Cisco Unified Computing System, Citrix XenDesktop, and Atlantis ILIO

White Paper

November 2010

Contents

Executive Summary

VDI has the potential to revolutionize enterprise desktop computing by lowering the total cost of desktop computing, increasing security and compliance and making desktop computing more agile. Many companies have deployed VDI only to realize that their VDI architecture could not scale beyond a thousand desktops without either degrading desktop performance or requiring a massive additional investment in computing, networking or storage infrastructure. The VDI cost and performance challenges are a result of memory and storage bottlenecks that lower VDI density per server, degrade user performance and ultimately increase the cost of VDI. In order for VDI to achieve broad adoption, it must deliver cost, performance and scalability characteristics that are equivalent or better than the existing physical PC-based computing infrastructure.

The VDI performance, density and cost challenges are compounded when organizations deploy VDI in combination with Microsoft Windows 7 and anti-virus. Anti-virus has a significant impact on desktop performance (150ms response time increase on performance benchmarks), density of desktops per server (30 percent lower density due to increased CPU and IO) and storage requirements (increase IOPS requiring additional storage disks) in a VDI environment. However, VDI benchmarking typically does not include anti-virus in the desktop image. In order to provide customers with real-world VDI deployment benchmark and reference architecture, ALL of the published testing within this document was performed with Microsoft Windows 7 and McAfee Enterprise anti-virus.

Cisco and Atlantis Computing™ have partnered to deliver a VDI solution and reference architecture that eliminates the VDI memory and storage bottlenecks, enabling customers to deploy VDI with better performance and at a lower cost than a physical PC. The joint solution includes the following components (Figure 1).

Figure 1. Solution Components

Cisco Unified Computing System: Computing Platform

The Cisco Unified Computing System (UCS) server portfolio consists of the Blade Server platform, B-Series and the C-Series Rack Mount platform. We chose the Cisco UCS B250-M2 Blade Server platform with extended memory technology running VMware vSphere 4.0U2 for this study. The system integrates a low-latency; lossless 10 Gigabit Ethernet unified network fabric with enterprise-class, x86-architecture servers. The system is an integrated, scalable, multi-chassis platform in which all resources participate in a unified management domain.

VDI Solution: Citrix XenDesktop

Citrix XenDesktop is a desktop virtualization solution that delivers Windows desktops as an on-demand service to any user, anywhere. With FlexCast™ delivery technology, XenDesktop can quickly and securely deliver individual applications or complete desktops to the entire enterprise, whether they are task workers, knowledge workers or mobile workers. All Citrix infrastructure components are virtualized on separate Cisco UCS blades on VMware vSphere.

VDI Storage and Performance Optimization: Atlantis ILIO

Atlantis ILIO is a VDI storage and performance optimization solution that integrates with VDI offerings to reduce storage costs, provide IT teams with more storage options and boost desktop performance. Atlantis ILIO is a unique and innovative IO virtualization technology that fundamentally changes the economics and performance characteristics of VDI by intelligently optimizing how the Microsoft

Windows operating system interacts with VDI storage.

There are two Atlantis deployment options documented in the reference architecture:

Atlantis ILIO Top-of-Rack—Atlantis ILIO running one dedicated Cisco UCS B250 M2 Blade Server with 192 GB of memory optimizing storage and performance for up to 8 blade servers.

Atlantis ILIO OnBlade— Atlantis ILIO running each Cisco UCS B250 M2 Blade Server with 192 GB of memory optimizing storage and performance for the desktops on that blade.

The test results show that the Cisco and Atlantis VDI Reference Architecture are able to deliver the required performance, cost and scalability required by enterprise customers with Microsoft Windows 7 running anti-virus as shown in Table 1.

Table 1. Test Results

Summary Test Results	Atlantis ILIO Top-of-Rack	Atlantis ILIO OnBlade
Virtual Desktop Density per Blade	80	80
Performance Benchmark Pass Rate	100%	100%
Atlantis ILIO Write IOPS Offload %	71%	67%
Atlantis ILIO Read IOPS Offload %	82%	91%

The Cisco UCS and Atlantis ILIO VDI reference architecture unites the compute, network, virtualization, storage optimization components of a VDI deployment into a cohesive and modular system designed to reduce total cost of ownership (TCO), deliver sustained desktop performance comparable to a physical PC and scale to an unlimited number of desktops without requiring large investment in additional network or storage infrastructure.

The Challenge

As organizations everywhere reassess their end-user computing strategies, they recognize the need to balance the competing requirements of IT departments and users. While users are demanding ever more flexibility, mobility and performance, IT departments need to reduce cost and complexity, increase security and compliance, design scalable infrastructure and choose an agile approach to desktop computing that they can be quickly put to work to better meet business needs.

IT departments are recognizing that the cost and risks of maintaining a traditional desktop infrastructure have become untenable. Today's globally distributed; application-laden desktops and laptops are cumbersome and difficult to manage. Over time, each PC in an organization develops its own unique operating system and application image, which leads to problems that must be solved, one system at a time. Mission-critical data is distributed across a global pool of resources and cannot be adequately controlled, leading to challenges in complying with governmental or industry regulations. Unforeseen events that limit workplace access threaten business continuity when users depend on their dedicated desktops to be productive. IT departments must respond to business events such as mergers, acquisitions, and expansions, but they are saddled with the task of integrating or deploying new desktops one PC at a time. With the prospect of migrating to Microsoft Windows 7 in the near future, IT departments are looking for an approach to make the transition as swift and cost-effective as possible.

Delivering a Quality VDI Desktop Experience at the Cost of a Physical PC

The challenge of operating in a global economy demands reductions in CAPEX spending, short return on investment time horizons and the utmost in user productivity. To be more effective, users are demanding access to applications anywhere, anytime, and on their choice of devices. User expectations are no longer set by the sophistication of desktop PCs at the office, but instead by a range of new consumer devices including highly featured mobile phones, tablets, and laptop computers that can access wireless networks almost anywhere. Users expect that if their personal devices can load new applications from online stores with click-of-the-mouse simplicity, they ought to have that same level of choice and empowerment from the IT departments that they believe are there to help make them more effective.

A desktop virtualization approach can solve these problems, but IT departments understand that they must choose the right solution among those available. The solution must be as cost effective as possible, easy to deploy and must scale incrementally as users transition from physical PCs to virtual desktops. Most important of all, the solution must achieve a balance between the cost, the needs of users and the needs of the IT department.

Over the past 20 years, IT organizations have built their infrastructure around physical PCs and users have become accustomed to using them. Therefore, IT organizations and users will measure Virtual Desktop Infrastructure (VDI) against physical PC characteristics including:

- **Cost**

  While the promise of reduced operating expenses (OPEX) from VDI is attractive to customers, the upfront capital expenditure (CAPEX) on a per desktop basis must be comparable to the upfront cost of a physical PC to make VDI compelling to a broad set of IT organization.

- **Performance**

  When end users transition from physical PCs to virtual desktops, they will demand comparable or better performance which will not diminish over time or when more users come online; there is negativity in certain areas from the business and resistance to move forward from a pilot to a production VDI deployment.

- **Scalability**

  IT organizations need to understand how to design and size servers, network and storage infrastructure for VDI environments in a way that enables VDI deployment to scale linearly without increase cost per desktop or impacting desktop performance.

Balancing VDI Desktop Performance, Cost, and Scalability

VDI delivers tremendous benefits in terms of reducing the cost of provisioning, upgrading and maintaining desktops, as well as, making computing resources more flexible. However, VDI is relatively new to most IT organizations and requires careful design and the right architecture to deliver a high-performance, cost-effective and scalable virtual desktop infrastructure.

With physical PCs, it was easy for IT organizations to deliver desktops without concern for scale. The desktop team would support a fixed number of standardized desktop and laptop PC models designed for different types of workers. Each model delivered a predictable level of performance for a predictable price. The reason for this is that physical PCs have dedicated and fixed computing resources (memory, CPU, hard drive). With virtualization, computing resources are abstracted and pooled to gain more efficiency. With server virtualization, the workloads are predictable enabling IT organizations to accurately predict the usage of computing resources. However, with desktop virtualization, workloads are unpredictable with large variation between average and peak resource utilization. In order to achieve a balance between VDI cost and performance, IT organizations need to find the right mix of server, networking and storage infrastructure components and architecture that can scale linearly as the VDI user base grows.

If the VDI architecture is undersized in terms of memory, CPU or storage, then the desktop performance will degrade and the user experience will suffer. If the VDI architecture is oversized, then the cost per desktop will increase to make it economically unfeasible to switch from physical PCs to VDI. In order to eliminate the risk of under-sizing or over-sizing VDI infrastructure, Cisco Systems and Atlantis Computing have developed a solution and reference architecture that is deployed in modular units that scale linearly without increasing the cost per desktop or degrading performance.

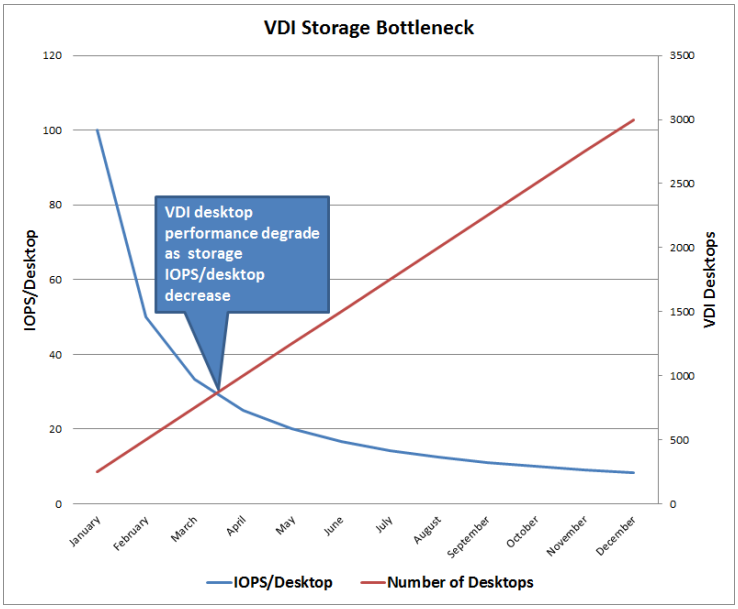
The VDI Memory Bottleneck

Running many desktops on a single virtualized server means running multiple OS and application instances on a single server, which demands large amounts of memory. Since CPU performance is outstripping memory performance, memory bottlenecks are a common problem. As companies migrate from Windows XP (128MB recommended memory) to Windows 7 (1-2GB recommended memory), the density of a server is constrained by memory and not CPU. Enterprises are often forced to deploy either four-socket servers or multiple two-socket servers to address this problem. These solutions result in more expensive servers, increased power costs, and higher licensing costs.

The VDI Storage Bottleneck

While the Memory and CPU of a VDI desktop remain on the physical hardware where the desktop executes, the virtual desktop hard drive is moved from being connected directly to the physical hardware to having to traverse multiple network switches. Simply stated, VDI replaces one dedicated, low latency and inexpensive physical PC hard drive with an expensive, shared, high latency storage array. The result is both increased latency based on the number of network hops from the Windows operating system to the storage array and decreased desktop performance. In addition, disk IO that is optimized by the OS for a dedicated physical PC hard drive is randomized by the hypervisor converting previously sequential IO that is easy for storage to consume to random IO that decreases storage and desktop performance (this is also known as the IO Blender effect). As more desktops are added to the VDI deployment, storage contention issues arise from large numbers of VDI desktops competing for a limited pool of storage input/output per second (IOPS).

Many IT organizations that have tried to deploy VDI in the past have done so using a shared storage infrastructure with a fixed amount of storage IOPS capacity sized based on a low numbers of IOPS per desktop. While storage IOPS are plentiful on a per desktop basis during the pilot phase, desktop performance is acceptable. As more users are added without increasing the total number of IOPS, the number of IOPS available per desktop reduces over time. As the number of IOPS per desktop decrease, the response time between the windows operating system and its hard drive located on shared storage drop. The result is long boot or logon times and poor overall application and desktop performance.



The Cisco UCS and Atlantis ILIO VDI architecture solve this problem by inserting an Atlantis ILIO virtual appliance in the data path between the Microsoft Windows 7 operating system and storage to deduplicate IO traffic by up to 90 percent and optimize IO traffic for efficient storage. The result is that VDI can be deployed with much less storage, any class of storage and better desktop performance. In addition, by eliminating the storage bottleneck, the CPU utilization on the VDI servers is reduced, enabling higher density of virtual desktops per server.

Persistent vs. Stateless VDI Desktops and the Implications for VDI Design

Persistent vs. Stateless Desktop Definitions

Generally there are three different VDI options available to customers:

Persistent VDI Desktop—User data, settings, applications and operating system files are all stored in the virtual machine, requiring massive storage capacity that increases linearly with every additional user. This approach preserves user files, settings and applications across multiple sessions but comes with prohibitively high storage cost and poor performance. Persistent desktops also do not require any changes to the existing desktop management or application provisioning processes.

Stateless VDI Desktop (Non-Persistent Desktop)—The operating system and corporate applications are installed in the virtual machine. After every session, all user data including user files, settings and installed applications are reset. This approach minimizes storage but is not allow users to have access to their personalized files, settings or applications. Typically, this model is only used for test labs, task workers or other users that don't require persistent data.

Stateless VDI Desktop with a Shared Master Disk (Citrix PVS with differencing disk or VMware Linked Clones)—The operating system and corporate applications are created in a read-only shared master disk. User files, settings and applications are written to a differential disk image. The two components are combined at boot time. This approach requires that user profiles containing user data and settings be virtualized using Microsoft Roaming User Profiles or another third-party profile virtualization tool such as AppSense. In this configuration, users do not have the ability to install their own applications and retain them after reboot.

The Stateless VDI Desktop with a Shared Master Disk was selected for the Cisco and Atlantis ILIO reference architecture testing based on its usage in Cisco Validated Designs and customer demand. While all testing for the reference architectures uses the Stateless VDI model, the Persistent VDI desktop model is discussed throughout this document.

- **Atlantis ILIO Impact of Persistent vs. Stateless Desktop Selection**

  Atlantis ILIO can be deployed with any of the three VDI models described above to reduce storage requirements by up to 20 times and increase desktop performance. With Atlantis ILIO, Persistent VDI desktops have roughly the same storage CAPEX costs as stateless VDI desktops, giving IT organization two cost-effective choices between persistent and stateless VDI desktops based on functionality and user experience.

- **Persistent VDI Desktop Considerations**

  With a persistent desktop, each user has a dedicated virtual machine that operates in a similar fashion to a physical PC. Persistent desktops don't require any significant changes to the corporate desktops image and can be deployed without significant involvement for the desktop team. However, user data, settings, applications and operating system files are all stored in the VM, requiring massive storage capacity that increases linearly with every additional user. This approach preserves user files, settings and applications across multiple sessions but comes with prohibitively high storage cost.

- **Stateless VDI Desktop Considerations**

  With a stateless desktop, each user is assigned a random virtual machine from a pool of identical virtual machines that contain a base corporate image including the operating system and corporate applications in a read-only shared master disk that is common among all desktops. The user files, settings and applications are written to a differential disk image. The two components are combined at boot time to form the user's desktop. The stateless approach requires a combination of user profile virtualization, application virtualization and a new set of management processes. In large organizations with thousands of users and hundreds or thousands of applications, the process of getting to a stateless VDI image can be very time consuming but should ultimately reduce upfront operating costs required.

