Lab Validation
Report

Fusion ioVDI and VMware Horizon View: Reference Architecture for VDI

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ESG Lab Reports

The goal of ESG Lab reports is to educate IT professionals about data center technology products for companies of all types and sizes. ESG Lab reports are not meant to replace the evaluation process that should be conducted before making purchasing decisions, but rather to provide insight into these emerging technologies. Our objective is to go over some of the more valuable feature/functions of products, show how they can be used to solve real customer problems and identify any areas needing improvement. ESG Lab's expert third-party perspective is based on our own hands-on testing as well as on interviews with customers who use these products in production environments. This ESG Lab report was sponsored by Fusion-io.

Executive Summary

A successful virtual desktop solution needs to meet two requirements simutaneously. First, it needs to deliver a peformance that is equal or better than physical desktops. Second, the cost needs to be equal or below that of traditional desktops.

Fusion ioVDI is a product that leverages cost-effective server-side flash and software intelligence to accelerate virtual desktops while seamlessly integrating with any DAS, SAN, or NAS storage. The solution is designed to deliver fast, efficient performance for both persistent and stateless desktops. Integration with VAAI-compliant storage ensures the integrity of VMware mobility features, including vMotion, Distributed Resource Scheduler (DRS), High Availability (HA), and Site Recovery Manager (SRM).

This document outlines a tested reference architecture for ioVDI with VMware Horizon View desktop virtualization for organizations of all sizes. Included in this document are results of scalability, performance, and manageability tests that were validated by the ESG Lab.

Testing of this solution was executed in an environment utilizing VMware Horizon View deployed on VMware vSphere ESXi hosts with Fusion ioVDI installed, consisting of ioVDI software and an ioMemory PCIe server-side flash device.

The goal of this report is to validate that ioVDI can provide customers with these real and tangible business benefits:

- Delivers a user experience equal to or better than physical desktops by delivering consistent, fast response time and a 10x reduction in boot times.
- Provides new efficiencies with significant savings in shared storage and network infrastructure costs with 90% SAN offload.
- Reduces utilization of power, cooling, floor space, and management overhead from a simple architecture that delivers a 3.5x increase in desktop density per server over a disk-only approach.
- Offers simple, linear scaling in 150-persistent-desktop increments per server, 1,500 desktops per block, and 4,500 desktops per pod.
- Enables organizations to leverage the availability and efficiency features of their existing storage—from VSAN to enterprise storage arrays—without tying users to any specific storage solution.

Introduction

Audience

This reference architecture document is intended for use by IT professionals responsible for architecting, designing, managing, and supporting Fusion ioVDI infrastructures. Consumers of this document should be reasonably familiar with the concepts pertaining to VMware vSphere and VMware Horizon View.

Purpose

This document will cover the following subject areas:

- Overview of VMware Horizon View and its use cases
- Overview of the Fusion ioVDI solution
- The benefits of using Fusion ioVDI with VMware Horizon View
- Architecting a complete VMware Horizon View solution on the Fusion ioVDI platform
- Design and configuration considerations when architecting a VMware Horizon View solution with ioVDI
- Benchmarking VMware Horizon View performance with ioVDI

Solution Overview

What Is VMware Horizon View?

VMware Horizon View is a complete solution for delivering desktops as a service. It simplifies and automates the secure management of thousands of desktops from a central location, at levels of availability and reliability that cannot be matched by traditional PCs. Horizon View enables end-users to have the same desktop experience on any device (desktop PC, laptop, or mobile device) while ensuring that IT retains responsibility for desktop management, security, and compliance. With consolidated, virtualized infrastructure and centralized management, Horizon View reduces the total cost of ownership of desktops across your organization. The key components of VMware Horizon View include:

- **VMware vSphere Desktop** is a vSphere platform specifically designed with the scalability, availability, and reliability to run virtual desktops and applications. The platform includes vShield Endpoint, which offloads and centralizes antivirus and anti-malware to a secure virtual appliance.
- **VMware vCenter Server Desktop** is the central management hub that provides control and visibility into clusters, hosts, VMs, storage, networking, and other elements of the virtual infrastructure.
- **Horizon View Manager** centralizes desktop management, provisioning, and deployment in a single console.
- **VMware ThinApp** is an agentless application virtualization solution that streamlines administrative tasks and reduces storage needs for virtual desktops by maintaining applications independently of the underlying OS.
- **Horizon View Persona Management** dynamically manages user persona details with stateless desktops.
- **Horizon View Composer** enables creation of master images for pools of desktops that can share a common virtual disk. Updates and patches to the master image are then included in cloned desktops without disruption or impact on the user's settings, data, or applications.
- **Horizon View Client** provides access to centrally hosted virtual desktops from Windows PCs, Macs, thin clients, zero clients, and iOS and Android mobile devices.

As Figure 1 shows, a VMware Horizon View environment is a stack. In the bottom layer, primary storage is accessed through the network layer and provides shared storage, enabling desktop mobility and availability functionality. ESXi servers reside at the compute layer, upon which the desktops run. The management layer provides infrastructure and resource management, while the remote access layer provides connectivity for end-users.

