VMware Horizon 6 with App Volumes and Virtual SAN Reference Architecture

TECHNICAL WHITE PAPER

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Executive Summary

This paper describes a deployment that supports over 960 users—700 View linked-clone desktops and 260 RDSH desktop sessions—based on VMware Horizon® 6 Enterprise Edition, which includes VMware App Volumes™ and VMware Virtual SAN™.

It is intended to help IT architects, consultants, and administrators involved in the early phases of planning, design, and deployment by offering a standard, repeatable, and highly scalable design that can easily be adapted to specific environments and requirements.

The reference environment was subjected to rigorous performance benchmarking, workload simulation, and operations testing. Performance tests, including workload testing with VMware View Planner and View operations testing, were also performed on the hardware configuration. The results can be characterized as follows.

Outstanding Desktop Performance

- Performance similar to high-end physical computers
- Excellent user experience characteristics, even with diverse use cases and burst-heavy workloads
- Consistent, first-rate performance across different application delivery methods

Increased Desktop Consolidation

- Reduced CPU and memory usage with App Volumes
- Improved desktop consolidation ratio

Fast Desktop Operations

- User desktop pools provisioned quickly
- Rapid desktop maintenance
- Enterprise use cases up and running the same day as requested
- Dynamic application delivery

Ease of Maintenance

- Entire environment maintained end-to-end by one administrator
- Effortless storage provisioning and management with Virtual SAN
- Application delivery and patching with App Volumes

Less CPU usage than Traditional Apps	4% less average CPU usage for linked clones and 5% less for RDSH desktop sessions than with Traditional Apps
Less memory consumed than Traditional Apps	10% less average ESXi memory consumed with AppStacks than with Traditional Apps
Linked clones with AppStack	Passed View Planner medium workload test: 100 linked clones per ESXi
Linked clones with AppStack and ThinApp	Passed View Planner medium workload test: 100 linked clones per ESXi
View RDSH desktop sessions with AppStack	Passed View Planner medium workload test: 130 RDSH sessions per ESXi
Time to provision 700 linked clones on Virtual SAN	60 minutes
Time to refresh 700 linked clones on Virtual SAN	29 minutes
Time to recompose 700 linked clones on Virtual SAN	77 minutes
Virtual SAN node failure	2 minutes to restore desktop session

Figure 1: Highlights

Introduction

Horizon 6 enables the delivery of virtualized or remote desktops and applications through a single virtual desktop infrastructure (VDI) platform, providing end users with access to all their desktops and applications through a single, unified workspace. Horizon provides

• Application remoting, based on Microsoft Remote Desktop Session Host (RDSH) technology

• Real-time application delivery and lifecycle management with App Volumes

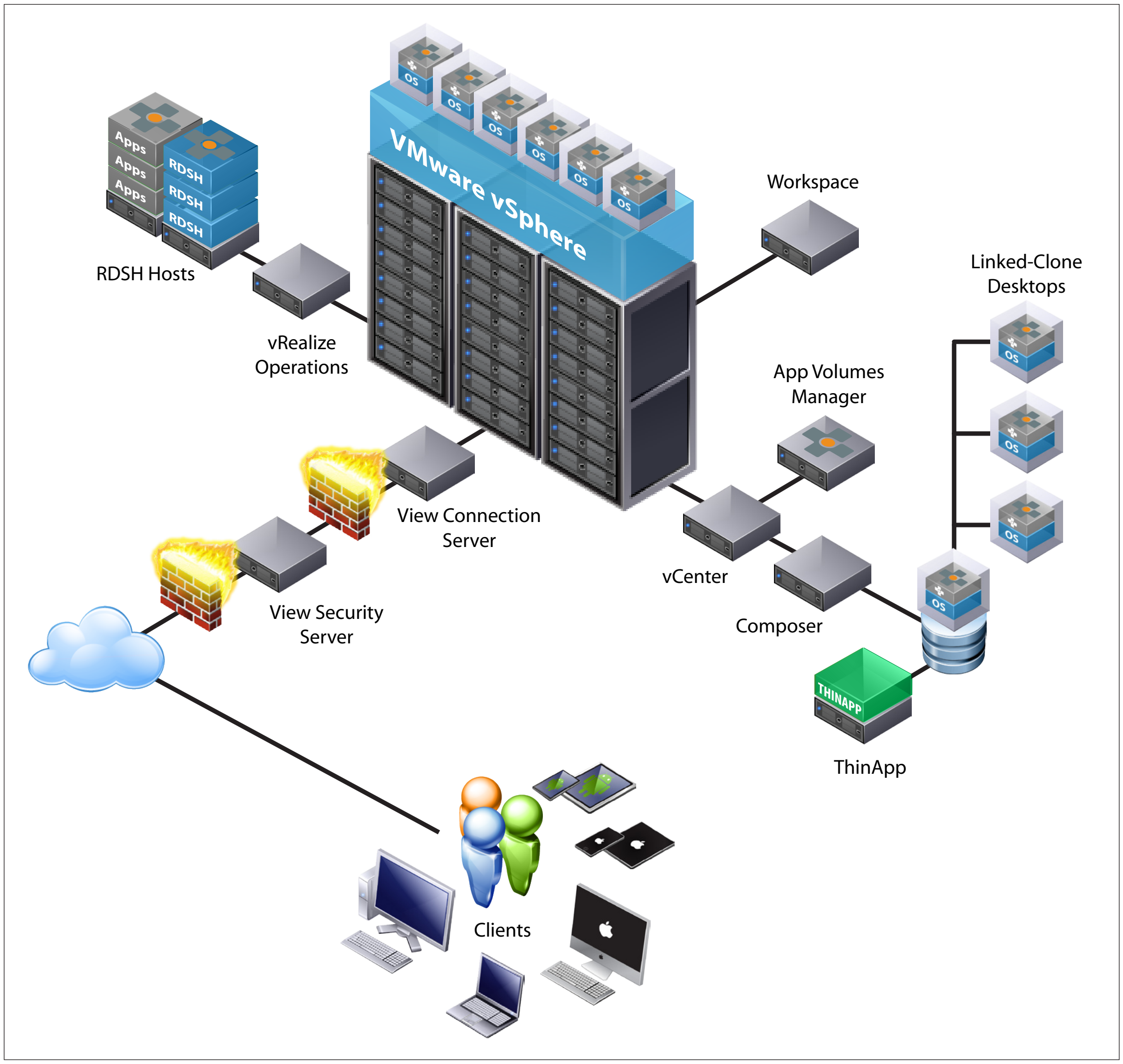


Figure 2: Horizon 6 System Components

Hardware Components

The desktop virtualization solution described here combines data center, virtualization, and network technologies, using Dell R720 rack mount servers, with local solid state drives (SSD) and hard disk drives (HDD) running on the VMware vSphere® 5.5 software suite for Virtual SAN desktop workloads. Dell R720 servers were also used for RDSH desktop workloads and management workloads.

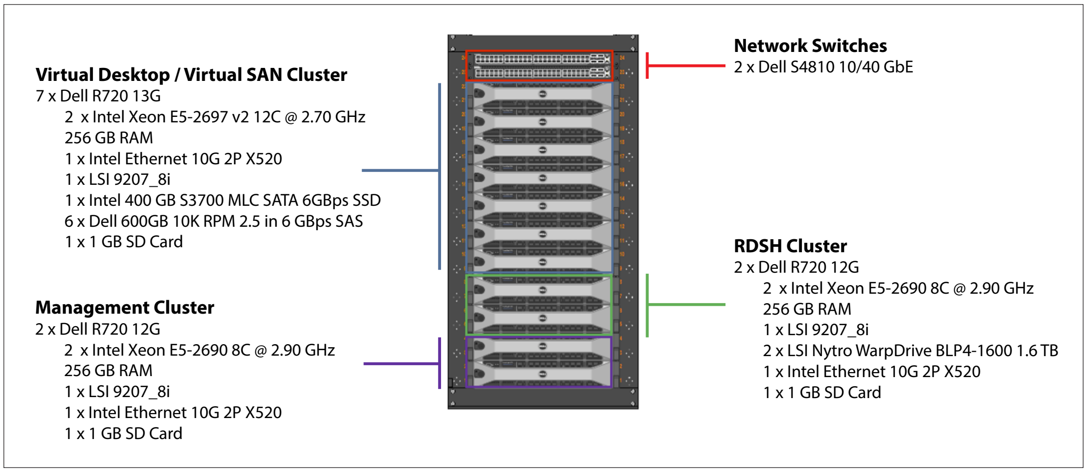


Figure 3: Hardware Components

Software Components

The software components and sub-components of this reference architecture are described in the following sections.

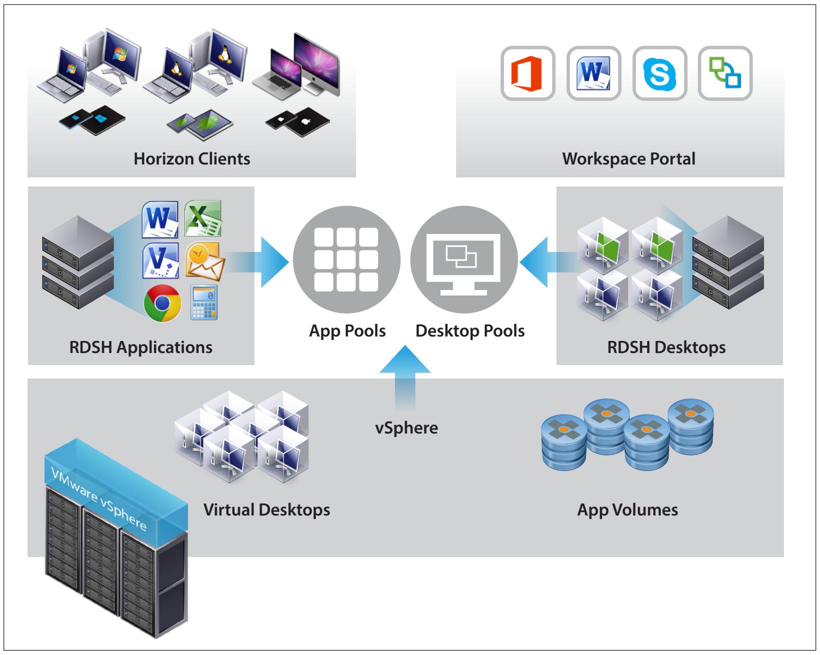


Figure 4: Software Components

VMware vSphere

vSphere is a virtualization platform for building cloud infrastructures. It separates applications and operating systems from the underlying hardware so that existing applications see dedicated resources, but servers can be managed as a pool of resources.

VMware Horizon 6

Horizon 6 delivers hosted virtual desktops and applications to end users through a single platform. Desktop and application services—including RDSH applications, applications packaged with VMware ThinApp®, software-as-a-service (SaaS) applications, and virtualized applications from Citrix—can all be accessed from a unified workspace across devices, locations, media, and connections.

VMware Virtual SAN

Virtual SAN is a hypervisor-converged, software-defined storage platform that is fully integrated with vSphere.

Virtual SAN uses a hybrid disk architecture, with flash-based devices for performance and magnetic disks for capacity and persistent data storage. Its distributed datastore is an object-store file system that uses the vSphere Storage Policy-Based Management (SPBM) feature to deliver centrally managed, application-centric storage services and capabilities. Administrators can specify storage attributes, such as capacity, performance, and availability, as a policy on a per-virtual machine basis. The policies dynamically self-tune and load-balance the system so that each virtual machine has the right level of resources.

Virtual SAN provides the ability to scale linearly, with each host capable of supporting approximately 100 users. This reference architecture ran 700 desktops on a Virtual SAN cluster with seven VMware ESXi™ hosts. VMware testing, however, has shown that View with Virtual SAN can scale up to 2,000 desktops on 20 ESXi hosts in a single cluster in vSphere 5.5.

VMware Workspace Portal

Horizon 6 allows users to access desktops and applications through VMware Workspace™ Portal. Workspace Portal also provides IT a central place to entitle and deliver Windows applications, desktops, SaaS applications, ThinApp packaged applications, and XenApp applications.

Workspace Portal provides a single pane of glass that gives users convenient access to their applications and desktops, regardless of type. Applications can be made available by default, and users can see and rearrange the applications for which they have been granted entitlements.

VMware vRealize Operations for Horizon

VMware vRealize™ Operations for Horizon is a monitoring solution that extends the capability of VMware vRealize Operations Manager™ to troubleshoot, monitor, and manage the health, capacity, and performance of View environments.

With advanced analytics, vRealize Operations for Horizon has the ability to learn normal operating parameters for infrastructure and user workloads. It offers proactive warnings and alerts based on dynamic thresholds (rather than hard thresholds) that adapt to each environment, and can send advance notifications before events affect end users.

VMware App Volumes

App Volumes provides real-time application delivery to end users and desktops. IT can use App Volumes to deliver applications and data to users without compromising the user experience.

Modular Pod and Block Design

This Horizon 6 reference architecture is based on the proven approach of scalable, modular pod and block design principles.