  The Cisco UCS and Atlantis ILIO reference architecture gives IT organizations the choice to deploy persistent or stateless VDI desktops with comparable storage requirements and cost per desktop. With Atlantis ILIO, the amount of storage capacity and IOPS required drops by up to 90 percent, eliminating the primary tradeoff between persistence and storage costs. In many cases, IT organizations choose to deploy VDI with persistent desktops initially and then migrate to stateless desktops over time.

  Citrix XenDesktop with Provisioning Server (PVS) provides a stateless desktop model which has been used in both Cisco UCS /Atlantis ILIO deployment options detailed later in this document for ease of testing. It should be noted though that the Atlantis ILIO supports and provides comparable performance for both Stateless and Persistent VDI desktop deployment models.

The Solution: Cisco Unified Computing System and Atlantis ILIO

Cisco UCS Solution Overview

The Cisco Unified Computing System is a next-generation data center platform that unites compute, network, storage access, and virtualization into a cohesive system designed to reduce total cost of ownership (TCO) and increase business agility. The Cisco Unified Computing System server portfolio consists of the Blade Server platform, B-Series and the C-Series Rack Mount platform. We chose the Cisco UCS B-Series Blade Server platform for this study. The system integrates a low-latency; lossless 10 Gigabit Ethernet unified network fabric with enterprise-class, x86-architecture servers. The system is an integrated, scalable, multi-chassis platform in which all resources participate in a unified management domain.

The main system components include:

Compute—the system is based on an entirely new class of computing system that incorporates blade servers based on Intel Xeon 5500 Series Processors. The Cisco UCS blade servers offer patented Cisco Extended Memory Technology to support applications with large datasets and allow more virtual machines per server.

Network—the system is integrated onto a low-latency, lossless, 10-Gbps unified network fabric. This network foundation consolidates what today are three separate networks: LANs, SANs, and high-performance computing networks. The unified fabric lowers costs by reducing the number of network adapters, switches, and cables, and by decreasing power and cooling requirements.

Virtualization—the system unleashes the full potential of virtualization by enhancing the scalability, performance, and operational control of virtual environments. Cisco security, policy enforcement, and diagnostic features are now extended into virtualized environments to better support changing business and IT requirements.

Storage access—the system provides consolidated access to both SAN storage and Network Attached Storage (NAS) over the unified fabric. Unifying storage access means that the Cisco Unified Computing System can access storage over Ethernet, Fiber Channel, Fiber Channel over Ethernet (FCoE), and iSCSI, providing customers with choice and investment protection. In addition, administrators can pre-assign storage-access policies for system connectivity to storage resources, simplifying storage connectivity and management while helping increase productivity.

Management—the system uniquely integrates all the system components, enabling the entire solution to be managed as a single entity through the Cisco UCS Manager software. The Cisco UCS Manager provides an intuitive graphical user interface (GUI), a command-line interface (CLI), and a robust application programming interface (API) to manage all system configuration and operations. The Cisco UCS Manager helps increase IT staff productivity, enabling storage, network, and server administrators to collaborate on defining service profiles for applications. Service profiles are logical representations of desired physical configurations and infrastructure policies. They help automate provisioning and increase business agility, allowing data center managers to provision resources in minutes instead of days.

Working as a single, cohesive system, these components unify technology in the data center. They represent a radical simplification in comparison to traditional systems, helping simplify data center operations while reducing power and cooling requirements. The system amplifies IT agility for improved business outcomes. The Cisco Unified Computing System components illustrated in Figure 1 include, from left to right, fabric interconnects, blade server chassis, blade servers, and in the foreground, fabric extenders and network adapters.

Cisco Extended Memory Architecture

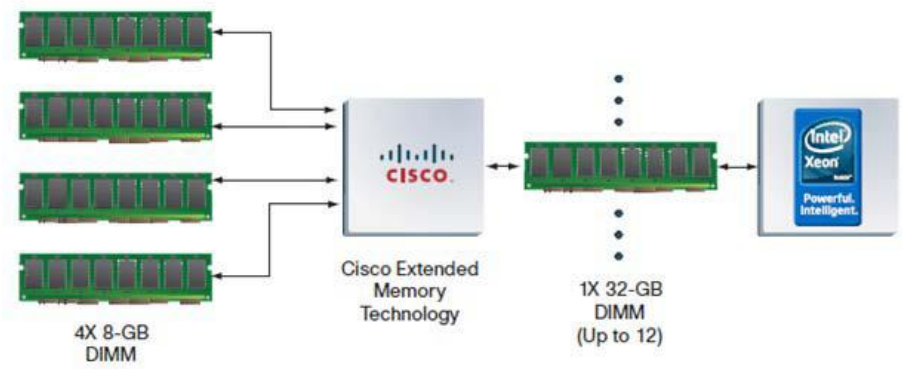
Modern CPUs with built-in memory controllers support a limited number of memory channels and slots per CPU. The need for virtualization software to run multiple OS instances demands large amounts of memory, and that, combined with the fact that CPU performance is outstripping memory performance, can lead to memory bottlenecks. Even some traditional non-virtualized applications demand large amounts of main memory: database management system performance can be improved dramatically by caching database tables in memory, and modeling and simulation software can benefit from caching more of the problem state in memory.

To obtain a larger memory footprint, most IT organizations are forced to upgrade to larger, more expensive, four-socket servers. CPUs that can support four-socket configurations are typically more expensive, require more power, and entail higher licensing costs. Cisco Extended Memory Technology expands the capabilities of CPU-based memory controllers by logically changing the geometry of main memory while still using standard DDR3 memory. This technology makes every four DIMM slots in the expanded memory blade server appear to the CPU's memory controller as a single DIMM that is four times the size (Figure below). For example, using standard DDR3 DIMMs, the technology makes four 8-GB DIMMS appear as a single 32-GB DIMM.

This patented technology allows the CPU to access more industry-standard memory than ever before in a two-socket server:

For memory-intensive environments, data centers can better balance the ratio of CPU power to memory and install larger amounts of memory without having the expense and energy waste of moving to four-socket servers simply to have a larger memory capacity. With a larger main-memory footprint, CPU utilization can improve because of fewer disk waits on page-in and other I/O operations, making more effective use of capital investments and more conservative use of energy.

For environments that need significant amounts of main memory but which do not need a full 384 GB, smaller-sized DIMMs can be used in place of 8-GB DIMMs, with resulting cost savings: two 4-GB DIMMS are typically less expensive than one 8-GB DIMM.

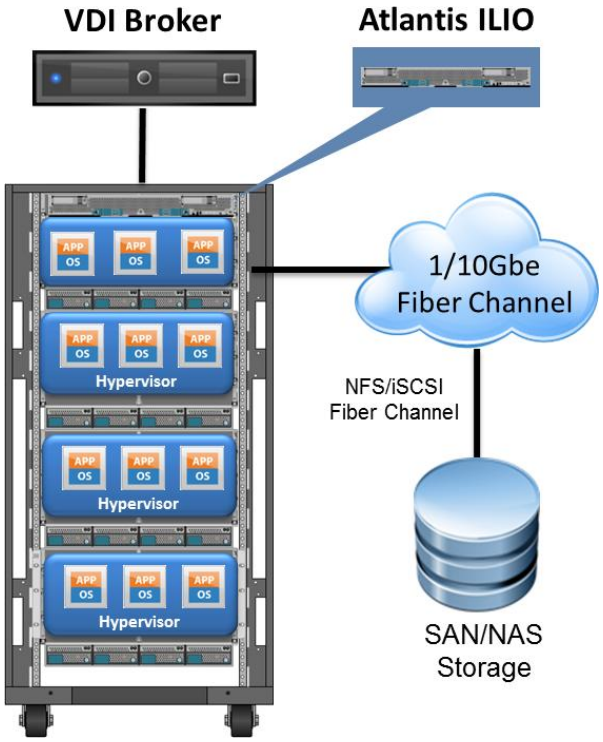


UCS B250-M2 blade servers based on the extended memory blade technology are the centerpiece of Cisco UCS and Atlantis ILIO work. By making use of the large memory footprint for the ILIO controller we are able to demonstrate unique value for customers to use Atlantis solution on Cisco Unified Computing System.

Atlantis ILIO Solution Overview

Atlantis ILIO is a VDI storage and performance optimization solution that integrates with VDI offerings to cut storage costs, provide IT teams with more storage options and boost desktop performance. Atlantis ILIO is a unique and innovative IO virtualization technology that fundamentally changes the economics and performance characteristics of VDI by intelligently optimizing how the Microsoft Windows operating system interacts with VDI storage.

Figure 2. Atlantis ILIO Solution



VDI Storage Reduction

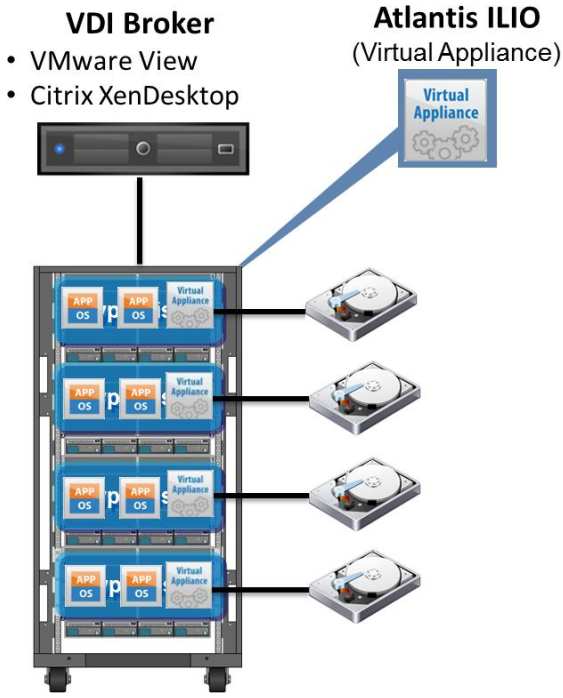
IOPS Offload

When VDI desktops using the Microsoft windows operating system boot, logon, run productivity applications and perform routine security and management operations, they generate Input/Outputs per second (IOPS) that must be serviced by VDI storage. When virtual desktop operating systems and applications generate too many IOPS for the storage system to handle, VDI desktop performance degrades, lowering productivity and thus frustrating users. Shared SAN/NAS storage has a fixed number of IOPS that can only be increased by adding most storage disks and controllers. Because the Windows operating system generates so many IOPS, IT organizations must normally buy many more storage disks and controllers than would be required for VDI based on storage capacity requirements. The result is that the cost of VDI storage per desktop to achieve the equivalent performance of a physical PC is extremely high. Atlantis ILIO, offloads up to 90 percent of the IOPS generated by VDI desktops, which enables IT organization to buy storage systems for VDI that require up to 90 percent fewer disk.

Physical Storage Consolidation

Atlantis ILIO consolidates the storage of duplicate information contained in virtual desktop images by reusing shared desktop image components such as the operating system and common applications. The result is a decrease of up to 20 times in the amount of storage capacity required for virtual desktops. For example, with a 1,000 user VDI deployment consuming 30GB of storage per desktop, Atlantis ILIO would reduce the physical storage requirements from 30TB to 1.5TB.

Figure 3. Physical Storage Overview



Increase Storage Choices

Because Atlantis ILIO reduces the amount of IO traffic going to storage and provides an NFS front-end, IT organization have the option to use SAN storage with fiber channel connections, less expensive SAN/NAS servers or local disk (SATA, SSD), further reducing the storage costs for VDI deployments.

VDI Performance Acceleration

Atlantis ILIO is a revolutionary approach to deploying VDI that makes the Windows operating system perform as fast as physical PC without massive investments in storage infrastructure. Atlantis ILIO boosts VDI desktop performance by transparently caching frequently used operating system and application files, optimizing IO traffic for efficient storage use and offloading IO intensive Windows operations from VDI shared storage. ILIO services operating system and application traffic on the same rack (top-of-rack deployment) or the same hypervisor (OnBlade deployment) as the VDI desktops before traffic hits the storage system. The result is a significant performance increase for VDI desktops, which translates into faster virtual desktop boot times, logon, antivirus scanning and overall desktop performance. Atlantis ILIO also eliminates VDI IO bottlenecks caused by boot storms, logon storms and antivirus scanning.

Cisco, Citrix, and Atlantis Joint VDI Architecture

Cisco Systems and Atlantis Computing have collaborated to develop a VDI reference architecture that is designed to simplify the deployment of VDI, lower the upfront capital expenditures required to deploy VDI, provide the ultimate in modular scalability and better desktop performance than a physical PC. The Cisco and Atlantis reference architectures integrate the compute, network and storage access components of the Cisco Unified Computing System™ with the storage optimization of Atlantis ILIO to deliver a cost efficient, scalable and agile VDI infrastructure. The solution is powered by high-performance Intel® Xeon® processors, and its reach can be extended through the performance and security of Cisco's end-to-end networking technology. By making effective use of the onboard memory on the Cisco UCS B250-M2 blade server, we are able to sustain majority of IOPS to the large memory blade hosting the Atlantis ILIO controller and delivering the storage optimization.

Pre-Configured Atlantis ILIO Virtual Appliances for Ease of Deployment

Cisco Systems and Atlantis ILIO have designed and tested multiple configurations to produce the optimal deployment configuration and package it for customers in a pre-configured virtual appliance kit that speeds deployment time. The Atlantis ILIO virtual appliance has been tested for interoperability, scalability and performance with the Cisco UCS and Citrix XenDesktop Validated Design (CVD). Atlantis ILIO is enabled with an auto configuration utility that makes setup quick and seamless when deployed in conjunction with VMware vSphere and Cisco Blades. This package is available in the OVF format and contains a Cisco Blade Identifier (CBI) to help ensure proper configuration.

Lower Cost per Desktop

The combination of the Cisco Unified Computing System and Atlantis ILIO reduces the cost per desktop of deploying VDI by reducing the amount of storage required for VDI, giving customers the option to use lower cost storage and achieving greater density per blade than competing solutions. Atlantis ILIO reduces the amount storage required for VDI by offloading up to 90 percent of the IOPS generated by the Windows 7 operating system and anti-virus. The Cisco UCS Extended Memory Technology enables IT organizations to deploy more virtual desktops per blade without reducing the amount of memory available per desktop. When Atlantis ILIO is integrated into a Cisco UCS VDI deployment, the elimination of storage contention issues reduces the CPU utilization dramatically on each blade and enables customers to further increase density per blade by adding more memory.

Flexibility in Storage Choices and VDI Desktop Models

The Cisco Systems and Atlantis Computing reference architecture gives customers the flexibility to choose their preferred VDI deployment mode, type of storage and storage optimization architecture:

VDI Deployment Mode—Persistent or Stateless (for example, Citrix PVS or VMware Linked-Clones)

Storage—SAN, NAS or Local SSD

Storage Optimization—Atlantis ILIO Top-of-Rack or OnBlade Deployment

Leading Density and Performance with Windows 7 and Anti-Virus

The combination of Windows 7 and Anti-virus more than doubles the amount of memory and IOPS required per desktop compared to Windows XP, which decreases virtual desktop density per server and degrades virtual desktop performance. Specifically, a significant impact on desktop performance (150ms response time increase on performance benchmarks), density of desktops per server (30 percent or more decrease in density due to increased CPU and IO), and storage requirements (increase IOPS requiring additional storage disks) in a VDI environment. Cisco and Atlantis Computing have partnered to deliver a VDI solution that eliminates the VDI memory and storage bottlenecks, enabling customers to deploy VDI with Windows 7 and anti-virus with higher density and better performance than traditional VDI architectures.