*Figure 1. Overview of VMware Horizon View Architecture*
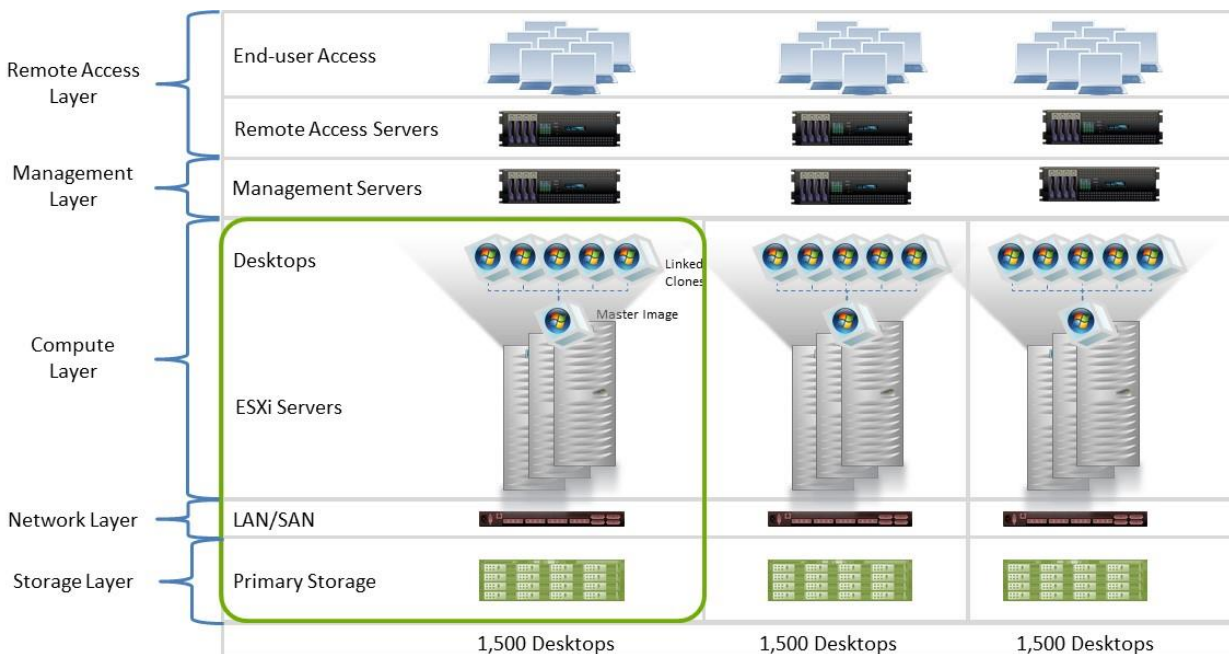
What is ioVDI?

ioVDI is a combined hardware and software solution designed to accelerate the performance of virtual desktops. It uses server-side flash and intelligent software to support persistent and stateless desktops in deployments of any size. The solution leverages Fusion ioMemory PCIe flash memory products in standard servers and ioVDI software that directs reads and writes to flash or disk for maximum performance and availability.

ioVDI can be easily integrated into any SAN or NAS environment, and it supports any VMware-supported shared VMFS datastore. Using VAAI-compliant shared storage, organizations can optimize their SAN/NAS investments and ensure that data stored there continues to take advantage of VMware features such as vMotion, DRS, HA, and SRM.

Figure 2 illustrates the key components of ioVDI running in an ESX server, and how it interacts with other layers of the stack.

Figure 2. Overview of ioVDI
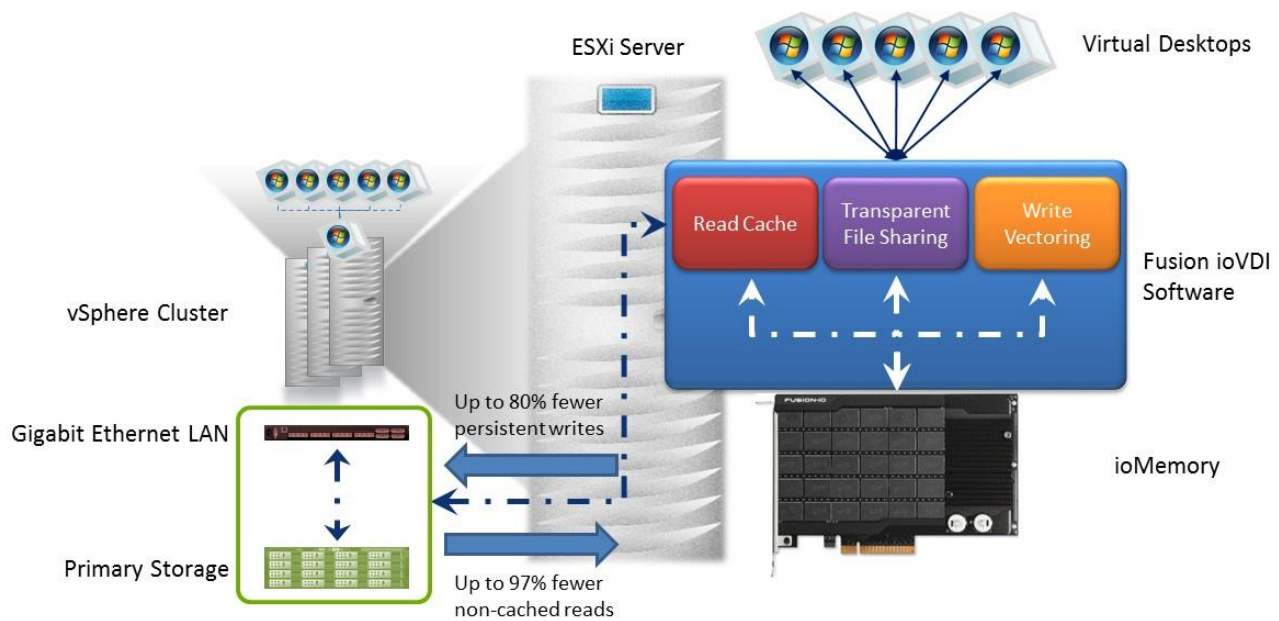
The key benefits of using ioVDI are:

- Up to 80% write and 97% read offload from primary storage with Write Vectoring and Transparent File Sharing.
- Simple, cost-efficient, linear scaling in 150-desktop increments.
- The ability to leverage SAN/NAS capacity with native data protection and capacity efficiency technologies.
- Increased resource efficiency, enabling increased VM performance and density per server.

The ioVDI solution uses several technologies to optimize performance using low-cost infrastructure.

- **Write Vectoring** intelligently directs desktop writes to either server flash or shared storage, reducing writes on shared storage by up to 80%. Transient writes such as page file I/O, temporary files, and browser temp data are recognized as non-persistent operations, and are intelligently directed to server flash. Desktop writes that must be retained, such as auto-saves and user profile updates, are sent to shared storage where they gain the advantage of storage-side HA and data protection.
- **Transparent File Sharing** delivers inline, file-level deduplication of all desktop data hosted on the server, so that partial or complete common files can be simultaneously accessed by hundreds of virtual desktops. This speeds boot time by up to 10x regardless of the number of desktops. VMDKs are deduplicated by up to 80%, ensuring optimization of flash capacity.

- **Dynamic Flash Reallocation** optimizes flash performance across desktops, ensuring consistent response times during login, boot, or virus protection storms, and variable user activity. Flash is also dynamically managed for all desktops during vMotion, DRS, and HA events.

The challenge for organizations is that most server-side solutions are only cost-effective for stateless desktops. As a result, storage-side solutions are usually proposed for persistent desktops, but these only become cost-effective at exceedingly large scale.

