VMware View 5.1 Stateless Reference Architecture with Atlantis ILIO Diskless VDI and Cisco UCS

July 2012

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1. Executive Summary

At a Glance
• VMware View 5.1 • vSphere 5 • VMware ThinApp • Atlantis ILIO Diskless VDI • Cisco UCS B230 M2 Blades

VMware View is transforming desktop computing by enhancing mobility, increasing end user productivity, and lowering the total cost of ownership associated with desktop computing. However, making a successful transition from physical to virtual desktop requires designing an infrastructure that delivers better-than-PC cost, performance and scalability.

GlassHouse Technologies was commissioned by VMware to develop a reference architecture that uses Atlantis ILIO Diskless VDI software to simplify VDI deployments by eliminating storage, enabling customers to deploy storage-less virtual desktops using only server CPU and RAM. VMware View combined with Atlantis ILIO Diskless VDI creates an infrastructure that is easier to manage, scales easily and cut the CAPEX cost while delivering an amazing user experience.

This document provides IT architects and consultants with a proven and tested VDI architecture using VMware View, vSphere, ThinApp, and Atlantis ILIO Diskless VDI software with Cisco UCS, the industry leading datacenter compute platform.

Test Results Summary	
Density (VMs per server)	120-140
Boot Time	12 sec
Avg. Response Time (95 percentile)	0.53 sec
Recompose time (per desktop)	45 sec
IOPS (per Desktop)	227 IOPS
Linked-Clone Size (After ILIO)	275MB

Reference Architecture Highlights:

- **Storage-less** – virtual desktop images (VMware View linked-clones) are stored using local server memory, eliminating the need for traditional storage (SAN/NAS, SSDs).
- **Storage Optimization** – Atlantis ILIO Diskless VDI provided 227 IOPS per desktop and reduced the amount of memory per VMware View Linked Clone to 275MB.
- **Density** – The reference architecture supported 120-140 virtual desktops per Cisco UCS blade server.
- **Performance** – The architecture achieved better-than-PC performance with:
    - **Boot Time** – 12 seconds per desktop with 2.5 minutes to boot 120 desktops.
    - **User Experience** - VMware View planner had average response time of 0.53 seconds with application launch times consistently below 1 second.
    - **Operational Performance** – VMware View can recompose in 45 seconds per desktop

2. Introduction

VMware engaged GlassHouse Technologies to create a storage-less VDI reference architecture leveraging the Atlantis ILIO Diskless VDI solution. The goal of the project was to deliver and validate a simple design demonstrating how Atlantis ILIO Diskless VDI could deliver unparalleled VDI storage performance, eliminate the cost of storage and simplify the deployment of VMware View on the Cisco UCS compute platform.

Included in this document is a description of the test environment, equipment, and test results. Validation for the reference architecture was performed for 1-building block, executing VMware View planner with a realistic desktop workload. With validated architectures, customers can have confidence that a virtual desktop environment can be efficiently implemented and that it will perform as expected. This document also includes specific information necessary for VMware customers to replicate the reference architecture in their environment.

Glasshouse performed the design and test validation activities for this reference architecture based on documentation and best practices provided by VMware and Atlantis Computing. The hardware for the testing was provided by Cisco Systems.

GlassHouse Technologies is a global provider of infrastructure consulting and managed services. GlassHouse partners with customers to define and execute data center strategies, and operate their environment, helping clients address the complexities of cloud, virtualization, storage, backup, security and next generation data centers. GlassHouse is uniquely "vendor independent" in that we do not sell vendor's products, enabling us to provide objective analysis and recommendations.

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3. Virtual Infrastructure Overview

VMware Software

The following VMware software provided the foundation for the virtualized environment:

- VMware vSphere 5
- VMware vCenter 5
- VMware View 5.1
- VMware Composer 3.0
- VMware View Persona Management

VMware vSphere 5

VMware vSphere 5 is the latest version of VMware's virtualization platform and is the foundation of VMware's cloud infrastructure suite. VMware vSphere 5 includes new features and enhancements to deliver better application performance and availability for all business-critical applications. It also introduces advanced automation capabilities to free IT from manual processes allowing it to be more responsive to changing business requirements.

VMware vCenter 5

The VMware vCenter server acts as a central administration point for VMware vSphere infrastructures. VMware vCenter Server, formerly called VMware Virtual Center, provides the central point for configuring, provisioning, managing virtual machines and ESXi hosts within a virtual infrastructure. VMware vCenter also provides for a more advanced hierarchy and functionality including virtual datacenters, virtual clusters, DRS, vMotion, HA and integrated services such as VMware View desktop infrastructure for virtual desktop deployments and Site Recovery Manager for business continuity.

VMware View 5.1

VMware View 5.1 is a desktop virtualization solution that simplifies IT manageability and control while delivering one of the highest fidelity end-user experiences across devices and networks.

The VMware View solution helps IT organizations automate desktop and application management reducing costs and increasing data security through centralization of the desktop environment. This centralization results in greater end-user freedom and increased control for IT organizations. By encapsulating the operating systems, applications and user data into isolated layers, IT organizations can deliver a modern desktop. It can then deliver dynamic, elastic desktop cloud services such as applications, unified communications and 3D graphics for real-world productivity and greater business agility.

Unlike other desktop virtualization products, VMware View is built on and it is tightly integrated with vSphere. It is also the industry-leading virtualization platform that allows customers to extend the value of VMware infrastructure. In addition, it has enterprise class features such as high availability, disaster recovery and business continuity.

View 5.1 includes many enhancements to the end-user experience and IT control. Some of the more notable features include:

- **PCoIP Optimization Controls**—deliver protocol efficiency and enable IT administrators to configure bandwidth settings by use case, user or network requirements and consume up to 75 percent less bandwidth
- **PCoIP Continuity Services**—deliver a seamless end-user experience regardless of network reliability by detecting interruptions and automatically reconnecting the session
- **PCoIP Extension Services**—allow Windows Management Instrumentation (WMI)–based tools to collect more than 20 session statistics for monitoring, trending and troubleshooting end-user support issues
- **View Media Services for 3D Graphics**—enable View desktops to run basic 3D applications such as Aero, Office 2010 or those requiring OpenGL or DirectX—without specialized graphics cards or client devices
- **View Media Services for Integrated Unified Communications**—integrate voice over IP (VoIP) and the View desktop experience for the end user through an architecture that optimizes performance for both the desktop and unified communications
- **View Persona Management (View Premier Editions only)**—dynamically associates a user persona with stateless floating desktops. IT administrators can deploy easier-to-manage stateless floating desktops to more use cases while enabling user personalization to persist between sessions
- **View Client for Android**—enables end users with Android-based tablets to access View virtual desktops

Support for VMware vSphere 5.1 leverages the latest functionality of the leading cloud infrastructure platform for highly available, scalable and reliable desktop services. For additional details and features available in VMware View 5.1, refer to links in the References section at the end of this document.

VMware View Composer

A vital component of VMware View, View Composer delivers advanced virtual image management to streamline virtual desktop provisioning and deployment. View Composer has the ability to create a pool of linked clones from a specified parent virtual machine.

Each linked clone acts like an independent desktop with a unique host name and IP address. Because linked clone desktop pools share a base image, an administrator can quickly deploy updates and patches by updating only the parent virtual machine. End users' settings, data and applications will not be affected.