Modularity and Scalability

The Cisco and Atlantis Computing VDI solution uses a modular and scalable architecture composed of Cisco UCS blade servers and Atlantis ILIO appliances pre-configured for Cisco UCS VDI deployments. This approach not only speeds up initial deployment and subsequent scaling but also reduces the chance of errors that can delay VDI deployments. There are two deployment options to fit different VDI deployment scenarios:

Cisco UCS with Atlantis ILIO Top-of-Rack

- **Storage:** SAN/NAS
- **VDI Deployment Mode:** Persistent or Stateless VDI Model

  In the Top-of-Rack deployment, Atlantis ILIO is deployed one Cisco UCS B250-M2 blade per rack, with a high availability (HA) option using a second Cisco UCS B250-M2 blade both with 192 GB of memory. The Atlantis ILIO Cisco UCS B250-M2 blade(s) are installed inline in the data path between the VDI servers and the storage array, serving up to 640 desktops for 2 Cisco UCS Chassis (8 B250 M2 Blade Servers). By taking advantage of the available large memory in a two socket Intel architecture (192 GB per blade in our configuration), the Atlantis ILIO appliance scales out easily to add more desktop capacity by adding more Cisco UCS blades without adding additional large and costly storage requirements. This configuration is ideal for existing VDI deployments.

Cisco UCS with Atlantis ILIO OnBlade

- **Storage:** SAN/NAS (Persistent or Stateless Models) or Local Disk (Stateless Model)
- **VDI Deployment Mode:** Stateless or Persistent VDI Model

  In the OnBlade deployment, Atlantis ILIO is deployed as a virtual appliance (software) on each Cisco UCS B250-M2 blade with 192 GB of memory running both the virtual desktops and the Atlantis ILIO virtual appliance. This configuration provides the highest level of desktop performance and least amount of network traffic because it contains all IO serviced by Atlantis ILIO to the hypervisor.

Cisco Unified Computing System and Atlantis ILIO Solution Architecture

Reference Architecture Overview

VDI Environment Configuration

Summary of Environment

- 3 Desktop Delivery Controllers
- 2 Provisioning Services Servers
- 1 Virtual Center (vCenter)
- 1 vSphere Clusters
- 1 Citrix Licensing Server
- 1 File Server for Roaming Profiles and VSI data
- 1 SQL 2008 Server for DDC and PVS DBs
- Multiple client launchers

Atlantis ILIO Top of Rack Solution

- 640 Virtual Desktops—Top-Of-Rack Option
- 1 NAS Storage Volume (256GB)

Atlantis ILIO OnBlade Solution

- 80 Virtual Desktops—OnBlade Option
- 2 x 96GB SSD Disks in Blade

Cisco UCS Hardware Configuration for Top of Rack Solution

- 10 X UCS B250-M2 blade servers with 2 X 5680 Intel processors (3.33 GHz), 4 X 48 (192) GB @1333MHz. Eight of them hosting the Virtual desktops and the other two hosting the ILIO Controllers.
- 2 X Cisco M81KR (VIC)
- 2 X Fabric Interconnect (Cisco UCS 6120 XP)

Figure 4. Atlantis ILIO Top-of-Rack Deployment Diagram

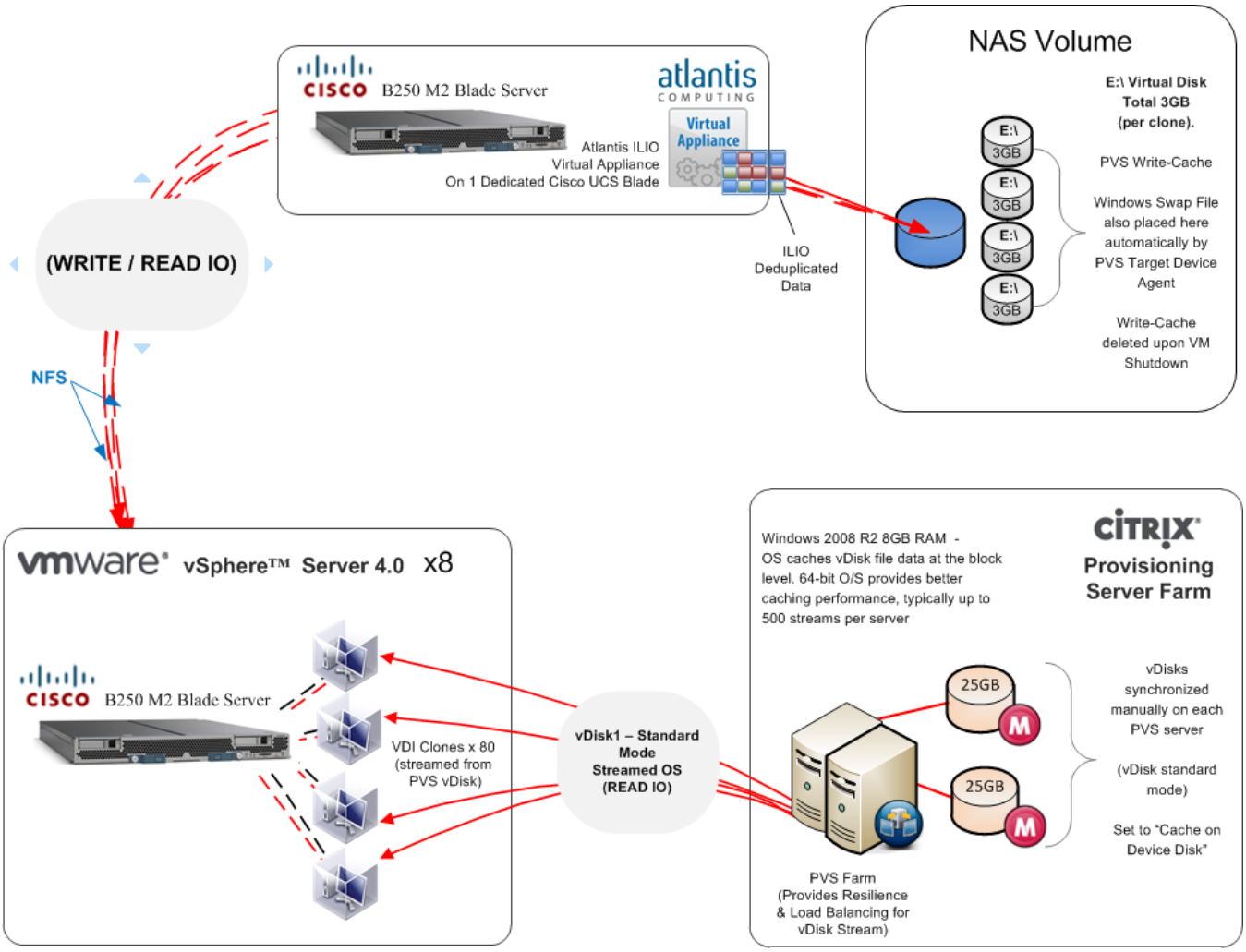
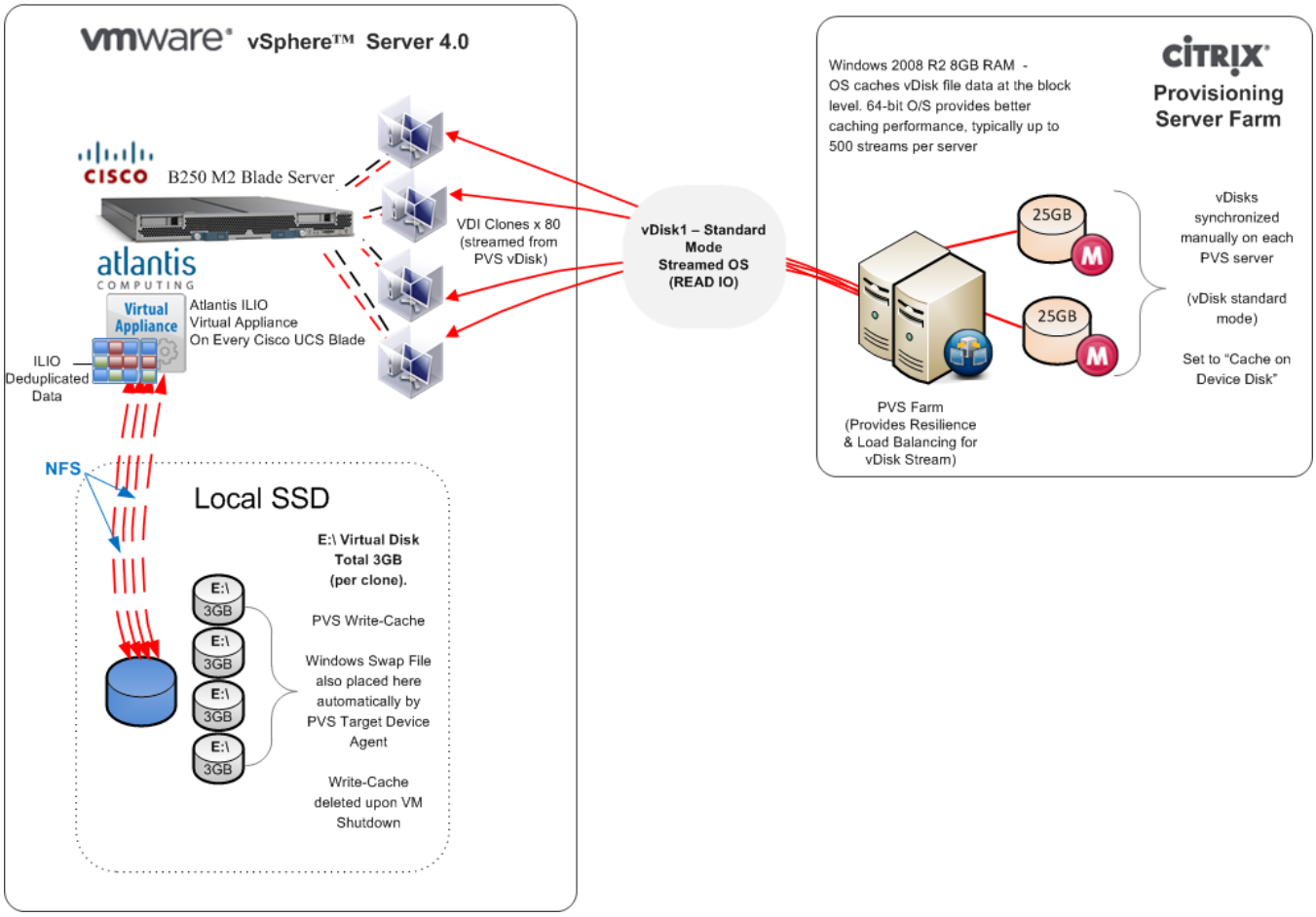


Figure 5. Atlantis ILIO OnBlade Deployment Diagram



Architecture and Design

The following tables list the configuration by component:

vSphere 4 Servers (For Virtual Desktops)			
Hardware:	Cisco UCS B-series Blade server	**Model:**	B250 –M2
OS:	VMware vSphere 4.0U2	**Service Pack:**	-
CPU:	2 x 6 Core Intel 5680 @ 3.33 GHz (24 Logical Cores Total)	**RAM:**	192 GB @ 1333 MHz
Disk:	Boot From SAN	**Network:**	Palo adapter 4 x 10GbE

vSphere 4 Server with Atlantis ILIO (Top-of-Rack)			
Hardware:	Cisco UCS B-Series Blade Server	**Model:**	B250 –M2
OS:	VMware vSphere 4.0U2	**Service Pack:**	U2
CPU:	2 x 6 Core Intel 5680 @ 3.33 GHz (24 Logical Cores Total)	**RAM:**	192 GB @ 1333 MHz
Disk:	Boot From SAN	**Network:**	Palo adapter 4 x 10GbE

- **2 x 15K 146 GB SAS Drives**
- **Atlantis ILIO v1.9 Virtual Appliance**

vSphere 4 Server with Atlantis ILIO (onBlade)			
Hardware:	Cisco UCS B-Series Blade Server	**Model:**	B250 –M2
OS:	VMware vSphere 4.0U2	**Service Pack:**	U2
CPU:	2 x 6 Core Intel 5680 @ 3.33 GHz (24 Logical Cores Total)	**RAM:**	192 GB @ 1333 MHz
Disk:	Boot From SAN	**Network:**	4 x 10GbE

- **2 x 96 GB SSD Drives**
- **Atlantis ILIO v1.9 Virtual Appliance**

Citrix Provisioning Server 5.6			
OS:	Windows 2008 Enterprise R2 64bit	**Service Pack:**	-
CPU:	2 x vCPU	**RAM:**	8192MB
Disk:	1 x70GB Virtual Disk	**Network:**	1 x 10GbE (VMXNET3)

- Database for PVS hosted on separate Microsoft SQL Server 2008 64bit

Citrix XenDesktop Desktop Delivery Controller			
OS:	Windows 2003 R2 Enterprise 64bit	**Service Pack:**	2
CPU:	4 vCPU	**RAM:**	4096MB
Disk:	1 x50GB Virtual Disk	**Network:**	1 x 10GbE (VMXNET3)

- Citrix XenDesktop DDC - 400W2K3X64004
  - Desktop Delivery Controller - Services Hotfix XD*400DDC002
  - Pool Management Service Hotfix XD*400PM003
- Citrix Web Interface
- Database for DDC hosted on separate Microsoft SQL Server 2008 64bit

Citrix Virtual Desktop Agent (Virtual Desktops)			
OS:	Windows7 Enterprise 32bit	**Service Pack:**	1
CPU:	1 vCPU	**RAM:**	1536MB
Disk:	C: 1 x 16GB (PVS vDisk) D: 1x 3GB Virtual Disk (PVS Write-Cache and OS paging file hosted on NFS Volume on Atlantis ILIO)	**Network:**	1 x 1GbE (E1000)
• VDA Service Pack 1 - XDE400VDAWX86SP1 (Version 4.0.5010)			

Citrix License Server			
OS:	Windows 2008 R2 Enterprise 64bit	**Service Pack:**	-
CPU:	1 vCPU	**RAM:**	2048MB
Disk:	1 x50GB Virtual Disk (hosted on NFS target volume on NetApp Filer)	**Network:**	1 x 10GbE (VMXNET3)

ICA Client Hosts (Login Consultants VSI Launchers)			
OS:	Windows 2003 R2 Enterprise 64bit	**Service Pack:**	2
CPU:	2 vCPU	**RAM:**	4096MB
Disk:	1 x40GB Virtual Disk	**Network:**	1 x 10GbE (VMXNET3)

Other dedicated Infrastructure Virtual Machines:

- Active Directory Server (Directory Services, DNS & DHCP)
- User Profile Server (Hosts Roaming Profiles)
- File Server (Collects Login VSI data)

Operating System

Microsoft introduced Windows 7 in the fall of 2009 as their next generation desktop operating system to succeed Windows XP, their other flagship software. According to IDC report, around 70 percent of the enterprise users are using Windows XP and a majority of them are already looking to migrate to Windows 7.

The operating system(s) that will be used on VDI desktops has significant implication for VDI design in terms of memory and storage sizing.