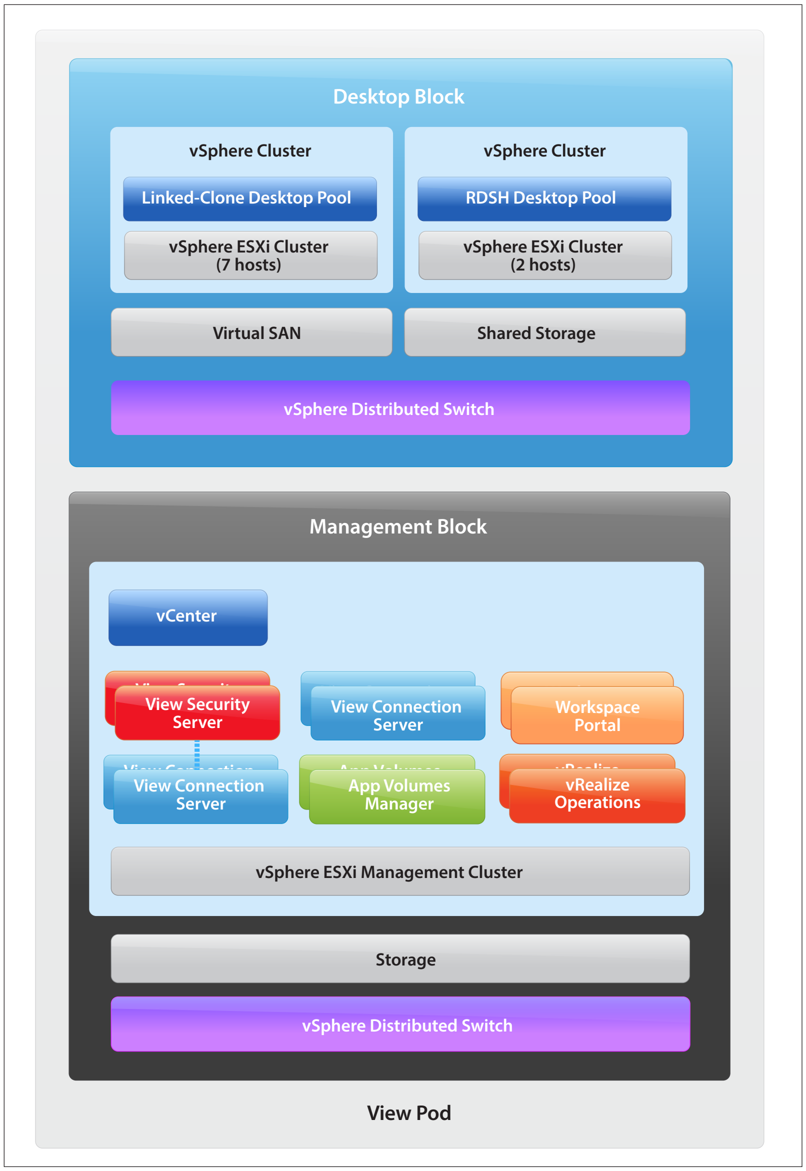


Figure 5: View Pod and Block

A View pod is a logical administrative entity that can support up to 10,000 users or sessions. That limit can be increased to 20,000 users or sessions with the use of two to four pods. In this reference architecture, the pod supported 960 users or sessions, consisting of 700 linked-clone virtual desktops and 260 RDSH sessions.

Each pod contains a *management* block and one or more *desktop* blocks. View, App Volumes, and Workspace Portal server workloads were placed in the management block of a Horizon 6 pod. Desktop workloads were placed in the desktop block. The use of distinct clusters and ESXi hosts kept the desktop and RDSH server workloads separated.

Management Block Design

The management block contained all the View server virtual machines. In customer production deployments, one VMware vCenter Server™ is typically deployed for every 2,000 virtual desktops. Although View can support up to 10,000 desktop virtual machines in a single VMware vCenter™ instance, a limit of 2,000 desktops improves power and provisioning operation times.

Each View Connection Server supports a maximum of 2,000 concurrent sessions. An additional View Connection Server is typically deployed for redundancy. Two additional View Connection Servers are paired with View security servers to provide secure, redundant external access to View desktops. Each security server can also handle up to 2,000 connections.

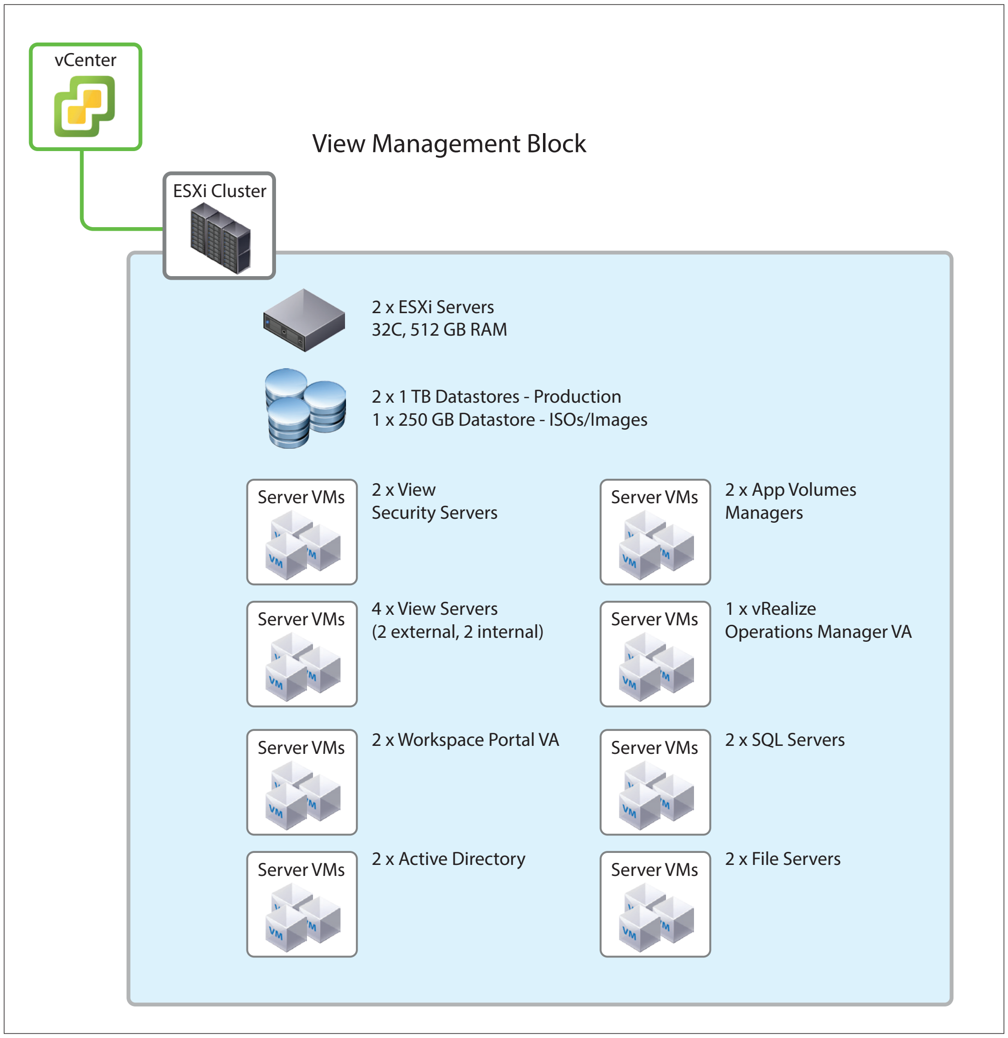


Figure 6: View Management Block

- A single Workspace vApp can scale to as many as 30,000 users. To provide redundancy, it is sufficient to deploy a single instance and add virtual appliances for each component.
- A single vRealize Operations Manager vApp can handle up to 10,000 virtual desktops.
- An App Volumes Manager server can handle 10,000 user-to-AppStack sessions at a time. Additional App Volumes managers can be added for load balancing and redundancy.
- A clustered SQL Server is capable of supporting the database requirements of all the core management block services.

Desktop Block Design

In a standard View reference architecture design, a desktop block, supported by a dedicated vCenter instance, supports up to 2,000 concurrent sessions. Multiple desktop blocks within a pod can support up to 10,000 concurrent sessions.

In this reference architecture, the desktop block contained two vSphere clusters to isolate the differentiated workloads of hosted virtual desktop instances from the RDSH server instances:

- A seven-node ESXi cluster with a Virtual SAN volume supporting 700 linked-clone virtual desktops
- A two-node vSphere cluster supporting 260 RDSH sessions

Shared storage allows RDSH servers to recover quickly and run on another host in the cluster in the event of a hardware fault on an ESXi host. The virtual desktops are floating desktops, so a user can quickly resume desktop connectivity on another virtual desktop on a different ESXi host.

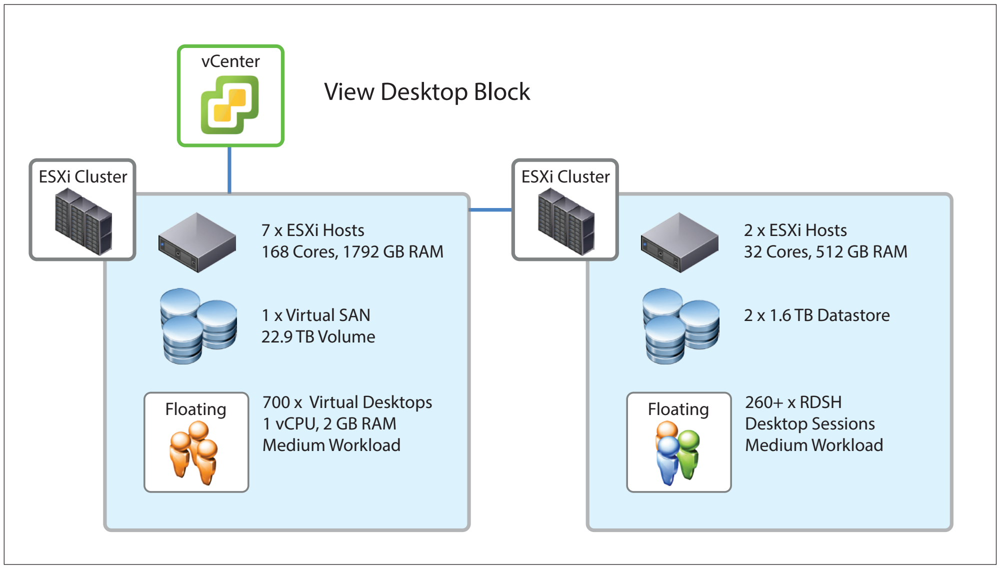


Figure 7: View Desktop Block

Testing and Results

The tools, tests, and configurations used in this reference architecture are described in the following sections.

Workload Testing Tool

VMware View Planner 3.5 was used to generate a synthetic workload for the 260 RDSH sessions and 700 virtual desktops. View Planner simulates application workloads for various user types by running applications typically used in a Windows desktop environment. During the execution of a workload, applications are randomly called to perform common user operations.

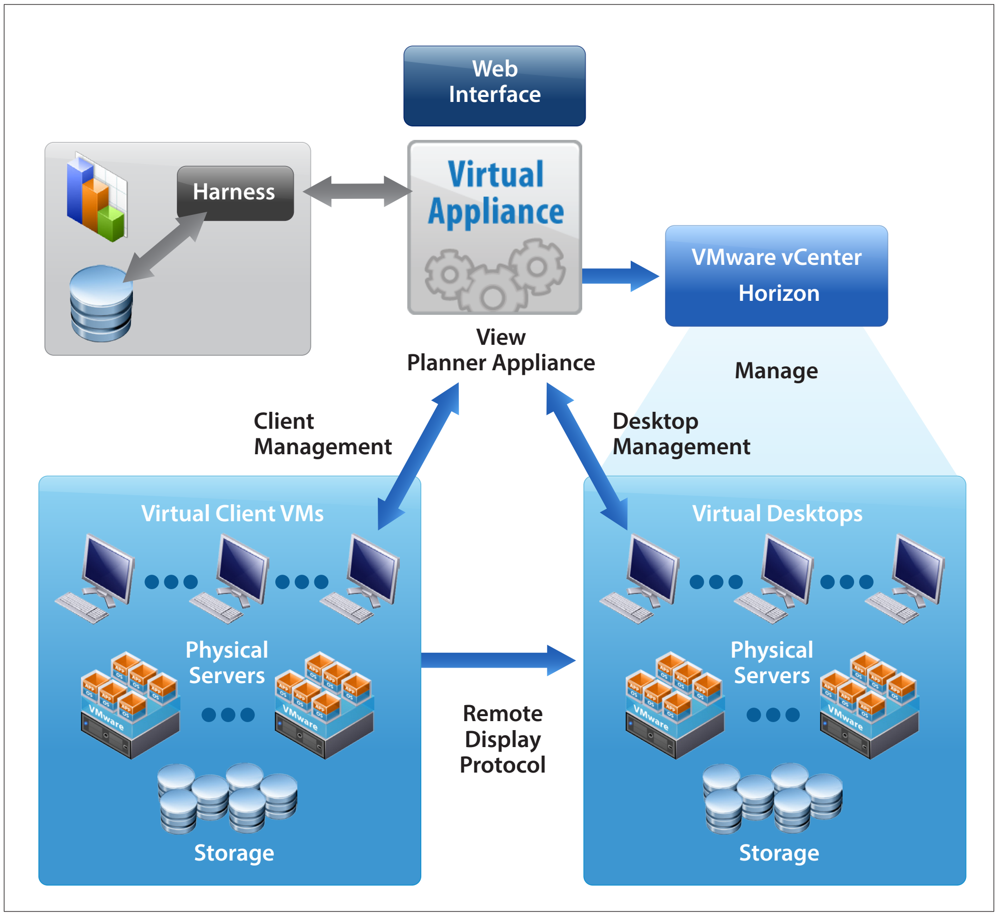


Figure 8: View Planner 3.5 Architecture

View Planner Operations

The View Planner workload consisted of seven applications, performing a total of 35 user operations. These user operations were separated into three groups: interactive operations (Group A); I/O operations (Group B); and background load operations (Group C). The operations in Group A were used to determine quality of service (QoS). The operations in Group C were used to generate additional load. The same workload was applied to the RDSH sessions and the virtual desktop sessions.

GROUP A – INTERACTIVE OPERATIONS	GROUP B – I/O OPERATIONS	GROUP C – BACKGROUND LOAD OPERATIONS
AdobeReader: Browse	AdobeReader: Open	7zip: Compress
AdobeReader: Close	Excel_Sort: Open	PowerPoint: SaveAs
AdobeReader: Maximize	Excel_Sort: Save	Video: Play
AdobeReader: Minimize	Firefox: Open	
Excel_Sort: Close	IE_ApacheDoc: Open	
Excel_Sort: Compute	IE_WebAlbum: Open	
Excel_Sort: Entry	PowerPoint: Open	
Excel_Sort: Maximize	Video: Open	
Excel_Sort: Minimize	Word: Open	
Firefox: Close	Word: Save	
IE_ApacheDoc: Browse		
IE_ApacheDoc: Close		
IE_WebAlbum: Browse		
IE_WebAlbum: Close		
PowerPoint: AppendSlides		
PowerPoint: Close		
PowerPoint: Maximize		
PowerPoint: ModifySlides		
PowerPoint: RunSlideShow		
Video: Close		
Word: Close		
Word: Maximize		
Word: Minimize		
Word: Modify		

Table 1: View Planner 3.5 Test Operations

View Planner Run Phases

View Planner performed a total of five iterations in test runs:

- Ramp up (first iteration)
- Steady state (second, third, and fourth iterations)
- Ramp down (fifth iteration)

During each iteration, View Planner reported the latencies for each operation performed in each virtual machine.

View Planner Quality of Service

QoS was determined separately for Group A and Group B user operations, with default thresholds of 1 second for Group A and 6 seconds for Group B and 95 percent of operations required to complete within the respective thresholds.

Linked-Clone Virtual Desktops on Virtual SAN

User operation workload testing was carried out on 700 linked-clone floating desktops running on Virtual SAN.