VMware View Planner

View Planner simulates application workloads for various user types (task, knowledge and power users) by running applications typically used in a Windows desktop environment. During the execution of a workload, applications are randomly called to perform common desktop user operations including open, save, close, minimize and maximize windows, view an HTML page, insert text, insert words and numbers, conduct a slideshow, view a video, send and receive email as well as compress files. View Planner uses a patent pending watermark technique to quantify the user experience and measure application latency on a user client/remote machine.

VMware View Persona Management

View Persona Management, one of the features of VMware View 5.1 Premier Edition, preserves user profiles and dynamically synchronizes them with a remote profile repository. By preserving the user's profile between sessions, View Persona enables IT administrators to provide a floating pool to users who previously required their own dedicated desktop.

Persona Management is a feature that seamlessly preserves a user's profile on to a network share for safe keeping between sessions in either floating or dedicated desktops. Persona persistently stores data and settings stored in the profile without specific knowledge of how a particular application works.

Cisco Systems

Unified Computing

The Cisco Unified Computing System™ is a next-generation data center platform that unites computing, networking, storage access, and virtualization resources into a cohesive system designed to reduce total cost of ownership (TCO) and increase business agility. 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.

Radically Simplified Server Management

Traditional blade servers add to data center complexity, with each chassis and chassis-resident switch acting as an independent point of management. Scaling out IT infrastructure using these systems is costly in terms of the number of I/O interfaces that each chassis must support, the power and cooling they require, the administrative and management overhead of individual blade servers, and the business agility lost because of delayed deployment times.

The Cisco Unified Computing System represents a radical simplification of the traditional blade server deployment model, with simplified, stateless blades and a blade server chassis that is centrally provisioned, configured, and managed by Cisco® UCS Manager. The result is a unified system that significantly reduces the number of components while offering a just-in-time provisioning model that allows systems to be deployed or redeployed in minutes rather than hours or days.

Compact Performance, Reliability and Energy Efficiency

The Cisco UCS B230 M2 Blade Server is one of the industry's highest-density two-socket blade server platforms. It is a critical new building block of the Cisco Unified Computing System portfolio that offers compact performance for enterprise-critical applications within the Cisco Unified Computing System architecture. It is well suited for IT departments that are looking for ways to increase computing performance and memory capacity while deriving the most value from the available space in their data centers.

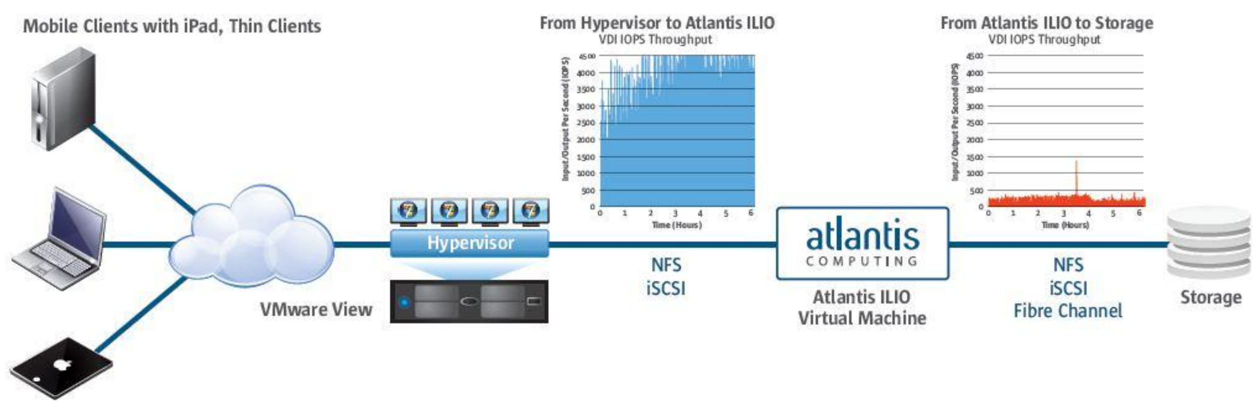
The Cisco UCS B230 M2 further extends the capabilities of the Cisco Unified Computing System by delivering new levels of performance, energy efficiency and reliability for mission-critical applications in a virtualized environment.

The Cisco UCS B230 M2 includes one or two Intel® Xeon® processor E7-2800 product family, 32 dual in-line module (DIMM) slots, up to 512 GB of Samsung 40-nanometer (nm) double-data-rate-3 (DDR3) memory, one mezzanine adapter slot, and two optional solid-state drive (SSD) bays.

Atlantis Computing

Atlantis ILIO Diskless VDI

Atlantis Computing is transforming enterprise desktop computing by solving the challenges of virtual desktop deployments: storage costs, performance, complexity and deployment risks. The Atlantis ILIO software complements VMware View to cut VDI costs and deliver a desktop that is faster and cheaper than a PC. With Atlantis ILIO, IT organizations can deploy 4-7 times more desktops on the same storage footprint, making VDI more affordable by both cutting the amount of storage needed per desktop and enabling the use of less expensive storage options.



The Atlantis ILIO software appliance is deployed on each VDI server to process storage IO traffic locally and perform inline deduplication of virtual desktop images. Atlantis ILIO runs in a dedicated virtual machine that is logically placed between the Virtual Desktop VMs and the storage for the virtual desktops. The Atlantis ILIO VM presents an NFS or iSCSI storage interface to the Virtual Desktop VMs. Then, Atlantis ILIO connects to any type of storage including server memory (Diskless VDI), local storage (SAS/SATA/SSDs) or shared storage (iSCSI/FC/NAS).

Software IO Processing: Atlantis ILIO software processes all VDI traffic locally with Windows NTFS file content awareness—within the same serverto dramatically reduce the amount of IO traffic going to storage and eliminate the huge burden normally placed on a storage array by hundreds or thousands of virtual desktops.

Inline Deduplication for VDI Workloads: Atlantis ILIO performs Inline De-duplication of all VDI images before they reach storage, effectively eliminating the need to store up to 99% of Windows image components, further reducing the amount of storage required for a successful VDI deployment.

Customers have the choice of using Atlantis ILIO Diskless VDI, Atlantis ILIO with local storage or Atlantis ILIO with shared SAN/NAS when deploying VDI. Customers that already have servers can increase performance and cut costs by using Atlantis ILIO with local storage (SAS or SSD). However, customers that are purchasing new servers for their a stateless VMware View deployment should use Atlantis ILIO Diskless VDI because it provides the optimal combination of lower CAPEX and OPEX costs, exceptional performance, simplicity, and ease of management.

Atlantis ILIO Diskless VDI

Atlantis ILIO Diskless VDI™ is a unique software solution that enables customers to deploy VDI with absolutely no storage for virtual desktops images. Atlantis ILIO creates an optimized NFS datastore for virtual desktops that uses a small amount of local server memory as storage to replace traditional storage, which was 275MB per desktop in the testing performed by GlassHouse.

The user profile and settings are streamed into the desktop over the network using VMware's Persona Management. The profiles can be located on a file share or network-based storage system.