By increasing VM density per server by 3.5x and offloading I/O to primary shared storage by up to 90%, ioVDI delivers the persistent functionality provided by storage-side solutions, with the cost-effective perfomance and simple deployment of server-side solutions.

ioVDI Solution Architecture

Key components of the ioVDI/VMware Horizon View Reference Architecture are outlined in Table 1 and Table 2.

Table 1. Management Block

	Quantity	Type	OS	Roles	Configuration
Infrastructure Compute	1	Physical	VMware ESXi 5.1	Fusion ioVDI Management Server Domain controller View servers vCenter server Admin Desktop	AMD Opteron 6376 2.29 GHz processor Two sockets, 16 cores per socket 256GB RAM 2x1G NICs
Network Switch	1	Physical	N/A	1Gb Ethernet Connectivity	24 1GbE ports
ioVDI Management Server	1	Virtual	Enterprise Linux	ioVDI management appliance to configure and manage VDI desktop acceleration	2 vCPU 4GB vRAM
Domain Controller	1	Virtual	Windows 2K8R2x64	Active Directory Domain Controller, DHCP and DNS server	2 vCPU 4GB vRAM
vCenter Server	1	Virtual	SUSE Linux Enterprise 11 (64-bit)	vCenter server to manage all ESXi servers in desktop block	2 vCPU 4GB vRAM
Horizon View 5 Connection Server	1	Virtual	Windows 2K8R2x64	VDI Broker	2 vCPU 4GB vRAM
Horizon View 5 Security Server	1	Virtual	Windows 2K8R2x64	Security layer between Internet and internal network	2 vCPU 4GB vRAM
VMware View Composer	1	Virtual	Windows 2K8R2x64	Used for creating VMware linked and full clones	2 vCPU 4GB vRAM

Table 2. 1,500 Desktop Block

	Quantity	Type	OS	Roles	Configuration
Desktop Compute	10	Physical	VMware ESXi 5.1	Hosts Windows 7 desktop virtual machines	AMD Opteron 6376 2.29 GHz processor Two sockets, 16 cores per socket 256GB RAM 2x1G NICs 1xPCIe slot
Fusion ioMemory Caching Device	10	Physical	Fusion ioMemory Driver	Caching device for the ioVDI software engine	~1TB
Primary Storage	1	Physical	Vendor Dependent	Primary storage for all Windows 7 desktop virtual machines	24x10K RPM disks[1] Parity RAID Protection One NFS volume
Windows Desktops	1,500	Virtual	Windows 7 Ultimate	Active Directory Domain Controller, DHCP and DNS server	1 vCPU 1GB vRAM 1x VMXNET3 Network Adapter 16GB Disk

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[1] The number of disks are to provide adequate disk IOPS. Size of disks can be adjusted based on required storage per desktop.

Deployment Architecture Considerations

VMware Horizon View Design Decisions

When designing a VDI deployment, optimal use of resources is critical. VDI requires consistent, low response times and the ability to sustain performance through periods of intense storage activity, like boot, login, and virus scan storms. DAS, NAS, SAN, or flash storage approaches taken alone all have different challenges. Disk-based storage will have difficulty meeting performance and response time requirements unless it is significantly over-provisioned with respect to the steady state requirements.

Solid-state storage—all flash or DRAM memory-based systems—offers the highest native performance, but requires high network bandwidth to transfer needed data to and from desktops. Also, VMware has found in its testing that when using linked clones with replica disks on SSDs, the user disk grows by 1GB/disk, which results in significant amount of unnessesary I/O to and from back-end storage.

The ioVDI server-side acceleration approach gives applications direct access to data using flash–without storage protocols or RAID controllers—can greatly reduce response times by placing the cache closer to the CPU while freeing up resources at the server, network, and storage layers. This provides room for a greater density of desktops per server, per storage array, and allows utilization of extremely cost-effective 1GbE networks for storage and network traffic.

Fusion ioVDI is designed to accelerate any direct attached or shared storage. ioVDI will accelerate VSAN, low-end NAS, midrange, or enterprise SAN equally well. ioVDI leverages the availability and efficiency of existing storage without tying users to any specific storage solution. For the best price-performance storage, a hybrid solution like Fusion's flash memory and ioControl hybrid flash storage can provide all-flash performance at the cost of disk.

Design example–A 1,500 Desktop "Block"

These key components of an ioVDI reference architecture can be deployed in a repeating pattern to provide cost-effective linear scaling of the environment as visually represented in Figure 3. A single rack can contain 3x 1,500 desktop blocks to compose a "Pod".