Workload Testing – Test Cases

Three pools of 700 virtual desktops underwent View Planner 3.5 workload testing. Each pool was based on a different image and used a different application deployment model. The virtual desktop images and application deployment models are described below and illustrated in Figure 9.

- **Traditional Desktop** – Windows 7 SP1 (32-bit) with test applications and View Planner agent installed on the desktop image (Traditional Apps)
- **Desktop with AppStack** – Windows 7 SP1 (32-bit) with test applications and View Planner agent installed in an AppStack, and App Volumes Agent in the Guest OS
- **Desktop with AppStack and ThinApp** – Windows 7 SP1 (32-bit) with Microsoft Office 2010 installed on the desktop image and ThinApp (Adobe Acrobat and Firefox) and View Planner agent installed in an AppStack, with App Volumes Agent installed in the Guest OS

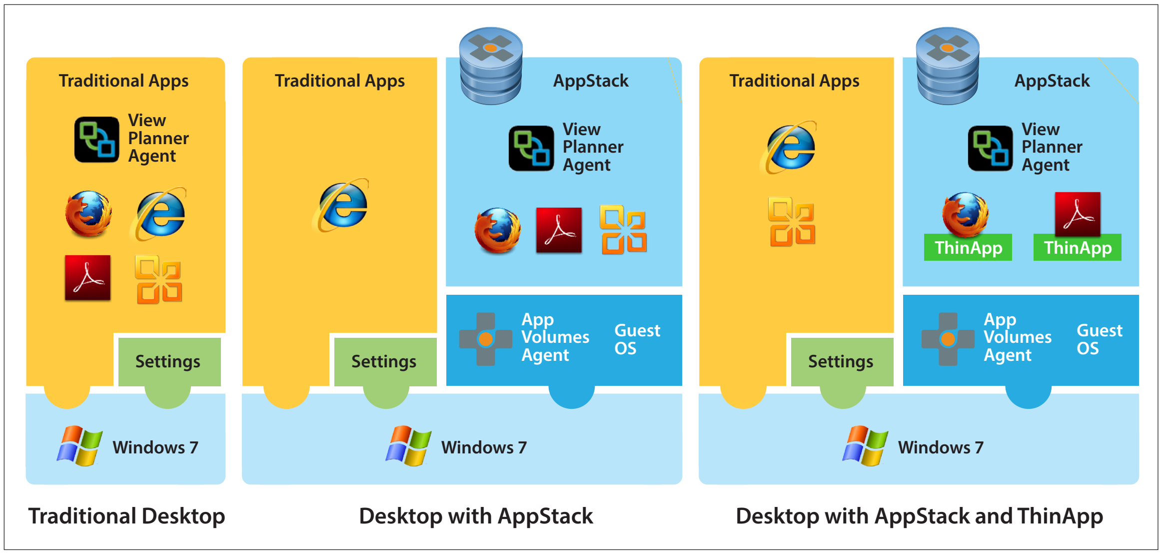


Figure 9: Linked-Clone Test Pools

ATTRIBUTE	TRADITIONAL DESKTOP	DESKTOP WITH APPSTACK	DESKTOP WITH APPSTACK AND THINAPP
Desktop OS	Windows 7 Enterprise Edition SP1 (32-bit)	Windows 7 Enterprise Edition SP1 (32-bit)	Windows 7 Enterprise Edition SP1 (32-bit)
VM hardware	v9	v9	v9
CPU	1	1	1
Memory	2048 MB	2048 MB	2048 MB
Memory reserved	0 MB	0 MB	0 MB
Video RAM	35 MB	35 MB	35 MB
3D graphics	Off	Off	Off
NICs	1	1	1
Virtual network adapter	VMXNet3 adapter	VMXNet3 adapter	VMXNet3 adapter
Virtual SCSI controller 0	Paravirtual	Paravirtual	Paravirtual
Virtual disk – VMDK 1	24 GB (OS C:\)	24 GB (OS C:\)	24 GB (OS C:\)
Virtual disk – VMDK 2	1 GB (View Planner Data E:\)	1 GB (View Planner Data E:\)	1 GB (View Planner Data E:\)
Virtual floppy drive	Removed	Removed	Removed
Virtual CD/DVD drive	Removed	Removed	Removed
Traditional apps	• Adobe Acrobat 10.1.4 • Firefox 7.01 • Internet Explorer 10 • Office 2010 SP2 • View Planner 3.5 agent	Internet Explorer 10	• Internet Explorer 10 • Office 2010
AppStack		1 (6.2 GB)	1 (1.4 GB)
AppStack applications		• Adobe Acrobat 10.1.4 • Firefox 7.01 • Office 2010 • View Planner 3.5 agent	• Adobe Acrobat 10.1.4 (ThinApp) • Firefox 7.01 (ThinApp) • View Planner 3.5 agent
App Volumes Agent		2.6.0 build 3106	2.6.0 – build 3106
VMware Tools™	9.4.11 – build 2400950	9.4.11 – build 2400950	9.4.11 – build 2400950
View Agent	6.0.2 – build 2331487	6.0.2 – build 2331487	6.0.2 – build 2331487

Table 2: Linked-Clone Test Pools – Configuration

Each image was optimized with the VMware OS Optimization tool in accordance with the Optimization Guide for Windows 7 and Windows 8 Virtual Desktops in Horizon with View and in conformity with the View Planner 3.5 test standards, which restrict the versions of applications to be tested.

Each desktop had a primary OS disk and a secondary 1 GB thick disk containing View Planner 3.5 data files. Each desktop was cloned from the same base OS image and had the same OS optimizations applied. A fourth clone was used as a clean desktop to provision the AppStacks.

Each AppStack was stored on the same Virtual SAN datastore as the test virtual desktops.

The AppStack named *W7-All* was provisioned to a template desktop with Adobe Reader, Firefox, Office, Office SP2, and View Planner. The size of the finished AppStack was 6283 MB. This AppStack was assigned to an AD user group for the *Desktop with AppStack* pool.

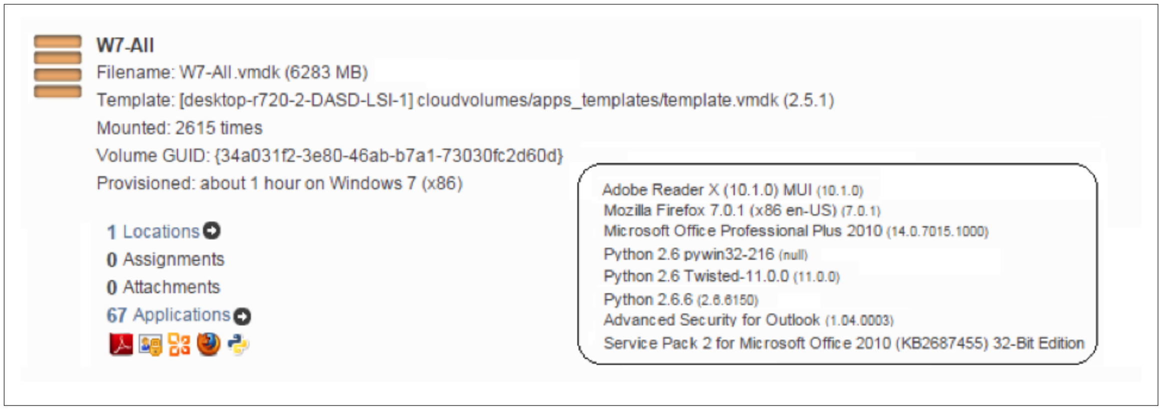


Figure 10: AppStack for Linked Clones

The AppStack named *W7-ThinappAppStack* was provisioned to a template desktop, and the Adobe Reader and Mozilla Firefox ThinApp packages were copied across and registered on the Win7 Guest OS with `Thinreg.exe`. View Planner agent was then installed in the AppStack. This AppStack was assigned to an AD user group for the *Desktop with AppStack and ThinApp* pool.

Figure 11: AppStack for RDSH Servers

View Planner 3.5 Test Results

Five iterations of View Planner medium workload were executed on each of the three desktop pools. During each iteration, the desktops executed the following operations to simulate 700 end users working on the desktop pool with 100 percent concurrency:

- Interactive (Group A)
- I/O operations (Group B)
- Background load (Group C)

Group A and B operations determine the QoS of the desktop and ensure a satisfactory end-user experience. The View Planner passing marks are: Group A < 1 second, Group B < 6 seconds.

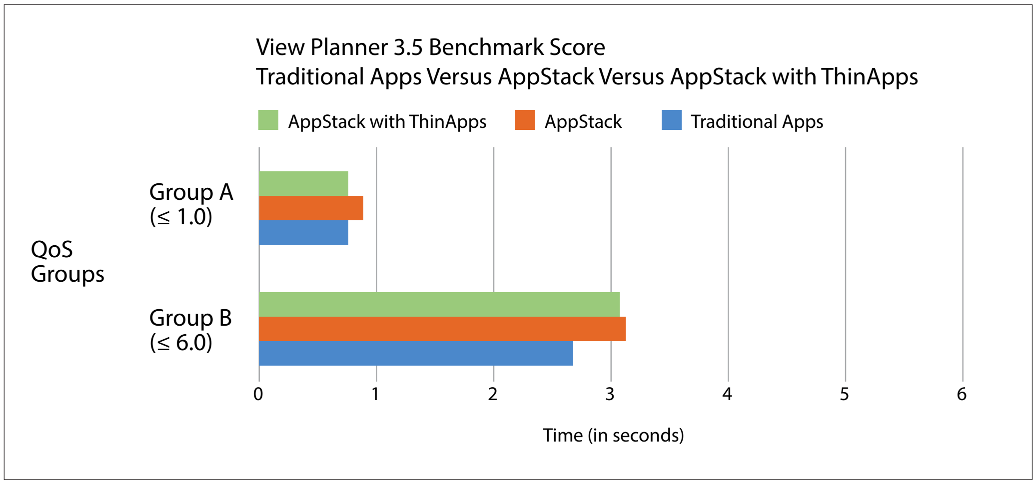


Figure 12: Linked-Clone Workload Test – View Planner Score Comparison

Each of the three pools met Group A and B requirements and passed the View Planner benchmark. AppStack and AppStack with ThinApp had some overhead, but it was light.

GROUP	POOL	TIME
Group A	Traditional	0.75 seconds
	AppStack with ThinApp	0.77 seconds
	AppStack	0.89 seconds
Group B	Traditional	2.66 seconds
	AppStack with ThinApp	3.08 seconds
	AppStack	3.11 seconds

Table 3: Linked-Clone Workload Test – View Planner Score Metrics

The most noticeable difference between the three test pools was in latencies for the AppStack with the ThinApp versions of Firefox and Adobe Reader. ThinApp Firefox and ThinApp Adobe Reader file open operations took 1–2 seconds longer to launch and open documents than the AppStack and Traditional Apps versions. The AppStack pool had slightly lower application latencies in eight of the twenty-five Group A operations (AdobeReader: Browse, AdobeReader: Maximize, AdobeReader: Minimize, Excel Sort: Minimize, PPT: AppendSlides, PPT: Close, PPT: Maximize, Word: Save). The Traditional Apps pool had lower latencies for all Group B operations, with differences on the order of hundredths and thousandths of a second.

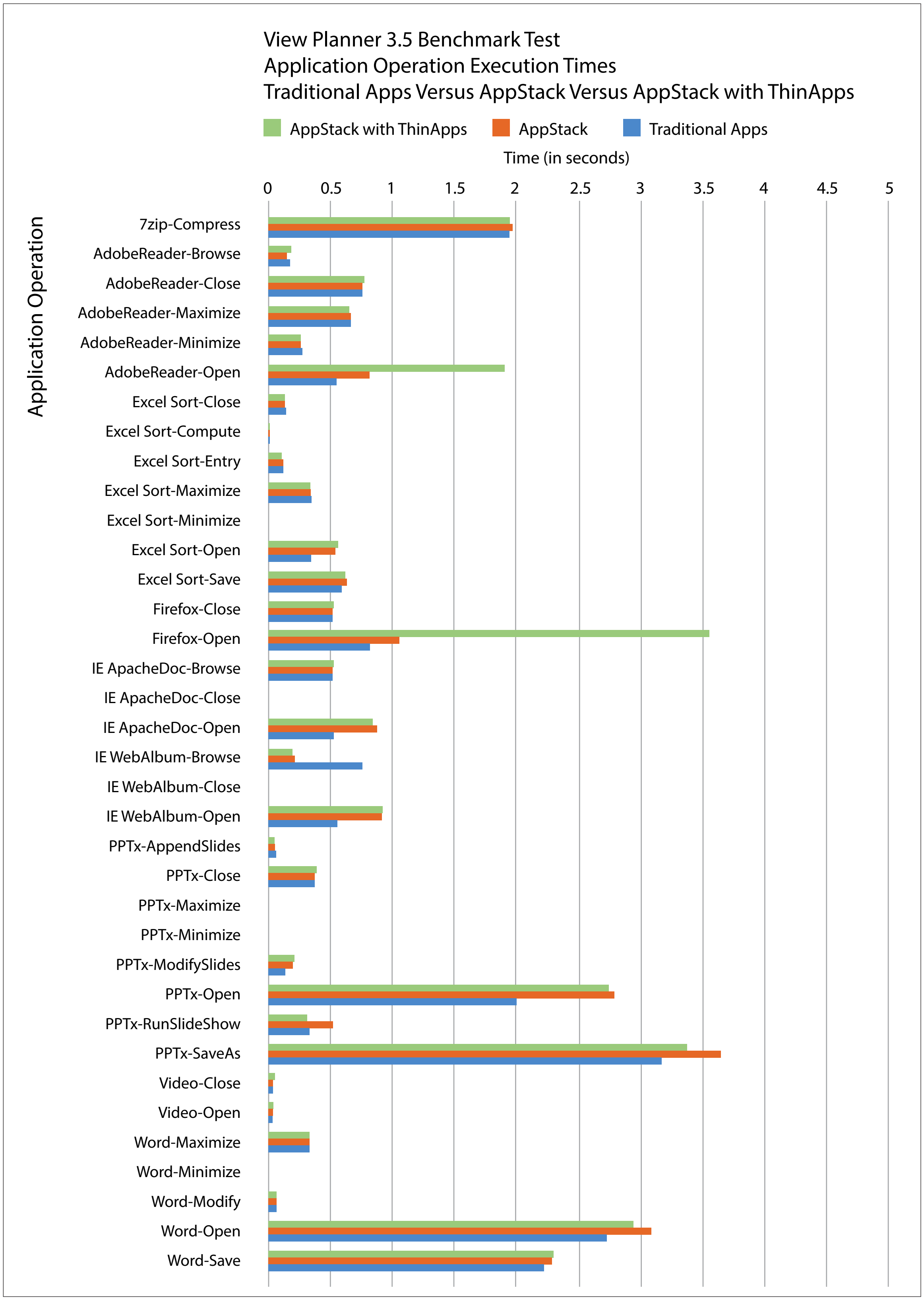


Figure 13: Linked-Clone Workload Test – View Planner Latency Comparison

Metrics were collected from the ESXi hosts in the Virtual SAN desktop cluster with a sample interval of 20 seconds. A comparison of the CPU usage for the clusters from each of the three View Planner workload test runs yields the following graph, showing average CPU usage per ESXi (approximately 100 virtual machines per host).