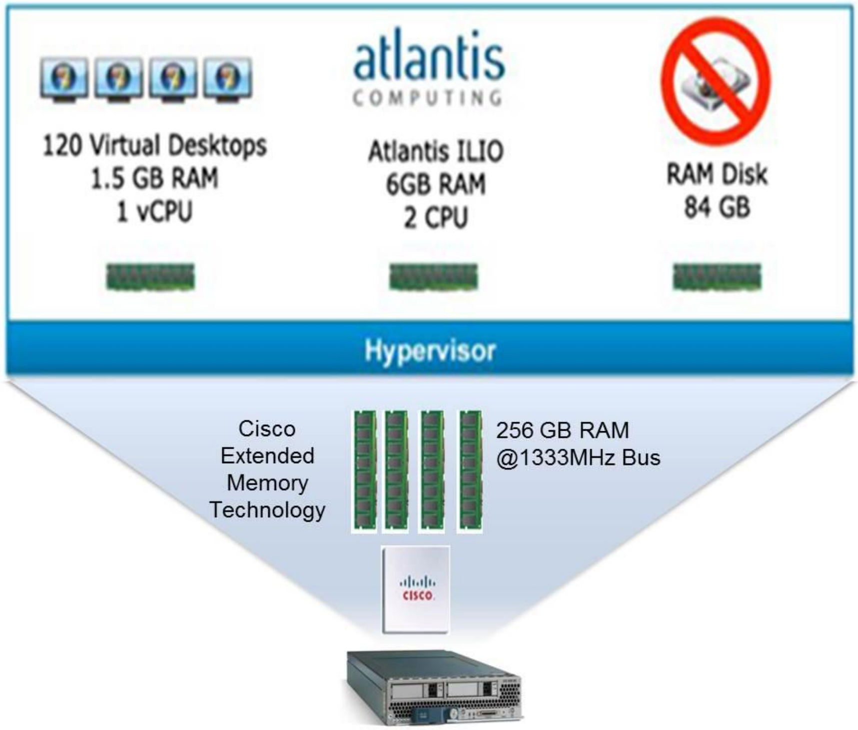


Figure 1. Atlantis ILIO Diskless VDI Configuration

Key Benefits

- **Amazing user experience** – 200-400 IOPS per desktop - faster than PC user experience – even with iPads.
- **Deliver a low CAPEX cost per desktop**
- **Lower OPEX** – Enable IT to lower operating expenses by eliminating rack space for SAN/NAS storage, lower power consumption, cooling costs, and eliminate the operational expenses of maintaining disk-based storage.
- **Simplifies deployment** – No storage to design, install or provision. The network design is simplified by terminating storage related traffic within each server.
- **Easy to manage** – Install, provision and administer desktops without adding or maintaining storage

4. Reference Architecture and Configuration

The reference architecture infrastructure consisted of a single host cluster with 2 Cisco UCS blades running VMware's ESXi 5.0 hypervisor. The cluster was managed with VMware vCenter Server. One host was used to setup the infrastructure needed to run the VMware View environment. The second host was dedicated to running the virtual desktops. The following infrastructure servers were set up to complete the VMware View 5.1 infrastructure:

- vCenter Server with View Composer 3.0
- Atlantis ILIO Center version 3.2
- VMware View Manager 5.1
- SQL database server VM
- Windows Server 2008 R2 domain controller

VMware vSphere 5 Infrastructure Design

All hardware chosen for this design has been verified against the VMware compatibility guides. This configuration ensures that the environment will be fully supported by VMware and Atlantis Computing. The test was backed by a NFS datastore for profile data and master image storage.

ESXi 5.0 Update 1

VMware ESXi 5.0 hypervisor was used as the virtualization platform. ESXi 5.0 is the latest hypervisor distributed by VMware and provides for a more secure and robust platform for hosting virtual infrastructures.

The base server design was developed using Cisco UCS and has the following configuration:

- Cisco B230 M2
- 2 x Intel Xeon E7-2870 Series CPU (2.4GHz)
- 256 GB RAM
- Cisco M81KR NIC

Local hardware component details and descriptions

This section details the components used in the design.

Processors

The processors selected for this test are the Intel Xeon E7-2870 Series CPU.

- 2.4 GHz
- 20 Cores
- 30 MB cache

Memory Allocation

The server was configured with 256 GB RAM with 1.5 GB of guest memory assigned to each Windows 7 VM based on the following parameters:

- 120 VMs
- 1.5 GB RAM per desktop
- Atlantis ILIO Diskless Memory was originally sized with 6GB of RAM for the appliance and 84GB RAM for the datastore. However, testing showed that only 33GB were required for the tested configuration. The amount of RAM required will vary based on the virtual desktop image and the amount of times that the virtual desktops run between re-compositions.

Hard drive configurations

ESXi 5.0 was installed locally but could also be configured to use "Boot from SAN" if the blade servers contained no local storage.

Network adapters

As a best practice, VMware recommends providing redundant network connections from each ESX host to the physical network. Atlantis Computing provided one physical network adapter and a Cisco Palo card that was configured as two virtual NICs for each UCS blade. The network adapter was checked against the VMware HCL to ensure that VMware certified compatibility with ESXi 5.0.

Cisco UCS Hardware Configuration

The following section outlines the various configurations for the Cisco UCS blades along with the network components of the virtual infrastructure. The standard is based on Cisco B230 M2 blades enclosed in a UCS 5100-series chassis.

Network design

The following section outlines the Atlantis network connectivity design for the test environment

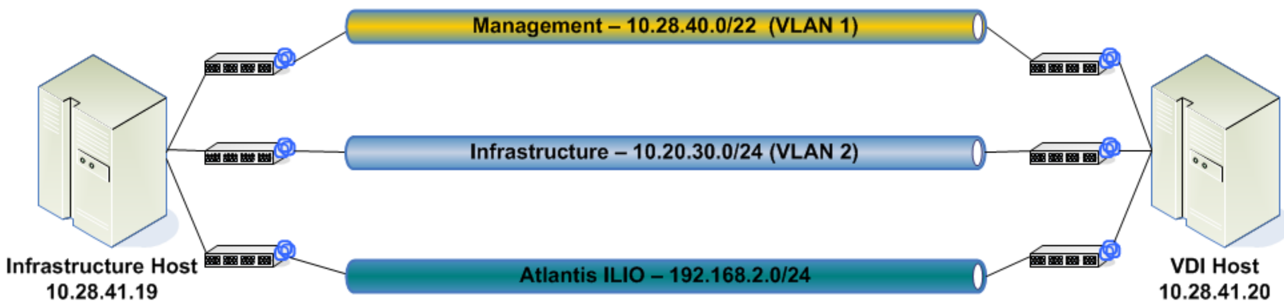


Figure 2. Network Connectivity Design

Physical network connectivity

Each Cisco UCS blade was configured with two virtual NICs, derived from the Cisco MK81R. The NICs were pinned to the IO module as shown in the following table.

Table 1. NIC Configuration.

Blade	IO Port
Host one - Slot 3	Left/3; Right/3
Host Two – Slot 4	Left/4; Right/4

The IO module was connected to a Cisco 2104 fabric extender (FEX). The physical NICs were not teamed and were configured to separate management traffic from virtual machine traffic.

Virtual Switch Overview

Virtual switches allow virtual machines to communicate with one another or with the outside world. They also provide a layer of redundancy by load-balancing virtual machine network traffic across all physical NICs used to create the switch.

vNetwork Standard Switches (vSwitch) were created within in this configuration in one of two different configurations: private and public. A private virtual switch has no connectivity to the physical network and creates private networks that are routed over the system. In this configuration, no physical adapters are bound to the virtual switch.

For the two ESXi 5.0 hosts, a single public vSwitch was used for the management network. A second public vSwitch was created for virtual machine traffic. This configuration separated management traffic from virtual machine traffic. A third private vSwitch was created on one of the ESXi 5.0 hosts for ILIO access. This vSwitch had no physical network adapter configured for use; it was used for virtual machine management.