The IOPS and Memory requirements of Windows 7 running anti-virus can be 2-3 times that of Windows XP.

Tuning Microsoft Windows 7 Image for VDI

When many Windows desktops run on a hypervisor it is necessary to try to reduce unnecessary CPU cycles and disk IO to improve system performance and stability. By turning off unnecessary processes and other unwanted desktop services are recommended.

The following tuning/configurations were made to the standard image used for testing:

- Configure fixed 1.5GB page file
- Configure Networking & Firewall
- Turn off firewall
- Set DNS IP addresses for domain
- Turn off IPV6
- Windows 7 optimization recommendations from the following Citrix blog - http://community.citrix.com/pages/viewpage.action?pageId=113247185

- Recommended “Default User Profile” settings were also applied and copied to “Default User” using the latest Forensit User Profile Manager tool, visit http://www.forensit.com/desktop-management.html
- Citrix PVS TCP Large Send Offload should be disabled on both the PVS server/s and the target device (Windows 7 image). To do this follow the instructions found here: http://support.citrix.com/article/CTX117374.

Microsoft Windows 7 has a large memory footprint that demands a new balance between a server’s memory capacity and its processing power. Cisco Unified Computing System provides an economical 192-GB memory footprint on a two-socket server through Cisco Extended Memory Technology. When used in combination with the Intel Virtualization Technology built into every Intel Xeon processor, the platform brings higher performance, scalability, and agility at a lower cost than comparable systems.

Anti-Virus

When deploying Virtual Desktop Infrastructure (VDI), anti-virus reduces the number of desktops per server, degrades performance and ultimately increases the infrastructure costs of VDI. For this reason, antivirus is often not included in VDI performance benchmarking and reference architectures. During testing, we found that adding anti-virus to VDI desktops reduce response time on the VSI performance benchmark by 150ms (25+ percent) and reduced density (25+ percent) due to increases in CPU, Memory and IOPS requirements. Given that nearly all enterprise customers use anti-virus and other endpoint agents in their images, we felt it was important to include antivirus in the testing performed for this document. Therefore, all the results published within this paper have been conducted with McAfee Virus Scan Enterprise 8.7i installed in the Citrix PVS vDisk image.

McAfee Virus Scan 8.7i Configuration

A default installation of McAfee Virus Scan was used in the master PVS vDisk image, NO scanning exclusions were configured except the following services, related to Citrix PVS services –BNNS.sys, BNNF.sys, BNPort.sys, and bnistack.sys. All of these files are in <systemroot>\windows\system32\drivers directory.

These exclusions and other recommendations, which we did NOT exclude due to the fact that many organizations are unable to exclude these due to mandatory internal security policies, are documented in the following Citrix support document: http://support.citrix.com/article/ctx124185.

Making additional exclusions may reduce CPU and IOPS overhead of running Anti-Virus but may also increase security risk and should be considered carefully by an information security professional. Additionally, no scheduled scans were run during benchmarking exercises. Running simultaneous antivirus scans can cause an IO storm that affects the performance of the entire network and storage system and increases CPU utilization of the hypervisor. When using Atlantis ILIO, IO storms due to anti-virus scans are handled based on the additional burst IOPS capability and contained to either a single hypervisor or single rack of virtual desktops.

Solution Validation and Testing Methodology

The section describes the solution validation and the testing methodology that was used in both Top-of-Rack solution (figure 6) and OnBlade solution (Figure 7).

Figure 6. Testing Architecture for Atlantis ILIO Top-of-Rack Solution

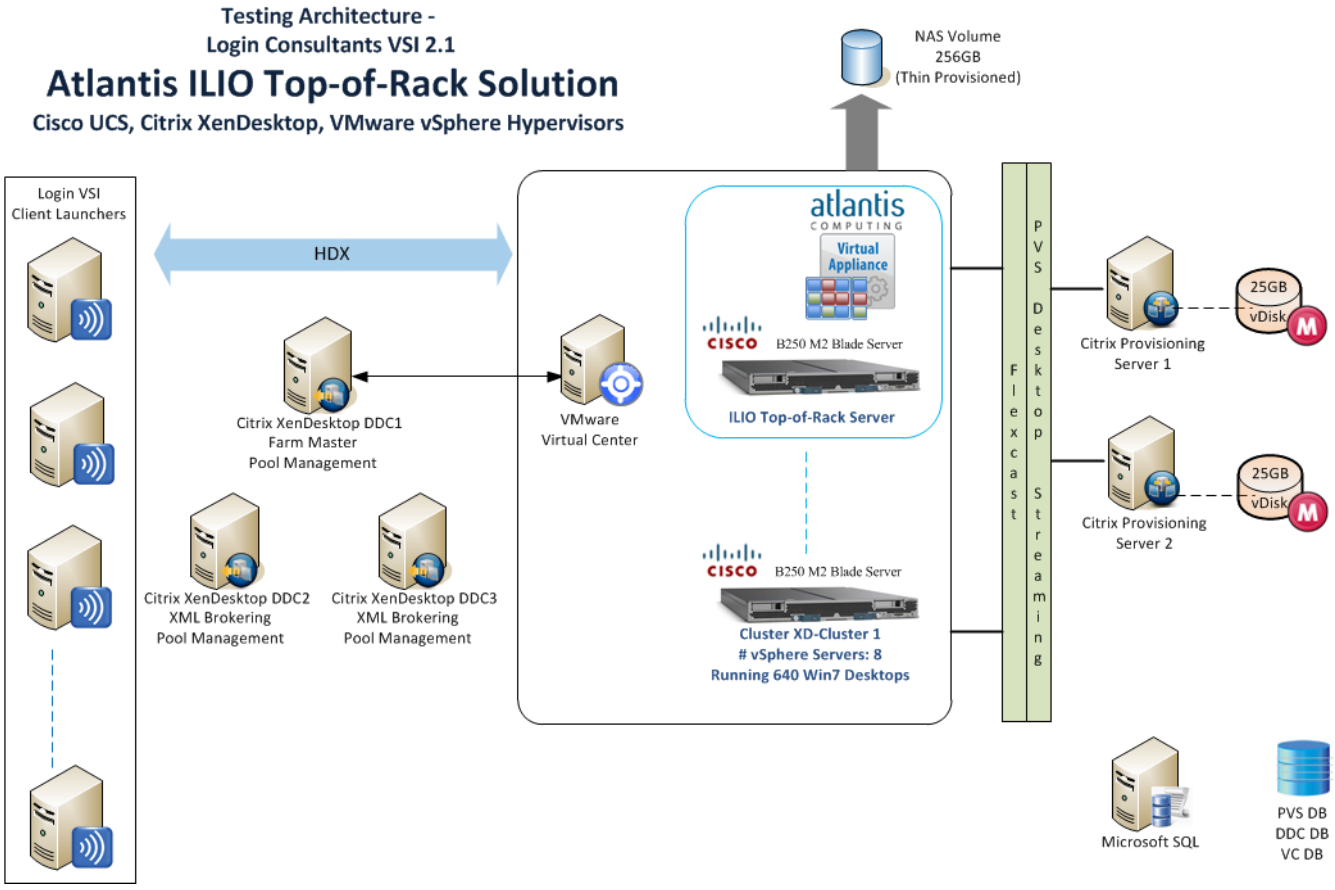
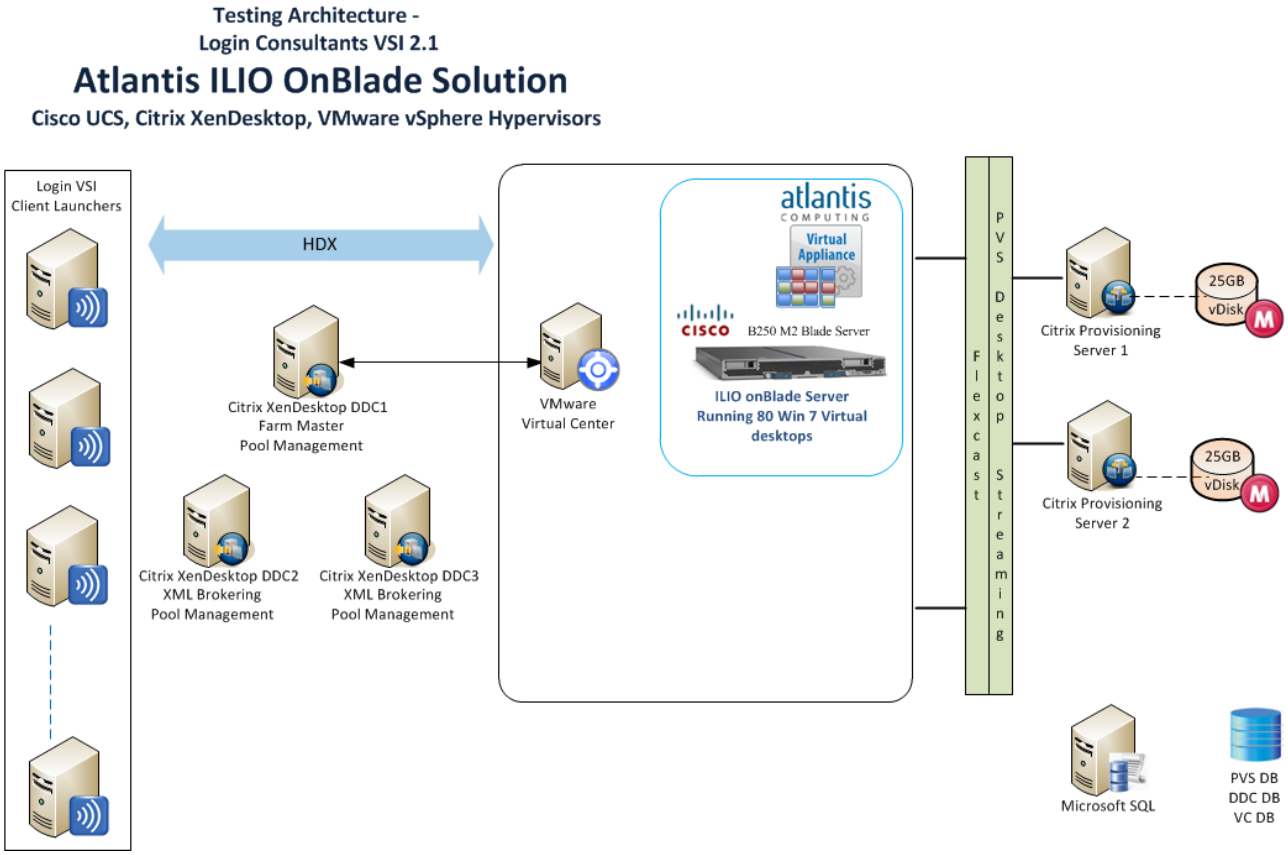


Figure 7. Testing Architecture for Atlantis ILIO OnBlade Solution



Test Methodology and Success Criteria

All validation testing was conducted on-site within the Cisco labs with joint support from Atlantis Computing resources. The testing results focused on the entire process of the virtual desktop lifecycle by capturing metrics during the desktop boot-up, user logon, user workload execution (also referred to as steady state), and user logoff for both of the VDI models. Test metrics were gathered from the hypervisor, virtual desktop, storage, and load generation software to assess the overall success of an individual test cycle. Each test cycle was not considered passing unless all metrics were within the permissible thresholds as noted as success criteria.

Load Generation

Within each test environment load generators were utilized to put demand on the system to simulate multiple users accessing the XenDesktop environment and executing a typical end-user workflow. To generate load within the environment, an auxiliary software application was required to generate the end user connection to the XenDesktop environment, provide unique user credentials, initiate the workload, and evaluate the end user experience.

User Workload Simulation—Login VSI From Login Consultants

One of the most critical factors of validating a XenDesktop deployment is identifying a real-world user workload that is easy for customers to replicate and standardized across platform to allow customers to realistically reference for a variety of worker tasks. To accurately represent a real-world user workload, third-party tools from Login Consultants were used throughout the VDI testing. These tools have the added benefit of taking measurements of the in-session response time, providing an objective way to measure the expected user experience for individual desktop throughout large scale testing, including login storms.

Login Virtual Session Indexer (Login Consultants VSI 2.1) methodology designed for benchmarking Server Based Computing (SBC) and Virtual Desktop Infrastructure (VDI) environments is completely platform and protocol independent and hence allows customers to easily replicate the testing results in their environment. Login VSI calculates an index based on the amount of simultaneous sessions that can be run on a single machine.

Login VSI simulates a medium-heavy workload user (intensive knowledge worker) running generic applications such as: Microsoft Office 2007, Internet Explorer including Flash applets and Adobe Acrobat Reader (Note: For the purposes of this test, applications were installed locally, not streamed or hosted on XenApp). Like real users, the scripted session will leave multiple applications open at the same time. Every session will average about 20 percent minimal user activity, similar to real world usage. Note that during each 12 minute loop users open and close files a couple of time per minutes which is probably more intensive that most users.

The following outline the automated Login VSI simulated user workflows that were used for this validation testing:

- This workload emulates a medium “knowledge worker” using the Office 2007, IE and PDF applications and opens up to 5 applications simultaneously with a type rate of 160ms for each character. The workload observes approximately 2 minutes of idle time which closely simulates real-world users.
- When a session has been started the medium workload will repeat every 12 minutes. During each loop the response time is measured every 2 minutes.
- Each loop consists of the following operations:
    - Browse and compose Outlook 2007 messages.
    - Open multiple instances of Internet Explorer based browsing sessions including heavy multimedia websites.
    - Open multiple instances of Word 2007 performing open, close and edit operations.
    - Print and review PDF documents using Bullzip PDF Printer and Acrobat Reader.
    - Open, edit and close a randomized large Excel 2007 sheet.
    - Review and edit a PowerPoint 2007 presentation.
    - Perform zip operations using 7-Zip.

Success Criteria

There were multiple metrics that were captured during each test run, but the success criteria for considering a single test run as pass or fail was based on two main metrics, Login VSI Max and Login VSI Correct Optimal Performance Index (COPI). The Login VSI Max evaluates the user response time during increasing user load and the Login VSI COPI score assess the successful start-to-finish execution of all the initiated virtual desktop sessions. These two main metrics are important not only based on the raw data that they provide, but also in their ability to align the test results between VDI models.

Login VSI Corrected Optimal Performance Index (COPI)

The Corrected Optimal Performance Index (COPI) is a calculated from specific measurements during each test run to determine how many desktops can be run simultaneously without excessively impacting user experience.

The corrected optimal performance index is based on these measurements:

The Uncorrected Optimal Performance Index (UOPI) is based on the first 5 consecutive sessions that hit the “Optimal Performance Max Reached” threshold. The “Optimal Performance Max Reached” value is calculated on the response time average of four sessions higher than 2000ms (4 session average response time > 8000ms).

- The Stuck Session Count (SSC) represents sessions which have become stuck before UOPI, and must therefore be accounted for in the Optimal Performance Index.
- The Lost Session Count (LSC) is a count of completely missing log files; these tests are discarded completely in the corrected index.
- The Corrected Optimal Performance Index (COPI) is then calculated:

  Incorporating the SSC and LSC into a corrected index helps ensure that the test results are fair and comparable. Therefore, the COPI is calculated as:

  COPI=UOPI - (SSC*50%) – LSC

Login VSI Max

VSI Max represents the maximum number of users the environment can handle before serious performance degradation occurs. VSI Max is calculated based on the response times of individual users as indicated during the workload execution. The user response time has a threshold of 2000ms and all users response times are expected to be less than 2000ms in order to assume that the user interaction with the virtual desktop is at a functional level. VSI Max is reached when the response times reaches or exceeds 2000ms for 6 consecutive occurrences. If VSI Max is reached, then the test run is considered a failure given that user experience has significantly degraded. The response time is generally an indicator of the host CPU resources, but this specific method of analyzing the user experience provides an objective method of comparison that can be aligned to host CPU performance.