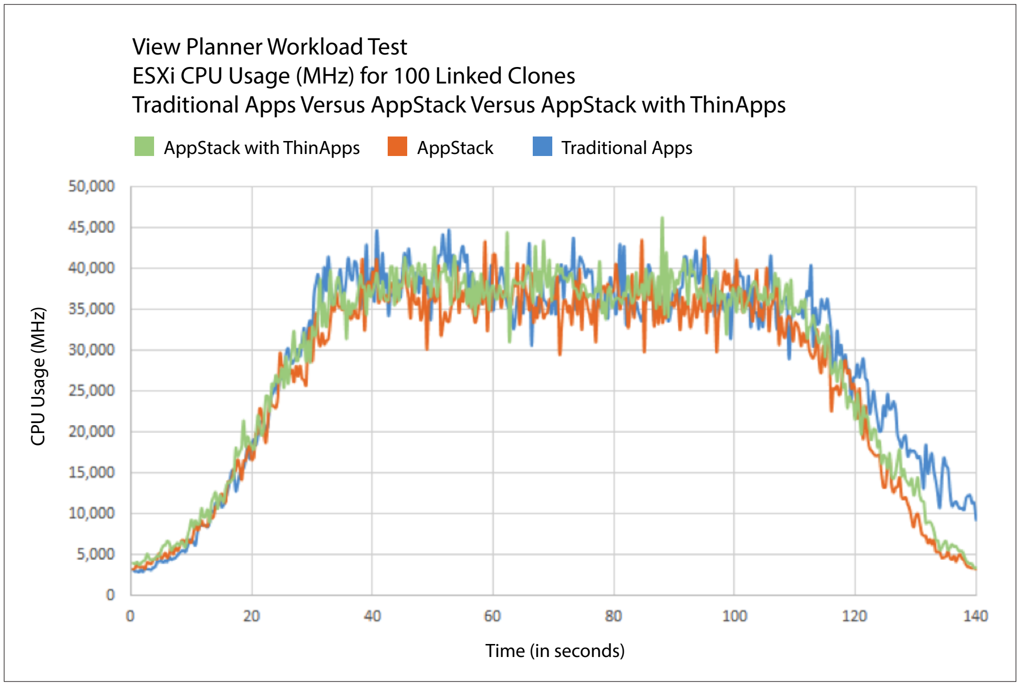


Figure 14: Linked-Clone Workload Test – ESXi CPU Usage (MHz) Comparison

Table 4 shows the average ESXi CPU usage for the three pools for the period from 40–100 minutes with the View Planner workload running concurrently on 700 desktops.

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average CPU Usage (MHz)	37,919	36,273	37,938
Maximum CPU Usage (MHz)	44,805	43,889	46,271

Table 4: Linked-Clone Workload Test – ESXi CPU Usage (MHz) Metrics

The AppStack Pool has 4 percent less average CPU usage and 2 percent less maximum CPU usage than Traditional Apps pool.

The memory consumed and active memory metrics are helpful for analyzing comparative memory usage on the ESXi host.

- Memory consumed is the amount of machine memory used on the host, including virtual machine memory, service console memory, and VMkernel memory.
- Active memory is the sum of the active guest physical memory of all powered-on virtual machines plus the memory used by basic VMkernel applications. Active memory is estimated by the VMkernel, based on the current workload on the hosts.

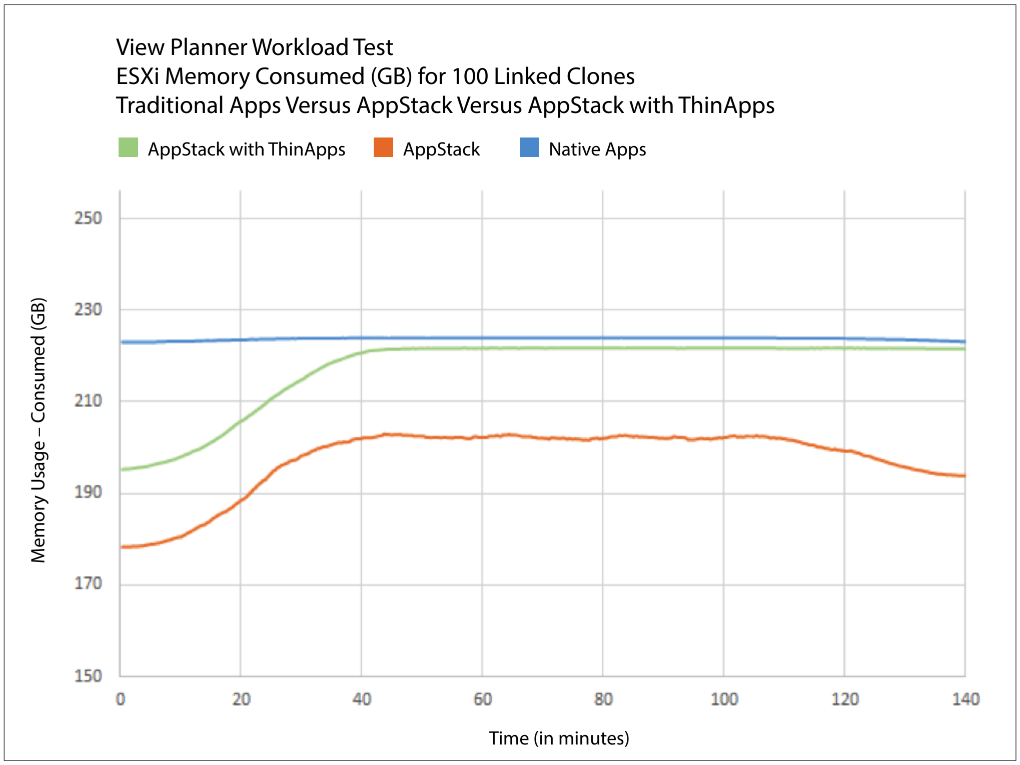


Figure 15: Linked-Clone Workload Test – ESXi Memory Consumed (GB) Comparison

Table 5 shows the average ESXi memory consumed for the three pools for the period from 40–100 minutes when the View Planner workload is running concurrently on 700 desktops.

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average Memory Consumed (GB)	224	202	222
Maximum Memory Consumed (GB)	224	203	222

Table 5: Linked-Clone Workload Test – ESXi Memory Consumed (GB) Metrics

The AppStack pool consumed 10 percent less average memory and 9.8 percent less maximum memory than the Traditional Apps pool.

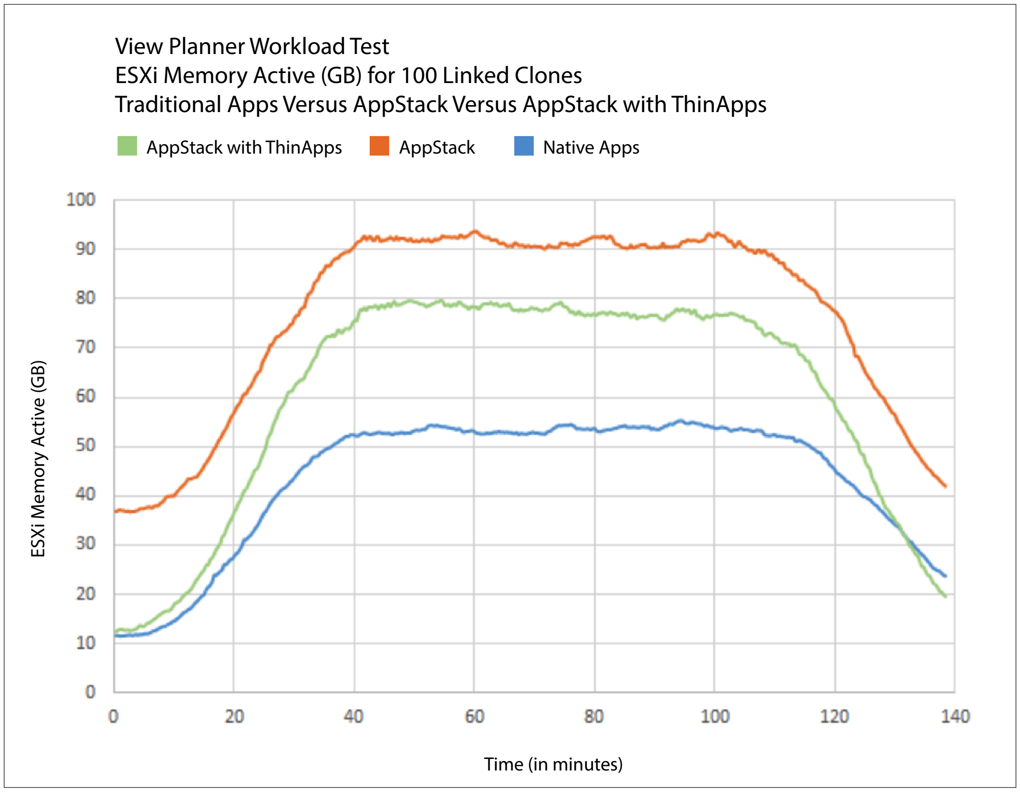


Figure 16: Linked-Clone Workload Test – ESXi Memory Active (GB) Comparison

Table 6 shows the average ESXi active memory for the three pools for the period from 40–100 minutes when the View Planner workload is running concurrently on 700 desktops.

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average Active Memory (GB)	53	92	78
Maximum Active Memory (GB)	55	94	80

Table 6: Linked-Clone Workload Test – ESXi Memory Active (GB) Metrics

The Traditional Apps pool uses 53 percent less average active memory and 52 percent less maximum active memory than the AppStack pool.

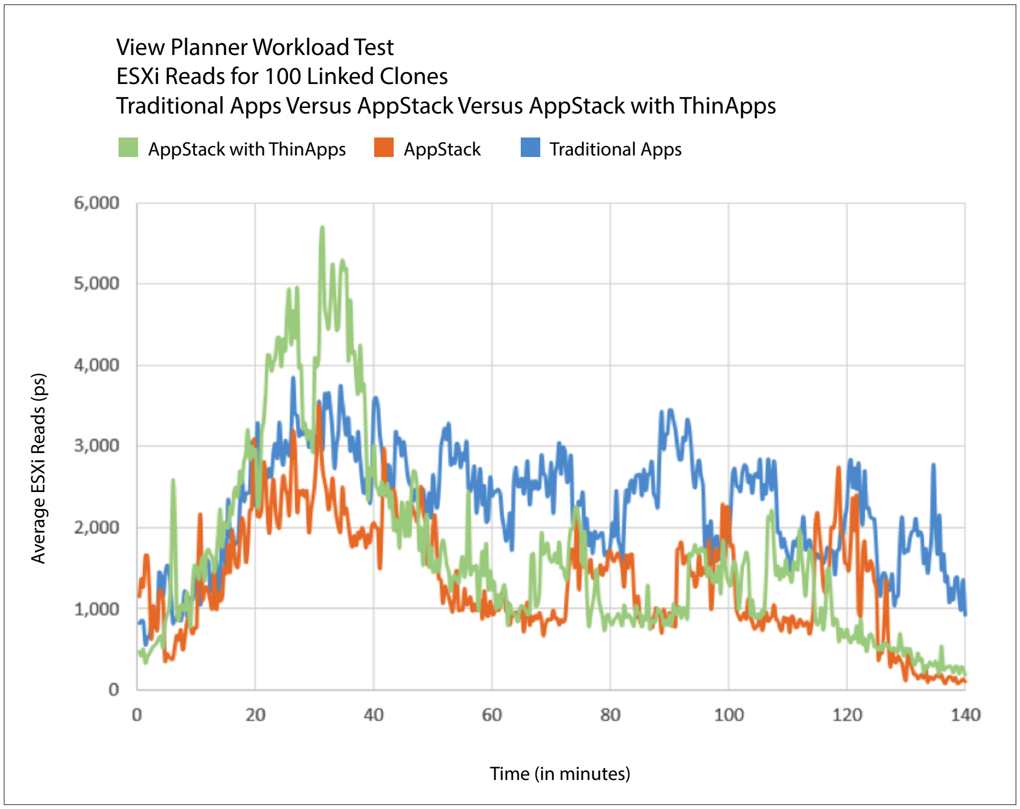


Figure 17: Linked-Clone Workload Test – ESXi Reads per Second Comparison

Table 7 shows the results of an analysis of the reads per second statistics for the 40–100 minute period with the workload running concurrently on 700 desktops.

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average Reads per Second	2,634	1,614	2,092
Maximum Reads per Second	3,842	3,514	5,695

Table 7: Linked-Clone Workload Test – ESXi Reads per Second Metrics

The AppStack pool has 48 percent fewer average reads per second and 8.9 percent fewer maximum reads per second than the Traditional Apps pool.

