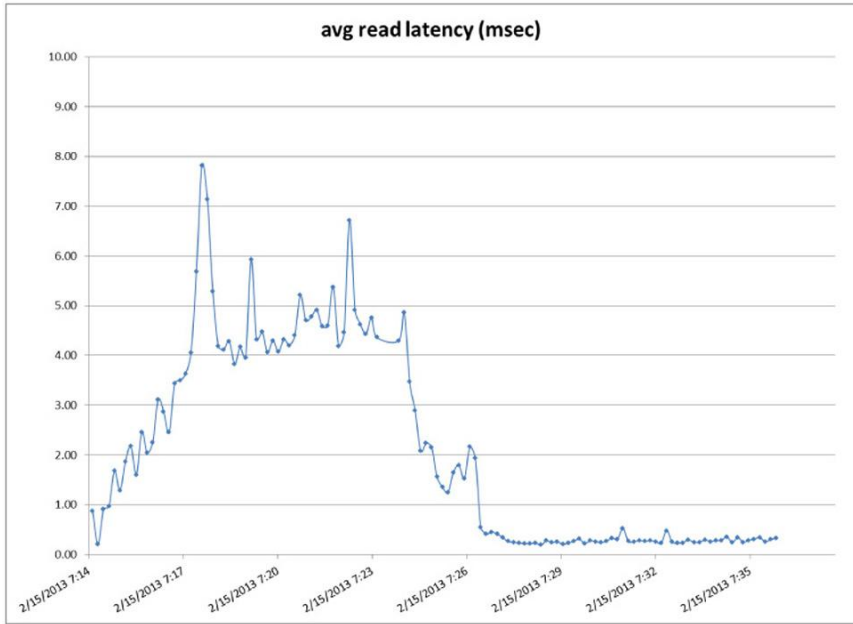
**Figure 42:** Boot Storm Storage Processor (CPU) Utilization