Test Results

The purpose of this testing is to provide the data needed to validate Citrix XenDesktop 4 FlexCast models Hosted Shared VDI with VMware vSphere 4.0 virtualizing Microsoft Windows 7 desktops with anti-virus on Cisco UCS blade servers using Atlantis ILIO storage optimization. The information contained in this section provides data points that a customer may reference in designing their own implementations. These validation results are an example of what is possible under the specific environment conditions outlined in this paper, and do not represent the full characterization of reference architecture scalability.

Summary

Table 2 below provides as summary of the key test results from both successfully tested configurations with McAfee Anti-Virus installed in the Windows 7 master image.

Table 2. Summary of Key Test Results

Number	Test Metrics	Atlantis ILIO Top-of-Rack	Atlantis ILIO OnBlade
1	Total Number of Desktops	640	80
2	Virtual Desktop Density per Blade	80	80
3	Total Write IOPS From Hypervisors	13,047,238	4,911,992
4	Total Write IOPS to SAN/Local Disk (After Atlantis Offload)	3,817,832	1,637,023
5	Total Write IOPS Offload Percentage from Atlantis ILIO	71%	67%
6	Total Read IOPS from Hypervisor	2,790,030	1,701,863
7	Total number of Read IOPS Serviced by ILIO Cache	506,557	154,135
8	Total Read IOPS Offload Percentage from Atlantis ILIO	82%	91%
9	Write Percentage of Total IOPS	82%	74%
10	Read Percentage of Total IOPS	18%	26%
11	Backend Storage Type	NAS with Atlantis ILIO Optimization	Shared SSD with Atlantis ILIO Optimization
12	VSI Corrected Optimal Performance Index Pass Rate (%)	99.9%	100%
13	Average VSI Response Time	555ms	596ms
14	Maximum VSI Response Time	611ms	683ms
15	Minimum VSI Response Time	521ms	541ms
16	Time to Boot All Desktops	37 minutes	6 minutes

- In both Atlantis ILIO configurations, we achieved successful passing Login VSI scores with 80 virtual desktops per blade running Windows 7 and McAfee Anti-Virus with on demand scanning enabled (dedicated with Top-of-Rack, shared with the ILIO controller with OnBlade).
- Line 13 shows average response times of 555ms (Top-of-Rack) & 596ms (OnBlade). The reason the OnBlade is slightly higher is because when the VSI test is started, all desktop activity (logons, running tests, logoffs etc.) are being processed by a single ILIO controller on the same hypervisor as the desktops, whereas the activities are distributed between 2 ILIO controllers on the Top-of-Rack implementation separate from the hypervisors actually running the desktops; which are started evenly distributed across 8 additional hypervisors. Therefore, CPU peaks are reached far later in the testing cycles. Once a steady state is reached these IOPS figures will be about the same but initially this slight difference is introduced thus increasing the average IOPS overall. Again this also demonstrates the effectiveness of Cisco UCS networking architecture that removes limitations of switching surrounding a chassis and 10 Gbe in removing latencies between the desktop hypervisor and the ILIO Top-of-Rack server.
- The reason the desktop pool boot times are not comparable between tests is because ultimately the VMware virtual Center API becomes a bottleneck for handling start requests issued from the Desktop delivery controller. In either case, the desktop boot times of 37 minutes for 640 desktops and 6 minutes for 80 desktops are significantly faster than VDI configurations without Atlantis ILIO.

Detailed Test Results

This section includes additional graphs and details of the information summarized above.

Atlantis ILIO Top-of-Rack

This graph shows the percentage of IOPS serviced by Atlantis ILIO (blue) vs. the percentage of IOPS serviced by the SAN/NAS device (Red). As discussed in the Storage Sizing section of this document, IOPS Offload and particularly Write IOPS offload is the determining factor in how much storage must be purchased in an Atlantis ILIO Top-of-Rack scenario. Therefore, an IOPS offload percentage of 70-90 percent means that you can reduce the amount of SAN/NAS storage required by 70-90 percent.

Figure 8. 640 Desktop Sessions on VMware vSphere With Atlantis ILIO Top-of-Rack IOPS Offload

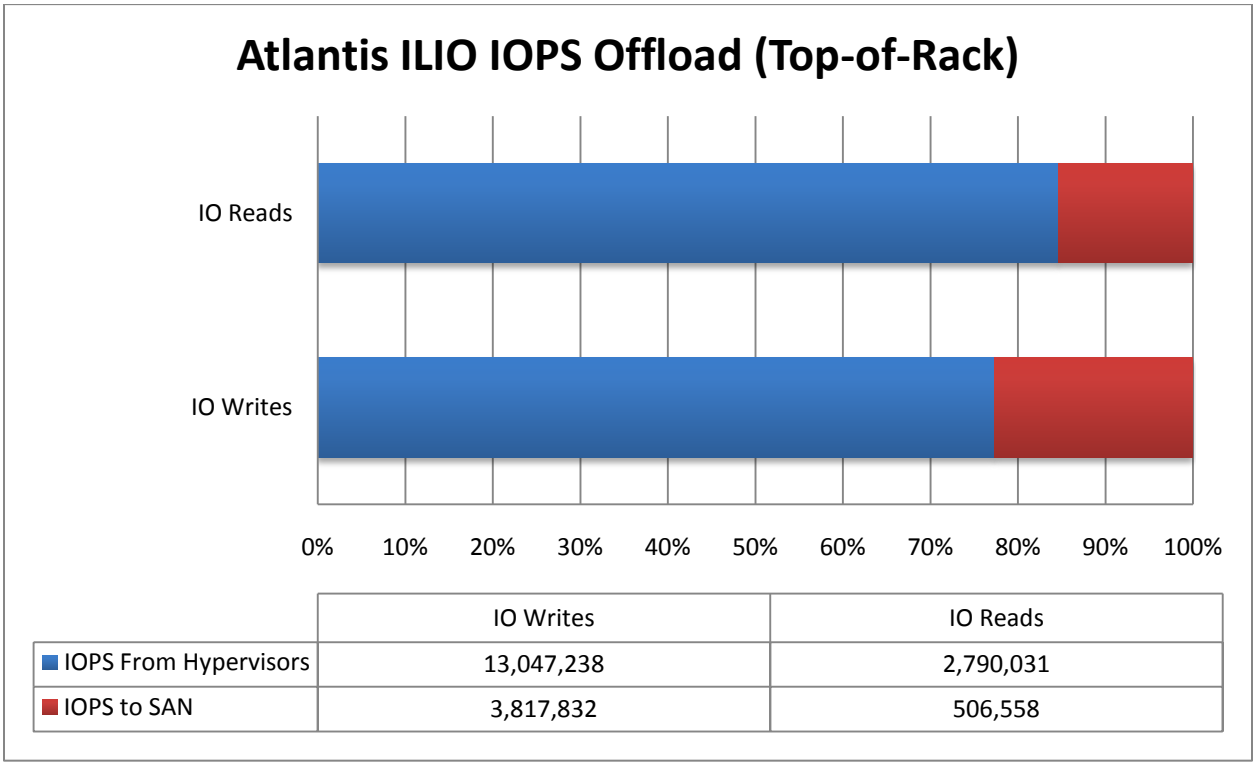
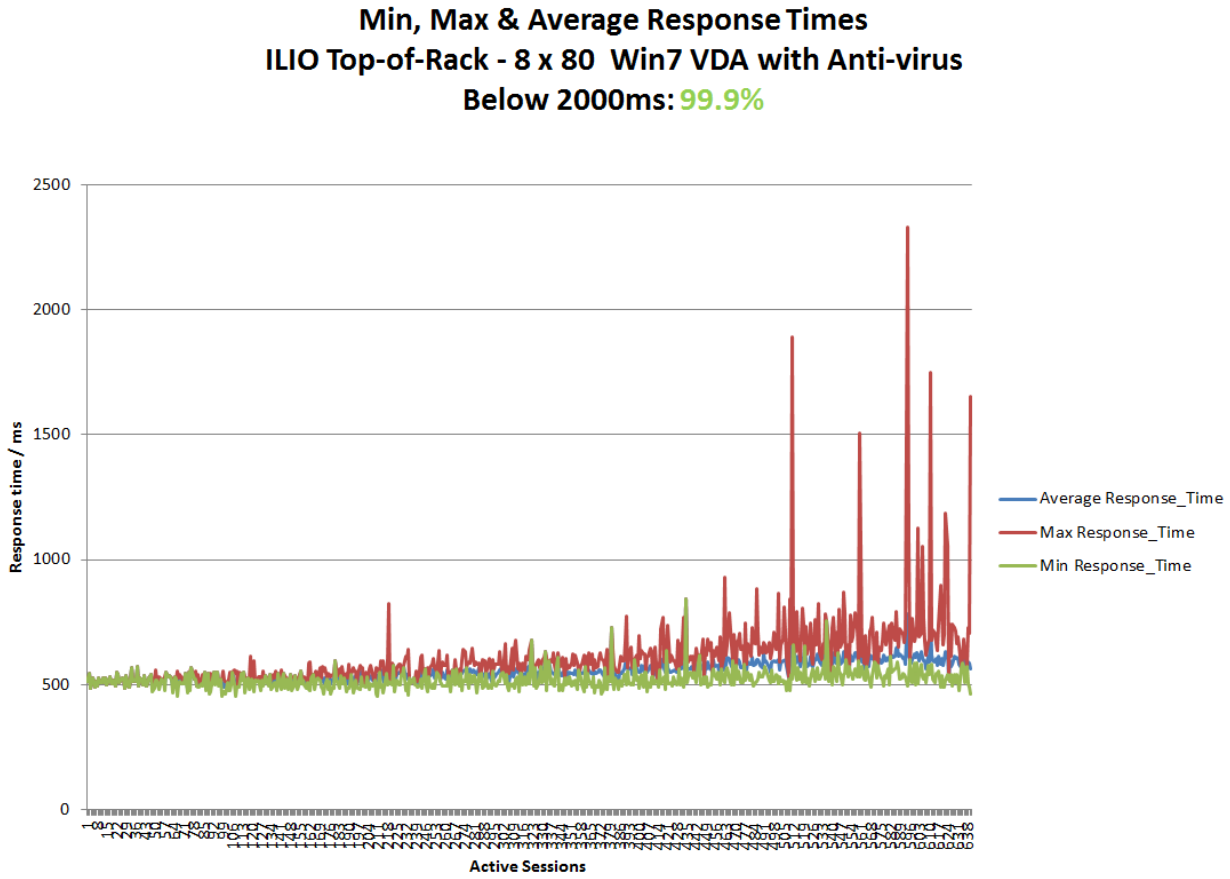


Table 3. Atlantis ILIO VSI Test Results (Top-of-Rack)

Total Sessions Launched	640
Uncorrected VSI Max (UVM)	640
Stuck Session Count before UVM (SSC)	3
Lost Session Count before UVM (LSC)	0
VSI Max (VSIMax = UVM - SSC - LSC)	**637**

Figure 9. 640 Desktop Sessions on VMware vSphere With Atlantis ILIO Top-of-Rack Below 2000ms



This graph shows the Minimum, Maximum and Average Response time for desktops in the Atlantis ILIO 640 desktop Top-of-Rack test. In our tests, using Anti-virus in the image represented a consistent 150ms increase in response time compared to the same image not running anti-virus. Response times under 2000ms are considered passing.

Figure 10. 640 Desktop Sessions on VMware vSphere With Atlantis ILIO Top-of-Rack With a Maximum of 45% CPU Utilization

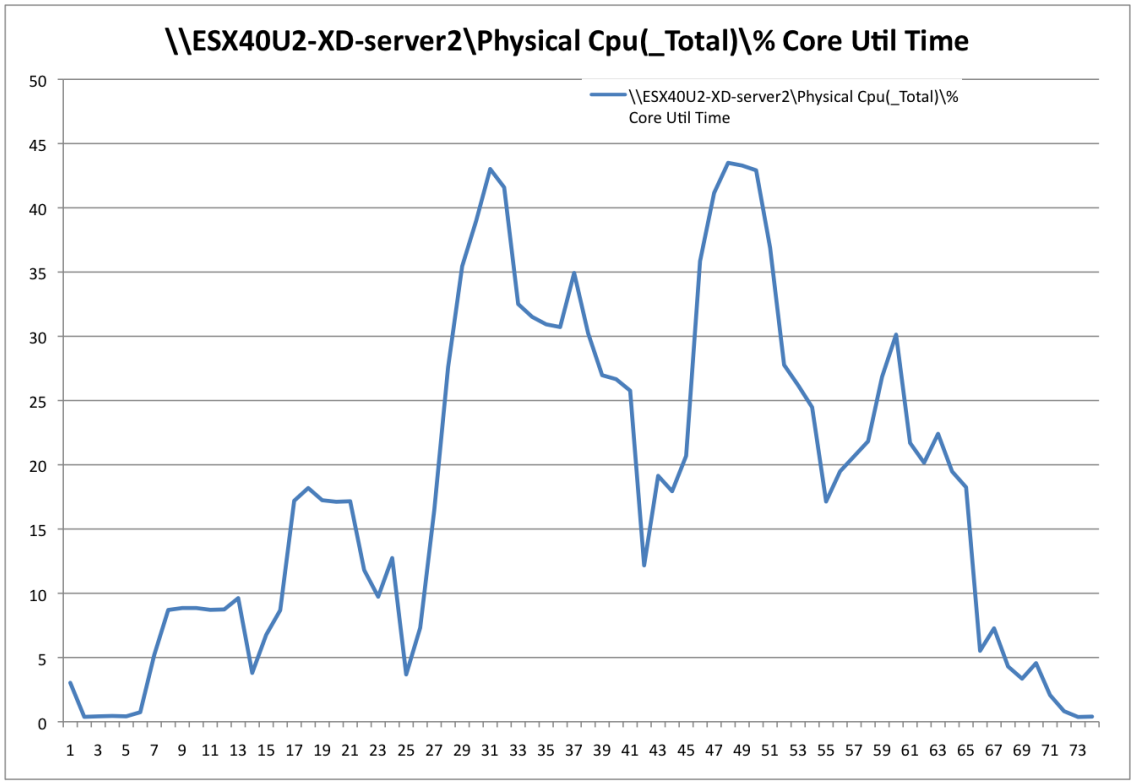


Figure 11. NonKernel Memory Utilization on the ILIO Controller in the Top-of-Rack Configuration