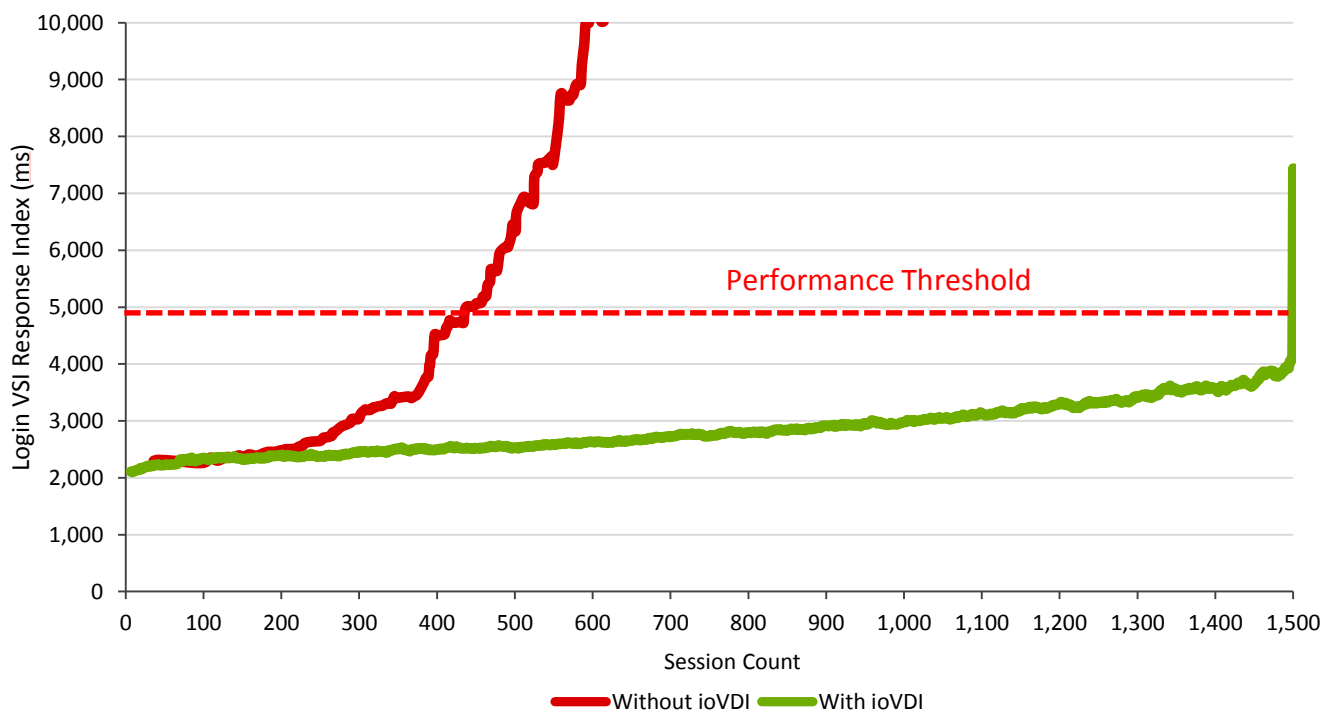*Figure 3. Design Example for a 1,500 Desktop Block*
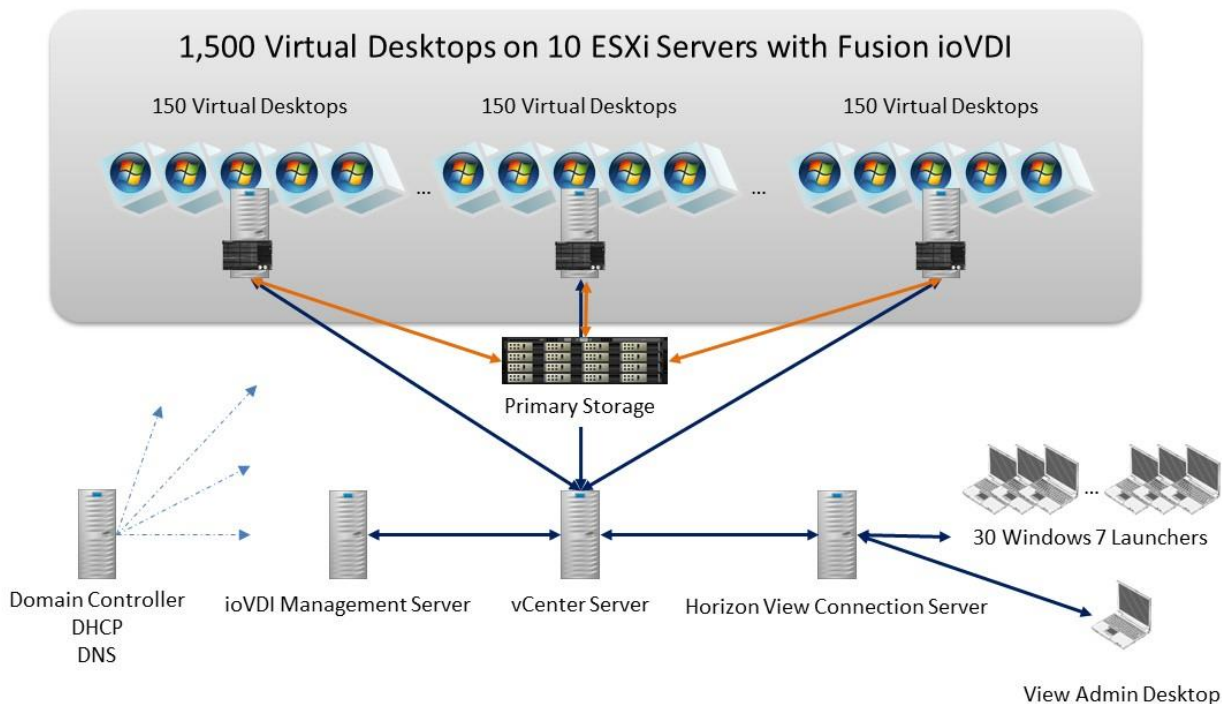
Benchmarking with Login VSI and results

In this section of the report, ESG Lab will present performance results that compare a virtual desktop environment with and without the Fusion ioVDI product. Testing was designed to highlight the performance improvements that organizations could expect with ioVDI, including a higher number of supported desktops, faster boot times, offloading of VDI read and write operations to server-based flash, improved resource utilization, and an overall more predictable and consistent performance experience.

ESG Lab used the industry-standard VDI benchmarking tool Login VSI, which validates application performance and response times for various predefined VDI workloads with an ultimate goal of showing desktop density potential for a given set of hardware and software components. Final results are presented using easily understandable Login VSI metrics that represent the number of concurrent sessions running when the VDI environment reaches a saturation point.

The first phase of testing simulated the activity of an increasing number of initiated remote desktop sessions with a goal of understanding the maximum number of supported full clone desktop sessions supportable by the tested storage infrastructure. Login VSI reported two metrics, the VSI Index Average and the VSImax v4 total. The VSI Index Average serves as an average response time measurement, but leverages built-in rules to help factor in spikes while not offsetting the overall average. VSImax4 shows the amount of concurrent sessions that can be active before the infrastructure is saturated. The VSImax v4 calculation is primarily used to provide insight into the potential scalability that an environment can sustain while meeting acceptable performance requirements. The results with and without the ioVDI platform are shown in Figure 4. The two lines represent the increasing Login VSI Response Index, while the VSImax of each line is the point at which the VSI Response Index crosses the performance threshold. Login VSI calculates VSI Response Index by aggregating the response times of all workload operations and applying their weights to eliminate spikes.[2]

Figure 4. Maximum Number of Concurrent Full Clone Sessions–VSI Index Average and VSImax v4


What the Numbers Mean

- The configuration that did not leverage ioVDI reached a VSImax of 420 active remote desktop sessions before reaching system saturation.
- When leveraging ioVDI technology, the environment was able to sustain 1,500 concurrent remote desktop sessions—a 3.5x improvement over the scenario without ioVDI.
- With ioVDI, the VSI Index Average score remained manageably low as the number of remote desktop sessions increased until the VSImax score was reached.