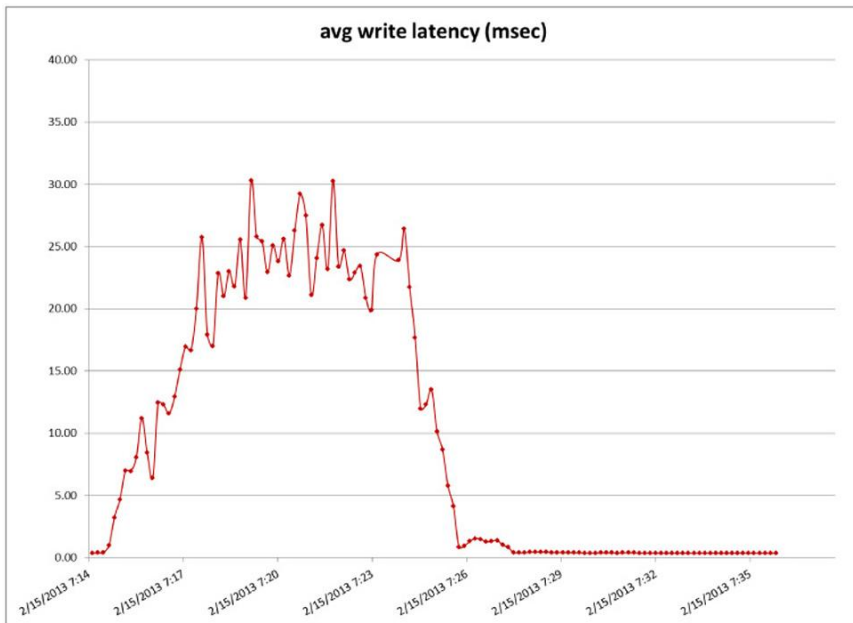
**Figure 43:** Boot Storm Storage IOPS



**Figure 44: Boot Storm Average Read Latency**



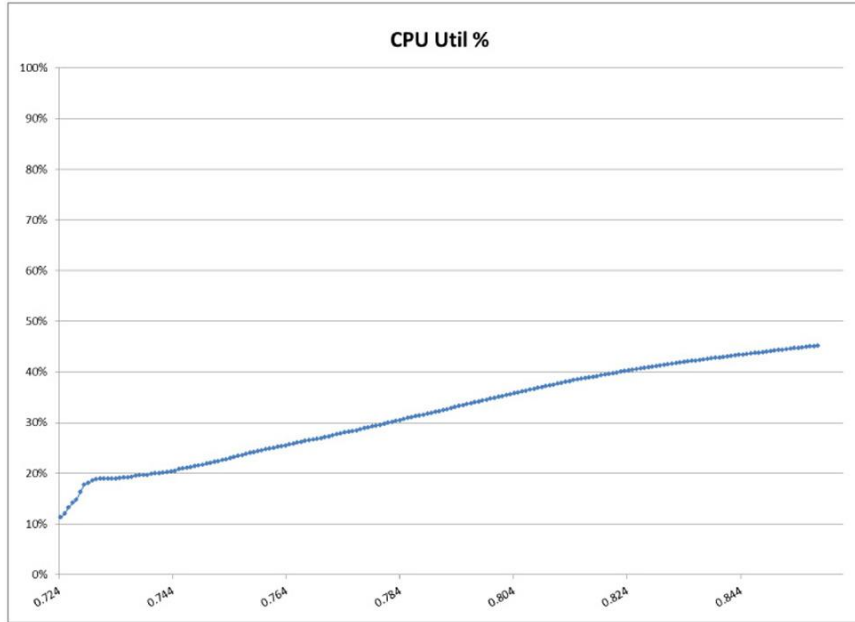
**Figure 45: Boot Storm Average Write Latency**



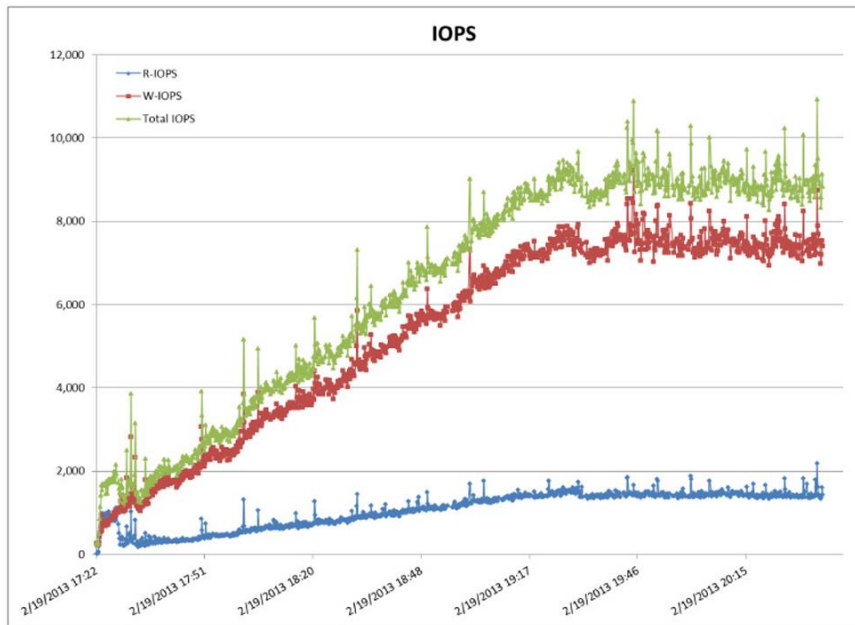
### Steady-State Storage Performance Graphs

Approximately 2 hours, including rollout of the test work load on 1500 desktops, were monitored (Figures 46 through 49).