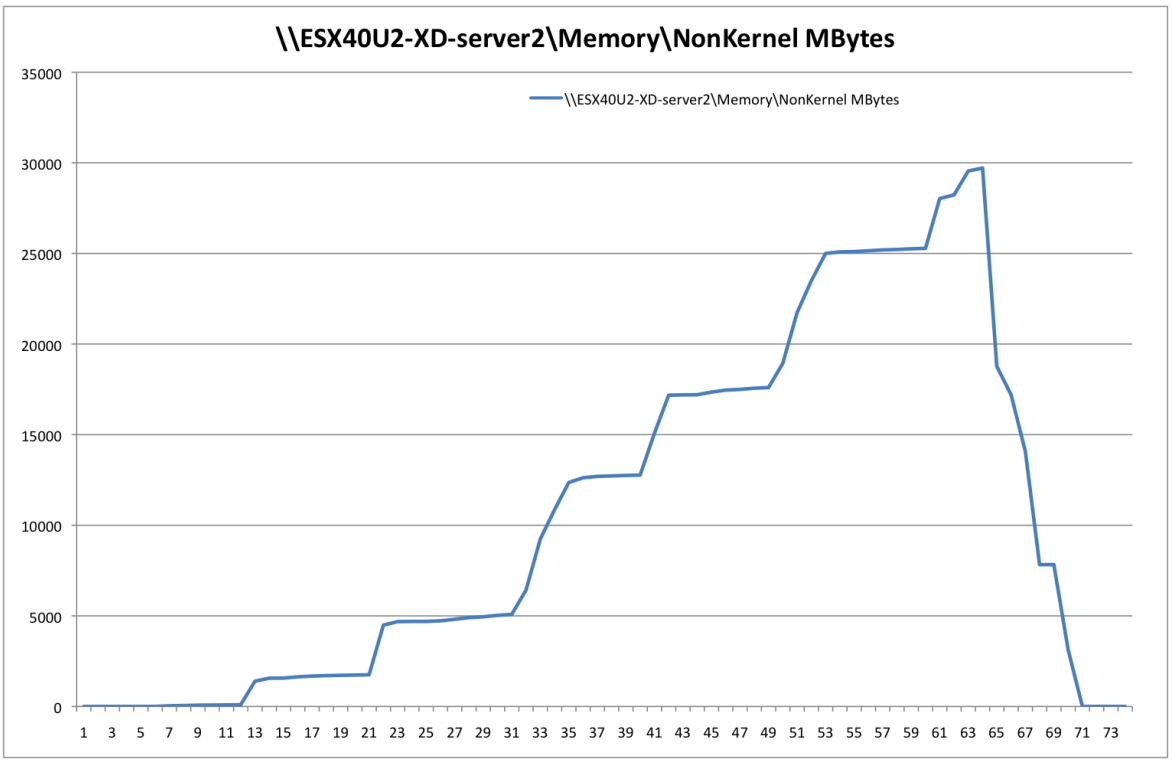
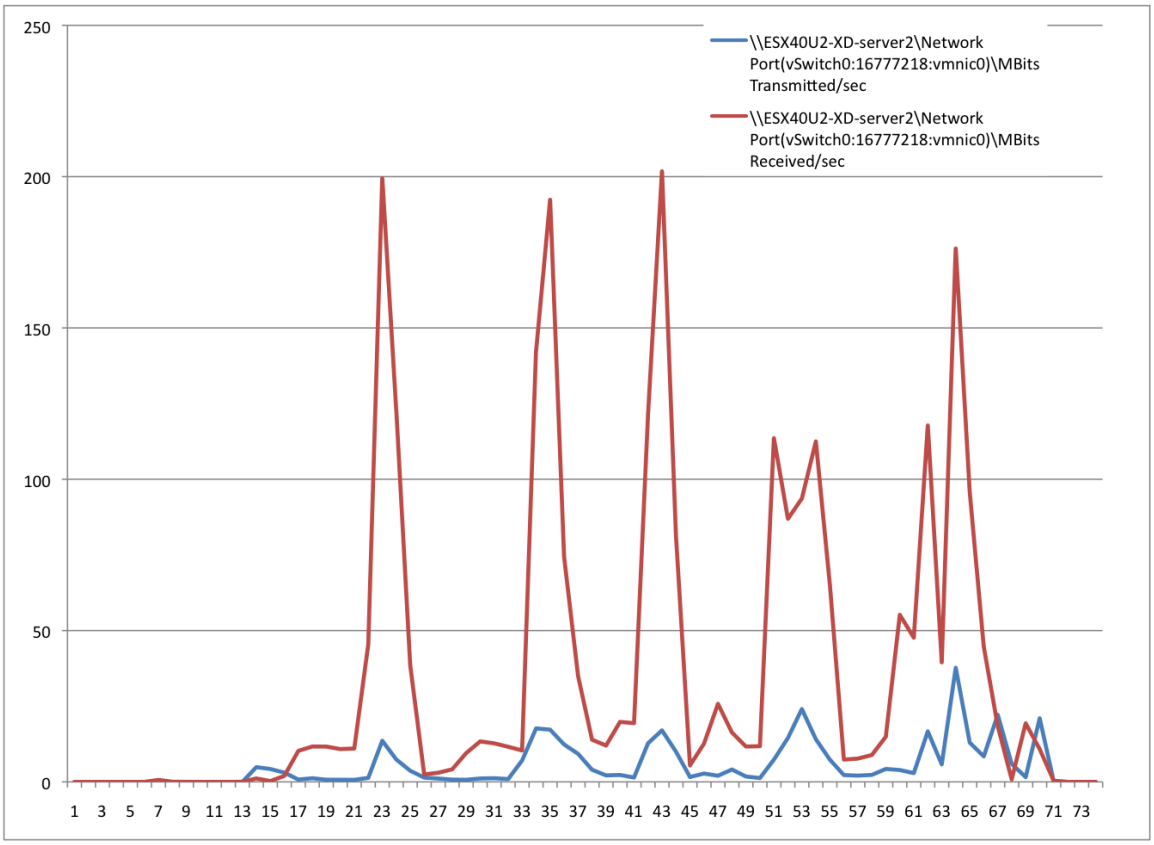


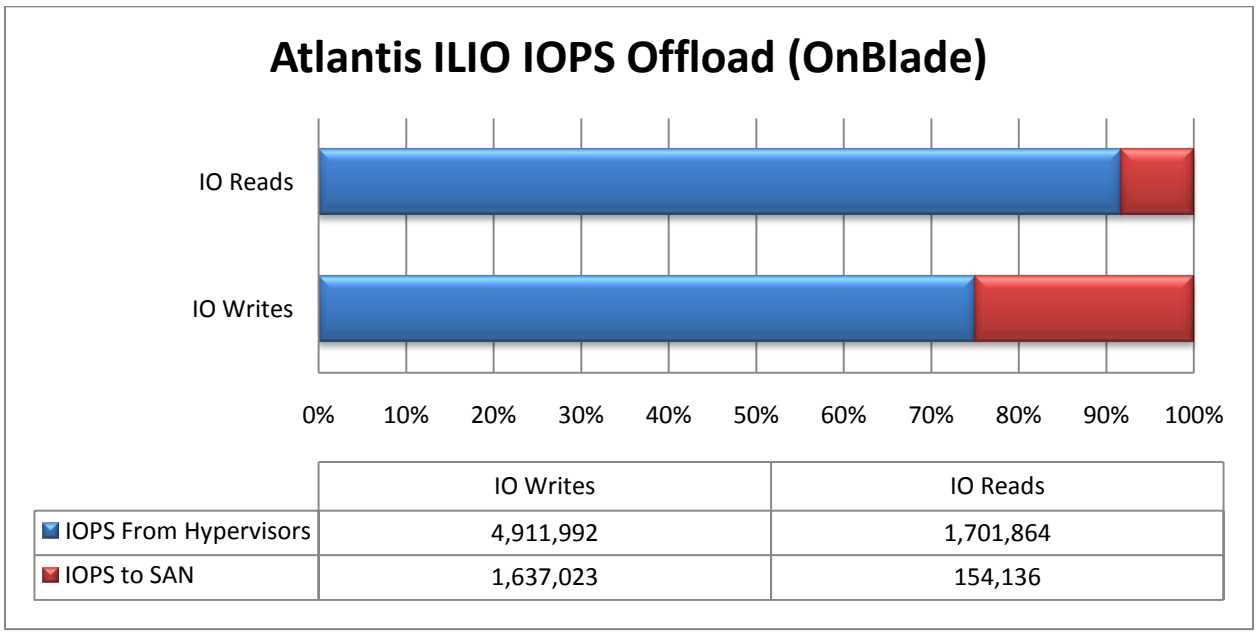
Figure 12. Network Bandwidth or Utilization Graph for the Atlantis ILIO Controller Showing a Maximum Utilization of 200 Mb/sec



Atlantis ILIO OnBlade

This graph shows the percentage of IOPS serviced by Atlantis ILIO (blue) vs. the percentage of IOPS serviced by the local disk (Red). The Atlantis ILIO OnBlade architecture uses an Atlantis ILIO controller on each VDI server blade to offload IO traffic going to the local disk. As a result of this IOPS offload, Atlantis ILIO makes it possible to achieve greater densities of virtual desktops per blade with fewer low cost local disks without degrading performance.

Figure 13. 80 Desktop Sessions on VMware vSphere With Atlantis ILIO OnBlade IOPS Offload

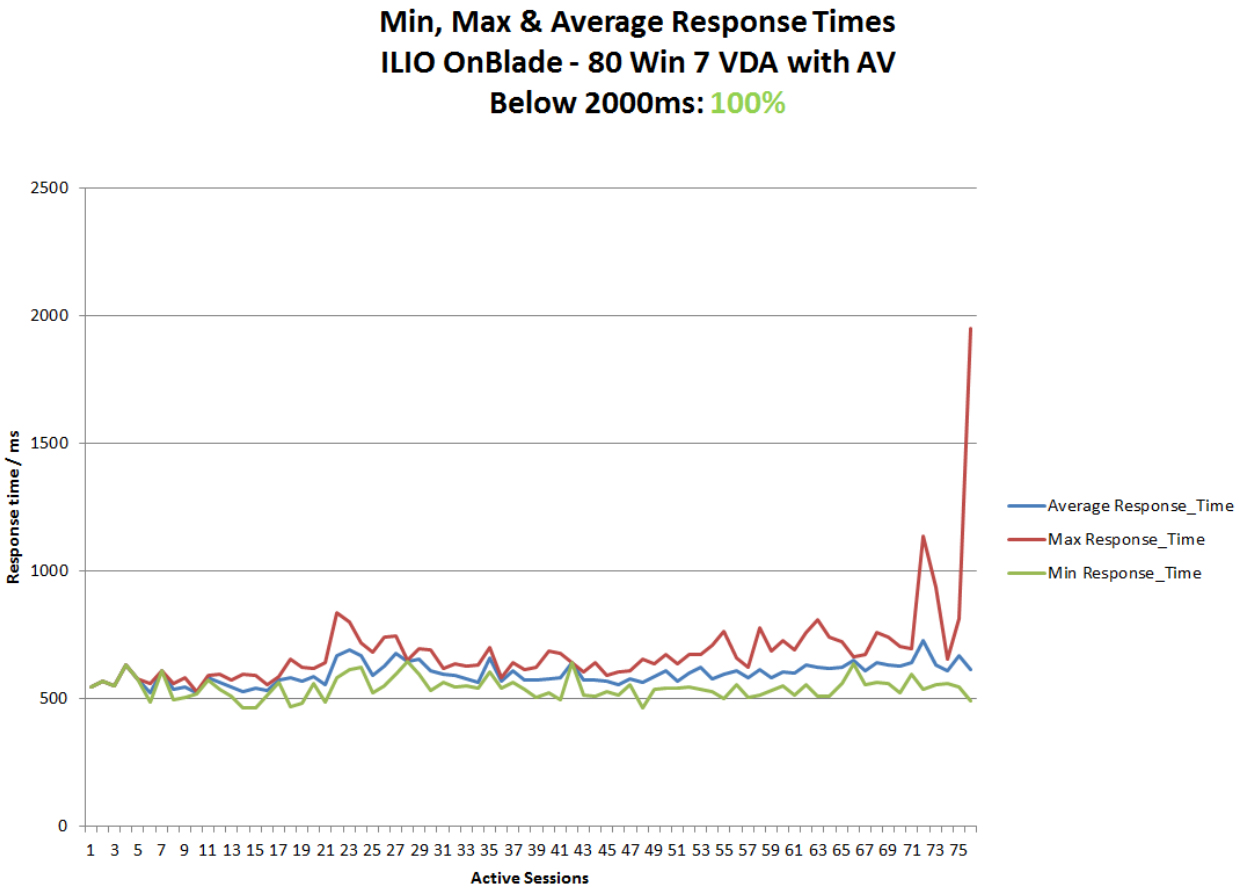


	IO Writes	IO Reads
IOPS From Hypervisors	4,911,992	1,701,864
IOPS to SAN	1,637,023	154,136

Figure 14. Atlantis ILIO VSI Test Results (On)

Total Sessions Launched	80
Uncorrected VSI Max (UVM)	80
Stuck Session Count before UVM (SSC)	0
Lost Session Count before UVM (LSC)	4
VSI Max (VSIMax = UVM - SSC - LSC)	**76**

Figure 15. 80 Desktop Sessions on VMware vSphere With Atlantis ILIO OnBlade Below 2000ms



This graph shows the Minimum, Maximum and Average Response time for desktops in the Atlantis ILIO 80 desktop OnBlade test. In our tests, using Anti-virus in the image represented a consistent 150ms increase in response time compared to the same image not running anti-virus. Response times under 2000ms are considered passing.