After understanding the maximum number of concurrent full clone RDP sessions that were supported with and without ioVDI technology, ESG Lab ran the same tests with VMware Horizon View linked clones. Full clones represent an independent copy of a VM that shares nothing with the parent VM after the cloning operation. Ongoing operation of a full clone is entirely separate from the parent VM. Linked clones represent a copy of a VM that shares virtual disks with the parent VM in an ongoing manner. This conserves disk space, and allows multiple VMs to use the same software installation.

Figure 5 shows the VSImax scores of full cloned RDP sessions, as well as Horizon View linked clones. For sessions that used full clones, the maximum achievable number without ioVDI technology was 420, while the results increased by 3.5x up to 1,500 supported virtual desktops with ioVDI. For linked clones with VMware Horizon View, the maximum supported number of virtual desktops without ioVDI was 223, with ioVDI, the maximum achieved was 1,004, a 4.5x improvement.

Figure 5. VSImax Scores with Full Clones and Linked Clones
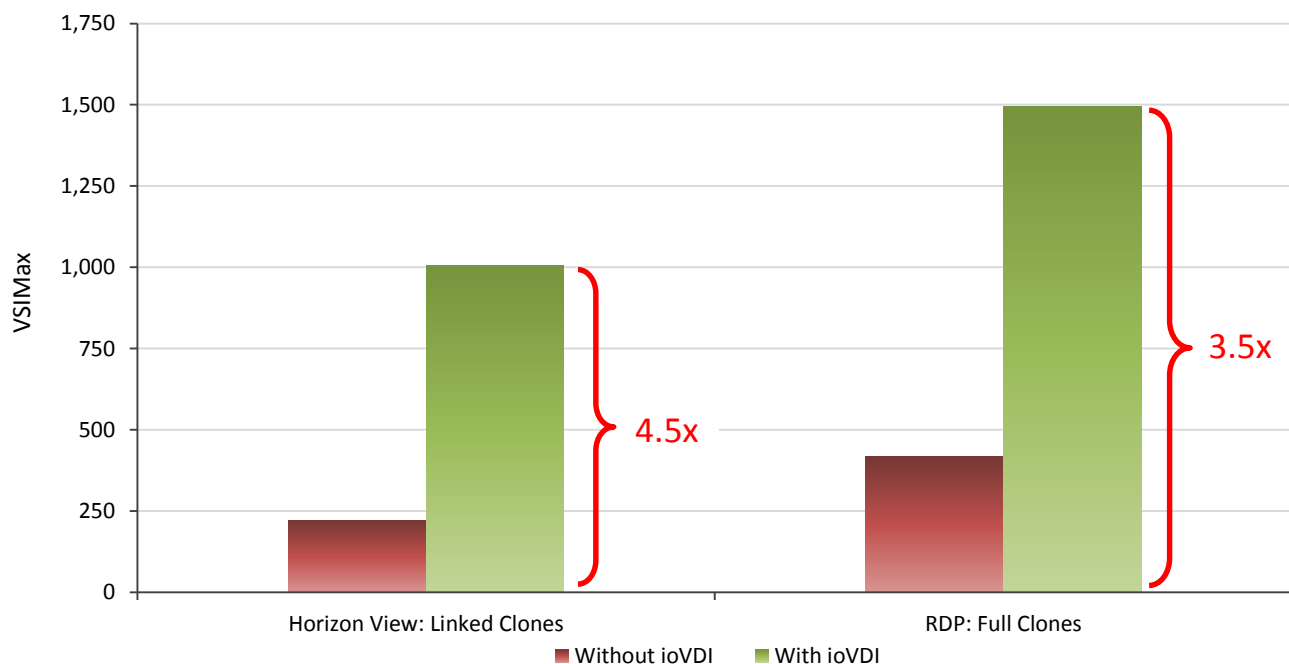
It's important to note that although linked clones saw a greater improvement with ioVDI, VSImax is lower in general for linked clones. Linked clones inherently present a greater performance challenge when compared to full clones. In exchange for the capacity efficiency of linked clones, significant metadata lookup overhead is incurred because the VM disks go through multiple levels of redirection.

Table 3. Maxmum Number of Concurrent Sessions

	Without ioVDI	With ioVDI
	VSImax	VSImax
Linked Clones	223	1,004
Full Clones	420	1,500

For the next phase of testing, ESG Lab focused on boot storms and measured the time required to power on 1,000 virtual desktops. Network and storage resource utilization was also monitored with a goal of understanding the benefits that can be achieved when leveraging ioVDI technology. A boot storm occurs when a large number of users boot up their virtual desktops in a similar time frame. The result is a potential degradation of performance due to the overwhelming number of network and data requests, leading to slow or unresponsive virtual desktop instances.

Table 4. Power on and Reboot Definitions

	Event Start	Event Stop
Power on	Windows bootup time (*wmic os get lastbootuptime*)	VMware tools running
Reboot	VMware tools stopped	VMware tools running

Figure 6 shows the average time (in seconds) that was required to power on each VM. An average boot time of three minutes and 45 seconds was measured without ioVDI. When leveraging ioVDI technology, each VM instance only needed an average of 25 seconds to boot, a 10x improvement over the environment without ioVDI. For the purposes of these tests, ESG Lab defined power on and reboot as described in Table 4.

Figure 6 shows the relative boot times for the environment while starting up 1,000 desktops, with and without ioVDI acceleration.