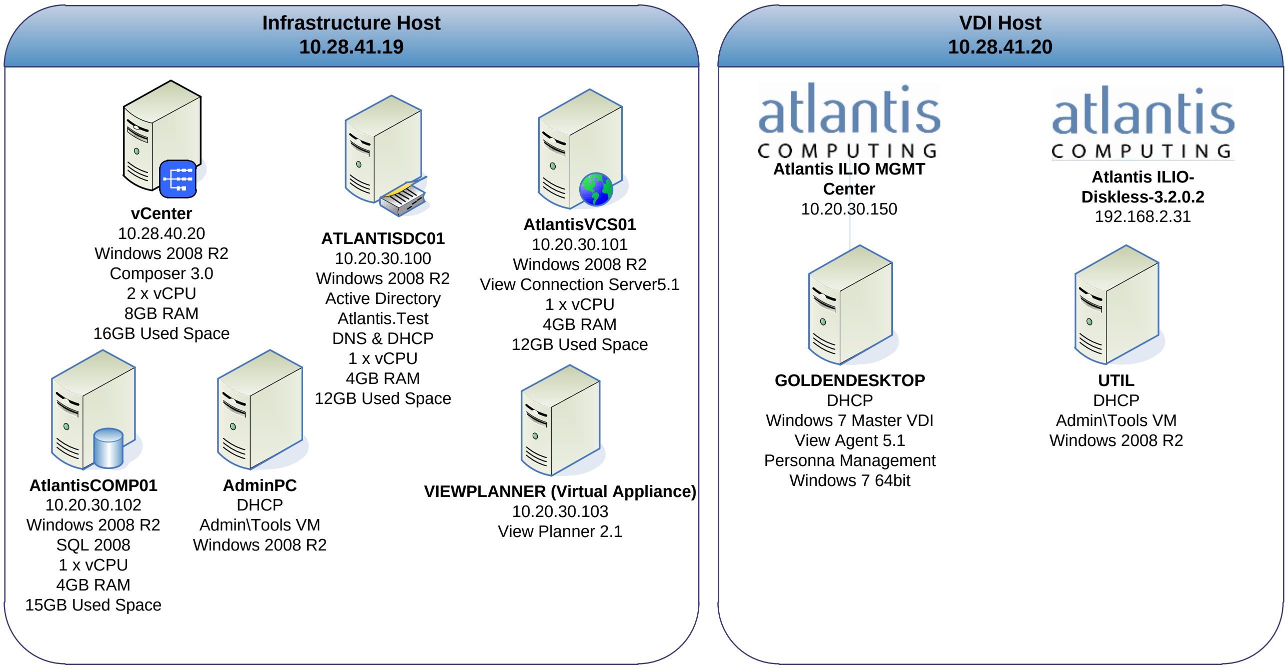


Figure 3. Virtual switch configuration - High Level Layout.

Virtual Switch Configuration

During the creation process of a virtual switch in VMware, a "Network Label" is given to the switch. This serves several purposes, the first being a meaningful way to manage the switch (e.g., "10.0.17.0" or "VLAN17"). All settings on both hosts were identical, including virtual switch and vmnic labels.

Note: By default ESXi is configured with 128 ports in a vSwitch. You will need to increase the ports if you want to enable expansion beyond 128 desktops on an ESXi5.0. This change requires a host reboot.

Virtual Machines

Virtual Machine Standards

Similar to standardization of physical machines, a virtual environment requires that a baseline or standard be created for new VMs. This standard creates an environment of like machines with very few deviations that is easier to administer and troubleshoot. Outlined below is the standard virtual hardware that was configured for the Windows 7 virtual desktops and the supporting virtual servers. These standards were used for all VMs unless a specific application requirement dictated a deviation.

Table 2. Virtual Machine Hardware.

Operating System	CPU	Memory	NIC	Disk
Windows 7 x64	1 CPU	1.5 GB	1 NIC	Linked Clone
Windows 2008 R2	1 CPU	4 GB	1 NIC	40 GB OS Drive

Table 3. Windows 7 x64 Virtual Desktop.

Virtual hardware setting	Configuration
Processors	Single vCPU
Memory	1.5 GB
Network	1 vmnic (VMXNET3)
Disk configuration	2 logical disks
SCSI driver (Windows 7)	LSI Logic
Disk size / partitioning for virtual machines	32 GB virtual machine disk file C: disk file for Windows 7 OS 1 GB virtual machine disk file E: data disk for View Planner
Disk file naming	No Naming – Managed by vCenter
Processor and memory share allocation	Default settings

Table 4. Windows 2008 R2.

Virtual hardware setting	Configuration
Processors	Single vCPU
Memory	4 GB
Network	1 vmnic (VMXNET3)
Disk configuration	1 logical disks
SCSI driver (Windows 2008)	SAS / Parallel
Disk size / partitioning for virtual machines	40GB virtual machine disk file C: disk file for W2K8 OS
Disk file naming	No Naming - vCenter will handle naming
Processor and memory share allocation	Default settings

VMware View Configuration

The following section describes the VDI components that were used in the tests and the configuration for each of the tests.

VMware View

VMware View is an enterprise ready desktop virtualization suite that is comprised of many components. The components that were configured in the test environment include View Manager (connection brokering and desktop provisioning), View Composer and Persona Management. A single View manager server installed on a Windows 2008 R2 virtual machine was configured on the infrastructure host. The View Manager was configured to communicate to vCenter for both management and View Composer operations. A Windows 2008 R2 virtual machine running SQL Server 2008 R2 housed the View Composer database and was configured for SQL authentication. The Active Directory OU that stored the pool VMs was configured with a GPO enabling Persona Management and stored user data on a CIFS share located on the Windows 2008 domain controller.

VMware vCenter Server

The vCenter architecture consists of several key components. In this deployment a single instance of vCenter was installed as a virtual machine running on Windows 2008 R2 Server. The vCenter server is the primary management component in the virtual infrastructure. The vCenter database stores all of the objects, permissions and historical data for the virtual infrastructure. This database can be one of three formats: Microsoft SQL Express, Microsoft SQL 2005/8 or Oracle. The reference architecture environment used a locally installed SQL Express database instance on the vCenter server.

Storage Configuration with Atlantis ILIO and Atlantis ILIO Diskless VDI

When planning the reference architecture, it was important to ensure that the Atlantis ILIO was sized to provide optimum response time and IOPS. The design also needed to accommodate for growth in linked clones over time.

Storage Selection, Optimization, and Sizing for Non-persistent Desktops

For non-persistent desktops, customers have the option to choose either an Atlantis ILIO Diskless VDI solution or use Atlantis ILIO with local storage for the virtual desktop images. A small amount of storage for the VMware user persona (i.e. my documents, applications, settings) also needs to be provisioned.

With Atlantis ILIO Diskless VDI, IOPS planning is eliminated because the server memory acting as a storage tier can provide virtually unlimited IOPS to the virtual desktops. Sizing local storage for a non-persistent VDI deployment involves planning for both Storage Capacity (GB) and Throughput (IOPS).

Atlantis ILIO Diskless VDI Sizing

Atlantis ILIO Diskless VDI leverages server memory to create a data store for stateless desktops. Unlike disk-based storage sizing, Diskless VDI does not have any IOPS constraints. This means that IOPS sizing is not required when using Diskless VDI. ***This is the recommended configuration for customers deploying stateless desktops.***

The Atlantis ILIO Diskless VM memory requirement is dependent on the number of virtual desktop sessions, the type of workload and the frequency of desktop image recompose/refresh. The testing for this reference architecture was performed with a typical office worker virtual desktop image (Office 2007, IE, Adobe…), using the View Planner load generator and the workload ran for a period of 33 continuous hours without performing a re-composition (equivalent of more than three 10 hour work days).