Additional ESX host CPU, Memory, and Network Utilization Data

Figure 16. Total Core Utilization on a Sample ESX Server With 80 Windows 7 Desktops and Atlantis ILIO Running OnBlade With 99% Peak CPU Utilization

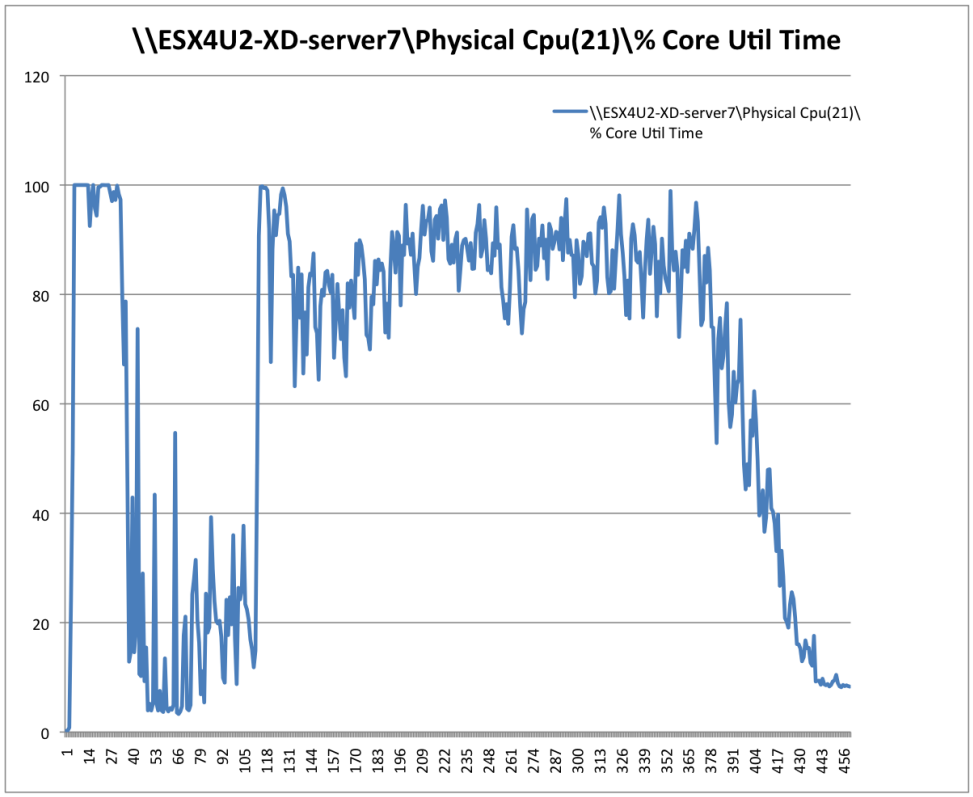


Figure 17. Memory Utilization on a Sample ESX Server With 80 Windows 7 Desktops on Atlantis ILIO Running OnBlade With 95% Peak Memory Utilization

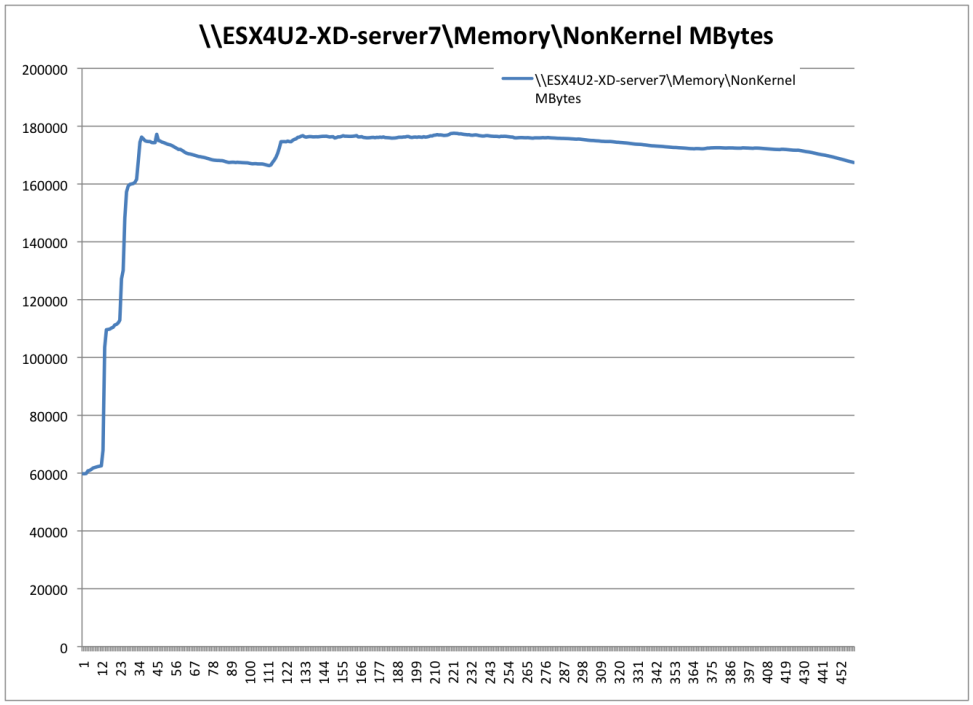
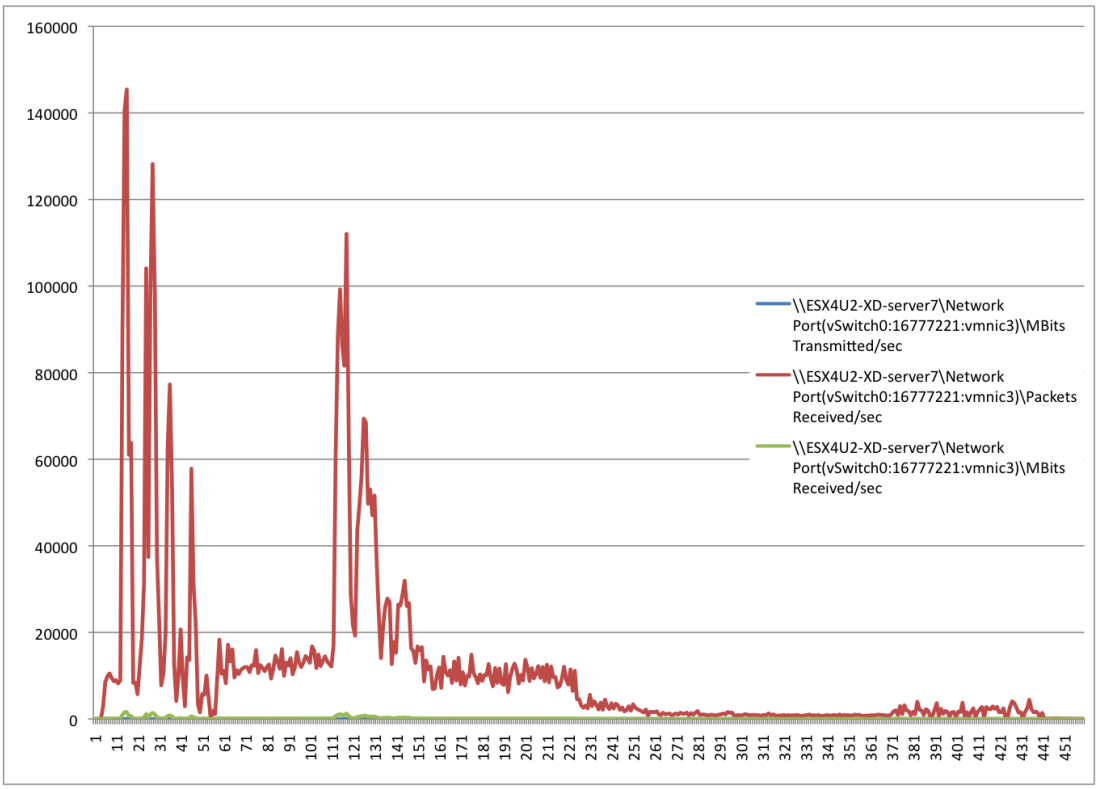


Figure 18. Network Utilization on a Sample ESX Server With 80 Windows 7 Desktop Running With Atlantis ILIO Running OnBlade Showing a Peak of 140000 packets received/sec



VDI Scaling and Sizing Guidelines

This section includes information that can be used for scaling and sizing Atlantis ILIO, Cisco Unified Computing System and Storage for VDI deployments.

Atlantis ILIO OnBlade Scaling Guidelines

The Atlantis ILIO OnBlade configuration includes 80 virtual desktops and 1 Atlantis ILIO virtual appliance per Cisco UCS blade and uses the local disks on the Cisco Unified Computing System as storage for the desktop images. As a result, the Atlantis ILIO OnBlade configuration is modular and scales linearly without adding shared storage. Therefore, adding additional desktops can be done in increments of 80. Due to the modularity of Atlantis ILIO OnBlade, the usage of hardware resources is extremely efficient. Based on the placement the Atlantis ILIO on the same hypervisor as the desktops, 70-90% of IO traffic is both contained within the hypervisor itself and has extremely low latency.

Figure 19. Atlantis ILIO OnBlade Configuration

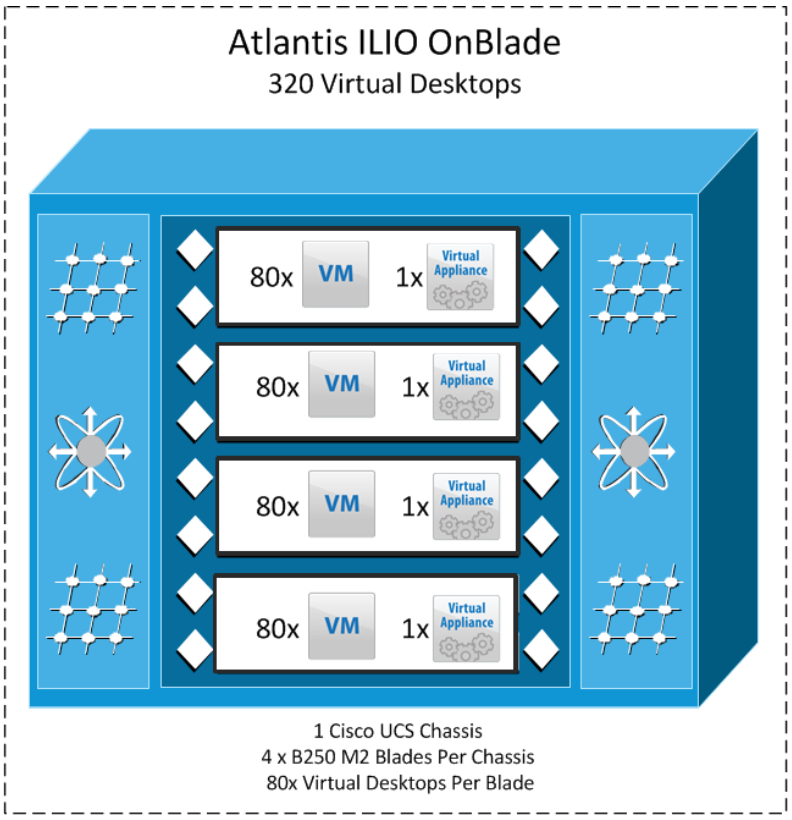


Table 4. VMware vSphere

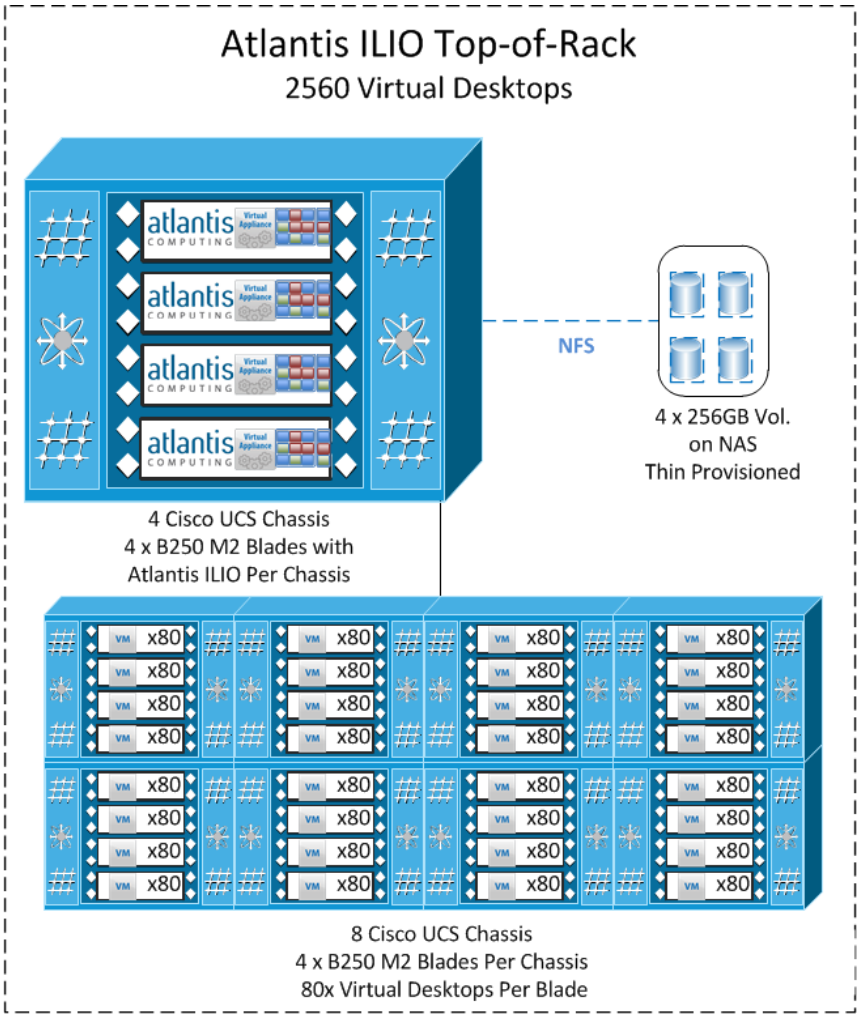
VMware vSphere			
No. of Chassis	No. of B250-M2 Servers tested	No. of VMs	VMs/Core
1	1 Blade	80	6.66
2	8 Blades	640	

The Cisco Unified Computing System supports up to 20 chassis within a single Cisco UCS domain on a Cisco UCS Fabric interconnect 6120 and up to 40 chassis on a FI 6140, extrapolating the values we got during the testing with Anti-Virus installed in the Windows 7 image we get the following scalability results when using the Atlantis OnBlade solution:

VMware vSphere			
No. of Chassis	No. of B250-M2 Servers	No. of VMs	VM/s Core
8	32 Blades	2560	6.66
12	48 Blades	3840	
16	64 Blades	5120	
20	80 Blades	6400	

To scale beyond 6400 desktops, requires multiple Cisco UCS domains.

Figure 20. Atlantis ILIO Top-of-Rack Scaling



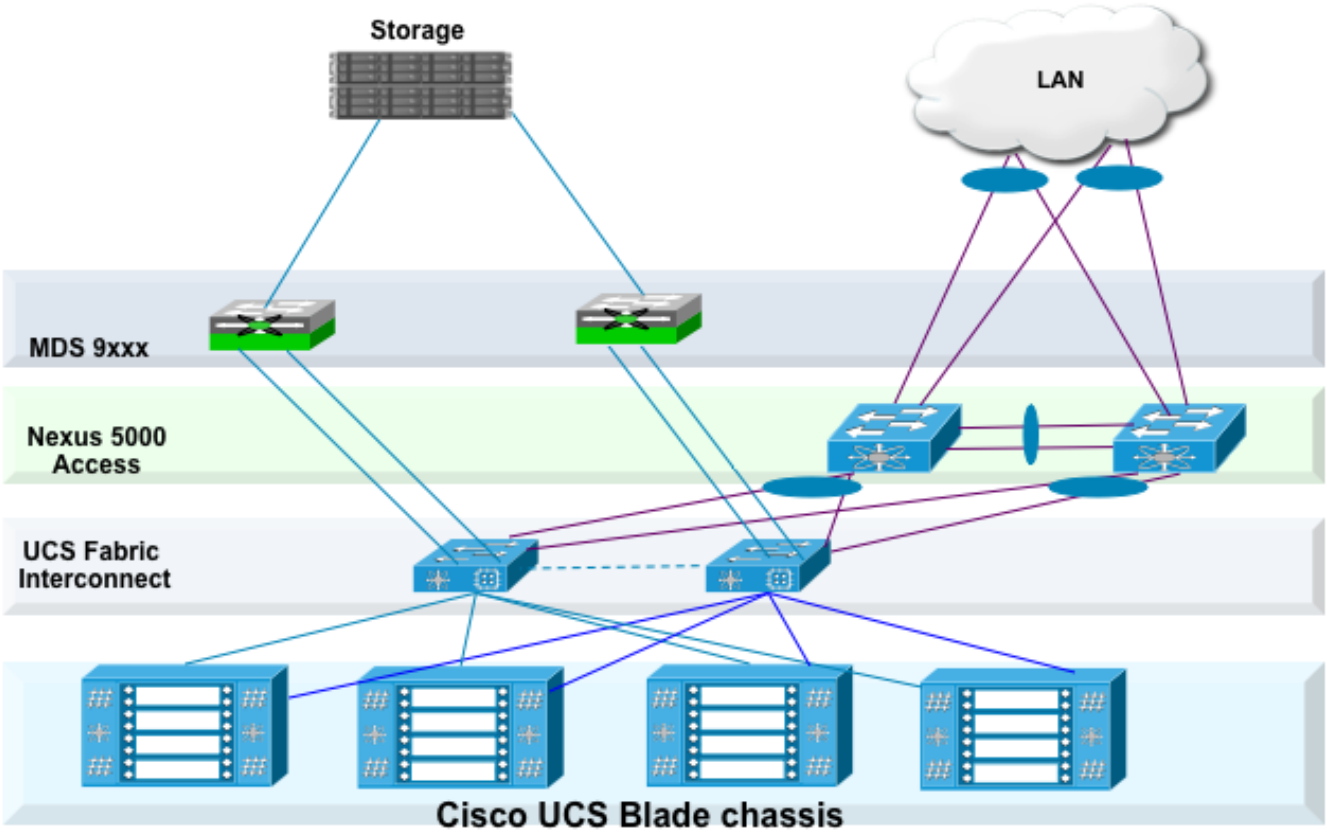
The Atlantis ILIO Top-of-Rack configuration includes 2560 virtual desktops and 4 Atlantis ILIO virtual appliances per Cisco UCS chassis and uses a shared SAN/NAS for storage of the desktop images. As a result, the Atlantis ILIO Top-of-Rack configuration scales using a ratio of 1 Atlantis ILIO controller running on 1 Cisco UCS blade to 8 Cisco UCS Blades running 640 desktops. Therefore, adding additional desktops can be done in increments of 640. However, deploying 2,560 desktops provides the most efficient usage of hardware resources by allocating 1 Cisco UCS chassis to house 4 Atlantis ILIO controllers running on 4 Cisco UCS blades. The architecture will scale linearly even further servicing up to 5120 by using 18 chassis 2:16, without having to extend the UCS network fabric and simply adding an additional 4 NAS data stores.