Figure 6. Boot storm Performance Analysis – Time to Power On for 1,000 Desktops
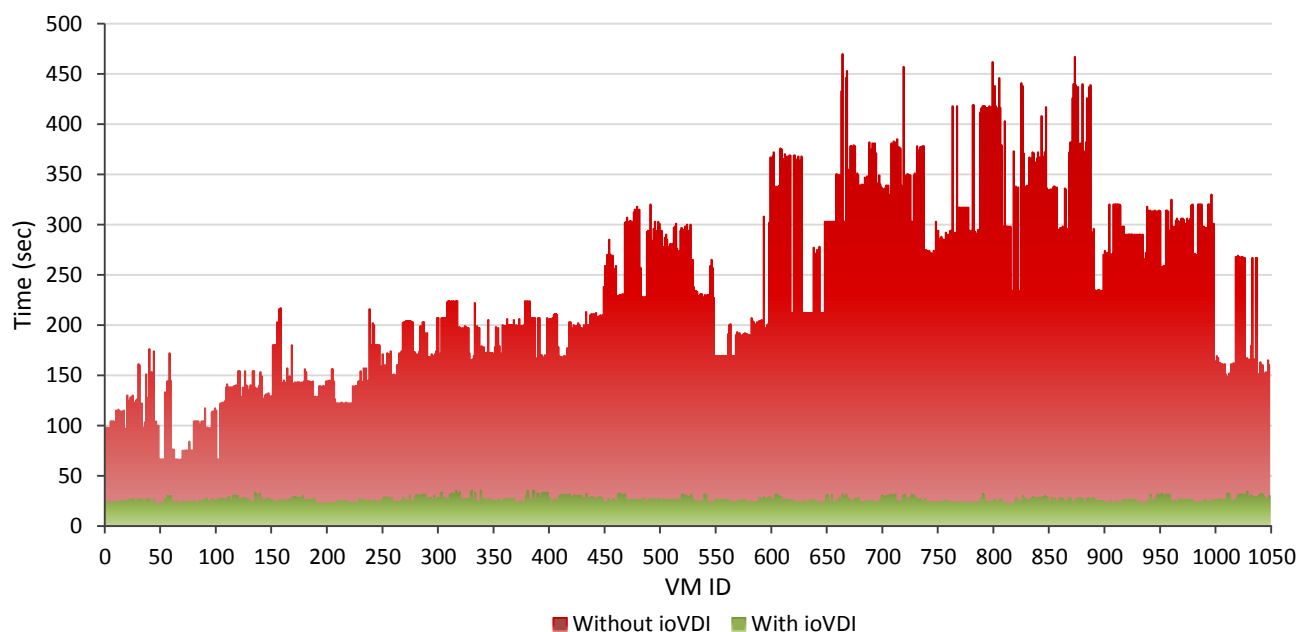
During the power-on analysis, ESG Lab measured the amount of networking read bandwidth that each test case consumed because the virtual desktop power on workload is much more read intensive. The results are shown in Figure 7. Without ioVDI, network bandwidth consumption averaged approximately 109MB/sec, while ioVDI required just 41MB/sec to deliver all 1,000 virtual desktop instances, a 2.5x reduction in network read throughput. This resulted in a power-on VDI workload that was not only more predictable with less variance, but also consumed significantly less network bandwidth.

**Figure 7. Network Traffic Read Throughput Analysis During Power On of 1,000 Desktops**
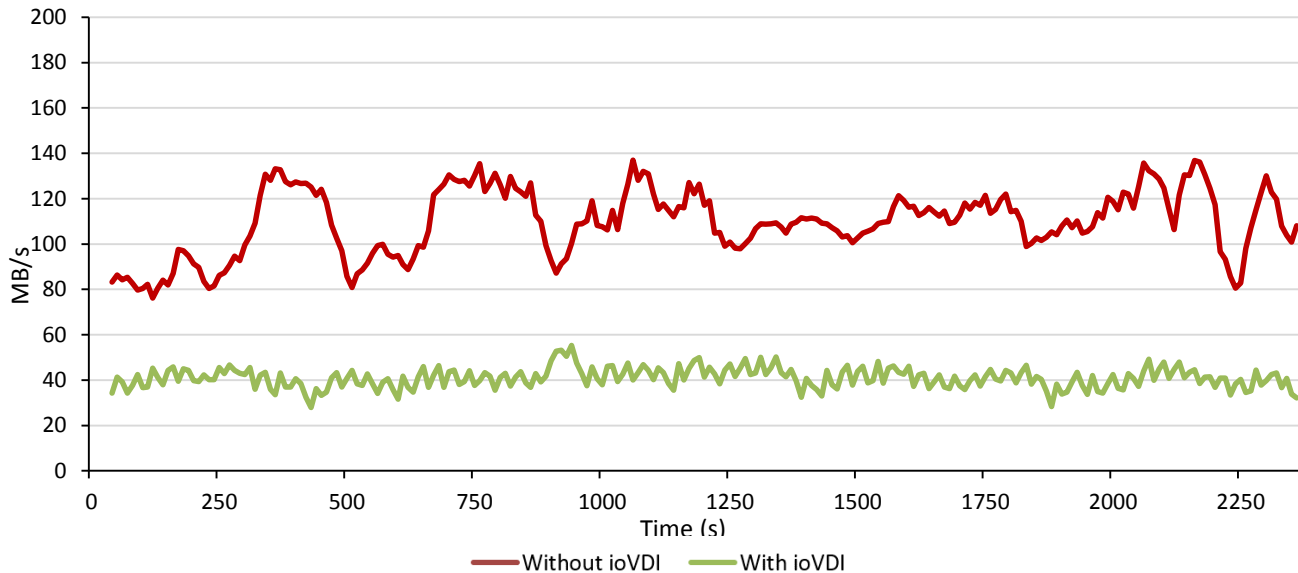
After analyzing VDI performance during power on from a networking standpoint, ESG Lab next focused on performance of the SAN from a disk utilization standpoint. The results are shown in Figure 8. As the virtual desktops were powered on, the scenario that did not utilize ioVDI quickly approached the 100% disk utilization threshold and the underlying storage system served as a bottleneck. In the scenario that utilized ioVDI, disk utilization averaged just over 50%.