For the Atlantis ILIO Diskless VDI architecture, a memory size of 90 GB was chosen for the Atlantis ILIO VM to provide significant head room (750MB per desktop) to measure the actual amount of memory consumed by the virtual desktops at different densities. From the 90 GB, 6 GB was allocated for the Atlantis ILIO VM and the remaining 84 GB was presented as a datastore to ESX host.

The results showed that the Atlantis ILIO optimized virtual desktop consumed only 33GB of memory for 120 virtual desktops (275MB per desktop) after more than three 10-hour work days. Therefore, customers that set their VMware View pools to refresh when users log-off will likely only need to allocate 275MB of RAM per desktop or less provided that their user log-off daily.

While it is a reasonable expectation to refresh the linked clones from time to time, it is important to ensure that the NFS datastore presented by Atlantis ILIO does not run out of memory space.

Table 5. Diskless VDI Configuration.

Configuration Item	Parameter
Virtual Desktops Per Server (Density)	120
RAM for the Hypervisor	2 GB
Windows 7 base image size	40 GB
RAM allocated per Desktop	1.5 GB
vCPUs for virtual desktops	1
RAM for the Atlantis ILIO virtual machine	90 GB (6 GB RAM for the virtual appliance and 84 GB RAM as a datastore)
vCPUs for Atlantis ILIO	2
vCPU reservation for Atlantis ILIO (with compression)	4790 MHz

Atlantis ILIO with Local Storage Sizing

Some customers may already have purchased servers with local storage that they want to optimize with Atlantis ILIO. The following is a sizing exercise to show how Atlantis ILIO can complement designs using 15K local SAS drives. Customers will be able to select the correct server and disk combinations to provide lowest cost per desktop and high performance.

In this reference architecture, the ILIO appliance utilized 2 drives on a single 140 GB datastore with 22 GB of memory and 2 vCPUs. A 5 GB drive was used for the Atlantis ILIO virtual machine OS and a 120 GB drive was created for the Linked Clones virtual machine disks. The datastore size was calculated based on the size of the master image and the growth of the linked clone expected and the refresh interval. The pools were set up to refresh every time the user logs off the system. This sizing was done based on the sizing guidelines provided in the Atlantis ILIO Administration Guide.

Table 6. Atlantis ILIO Configuration.

Configuration Item	Setting
Virtual Desktops Per Server (Density)	45
RAM for the Hypervisor	2 GB
Windows 7 base image size	40 GB
RAM allocated per Desktop	1.5 GB
RAM for the Atlantis ILIO	22 GB
CPUs for Atlantis ILIO	2

5. Test Scenarios

There were two main scenarios tested in this Reference Architecture

1. Stateless Desktops with Atlantis ILIO Diskless VDI (Recommended configuration)
2. Stateless Desktops with local storage
    a. Stateless Desktops with local drives using Atlantis ILIO
    b. Stateless Desktops with just local storage without Atlantis ILIO

Overall desktop performance was determined by using VMware View Planner to measure response times of a typical desktop workload. VMware View Planner requires an average response time of 1.5 seconds to be considered a passing test run.

Test Environment

Diskless VDI: Cisco UCS B230 M2 was chosen to run the virtual desktops with 256 GB of memory. 120 desktops were provisioned using VMware linked clones.

Atlantis ILIO with/without Local Storage: Cisco UCS B200 M2 was chosen with 96GB memory with two 15k SAS drives.

Test Tools

In performing these test scenarios, GlassHouse used Iometer with a simulated VDI workload (80% write, 20% read and 80% random blocks) to measure the total number of IOPS. Furthermore, Iometer was also used to compare storage performance between a physical laptop and the Atlantis ILIO configuration.

Test Cases

Test 1: Iometer Tests to Measure IO Throughput.

For datastore based results we ran the same access specification on a single Windows 7 x64 VM running on the Atlantis ILIO NFS datastore and the SAS disk-based datastore. Iometer was also run against a laptop to compare the IO performance results.

Test 2: Provisioning Desktops Using View Composer

Atlantis ILIO Diskless VDI: A VMware Linked clone virtual desktop pool was created to deploy 120 virtual machines. The pool was based on Windows 7 x 64 desktop virtual machine base images.

Atlantis ILIO with Local Storage: A 45 virtual machine pool based on a Windows 7 x64 desktop was provisioned to both the ILIO NFS and the local SAS disk based datastore for comparison. The pool was configured to store the replica and linked clones on the same datastore.

Test 3: Desktop Boot Operation

A boot storm occurs when hundreds if not thousands of Virtual Desktops boot at the same time from the same data store. Storage, network or hosts are not typically designed to handle all of the peak traffic.

Atlantis ILIO Diskless VDI: To simulate this condition, all 120 Windows 7 x64 virtual machines configured in the linked clone pool were rebooted at the same time while the time it took for the virtual machines to come back online was measured.

Atlantis ILIO with Local Storage: Two different boot storm operations were performed against each storage configuration. As recommended by the Atlantis ILIO Administration Guide, Configuration One consisted of 3 phases (A: 1 VM, B: 5VMs and C: 39 VMs) and in Configuration Two, all 45 VMs were powered up at the same time.

Test 4: Recompose Operation for One Building Block

A recompose operation pushes new versions of a master image out to all users or a subset of linked clones. Recomposing provides a quick way to redeploy desktops that require software patching, updates, service packs or additional software.

Atlantis ILIO Diskless VDI: a refresh operation was performed on a pool of 120 Windows 7 x64 virtual machines to monitor and compare the resources used during the refresh.

Atlantis ILIO with Local Storage: A recompose operation on a pool of 45 Windows 7 x64 virtual machines was performed against the ILIO NFS based pool. The same 45 VM recompose operation was tried on the local storage without ILIO. The updated snapshot added default installs of Microsoft Project 2007 and Microsoft Visio 2007.

Test 5: Steady State Operation for One Building Block over 3 days (10 hour work days)

The steady state load test was performed with the VMware View Planner 2.1 workload utility. View Planner 2.1 executes a standard set of applications to emulate an end user's typical work day. The applications that were selected to run in that workload were the following:

- Microsoft Word 2007
- Microsoft Excel 2007
- Microsoft PowerPoint 2007
- Microsoft Outlook 2007
- Internet Explorer 9
- Mozilla Firefox 6
- Adobe Acrobat Reader X
- 7Zip compression utility
- Multimedia Application
- Web Album

Atlantis ILIO Diskless VDI: The knowledge-worker workload profile was configured to execute 25 iterations with a 'think time' (pause between workloads) of 20 seconds. The test was run against 120 Windows 7 x64 virtual machines in View Planner "Local" mode with a ramp up time of 5 seconds. The main performance counter that View Planner monitors is "Application Response Time" and any score less than 1.5 seconds is considered a passing score. In order to qualify for a "compliant" View Planner 2.1 test run, a minimum of 5 iterations must be executed.

Atlantis ILIO with Local Storage: The knowledge-worker workload profile was configured to execute 54 iterations with a 'think time' of 20 seconds. The test was run against 45 Windows 7 x64 virtual machines in View Planner "Local" mode with a ramp up time of 5 seconds. The main performance counter that View Planner monitors is "Application Response Time" and any score less than 1.5 seconds is considered a passing score. In order to qualify for a "compliant" View Planner 2.1 test run, a minimum of 5 iterations must be executed.