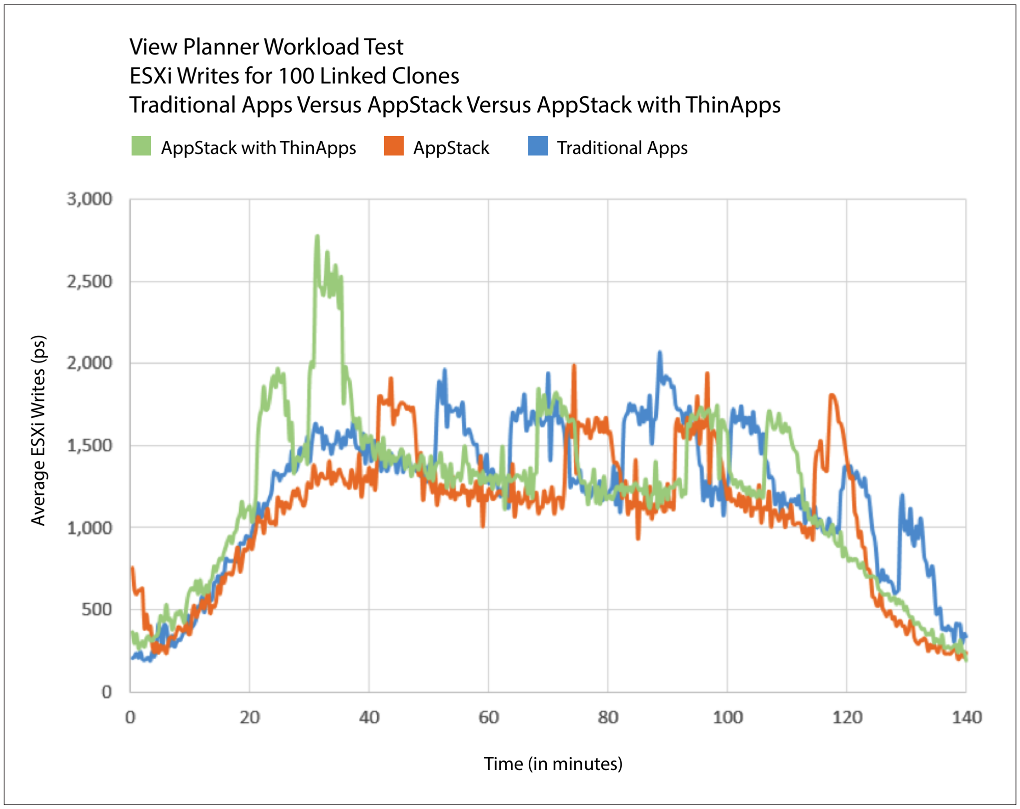


Figure 18: Linked-Clone Workload Test – ESXi Writes per Second Comparison

Table 8 shows the results of an analysis of the writes per second statistics for the 40–100 minute period with the workload running concurrently on 700 desktops.

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average Writes per Second	1,473	1,327	1,505
Maximum Writes per Second	2,068	1,990	2,774

Table 8: Linked-Clone Workload Test ESXi Writes per Second Comparison

Findings of View Planner Workload Tests

The AppStack, Traditional Apps, and AppStack with ThinApp test cases all comfortably passed View Planner benchmark tests for this Virtual SAN configuration.

Resource usage:

- The AppStack pool had 4 percent less average CPU usage and 2 percent less maximum CPU usage than Traditional Apps when deployed on Virtual SAN.
- The AppStack pool had 10 percent less average memory consumed and 9.8 percent less maximum memory consumed than the Traditional Apps pool.
- The Traditional Desktop pool had 53 percent less average active memory and 52 percent less maximum memory active than the AppStack pool.
- The AppStack pool had 48 percent fewer average reads per second and 8.9 percent fewer maximum reads per second than the Traditional Apps pool.

- The AppStack pool had 10 percent fewer average writes per second and 3.8 percent fewer maximum writes per second than the Traditional Apps pool.

Virtual SAN performance:

- Latency, congestion, and outstanding I/O were all minimal.
- Virtual SAN read cache hit rate operated at over 95 percent for almost the entire test period, and the write buffer was never more than 32 percent full.
- App Volumes and ThinApp work effectively together with no performance penalty other than the usual ThinApp launch time.

Operations Testing

The following sections describe the operations testing carried out on 700 linked-clone floating desktops running on Virtual SAN.

Provisioning

A new pool of 700 32-bit Windows 7 linked-clone virtual desktops was provisioned on the Virtual SAN datastore with an average of 100 desktops per ESXi host. To complete this task, View Composer first created a replica copy of the 24 GB base image on the Virtual SAN datastore and then created and customized the desktops and joined them to the Active Directory domain. It then took a snapshot of the virtual desktop, and the desktop went into an Available state in the View Administrator console, ready for user login.

This process took 60 minutes and 54 seconds.

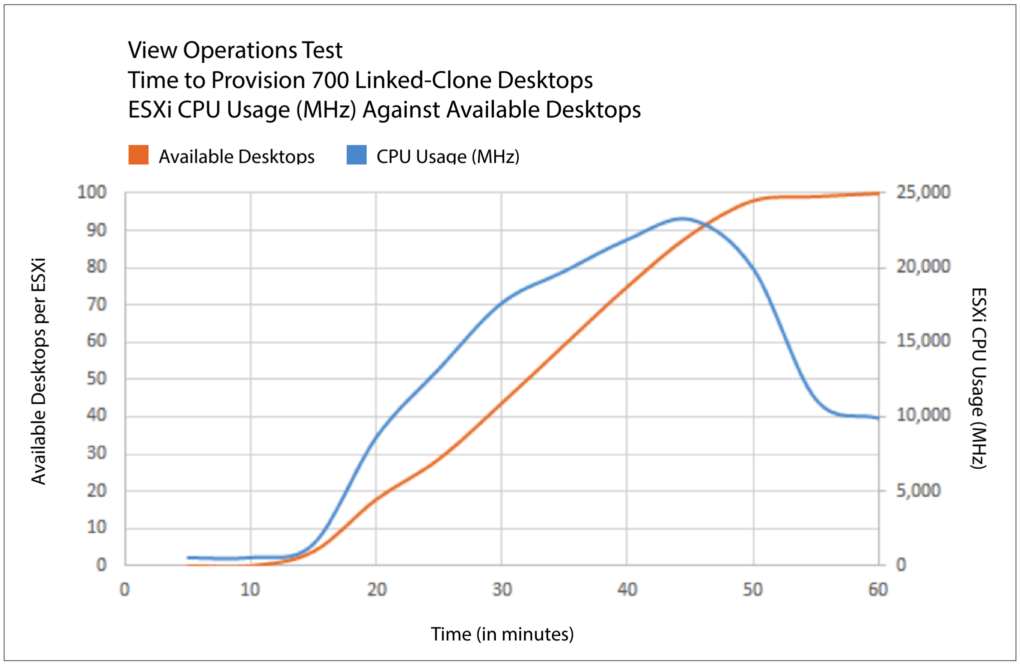


Figure 19: Time to Provision 700 Linked Clones Against Average ESXi CPU Usage

Average ESXi CPU usage peaked at 23,253 MHz (36 percent) and fell to 9,907 MHz (15 percent) as virtual desktops settled down and ran at steady state.

Power On and Login of 700 Linked Clones

A boot-and-login storm was simulated for a pool of 700 virtual desktops. The virtual desktops were configured for automatic login to the AD domain and booted simultaneously from vCenter. The objective was to measure time to completion and observe Virtual SAN performance under stress.

It took just under 10 minutes for all 700 desktops to power on and report their status as Connected in View Manager.

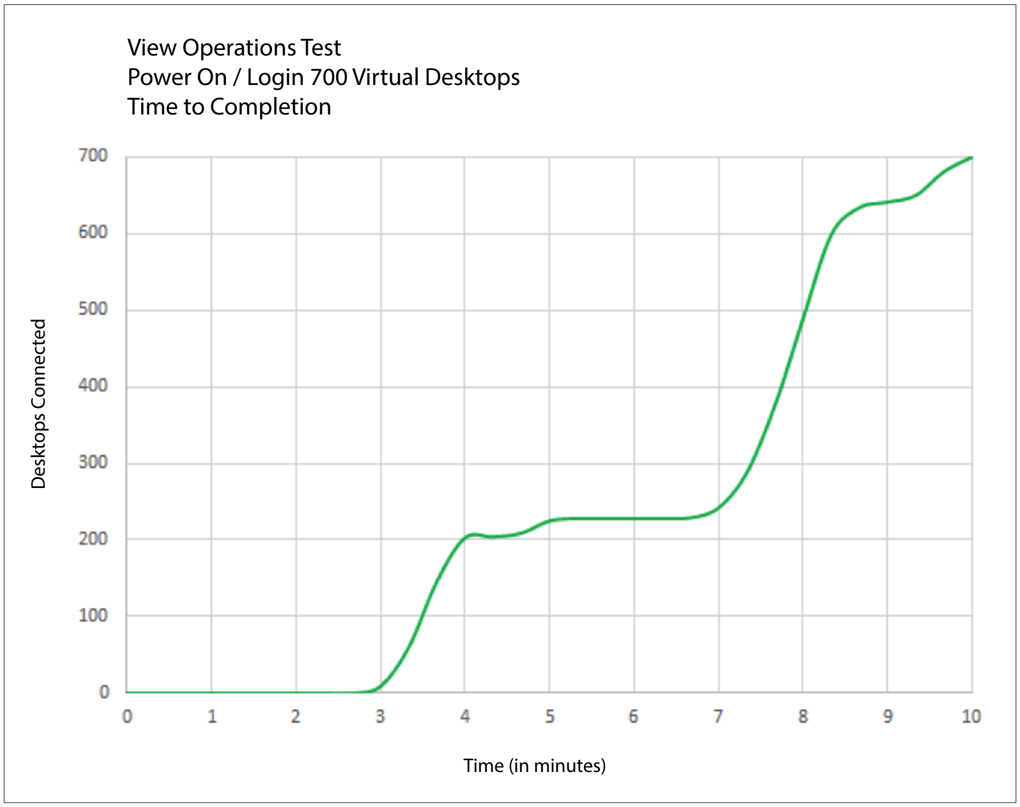


Figure 20: Power-On and AD Login Test for 700 Virtual Desktops on Virtual SAN

The Virtual SAN Observer tool gathered performance statistics from the Virtual SAN cluster at sample intervals of 30 seconds throughout the tests and examined them from the points of view of the Virtual SAN client, the virtual desktops running on the cluster, and the disk layer, reporting on the following measures:

- **Latency** – Length of time it takes an I/O operation to complete
- **IOPS** – Number of read and write operations per second
- **Bandwidth** – Amount of data being transferred
- **Congestion** – Difficulty the underlying disk layer has in keeping up with I/O, indicating a problem in the configuration
- **Outstanding I/O** – Number of I/O requests that are waiting to be completed (the fewer outstanding I/O requests, the better)

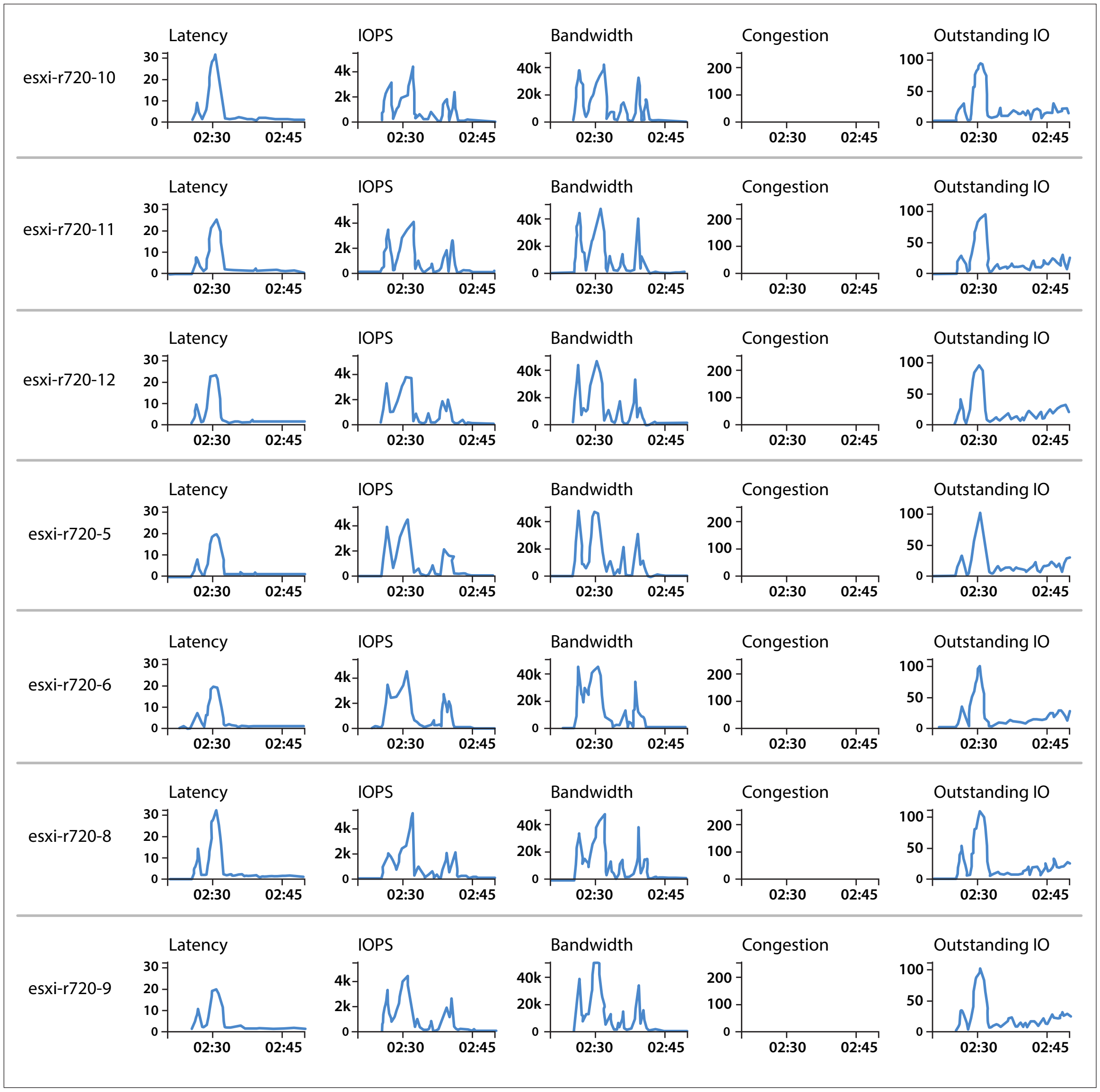


Figure 21: Virtual SAN Observer – Client Layer Statistics

The Virtual SAN Observer client showed that outstanding I/O spiked temporarily to 97, but this spike was not a cause for concern because the LSI Logic storage controllers have a queue depth of 600. Latency reached a maximum of 33 ms at 2,267 read IOPS, 33,790 KBps per host. The total combined read IOPS at peak was 18,583 at 224,785 KBps. No congestion was observed.

Virtual SAN is fully compatible with View Storage Accelerator, which uses the vSphere Content Based Read Cache (CBRC) feature. CBRC allows some ESXi host RAM to be dedicated for use as a cache for common read blocks, thus reducing I/O to the storage system. CBRC was enabled in vSphere and configured and managed through the View Management Console.