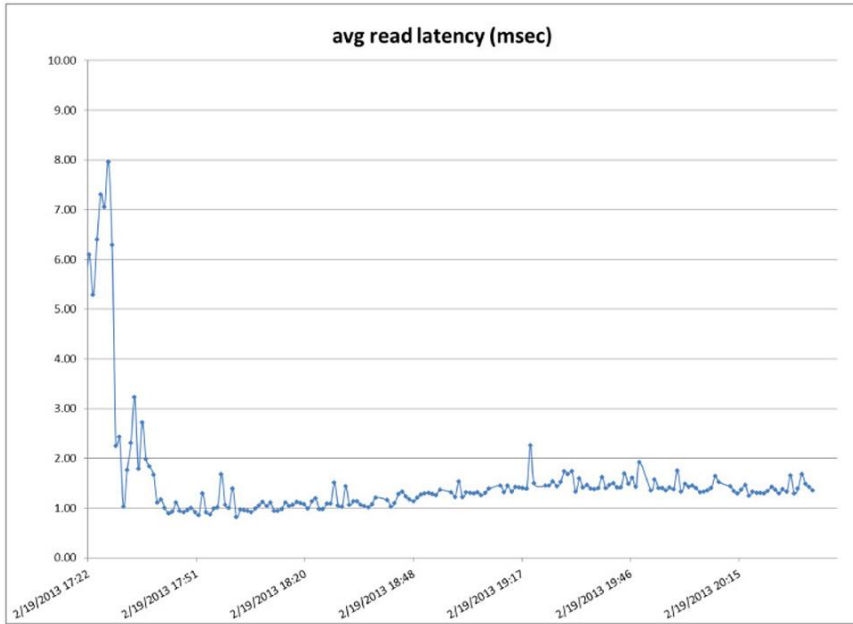
**Figure 46:** Steady-State Storage Processor (CPU) Utilization



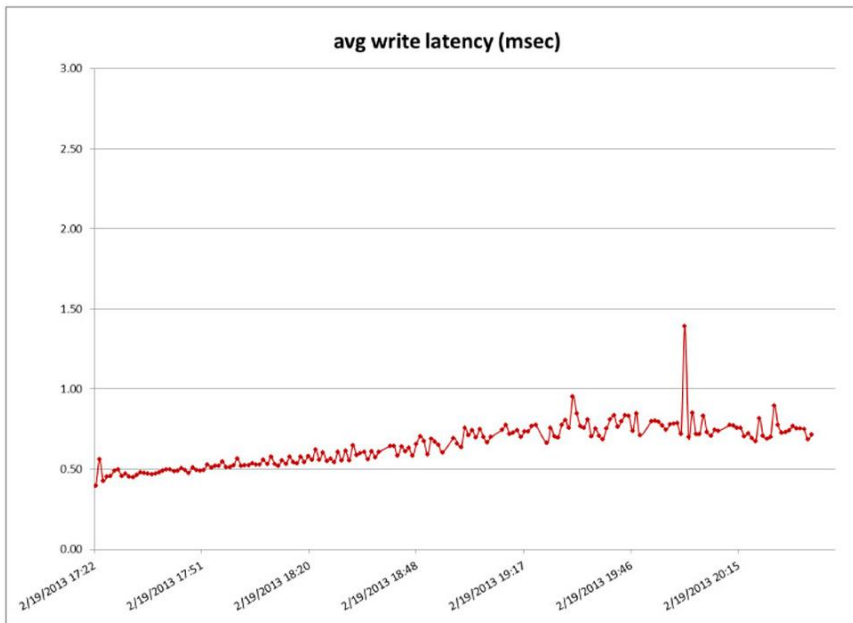
**Figure 47:** Steady-State Storage IOPS