The steady state test was run against the Atlantis ILIO NFS-based pool and not the SAS disk-based pool.

6. Test Results

The summary test results can be found in the tables below for both the Atlantis ILIO Diskless VDI and Atlantis ILIO with local storage implementations. Customers should note that this sizing will vary from image to image depending on the base image size and the applications installed in them.

**Note that there is no before and after comparison when testing with Diskless VDI because it is not possible to do Diskless VDI without Atlantis ILIO.*

Iometer

To measure the maximum possible performance of the storage systems for each configuration, a free load generation tool created by Intel Corporation called Iometer was configured to simulate the IO profile of VDI. Using Iometer, you can increase the load on a given storage system until you have maximized the total IOPS available. Iometer is not an actual desktop workload but rather represents the maximum possible IOPS with an IO profile that is similar to steady state (post logon) desktop workload. However, Iometer is useful to determine the available peak IOPS of the storage system.

Diskless VDI datastore was able to deliver an average of 27358 peak IOPS per server translating to 227 IOPS per desktop. The same test run on a physical laptop yielded 188 IOPS.

Total IOPS

	Total IOPS Before Atlantis ILIO	Total IOPS with Atlantis ILIO
Diskless VDI	NA	227 IOPS per desktop Total IOPS = 27,358
Local SAS Disks	7.7 IOPS per desktop* Total IOPS = 350*	478 IOPS per desktop Total IOPS = 21,536

*Customers can increase the number of SAS drives to deliver higher IOPS to the desktops. This scenario focused more on showing the performance boost of Atlantis ILIO with just two local drives.

Storage Capacity Requirements

Total Capacity Required

	Total Storage Consumed Before Atlantis ILIO	Total Storage Consumed After Atlantis ILIO
Diskless VDI	NA	33 GB (120 Desktops)
Atlantis ILIO with Local Storage	95 GB	13 GB (45 desktops)

Capacity Required Per Desktop

	Storage Consumed Per Desktop Before Atlantis ILIO	Storage Consumed Per Desktop After Atlantis ILIO
Diskless VDI	NA	0.275 GB
Non-Persistent Desktops	2.1 GB	0.28 GB

Provisioning desktops using View Composer

Atlantis ILIO Diskless VDI: During the testing, the cloning time of a 15 GB thin provisioned base virtual desktop took an average of 45 seconds per linked clone virtual desktop. Therefore, it would take 1.5 hours to deploy 120 non-persistent virtual desktops.

Atlantis ILIO with Local Storage: During the testing, the cloning time of a 15 GB thin provisioned base virtual desktop took an average of 47 seconds per linked clone virtual desktop using Atlantis ILIO and 137 seconds per desktop using local storage.

Table 7. Atlantis ILIO Time to Provision.

	Provisioning Time per desktop with Atlantis ILIO Storage	Provisioning Time per desktop with Local SAS
Diskless VDI	45 seconds	NA
Atlantis ILIO Local Storage	47 seconds	137 seconds

Boot Storm Operation

Boot storms are the most IO intensive task performed by virtual desktops. As a result, when virtual desktops are IO bound as with the non-ILIO configurations, they tend to have extremely long boot times during a boot storm on conventional SAN. During our tests it only took 150 seconds to boot 120 VM's with Diskless VDI. Note that customers can turn slow performing drivers into fast storage when used with Atlantis ILIO. During our tests it only took 131 seconds to boot 45 VMs using Atlantis ILIO Storage and 723 second to boot the VMs on local SAS storage.

Table 8. Atlantis ILIO Diskless VDI Virtual Desktop Boot Times.

	Time to boot all desktops With Atlantis ILIO	Time to boot all desktops Without Atlantis ILIO
Diskless VDI	2 minutes 30 sec (120 desktop)	NA
Atlantis ILIO with Local Storage	2 Minute 20 sec (45 desktop)	19 minutes*

*Some VM's were non-functional after boot. VDI performance is expected to be poor with non-optimized local SAS drive

Recompose Operation for One Building Block

A View Composer recompose operation is the equivalent of rebuilding a desktop image and is useful for OS and application updates. We tested a recompose operation on 45 Windows 7 x64 VMs that were 15 GB in size and it took approximately 41 minutes to complete on the Atlantis ILIO datastore.

The same recompose operation on the local SAS datastore took 150 seconds per desktop. The recompose was performed using the base image plus default installations of Microsoft Visio 2007 and Microsoft Project 2007.

Table 9. Time to Recompose.

	With Atlantis ILIO	Without Atlantis ILIO
Diskless VDI	45 seconds per desktop	NA
Local Storage	54 seconds per desktop	75 minutes* (30 Desktops)

* Recompose without ILIO failed for 45 VM test and needed to be rerun only for 30 desktops

Refresh Operation for One Building Block

The refresh operation was executed to restore the linked clones back to their original state. We paid attention to the amount of time it took and the impact on the host and ILIO appliance. The test took approximately 43 minutes to complete for 120 VMs running Windows 7 x64 and 15GB in size.

Table 10. Time to Refresh

	Time to refresh all desktops	Average time per desktop
Diskless VDI	43 minutes (120 desktops)	21.5 seconds

Table 11. Time to Refresh

	Time to refresh all desktops	Average time per desktop
Atlantis ILIO with Local Disk	25 minutes (45 desktops)	33 seconds

Steady State Operation for One Building Block for 3 Working Days (10 Hour Workday)

Overall desktop performance was determined by using VMware View Planner to measure response times of a typical desktop workload. VMware View Planner requires an average response time of 1.5 seconds before it is considered a passing test run. The two Atlantis ILIO configurations described below passed the View Planner benchmark test with response times that were significantly faster than the required response time.

Overall desktop performance was determined by using VMware View Planner to measure response times of a typical desktop workload. VMware View Planner requires an average response time of 1.5 seconds before it is considered a passing test run. The two Atlantis ILIO configurations bulleted below passed the View Planner benchmark test with response times that were significantly faster than the required response time.

Atlantis ILIO Diskless VDI: 120 desktops with 1.5 GB memory each ran over 33 hours. The test was run 10 times longer as compared to a typical View Planner test recommended by VMware.

```
33 hour results:

Test Name: SS72
Test Mode: local

QoS Summary
-----------
Group A:  PASSED
The 95th percentile was: 0.529646 seconds
(To pass, this must not be more than 1.5 seconds)

Workload Summary
-----------------
Users: 120
Iterations (Total): 25 (to pass, this must be at least 5)
Iterations (Scored): 23

Workload Status: PASSED
```

A similar test was run with desktops configured with 1.75 GB of memory. Test results showed a negligible difference in application response time proving that memory was not a limitation in the tests performed.