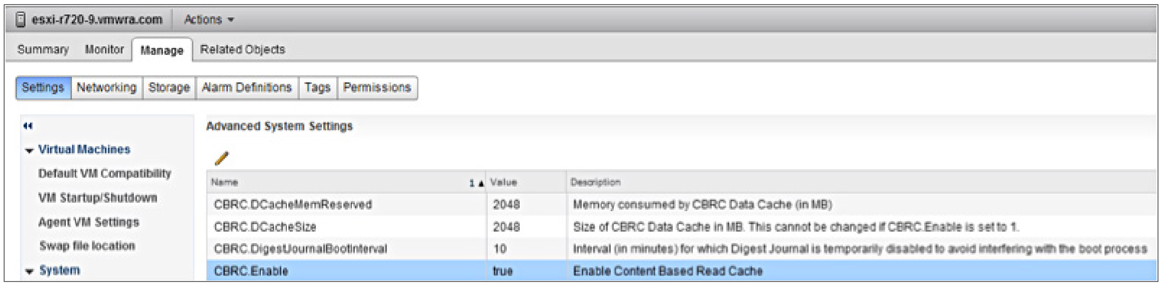


Figure 22: ESXi Host Advanced System Settings – Enable CBRC

View Storage Accelerator was enabled, with the host cache size set to a maximum of 2048 MB for all tests.

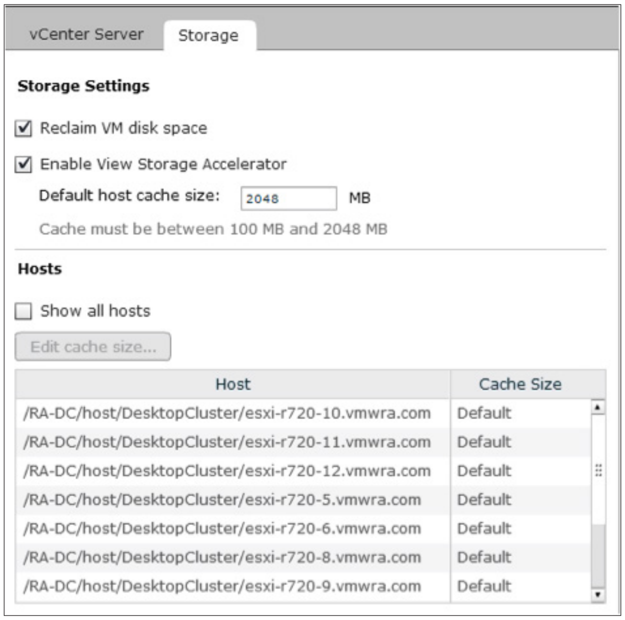


Figure 23: View Console – vCenter Settings for View Storage Accelerator (CBRC)

As shown in Figure 24, CBRC on a single ESXi host had a hit ratio of 90 percent at peak during a boot and login storm, serving 9,768 read operations from its in-memory cache.

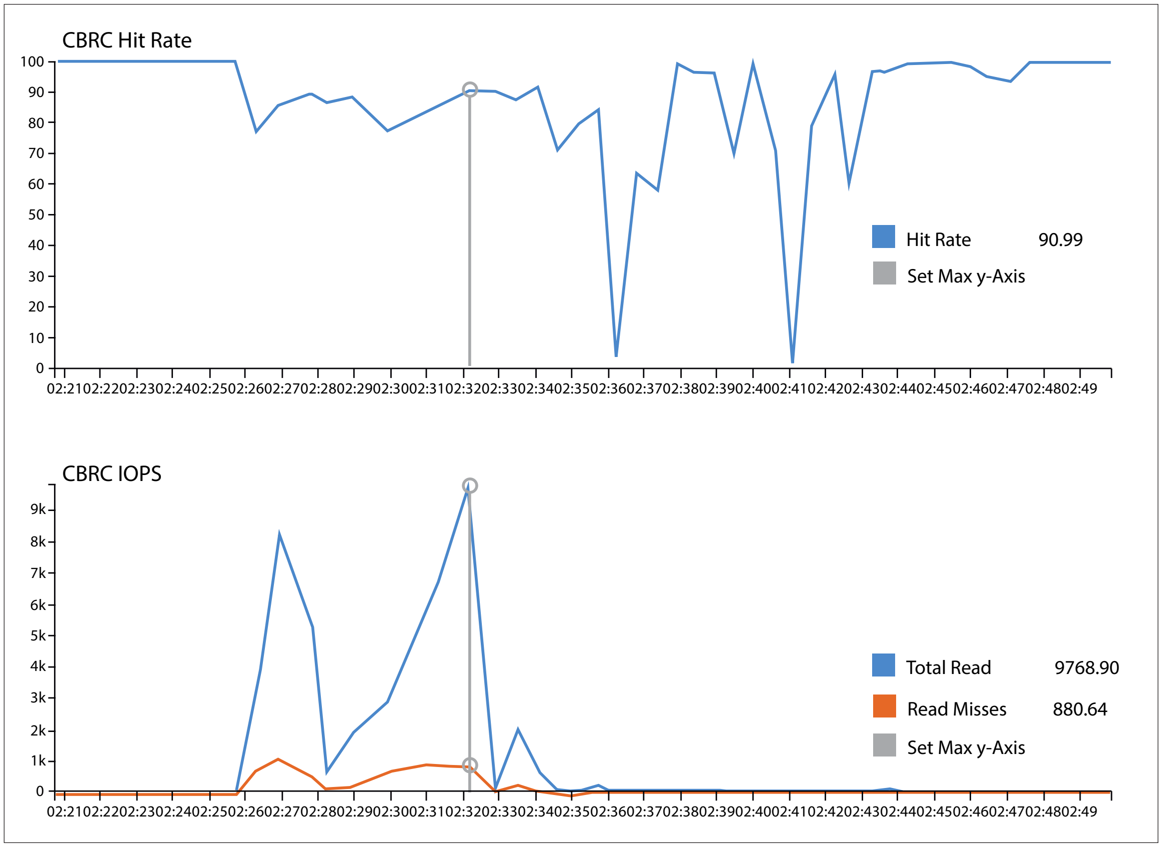


Figure 24: Virtual SAN Observer – CBRC

Virtual SAN Observer disk statistics show that the read cache (RC) hit rate remained above 95 percent across all hosts for the duration of the boot and login test. Write buffer fill did not exceed 10 percent full on any host during the test, and read latency spiked to 4 ms.

The Virtual SAN Observer disk layer section offers a deep view into the physical disk layer of a Virtual SAN host, with an aggregate view across the disks. The performance of the read cache can be observed through its hit ratio and the write buffer.

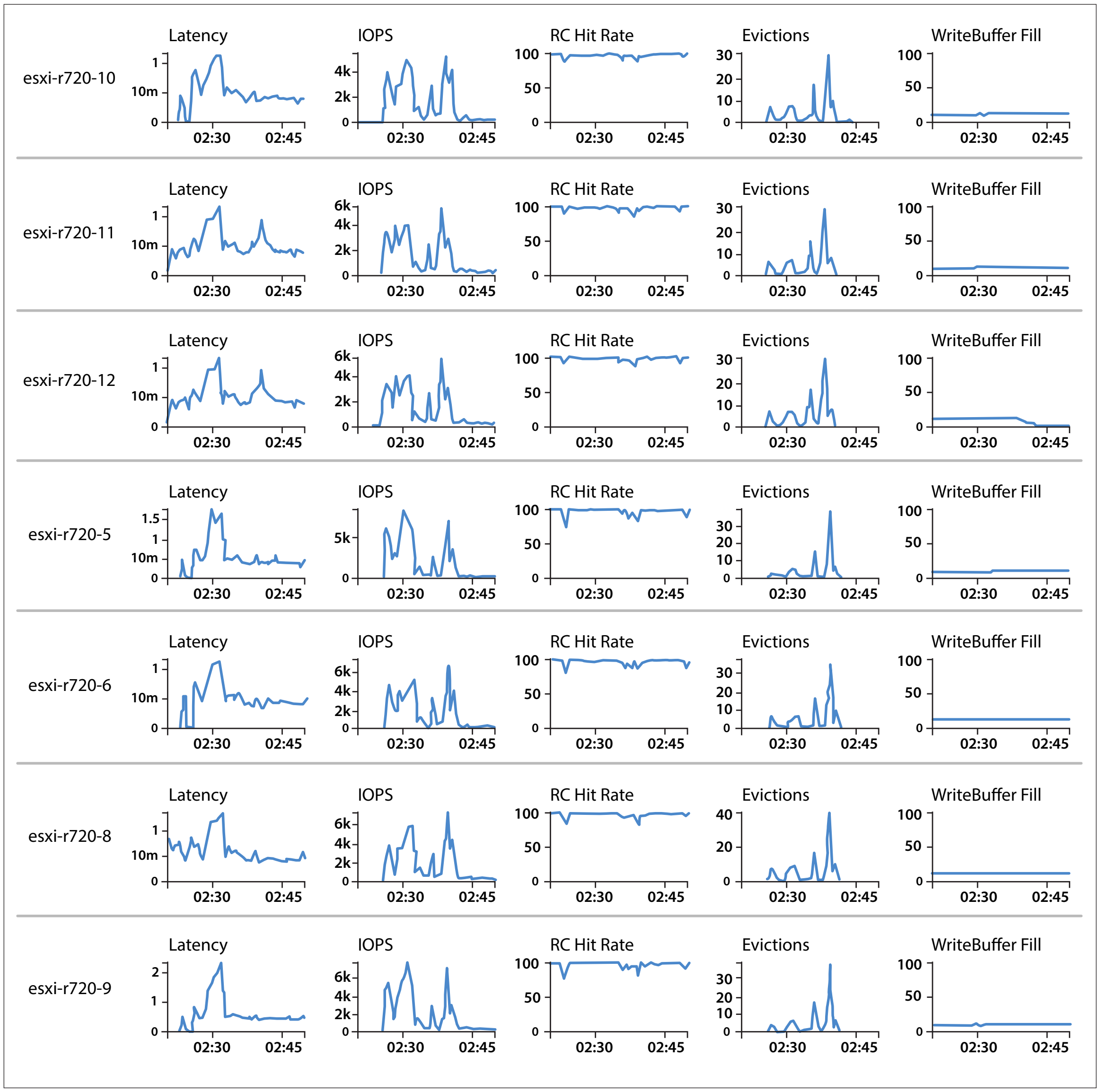


Figure 25: Virtual SAN Observer – Disk Layer Statistics

Refresh of 700 Linked Clones

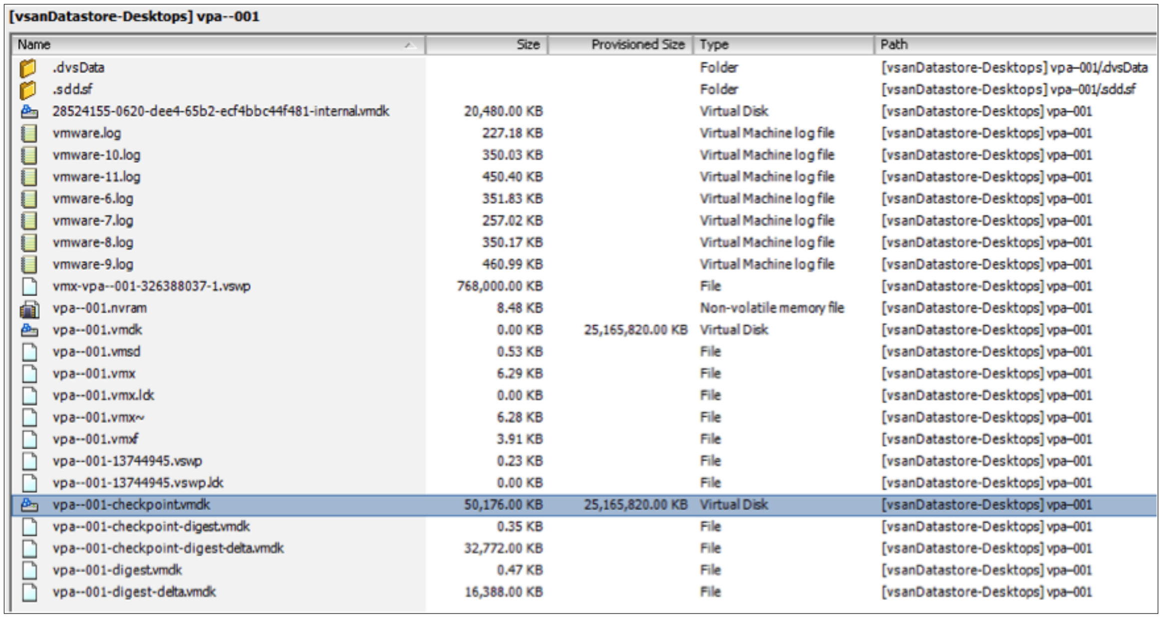
A View refresh operation reverts a pool of linked-clone desktops to their original state. Any changes made to the desktop after it was provisioned, recomposed, or last refreshed are discarded. When a refresh operation is initiated, desktops in the pool are refreshed in a rolling fashion, several at a time.

A refresh test was conducted on a pool of floating linked-clone desktops with no AppStacks assigned or attached, and the same refresh operation was repeated for a pool of virtual desktops with an Office 2010 AppStack assigned and attached. AD users were logged in to all desktops in the pool for both tests. Several desktops were refreshed simultaneously, and users were logged off automatically before their desktops were taken down for maintenance. After a desktop was refreshed, the AD user was logged back in automatically. The AppStack was assigned to the AD users and mounted on login.

The objectives of the test were to measure time to completion for both pools and to record the performance metrics.

Figure 26: Office 2010 AppStack Used for Refresh Test

Before the refresh operation, 101 MB of changes were written to the C drive of each virtual desktop in the pool.