**Figure 48: Steady-State Average Read Latency**



**Figure 49: Steady-State Average Write Latency**

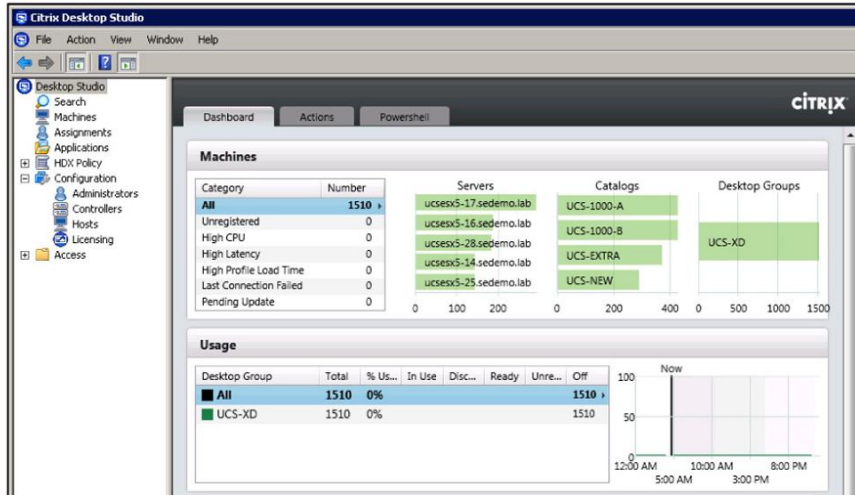




## Appendix D: Citrix XenDesktop Configuration Details

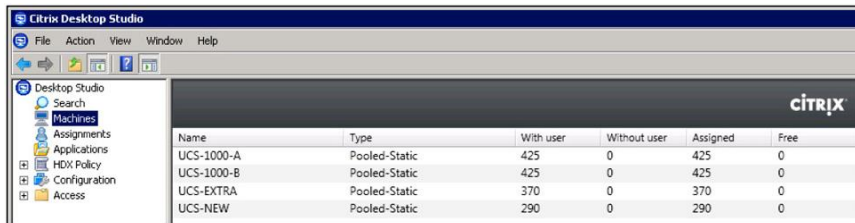
A single Citrix XenDesktop 5.6 desktop group of 1510 Microsoft Windows 7 x86 virtual machines was defined as depicted in Figure 50.

**Figure 50:** Citrix Desktop Studio: Dashboard View



The Citrix XenDesktop 5.6 MCS desktop pools were configured as static, pooled desktops. To test 1500 desktops, four Citrix XenDesktop machine catalogs of about 300 to 400 desktop virtual machines per catalog were created in the test configuration (Figure 51).

**Figure 51:** Citrix XenDesktop MCS Pooled Desktops Configuration



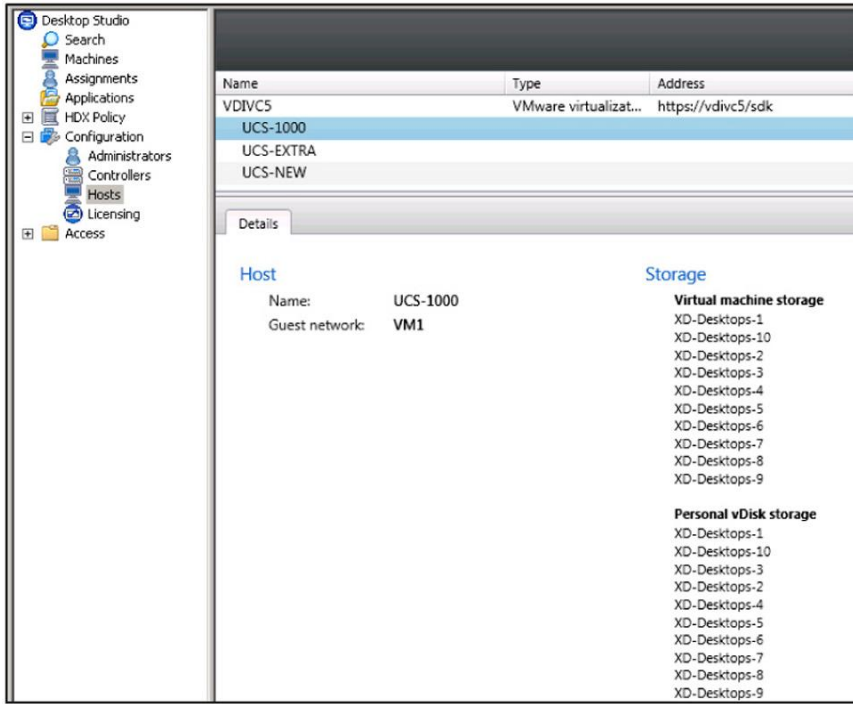
Each machine catalog had multiple separate data stores provisioned to it from the Nimble Storage volumes presented as VMFS data stores to the underlying VMware ESXi hosts. All related desktop storage (virtual machine and personal vDisk) was placed on the same set of data stores for that catalog.