Atlantis ILIO with Local Storage: 45 desktops with 1.5 GB memory each run over at least 3 working days.

```
Test Name: P2-72
Test Mode: local
QoS Summary
Group A:  PASSED
The 95th percentile was: 0.526309 seconds
(To pass, this must not be more than 1.5 seconds)
Workload Summary
Users: 45
Iterations (Total): 54 (to pass, this must be at least 5)
Iterations (Scored): 52
Workload Status: PASSED
```

Application Launch Time

In addition to measuring the average response time, VMware View Planner also measures response times for individual applications that are part of the workload. This includes launch time, open, close and performing a task with the application. View Planner ran a minimum of twenty five iterations of the test to measure response times and the median response times are shown below for each application. View Planner was not executed against the local SAD drive without Atlantis ILIO.The following charts show the applications response times for the Atlantis ILIO Diskless VDI configurations

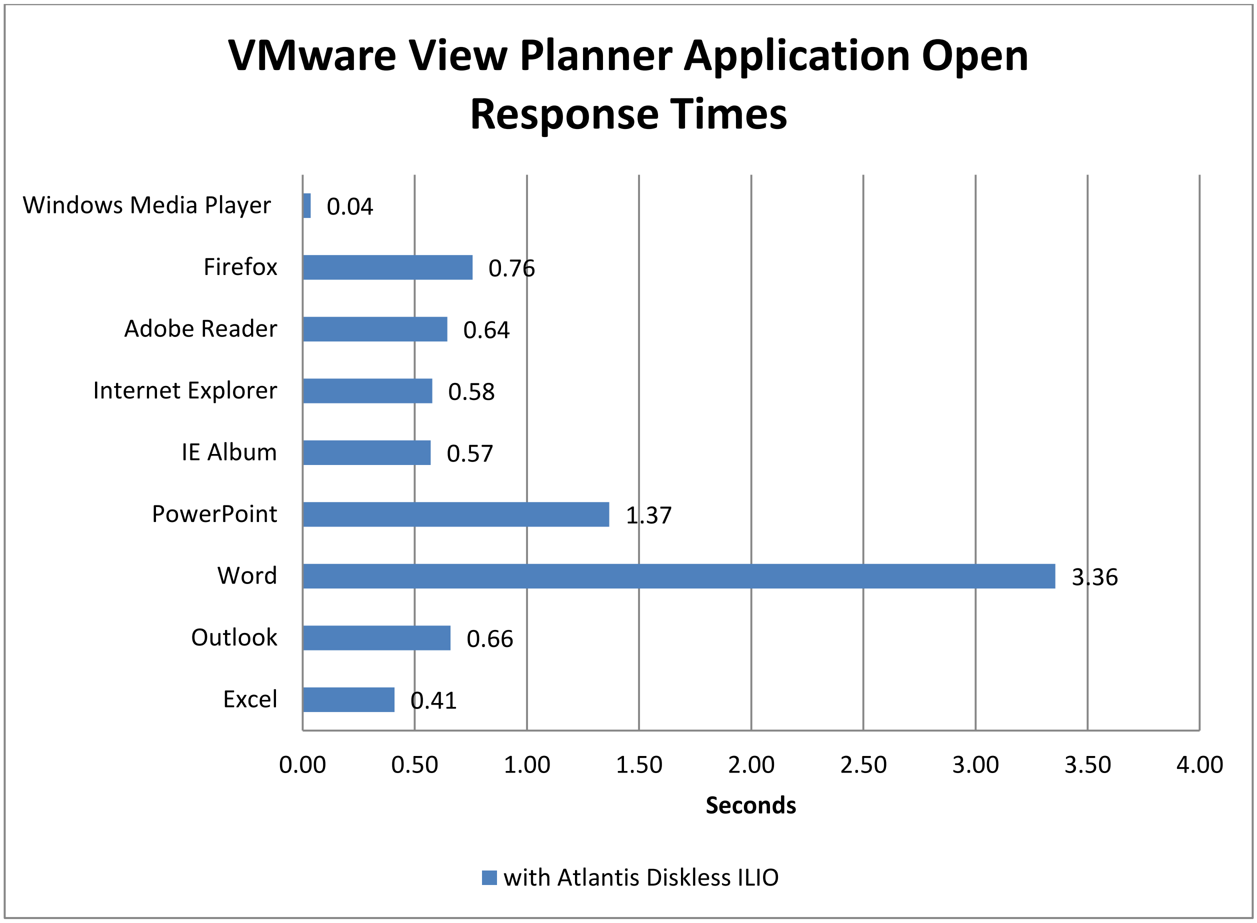


Figure 4. Application Response Time

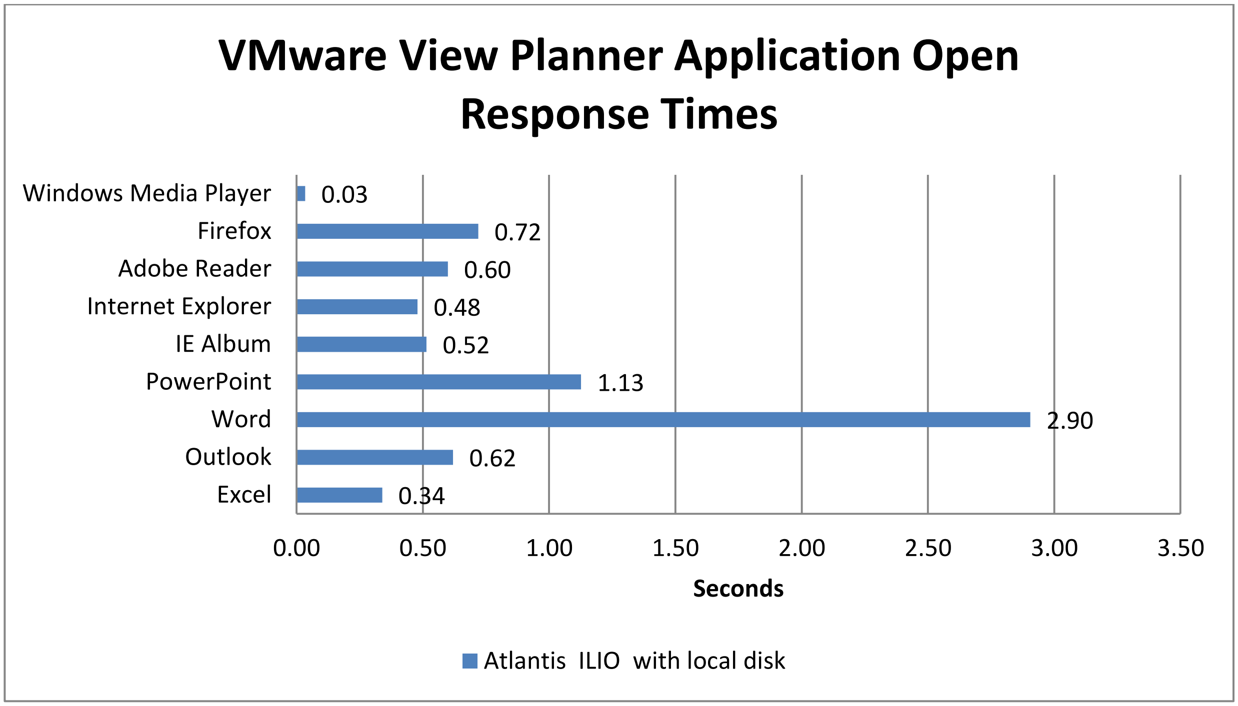


Figure 5. Application Response Time

7. Results Summary

For more detailed results from the tables below, refer to Appendix A.

Table 12. Atlantis ILIO Diskless VDI Test Result Summary.

Measurement	Stateless desktop with Atlantis ILIO Diskless VDI
Number of Desktops	120
Provisioning Desktops Using View Composer	~90 minutes
Boot Storm Operation	~2.5 minutes for 120 desktops
Refresh Operation	~43 minutes
Recompose Operation	~90 minutes
Steady State Operation (3 day) – Application Response Time	0.5297 sec [a]
RAM Consumed	33 GB

Table 13. ILIO Test Result Summary.