[vsanDatastore-Desktops] vpa--001

Name	Size	Provisioned Size	Type	Path
.dvsData			Folder	[vsanDatastore-Desktops] vpa–001/.dvsData
.sdd.sf			Folder	[vsanDatastore-Desktops] vpa–001/.sdd.sf
28524155-0620-dee4-65b2-ecf4bbc44f481-internal.vmdk	20,480.00 KB		Virtual Disk	[vsanDatastore-Desktops] vpa–001
vmware.log	227.18 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmware-10.log	350.03 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmware-11.log	450.40 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmware-6.log	351.83 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmware-7.log	257.02 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmware-8.log	350.17 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmware-9.log	460.99 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa–001
vmx-vpa--001-326388037-1.vswp	768,000.00 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001.nvram	8.48 KB		Non-volatile memory file	[vsanDatastore-Desktops] vpa–001
vpa--001.vmdk	0.00 KB	25,165,820.00 KB	Virtual Disk	[vsanDatastore-Desktops] vpa–001
vpa--001.vmsd	0.53 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001.vmx	6.29 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001.vmx.lck	0.00 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001.vmx~	6.28 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001.vmxf	3.91 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001-13744945.vswp	0.23 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001-13744945.vswp.lck	0.00 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001-checkpoint.vmdk	50,176.00 KB	25,165,820.00 KB	Virtual Disk	[vsanDatastore-Desktops] vpa–001
vpa--001-checkpoint-digest.vmdk	0.35 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001-checkpoint-digest-delta.vmdk	32,772.00 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001-digest.vmdk	0.47 KB		File	[vsanDatastore-Desktops] vpa–001
vpa--001-digest-delta.vmdk	16,388.00 KB		File	[vsanDatastore-Desktops] vpa–001

Figure 27: Sample Desktop Before Delta Increase

[vsanDatastore-Desktops] vpa--001

Name	Size	Provisioned Size	Type	Path
.dvsData			Folder	[vsanDatastore-Desktops] vpa--001/.dvsData
.sdd.sf			Folder	[vsanDatastore-Desktops] vpa--001/.sdd.sf
28524155-0620-dee4-65b2-ecf4bbc44f481-internal.vmdk	20,480.00 KB		Virtual Disk	[vsanDatastore-Desktops] vpa--001
vmware.log	227.03 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmware-10.log	350.03 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmware-11.log	450.40 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmware-12.log	249.37 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmware-7.log	257.02 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmware-8.log	350.17 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmware-9.log	460.99 KB		Virtual Machine log file	[vsanDatastore-Desktops] vpa--001
vmx-vpa--001-326388037-1.vswp	768,000.00 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001.nvram	8.48 KB		Non-volatile memory file	[vsanDatastore-Desktops] vpa--001
vpa--001.vmdk	0.00 KB	25,165,820.00 KB	Virtual Disk	[vsanDatastore-Desktops] vpa--001
vpa--001.vmsd	0.53 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001.vmx	6.29 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001.vmx.lck	0.00 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001.vmx~	6.28 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001.vmxf	3.91 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001-13744945.vswp	0.23 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001-13744945.vswp.lck	0.00 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001-checkpoint.vmdk	158,720.00 KB	25,165,820.00 KB	Virtual Disk	[vsanDatastore-Desktops] vpa--001
vpa--001-checkpoint-digest.vmdk	0.35 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001-checkpoint-digest-delta.vmdk	32,772.00 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001-digest.vmdk	0.47 KB		File	[vsanDatastore-Desktops] vpa--001
vpa--001-digest-delta.vmdk	16,388.00 KB		File	[vsanDatastore-Desktops] vpa--001

Figure 28: Sample Desktop – Post-Delta Increase (101 MB of Files Written to C: Drive)

It took 28 minutes and 12 seconds for the pool of 700 virtual desktops with no AppStacks attached to complete a refresh. The pool of 700 desktops with an AppStack attached took 29 minutes and 52 seconds to refresh. This time included AD users reconnecting with their desktops.

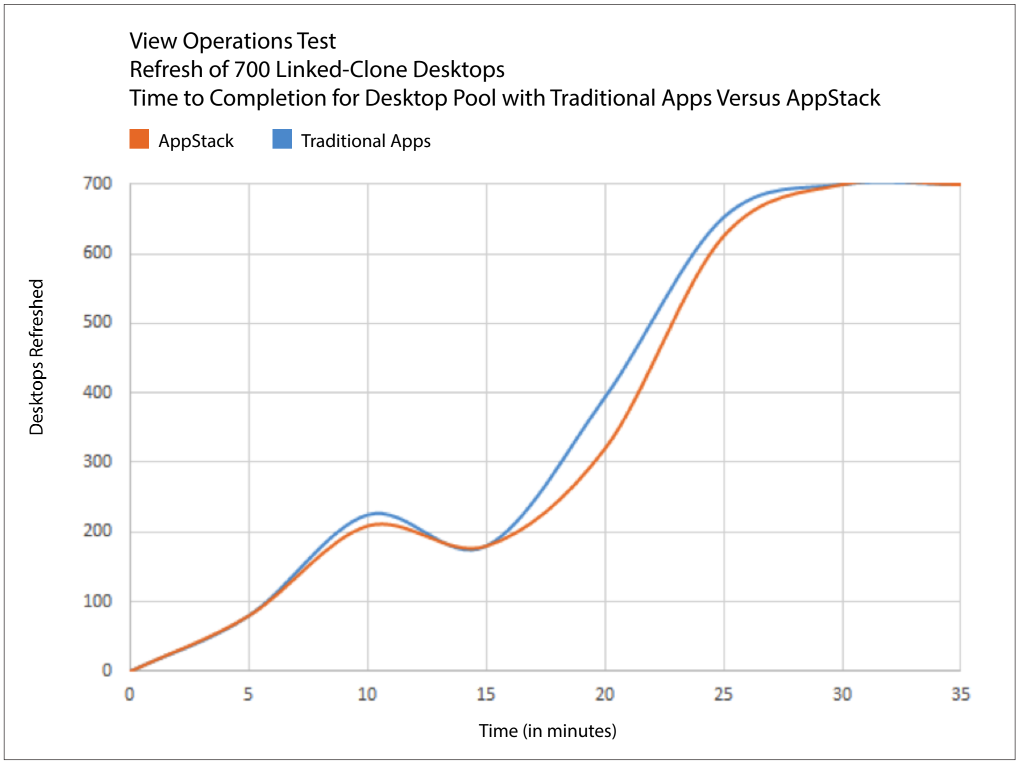


Figure 29: Time to Refresh Desktop Pool with and Without AppStack Attached

Recompose of 700 Linked Clones

A View recompose operation changes the linked clones to a new parent base image. View Composer creates a replica of the new base image on the Virtual SAN datastore. It then creates a new OS disk for each virtual desktop and deletes the old one. The new desktop is customized, and a new snapshot created. This is the operation that administrators use to push out patches and software updates to pools of desktops.

A recompose operation was carried out for a pool of 700 floating linked-clone Windows 7 desktops with no AppStacks assigned or attached. The new replica image for the recompose operation was the old base image with an additional 357 MB of files copied to the C: drive. A recompose operation was repeated for a pool of 700 Windows 7 desktops with an Office 2010 32-bit AppStack attached. AD users were logged in to all desktops in the pool for both tests. Several desktops were refreshed simultaneously, and AD users were automatically logged in to available desktops when the desktops were refreshed.

The Traditional Apps linked-clone pool took 73 minutes and 10 seconds to recompose to a new base image. The linked-clone pool with an AppStack attached took 77 minutes and 36 seconds.

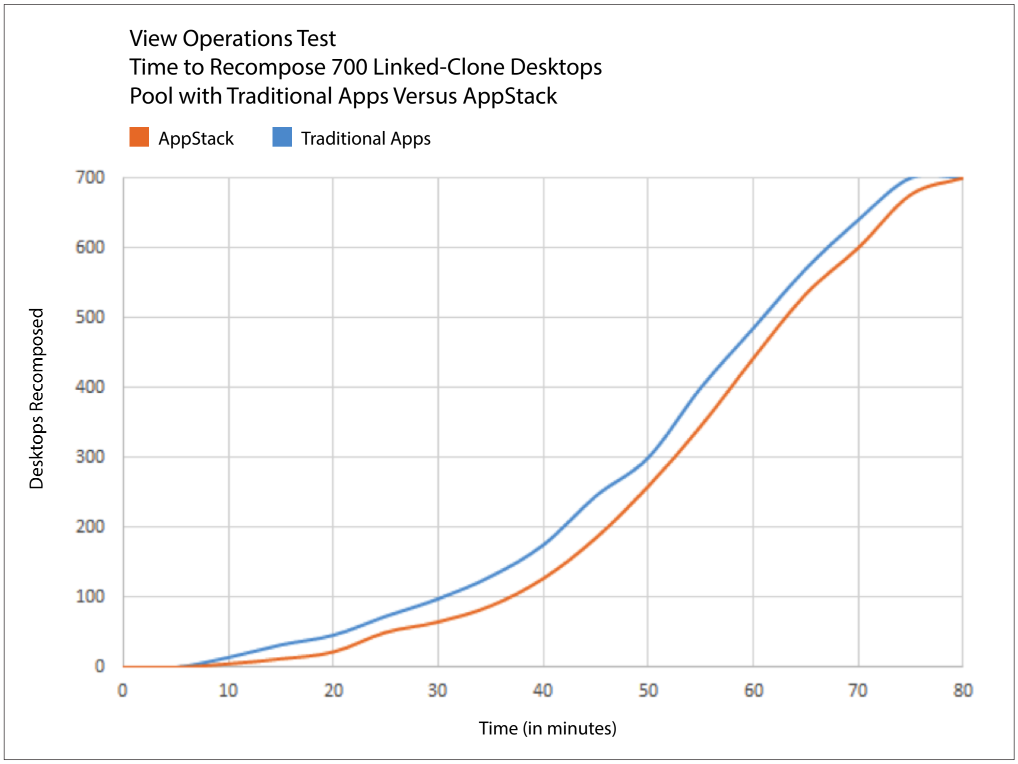


Figure 30: Time to Recompose a Desktop Pool with and Without AppStack

Resiliency Testing – Virtual SAN

The following sections describe the testing carried out to simulate a hardware outage on a seven-node Virtual SAN cluster with 700 running virtual desktops.

Single Host Failure Exercise

This test simulated a Virtual SAN host failure, to observe the effect on the App Volumes AppStack assigned to other hosts in the cluster.

An ESXi host with 97 running virtual desktops was manually powered off from the Dell DRAC to simulate a hardware failure. The host went into Not Responding state, and desktops became unavailable.

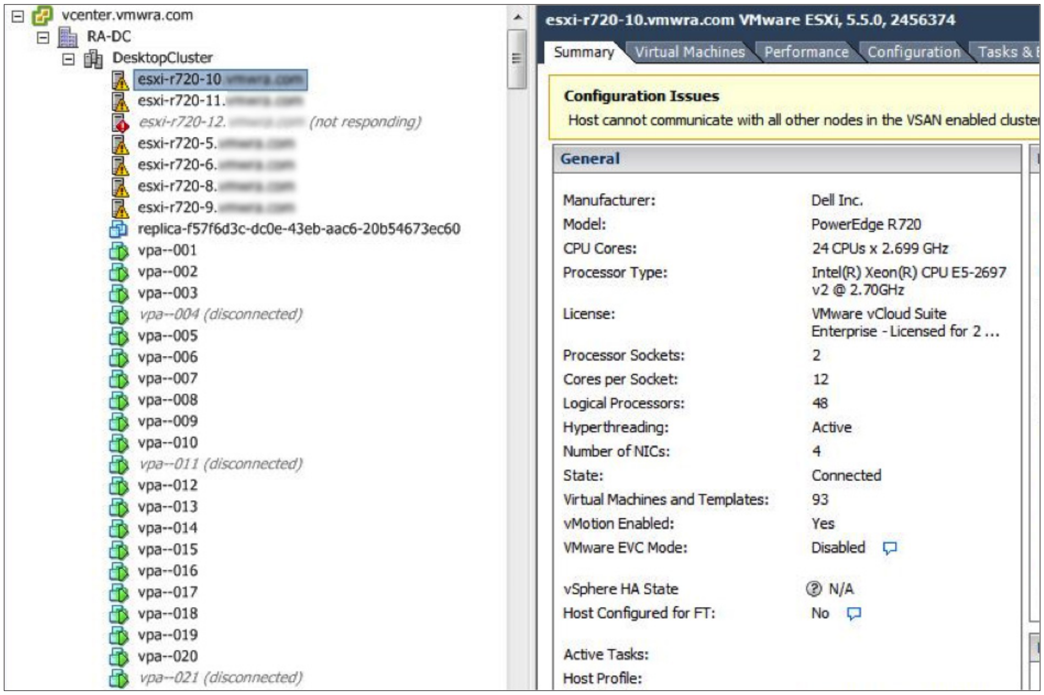


Figure 31: ESXi Host – Simulated Hardware Failure

Examination of an AppStack that had a Virtual SAN replica component on the failed host showed that the AppStack component changed state from **Active** to **Absent**.

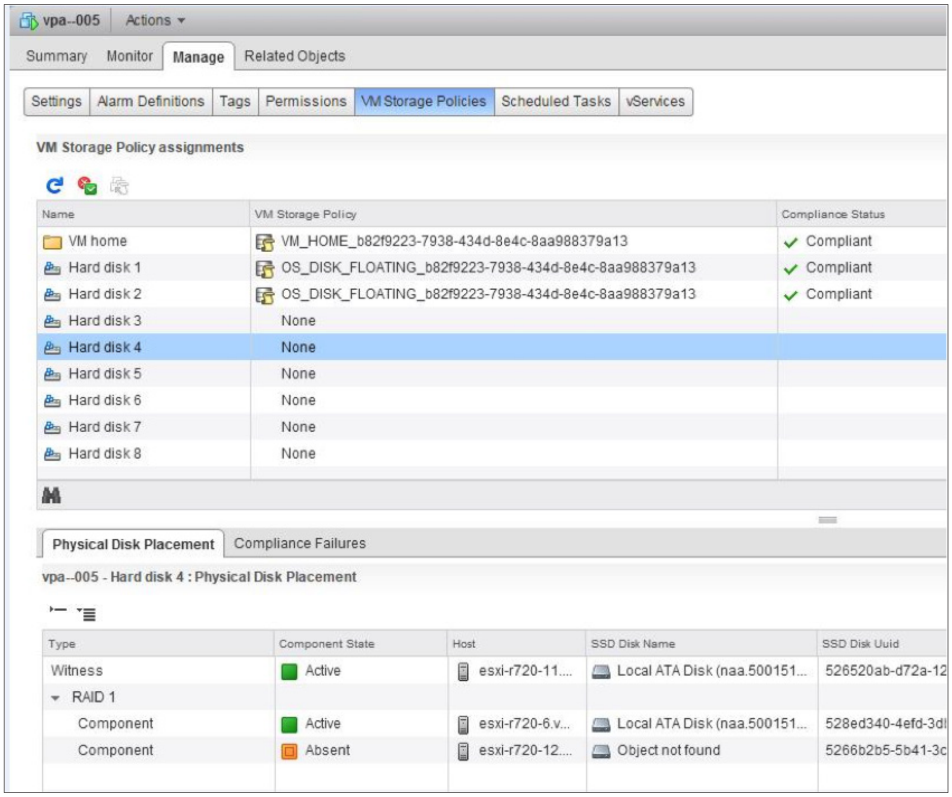


Figure 32: Simulated ESXi Host Hardware Failure – AppStack Replica Component Absent

There was no impact on AppStack accessibility or performance of virtual desktops on the remaining ESXi hosts in the cluster.