**Figure 8. Disk Utilization Analysis During Power On**
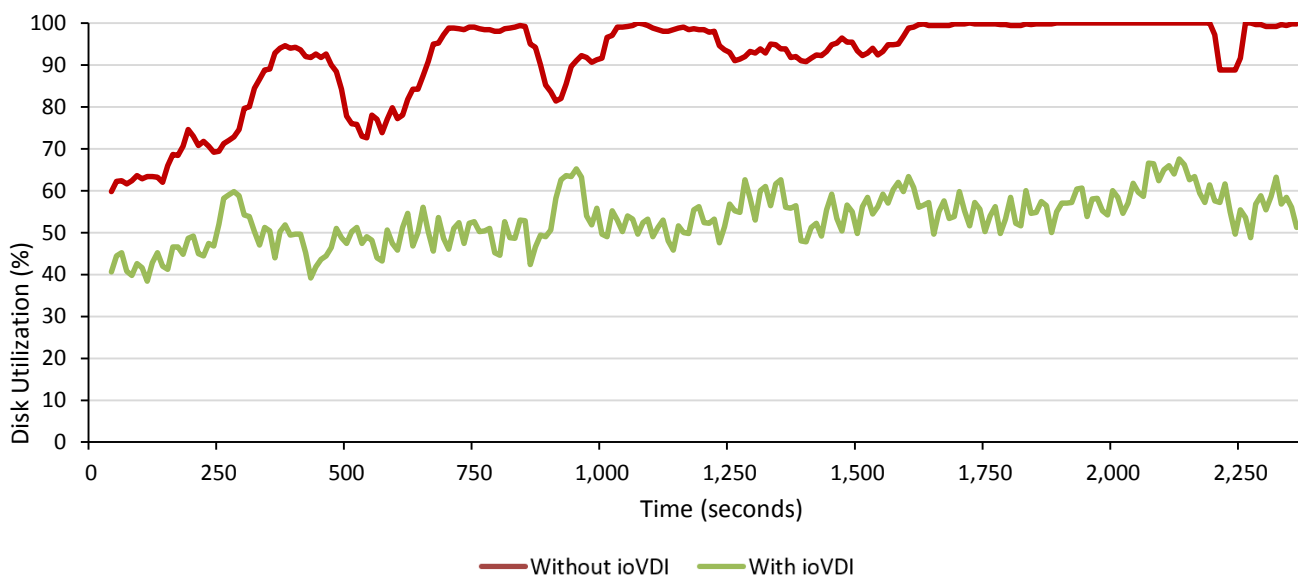
After measuring performance during boot storms, ESG Lab shifted focus to a VDI steady state workload. VDI steady state represents what an environment looks like after all the virtual desktops have been booted and users have logged into their systems. Again, ESG Lab compared two scenarios: with and without ioVDI technology. The steady state performance was measured with an increasing number of virtual desktops until a VSImax score was reached, in which virtual desktop sessions began to log off. The VSImax scores for the two test scenarios were discussed earlier in this section of the report. The number of supported virtual desktops without ioVDI was 420, and with ioVDI the number was 1,500. The results are shown in Figure 9. I/O Reduction: SAN/NAS offload enables support for 3.5x the number of desktops with much lower back-end storage traffic.

Figure 9. Network Traffic Read Throughput Analysis During Steady State
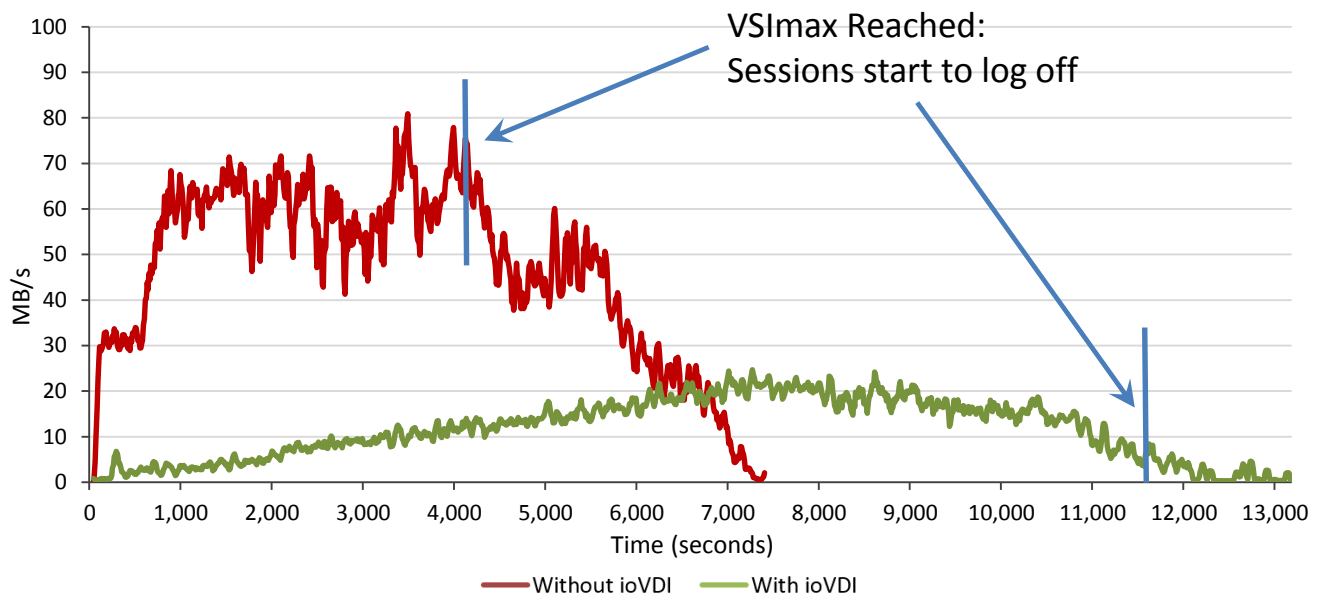
ESG Lab also looked at total megabytes read from disk in the steady state scenario, as seen in Figure 10.

Figure 10. Total MB Read from Disk during VSImax Test
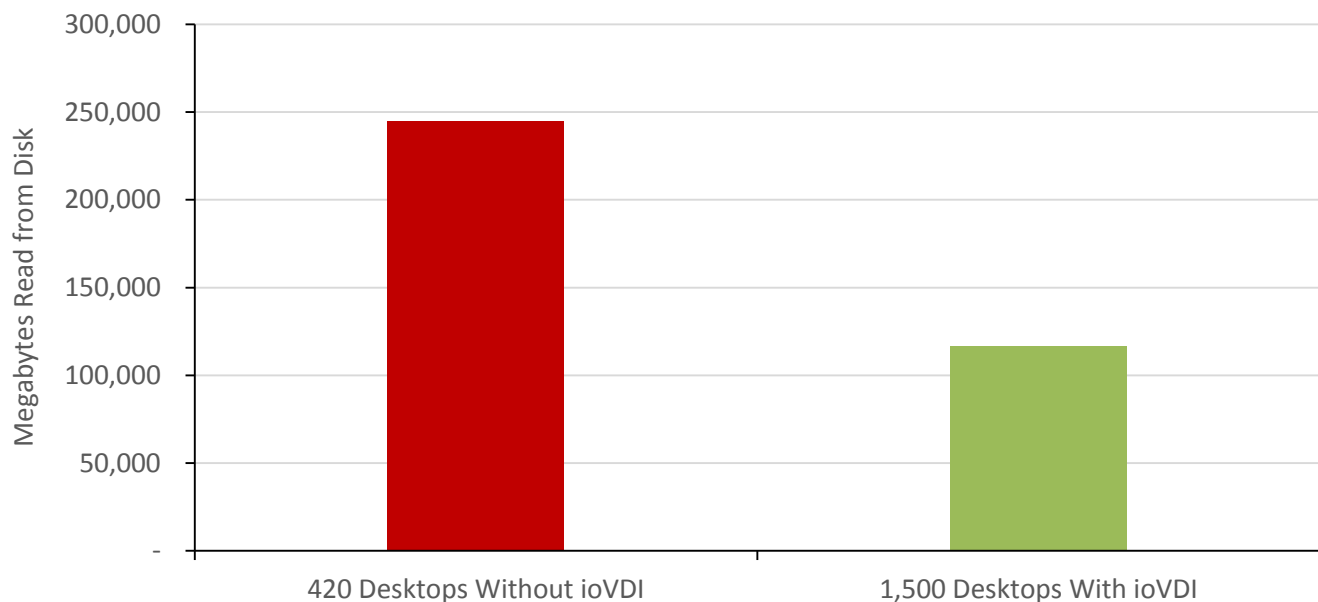
What the Numbers Mean