Three hosts were presented to the Citrix XenDesktop controllers. Each Citrix XenDesktop host was a clustered configuration of individual VMware ESXi 5.0u1 hosts, virtual machines, and storage as follows:

- UCS-1000: 7 Cisco UCS B230 M2 blades, 850 desktops, and 10 storage volumes (2 TB each)
- UCS-EXTRA: 3 Cisco UCS B230 M2 blades, 370 desktops, and 6 storage volumes (2 TB each)
- UCS-NEW: 2 Cisco UCS B200 M3 blades, 290 desktops, and 4 storage volumes (2 TB each)

Figure 52 shows an example of the host and storage configuration for UCS-1000.

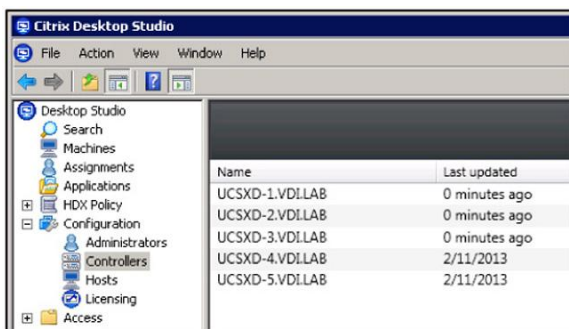
**Figure 52:** Host and Storage Configuration



All desktops were provisioned at the start and assigned static users through Login VSI initialization runs and Citrix XenDesktop allocation methods. After they were provisioned and assigned, the desktop virtual machines could then easily be manipulated for boot, login, and workload testing.

All other Citrix XenDesktop MCS settings were basic default values. The 1500 desktops were managed through a set of three active Citrix XenDesktop desktop controller virtual machines. A total of five desktop controllers were constructed, but no more than three were needed to support the test workloads (Figure 53).

**Figure 53:** Citrix XenDesktop Desktop Controller Configuration

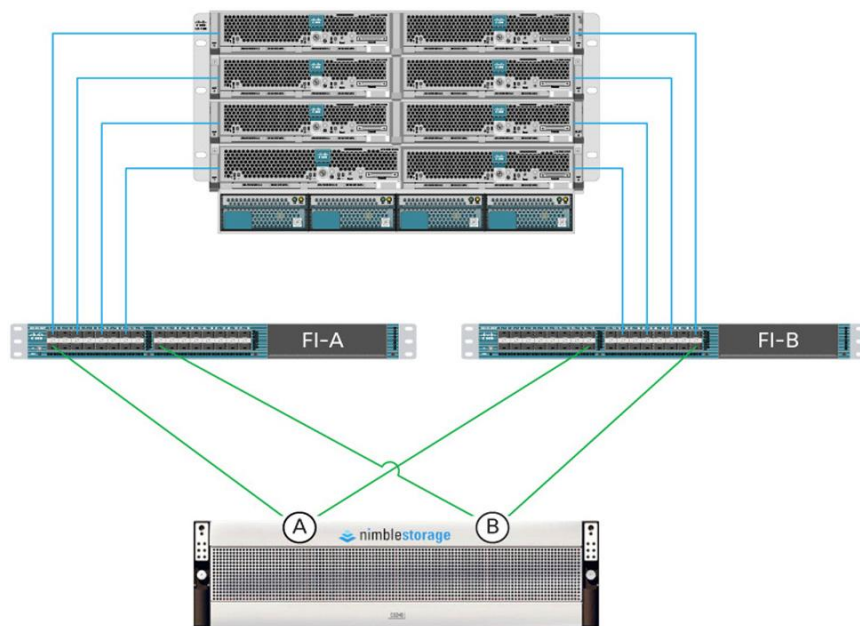


## Appendix E: Nimble Storage Connectivity with Cisco UCS

### Controller to Fabric Interconnect Cross-Connection Method

Connect one path from each Nimble Storage controller (A and B) to a separate Cisco UCS fabric interconnect (A and B). This setup enables support for path failover with only a slight reduction in the MPIO configuration for the Nimble Storage array during a Cisco UCS component failure. The Cisco UCS configuration of vNICs for iSCSI traffic is required to support the separate networks and VLANs for this configuration. The basic solution looks like Figure 54.

**Figure 54:** Controller to Fabric Interconnect Cross-Connection Method



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