Measurement	A non-persistent virtual desktop with Atlantis ILIO	A non-persistent virtual desktop with local SAS storage
Number of Desktops	45	45
Provisioning Desktops Using View Composer	~35 minutes	~ 103 minutes
Boot Storm Operation (3 phased)	2 minutes 11 seconds for 45 desktops	12 minutes 3 seconds for 45 desktops
Recompose Operation	~41 minutes	~75 minutes (30 VM's due to disk space constraints)

Steady State Operation (33 hours) – Application Response Time	0.5263 sec	Out of scope

Response time was 0.5 seconds in the view planner test. The benchmark tool passing criteria is 1.5 seconds.

The following is a compute resource comparison between the virtual desktop and the physical laptop used in the testing scenarios.

Table 14. Client Comparison: Atlantis ILIO Diskless VDI vs. a Physical Laptop.

Hardware Configuration	Atlantis ILIO Diskless VDI	Laptop
Device	Windows 7 x64 VM, ESXi 5, Cisco B230 M2	Single mid-range Lenovo Laptop
CPU	2 x Intel Xeon E23870 (20 core)	Intel Core i5 @ 2.67GHZ
RAM	256 GB	4 GB
Storage	No storage required	7200 RPM local disk
Density per Device	120	1
Total IOPs per Device	27358 for 120 desktops = 227 IOPS per desktop	188 for one desktop

8. Conclusions

This reference architecture provides customers and partners with an approach to design VDI solutions with storage-less architecture or local drives for non-persistent desktops. The flexibility in the design allows an organization to start with a single host and scale modularly as they grow.

Atlantis ILIO Diskless VDI passed all test criteria and provided a high performance desktop with no storage. Since the solution does not need customers to size, install and maintain any kind of storage it becomes a very simple solution that can be just built with CPU and RAM for building stateless VDI deployments.

Atlantis ILIO, a VDI storage optimization software solution, can be seamlessly deployed into customer environments to provide better than PC storage performance. Together, VMware View, Atlantis ILIO and Cisco UCS deliver a cost-effective, high performance, scalable, secure, and resilient VDI architecture that can be deployed quickly in order to realize the cost, and agility benefits of desktop virtualization.

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GlassHouse Technologies: Erwin Vollering, Ken Zuidema, Mike Valuck, John MacInnes, Munit Yilma, Jay Seaton

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Appendix A: Iometer Data

Table 15. Iometer Results for Laptop

Target Type	Target Name	Access Specification Name	# Managers	# Workers	# Disks	IOPS	Read IOPS	Write IOPS	MBps	Read MBps	Write MBps	Transactions per Second
ALL	All	HP8440p	1	1	1	187.935692	37.025148	150.910544	0.734124	0.144629	0.589494	187.935692
MANAGER	WES-N56535	HP8440p		1	1	187.935692	37.025148	150.910544	0.734124	0.144629	0.589494	187.935692
PROCESSOR	CPU 0											
PROCESSOR	CPU 1											
WORKER	Worker 1	HP8440p			1	187.935692	37.025148	150.910544	0.734124	0.144629	0.589494	187.935692
DISK	C:					187.935692	37.025148	150.910544	0.734124	0.144629	0.589494	187.935692

Table 16. Iometer Results for Atlantis ILIO

Target Type	Target Name	Access Specification Name	# Managers	# Workers	# Disks	IOPS	Read IOPS	Write IOPS	MBps	Read MBps	Write MBps	Transactions per Second
ALL	All	VDI	1	1	1	27358.33894	5488.014419	21870.32452	106.868511	21.437556	85.430955	27358.33894
MANAGER	WIN7-FULLVM01	VDI		1	1	27358.33894	5488.014419	21870.32452	106.868511	21.437556	85.430955	27358.33894
PROCESSOR	CPU 0											
PROCESSOR	CPU 1											
WORKER	Worker 1	VDI			1	27358.33894	5488.014419	21870.32452	106.868511	21.437556	85.430955	27358.33894
DISK	F:New Volume					27358.33894	5488.014419	21870.32452	106.868511	21.437556	85.430955	27358.33894

Appendix B: List of Definitions

Name	Definition
Host	Defined in this document as an ESXi host. ESXi is the bare-metal host operating system from VMware that creates and manages virtual machines on a single piece of x86 hardware. ESXi hosts can be stand alone or logically combined into virtual clusters managed by vCenter. Guest operating systems, or virtual machines running x86 operating systems, are hosted on these stand alone or clustered environments.
Guest	A hosted operating system is typically referred to as a Guest (logical Windows, Linux or Apple OSx) running within a virtual Infrastructure environment. A guest can be a virtual appliance (usually Linux based) or a logical representation of a traditional OS.
vSphere	VMware vSphere 5 is the latest version of VMware's virtualization platform and is the foundation of VMware's cloud infrastructure suite. VMware vSphere 5 includes new features and enhancements to deliver better application performance and availability for all business-critical applications. It also introduces advanced automation capabilities to free IT from manual processes and allow it to be more responsive to changing business requirements.
Virtual Infrastructure	A virtual infrastructure decouples the physical infrastructure from the operating system and provides for the dynamic aggregation of resources across the environment. A virtual infrastructure can include server and desktop environments as well as integrate technologies such as vSphere Data Recovery for backup and Site Recovery Manager for business continuity.
Virtual Cluster	A group of like-configured ESXi hosts that are managed as a unit within a logical container and zoned to the same storage. Virtual machines/guests can move between hosts in a cluster. In vSphere, a virtual cluster allows for more advanced management features including DRS, HA and EVC.
Physical Cluster	A non-vSphere cluster that uses "traditional" cluster models like Veritas or MSCS and requires shared centralized storage. Traditional clustering can be either virtual or physical, but use an OS/guest level solution.
VM	A virtual machine (VM) is a software implementation of a server or desktop operating system. A logical machine created by the host operating system and presented to the Guest OS as if it were native hardware. VMs are a logical configuration that map to physical hardware through the hypervisor on a Sphere ESXi host.
VMDK	VMDK is the file extension for virtual machine disk files. These files are assigned to virtual machines and act as the "disk" for the virtual machine. VMDK files can be stored on local host storage or more commonly stored together on shared storage volumes.

VMFS	Virtual Machine File System. A high-performance file system created by VMware specifically for hosting VMDK files. This file system is unique in that it is truly *clusterable* and is not locked at the volume level by a single server; thus numerous virtual machine VMDKs can be stored on a single VMFS volume with various ESXi hosts accessing the volume simultaneously.
vCenter	The vCenter server acts as a central administration point for VMware vSphere infrastructures. VMware's vCenter server, formerly called VMware Virtual Center, provides the central point for configuring, provisioning and managing virtual machines and ESXi hosts within a virtual infrastructure. vCenter also provides for a more advanced hierarchy and functionality including virtual datacenters, virtual clusters, DRS, vMotion and HA

Appendix C: Bill of Materials

Below is the bill of material used in the reference architecture.

VDI Environment	Software or Hardware
Technologies	VMware View 5.1
	View Persona Management
	View Composer 3.0
	VMware View Planner 2.1
	VMware vSphere 5
	Atlantis ILIO Atlantis ILIO Installed On-Each-Server with 1 vCPU and 90GB RAM
Infrastructure	B230 M2's with 256GB of RAM 1x1GbE B200 M2 with 96 GB RAM 2x146GB 15k SAS (R0)
Desktops	120 Windows 7 Desktops Windows License

GlassHouse Technologies, Inc.
200 Crossing Boulevard
Framingham, MA 01702