- The disk-only full clone configuration was able to support up to 420 desktops before exceeding the response time threshold calculated by Login VSI, while the same configuration—accelerated by ioVDI—was able to support 1,500 virtual desktops, 3.5x as many.
- ioVDI was able to provide similar acceleration for both full clones and linked clones.
- The configuration that did not leverage ioVDI started out consuming around 35 MB/s and quickly increased to average about 60-70 MB/s as the number of active steady state virtual desktops increased to a maximum of 420 active sessions.
- When leveraging ioVDI technology, the environment consumed no more than around 20 MB/s with a peak of 31 MB/s when the VSImax of 1,500 concurrent sessions was reached.
- The minimum network read throughput for a steady state workload to support just 420 virtual desktops without ioVDI was the same as the maximum network read throughout required with ioVDI for 1,500 virtual desktop sessions.
- When compared with a scenario without ioVDI, ioVDI technology supported 3.5x more virtual desktop instances during steady state while utilizing 2.5x less network read bandwidth.
- ioVDI reduced boot times from an average of nearly four minutes to just 26 seconds on average, and provided consistent boot times throughout the power-on test.
- Examining the total Megabytes read from disk during both the power-on and VSImax tests revealed that ioVDI reduces primary storage traffic significantly even during initial boot up, when cache is not yet populated.

Why This Matters

This disk utilization analysis is a key takeaway from ESG Lab's analysis. By leveraging server-based flash, Fusion ioVDI technology can not only support a larger number of virtual desktops than a standard VDI deployment without ioVDI, but can also deliver 3.5x more desktops while utilizing less of the infrastructure's resources. This offloading of server, network, and storage workloads enables the newly available resources to handle other workloads common to IT infrastructures. By leveraging Fusion ioVDI technology with its server-based ioMemory flash, customers can realize more than just the benefits of accelerated performance. With ioVDI, VDI deployments can be much more cost-effective and can also sustain much higher levels of virtual desktop density and overall infrastructure efficiency, in a simple, scalable configuration.

Through hands-on testing and analysis, ESG Lab validated that Fusion ioVDI technology was able to support 3.5x more virtual desktop instances while consuming 2.5x less network read bandwidth, all while accelerating both initial power on and reboot times by 10x.

The Fusion-io Reference Architecture enabled granular scaling in 150-desktop increments with consistent, predictable performance. The high desktop density and storage offload reduces required power, cooling, and floor space while providing simplicity of deployment and operation.

Performance of desktops is not subject to negotiation. Users demand performance at the level of or better than physical machines, and Fusion ioVDI delivers.

The Bigger Truth

Delivering a good user experience is essential to the success of VDI deployments because users will not tolerate diminished performance. As a result, fast, predictable performance and scalability are critical concerns. Virtual desktop environments can hammer an infrastructure with random, shifting I/O; bottlenecks can occur in the storage domain that will have an impact on performance. To resolve this issue, organizations have become accustomed to deploying more shared storage, resulting in not only higher equipment costs, but also higher costs for storage management, data center floor space, and energy for power and cooling. Ironically, the cost savings that VDI offers can be significantly reduced or even eliminated in the effort to maintain expected performance.

ESG Lab tested an environment built to the specifications of the reference architecture in this report to validate the key claimed benefits of using ioVDI. ESG Lab observed:

- Up to 80% write and 97% read offload from primary storage.
- A 10x improvement in power-on and reboot times.
- Simple, cost-efficient, linear scaling in 150-desktop increments.
- The ability to leverage shared storage capacity with native data protection and capacity efficiency technologies.
- The ability to use a commodity 1GbE network to support a pod of 1,500 virtual desktops.
- Increased resource efficiency and a 3.5x improvement in VM density per server.

Fusion's ioVDI technology proved their ability to optimize performance using low-cost infrastructure. Write Vectoring significantly reduced writes to shared storage by directing Transient writes such as page file I/O, temporary files, and browser temp data to server flash, sending only desktop writes that must be retained, such as auto-saves and user profile updates, to shared storage where they gain the advantage of storage-side HA and data protection. Transparent File Sharing delivered inline, file-level deduplication of all desktop data hosted on the server, which accelerated boot time by 10x in the tested configuration. Dynamic Flash Reallocation optimized flash performance across desktops, which provided consistent, low response times during login, boot storms, virus protection storms, and variable user activity.

The Fusion ioVDI/VMware Horizon View Reference Architecture offers customers a blueprint for easily implementing virtual desktop deployments–persistent and stateless–using a minimum number of servers and storage systems. The ioVDI product delivers cost-effective, enterprise-class performance for any size deployment; it is easy to scale from 150 virtual desktops to thousands, without the expense and complexity of deploying masses of expensive storage and network infrastructure. The server-side approach ensures that most data is processed rapidly and efficiently in the server, minimizing latency as it travels across the network to storage. Data requirements for high availability, persistence, and protection are met with a minimum of expensive shared storage and network infrastructure, while performance is maximized during all activities, from boot storms to typical work activities. The result is cost-effective, high-performance VDI, even for small deployments, with linear scalability of performance and cost for large environments.