***Note**: The 256GB volume can be thin provisioned on the NAS, these backing store volumes have to be sized depending on the Windows 7 image size and/or what VDI technologies are to be used (Citrix PVS, Full size clones etc.); the actual space consumed is over 70% less but the Hypervisor needs to see all the space to allocated virtual drives.*

We achieve a 1:8 ILIO:VDA chassis ratio when using the Top-of-Rack solution plus 4 backing storage data stores which allows us to run at total of 2560 virtual desktops (640 per ILIO blade). As there is no networking boundaries found in other vendor blade solutions (i.e. no switches surrounding each physical blade chassis) and 10GigE; Cisco Unified Computing System is an ideal architecture for this type of deployment

Cisco Unified Computing System

To accommodate the Cisco Nexus 5000 upstream connectivity in the way we describe in the LAN configuration section, we need four Ethernet uplinks to be configured on the Cisco UCS Fabric interconnect. And based on the number of uplinks from each chassis, we could calculate how many desktops can be hosted in a single UCS domain. Assuming two links per chassis, scaling beyond 10 chassis would need a Cisco UCS 6140 fabric interconnect. A 5000 building block can be built out of the RA described in this study with two links per chassis and 12 Cisco UCS chassis comprising of four B250-M2 blades servers each.



By deploying Atlantis ILIO OnBlade solution using Citrix PVS means that there is no requirement for additional shared storage meaning that the blade/chassis modular scaling now is not only true for compute and network but also for storage capacity and performance (IOPS). Only the supporting active directory and Citrix XenDesktop component resources need to be increased as you scale out, but even these are virtualized making this task easier to manage and more cost effective.

Citrix has a modular reference architecture design that details how to scale their components as you scale the number of desktops. Please refer to http://support.citrix.com/article/ctx124087.

Storage

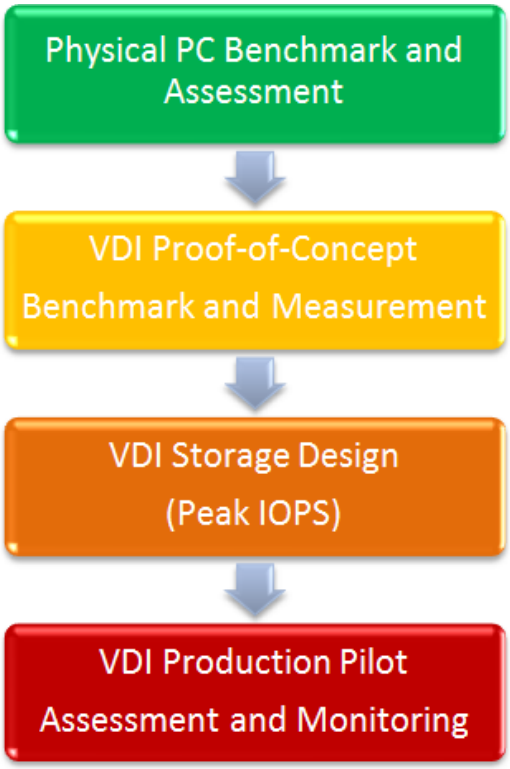
The exercise of sizing storage for VDI differs based on the Cisco and Atlantis VDI architecture selected:

Atlantis ILIO OnBlade

The Cisco UCS and Atlantis ILIO OnBlade architecture stores the VDI desktop image (PVS write cache and windows swap file) on local disk and the user data (user profile, user data) on shared storage (NAS, SAN). Atlantis ILIO is placed on each hypervisor to both offload IOPS (reducing the number of disks required) and deduplicate OS and application data (reducing storage capacity used). The Atlantis ILIO OnBlade deployment model is completely modular from a storage perspective because the local disk has been sized and tested with Atlantis ILIO to handle all of the storage IOPS and capacity requirements for the virtual desktop image. The shared storage for user data (SAN,NAS) will still need to be sized appropriately for user data.

Atlantis ILIO Top-of-Rack

The Cisco UCS and Atlantis ILIO Top-of-Rack architecture stores the VDI desktop image (PVS write cache and windows swap file) and the user data (user profile, user data) on shared storage (NAS, SAN). Atlantis ILIO is placed on dedicated Cisco UCS blades to both offload IOPS (reducing the number of disks required) and deduplicate OS and application data (reducing storage capacity used). The Atlantis ILIO Top-of-Rack deployment model requires that shared storage (SAN, NAS) be sized based on both the IOPS load placed on storage and the capacity consumed by both desktop images and user data. Atlantis ILIO offloads IOPS and reduces the capacity required for shared storage.



Storage Sizing Considerations for VDI Deployments using Shared Storage (Cisco UCS and Atlantis ILIO Top-of-Rack)

The VDI storage architecture should be designed with both performance and capacity in mind. From a performance perspective, VDI should be designed to meet or exceed physical PC performance in order to gain user acceptance for VDI deployments. Storage sizing has a significant impact on desktop performance and depends on many factors including the storage product used, number of disks, RAID configuration, and desktop workloads.

When designing your storage architecture for VDI, we recommend benchmarking the performance of physical PCs with comparable workloads to those you plan on deploying for VDI using tools from LiquidWareLabs, Lakeside Software or Veeam. Then, IT organizations should conduct a VDI proof-of-concepts (POC) with representative workloads and desktop images. During the POC, administrators should measure the Average Peak IOPS that are being generated by different type of workloads and can simulate IO intensive activities such as boot storms, application usage and anti-virus scans that would be likely to degrade performance by overloading storage with IO traffic. With that information, companies can design a VDI storage architecture that will provide adequate IOPS to maintain desktop performance.

For more information and resources on storage sizing, please see www.atlantiscomputing.com/storagesizing.

Storage Sizing Based on IOPS

IOPS is almost always the determining factor in how much storage must be purchased for VDI deployments to achieve the equivalent performance of a physical PC. The amount of IOPS generated per desktop and the ratio of read/write IOPS varies based on the operating system, applications, anti-virus and type of workers. VDI storage has a limited amount of available read and write IOPS available that depends on the storage system. To ensure performance equivalent to a physical PC, the storage system must have enough IOPS available to service VDI desktops at all times. The IOPS generated by VDI Desktops can either be read or write IOPS. In general, VDI desktops tend to be 80% write IOPS and 20% read IOPS, which is confirmed in the Test Results. Storage technologies such as caching and performance acceleration modules can cache and offload read IOPS efficiently but typically don't offload write IOPS intelligently. Therefore, VDI deployments require a large number of additional disks to handle the write IOPS load generated by VDI Desktops.

Storage Sizing for Capacity

Persistent Desktop Capacity

Storage sizing based on capacity is a relatively simple calculation with a persistent desktop VDI model. IT administrators simply add the average VDI desktop image size and the average VDI desktop user data allocation size and then multiply the sum by the number of desktops to determine the total amount of usable storage capacity required for VDI.

Stateless Desktop Capacity

With a Stateless desktop (i.e. using Citrix PVS or VMware Linked Clones), the VDI desktop image (i.e. PVS Write-cache or linked clone) is shared amongst all of the desktops, reducing the total amount of storage capacity required.

However, keep in mind that the number of IOPS required per desktop remains constant. Therefore, the number of storage disks cannot be reduced based on the capacity savings of a stateless VDI desktop model. Also, keep in mind that stateless desktops require a significant amount of changes to the desktop image when migrating from physical PCs including profile virtualization and application virtualization. (See the Persistent Desktop vs. Stateless Desktop section of this document for information)

Atlantis ILIO Impact on Storage Sizing (Persistent or Stateless)

Atlantis ILIO provides dynamic and transparent inline deduplication of common VDI desktop image components that reduces the amount of storage required for VDI desktops. In contrast to traditional back-end deduplication performed by storage systems, Atlantis ILIO deduplication occurs on-the-wire before IO traffic reaches the storage system. As a result, up to 90% of IO that is deduplicated never needs to be written to disk. Atlantis ILIO deduplication works with either Persistent or Stateless VDI desktops without requiring any changes to the desktop image or agents installed on the virtual desktop. If customers prefer the persistent desktop model, they can deploy persistent VDI desktops with Atlantis ILIO to reduce storage capacity by up to 20 times. If IT administrators prefer a stateless desktop, Atlantis ILIO will further reduce storage capacity required and offload IOPS, enabling organizations to dramatically reduce the amount and cost of storage for VDI. For the purposes of this document, we have focuses on the most common scenario used at Cisco of a Stateless VDI Desktop. In real-world VDI deployments, the amount of storage deduplication achieved by Atlantis ILIO will depend on the homogeneity of the desktop images and applications and will vary for each customer.

Conclusion

VDI has the potential to revolutionize enterprise desktop computing by lowering the total cost of desktop computing, increase security and compliance while making desktop computing more agile. Many companies have deployed VDI only to realize that their VDI architecture could not scale beyond a thousand desktops without either degrading desktop performance or requiring a massive additional investment in computing, networking or storage infrastructure. The VDI cost and performance challenges are a result of memory and storage bottlenecks that lower VDI density per server, degrade user performance and ultimately increase the cost of VDI. In order for VDI to achieve broad adoption, it must deliver cost, performance and scalability characteristics that are equivalent or better than the existing physical PC-based computing infrastructure.

The VDI performance, density and cost challenges are compounded when organizations deploy VDI in combination with Microsoft Windows 7 and anti-virus. Anti-virus has a significant impact on desktop performance (150ms response time increase on performance benchmarks), density of desktops per server (25+percent lower density due to increased CPU, Memory and IO requirements) and storage requirements (increase IOPS requiring additional storage disks) in a VDI environment. However, VDI benchmarking typically does not included Anti-virus in the desktop image.

The Cisco Desktop Virtualization Solution with Citrix XenDesktop and Atlantis ILIO achieves an optimal balance between cost, performance and scalability. The integrated solution is designed for straightforward, rapid deployment with minimal risk and is backed by a set of complete, tested, and verified Cisco Unified Computing System deployment packages with downloadable service profiles and pre-configured Atlantis ILIO virtual appliances that provide on-demand infrastructure to match the solution's on-demand virtual desktops and applications. The solution is proven and tested through a Cisco Validated Design that includes components from Cisco, Citrix, and Atlantis Computing. Cisco has tested the solution's ability to host both the Atlantis ILIO Top-of-Rack and Atlantis ILIO OnBlade VDI architecture.

The Cisco Desktop Virtualization Solution with Citrix XenDesktop and Atlantis ILIO is the first of its kind in the industry. Cisco and Atlantis Computing designed the solution to address a common vision of the changing workplace, and both companies are dedicated to delivering the software, end-to-end networking, and storage optimization solution that scale out in small integrated modules that don't require adding additional networking or storage infrastructure. By using Atlantis ILIO in this modular architecture, customers are guaranteed that the storage costs and performance of VDI are fixed, making the switch from physical PCs to VDI an easy decision. With Cisco the leader in enterprise networking and the creator of the industry-leading Cisco Unified Computing System, Citrix the leader in desktop virtualization and Atlantis Computing the leader in VDI storage and performance optimization, the joint solution provides the centralized, cost-effective, high-performance and scalable virtual desktop environment that organizations need. The time to move to such an environment is now.

For More Information

Cisco Systems Information

Cisco Validates Design for VDI – Cisco UCS, Citrix XenDesktop with XenServer

http://www.cisco.com/en/US/docs/solutions/Enterprise/Data_Center/Virtualization/ucs_xd_xenserver_ntap.pdf

Cisco Validates Design for VDI–Cisco UCS, Citrix XenDesktop with VMware vSphere

http://www.cisco.com/en/US/docs/solutions/Enterprise/Data_Center/Virtualization/ucs_xd_vsphere_ntap.pdf

Cisco Nexus 5000 Series Switch CLI Software Configuration Guide:

http://www.cisco.com/en/US/docs/switches/datacenter/nexus5000/sw/configuration/guide/cli_rel_4_0_1a/CLIConfigurationGuide.html

Atlantis Computing Information

General information on Atlantis Computing:

http://www.atlantiscomputing.com/

Atlantis ILIO Evaluation Request:

http://www.atlantiscomputing.com/resources/evaluation-request/

Information and Resources on VDI Storage Sizing:

www.atlantiscomputing.com/storagesizing

Atlantis ILIO Solution Brief:

http://www.atlantiscomputing.com/downloads/VDIStorage_SolBrief_060410.pdf

Atlantis ILIO Financial Services Case Study:

http://www.atlantiscomputing.com/FinancialCaseStudy

GlassHouse Technologies vLab Case Study:

http://www.atlantiscomputing.com/downloads/GlassHouse_vLab_Case_Study-8-29-2010.pdf

Citrix Information

PVS on XD BP:

http://support.citrix.com/servlet/KbServlet/download/19042-102-19576/XenDesktop%20Best%20Practices.pdf

XD Design Handbook:

http://support.citrix.com/article/CTX120760

Citrix eDocs (Citrix Product, Solutions and Technologies Document Library):

http://support.citrix.com/proddocs/index.jsp

Citrix Article on Recommended Anti-Virus Exclusions for VDI:

http://support.citrix.com/article/ctx124185

Citrix Article on Windows 7 Tuning for VDI:

http://community.citrix.com/pages/viewpage.action?pageId=113247185

Acknowledgements

Key contributors

Ravindra “Ravi” Venkat (Cisco Systems)

Satinder Sethi (Cisco Systems)

Steve Atkinson (Atlantis Computing)

Chetan Venkatesh (Atlantis Computing)

Seth Knox (Atlantis Computing)

Cisco would like to thank Login Consultants for the rights to use the Login VSI benchmarking tool for SBC and VDI environments referenced in this paper. If looking to replicate aspects of the testing represented in this document, please contact Login Consultants to purchase licenses for the Login VSI benchmarking tool.

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

Document number: UCS-TR100022