Timeout Interval

By default, Virtual SAN waits 60 minutes before marking the *Absent* component as Degraded. If the components do not become available within this time, Virtual SAN begins rebuilding them elsewhere in the cluster. To modify the default Virtual SAN timeout interval (`VSAN.ClomRepairDelay`), change the ESXi advanced options for each ESXi in the Virtual SAN cluster, as shown in Figure 33.

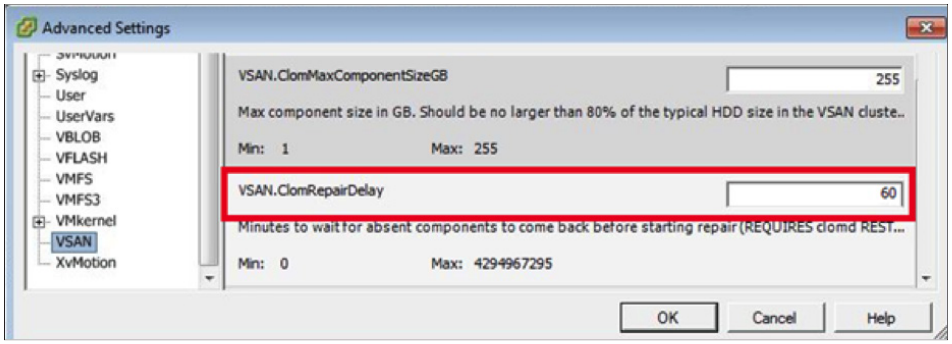


Figure 33: ESXi Advanced Settings – Setting Rebuild Timer

After setting the default timeout, use the following command to restart the Cluster Level Object Manager on each host.

```
/init.d/clomd restart
```

Simulating Host Failure

Virtual SAN has a useful Ruby vSphere Console command that simulates the effect of the loss of a host. It reports back the current cache reservations, capacity, and components used and the effect of a host failure and rebuild on the remaining nodes in the cluster.

```
/vcenter.vmwra.com/RA-DC/computers> vsan.whatif_host_failures -s DesktopCluster/

Current utilization of hosts:

+------------------------+---------+--------------+------+----------+------------
------+--------------+

|  | | HDD Capacity | | | Components | SSD Capacity |

| Host   | NumHDDs | Total | Used | Reserved | Used | Reserved |

+------------------------+---------+--------------+------+----------+------------
------+--------------+

| esxi-r720-5.vmwra.com  | 6 | 3352.50 GB | 5 % | 3 % | 2706/3000 (90 %) | 0 % |

| esxi-r720-8.vmwra.com  | 6 | 3352.50 GB | 5 % | 3 % | 2705/3000 (90 %) | 0 % |

| esxi-r720-12.vmwra.com | 6 | 3352.50 GB | 5 % | 3 % | 2704/3000 (90 %) | 0 % |

| esxi-r720-9.vmwra.com  | 6 | 3352.50 GB | 6 % | 3 % | 2704/3000 (90 %) | 0 % |

| esxi-r720-6.vmwra.com  | 6 | 3352.50 GB | 6 % | 2 % | 2709/3000 (90 %) | 0 % |

| esxi-r720-11.vmwra.com | 6 | 3352.50 GB | 6 % | 3 % | 2705/3000 (90 %) | 0 % |

| esxi-r720-10.vmwra.com | 6 | 3352.50 GB | 5 % | 2 % | 2706/3000 (90 %) | 0 % |

+------------------------+---------+--------------+------+----------+------------
------+--------------+

Simulating 1 host failures:

+-----------------+------------------------------+------------------------------
-----+

| Resource | Usage right now | Usage after failure/re-protection |

+-----------------+------------------------------+------------------------------
-----+

| HDD capacity | 6% used (22159.15 GB free) | 7% used (18806.65 GB free) |

| Components | 90% used (2061 available) | 105% used (-939 available) |

| RC reservations | 0% used (1820.96 GB free) | 0% used (1560.13 GB free) |

+-----------------+------------------------------+------------------------------
-----+
```

AppStacks and Failure to Tolerate (FTT)

AppStacks are created with the default Virtual SAN storage policy of FTT=1, which means an AppStack can suffer the loss of one host in a cluster and still remain accessible. For larger clusters, FTT can be increased for added resiliency.

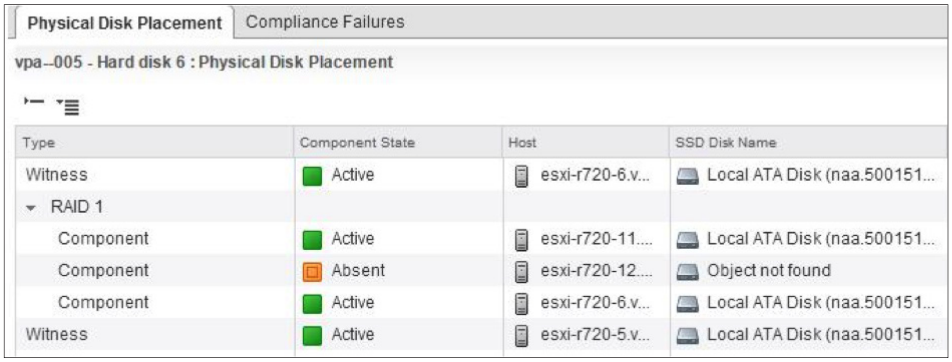


Figure 34: Virtual SAN Object Components – AppStack with FTT=2

To modify the FTT for an AppStack, create a new storage policy in vCenter. The maximum FTT value is 3.

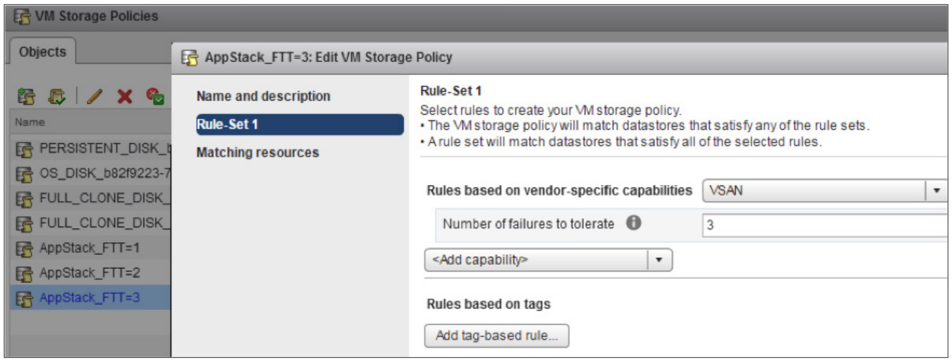


Figure 35: vSphere – Create New Storage Policy

Mount the AppStack on a powered-off virtual machine, and apply the new storage policy to the AppStack disk. The AppStack can be in use and attached to other virtual machines.

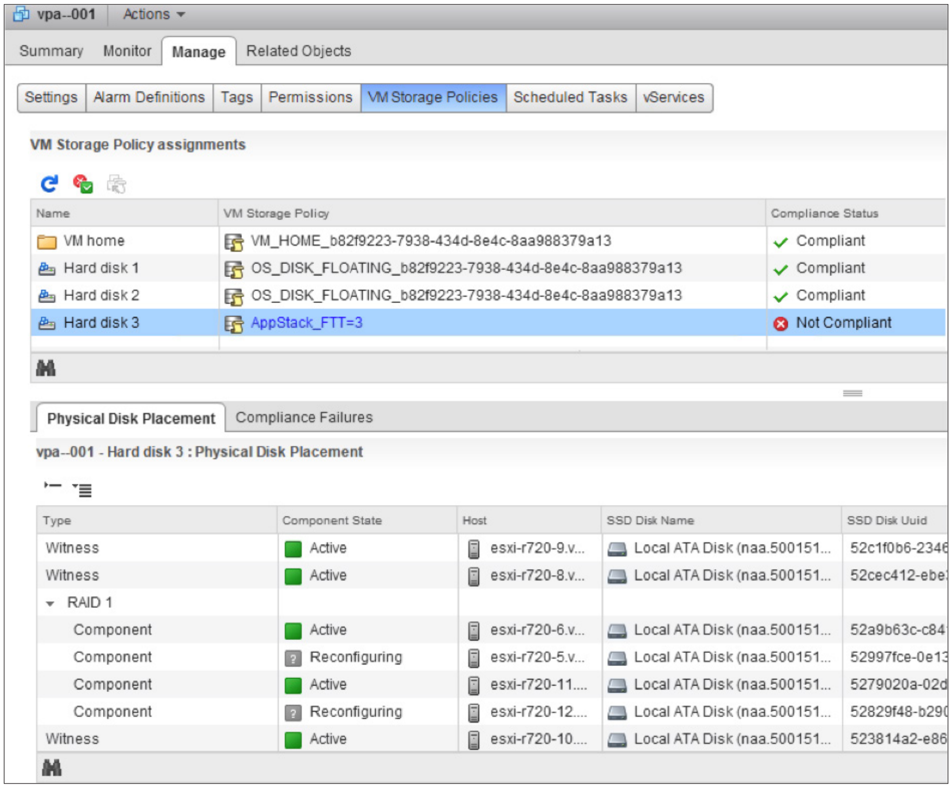


Figure 36: AppStack After New FTT=3 Storage Policy Applied

Virtual SAN creates additional replicas, which go into *Reconfiguring* state before becoming Active after the copy operation has completed. It also creates additional *witnesses*, which are used as tiebreakers in Virtual SAN availability decisions.

Increasing the FTT for an AppStack contributes components only to the VMDK file, not to the redo files, which are created on attachment.

Findings of Operations Tests

Operations testing produced the following results.

- Rapid provisioning – 700 linked clones provisioned in 60 minutes and 54 seconds
- Fast desktop maintenance operations
  - Refresh of 700 linked clones in less than 30 minutes
  - Recompose of 700 linked clones in less than 74 minutes
- AppStack usage – No significant increase in maintenance operation times
  - Refresh times – Traditional 28 minutes and 12 seconds versus AppStack 29 minutes and 52 seconds
  - Recompose – Traditional 73 minutes and 10 seconds versus AppStack 77 minutes and 36 seconds
- View Storage Accelerator and Virtual SAN – Form an effective partnership to tackle boot and login storms
  - 18,583 reads at peak of boot and login storm
  - Peak latency of 33 ms and no congestion
- Resilient platform for deploying virtual desktops with App Volumes AppStack

View RDSH Desktops

To compare the performance characteristics for traditional RDSH and RDSH with AppStacks under a View Planner workload, a cluster was created with two ESXi hosts, each with a single datastore. Two types of RDSH configurations were tested:

- 8 x RDSH servers with Traditional Apps installed in the Guest OS
- 8 x RDSH servers with departmental AppStack assigned

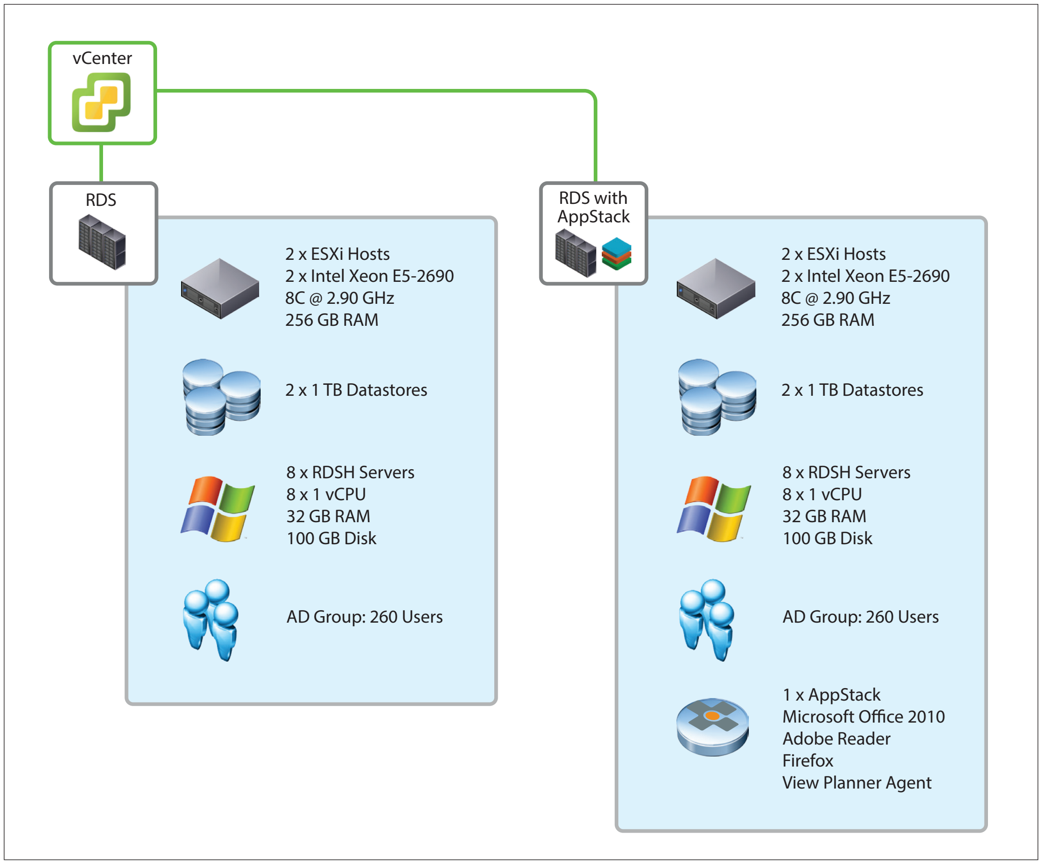


Figure 37: RDSH Test Pools

Two separate RDSH farms were created in View. Two desktop pools were then created using these RDSH farms.

View Planner 3.5 was used to drive a synthetic workload on the RDSH servers to simulate 260 concurrent users running applications and executing a workload of common user operations.

RDSH Server Image Build

The RDSH images and application deployment methods were:

- **Traditional RDSH server** – Windows 2012 R2 with test applications and View Planner agent installed on the server image (Traditional Apps)
- **RDSH server with AppStack** – Windows 2012 R2 with test applications and View Planner agent installed in an AppStack

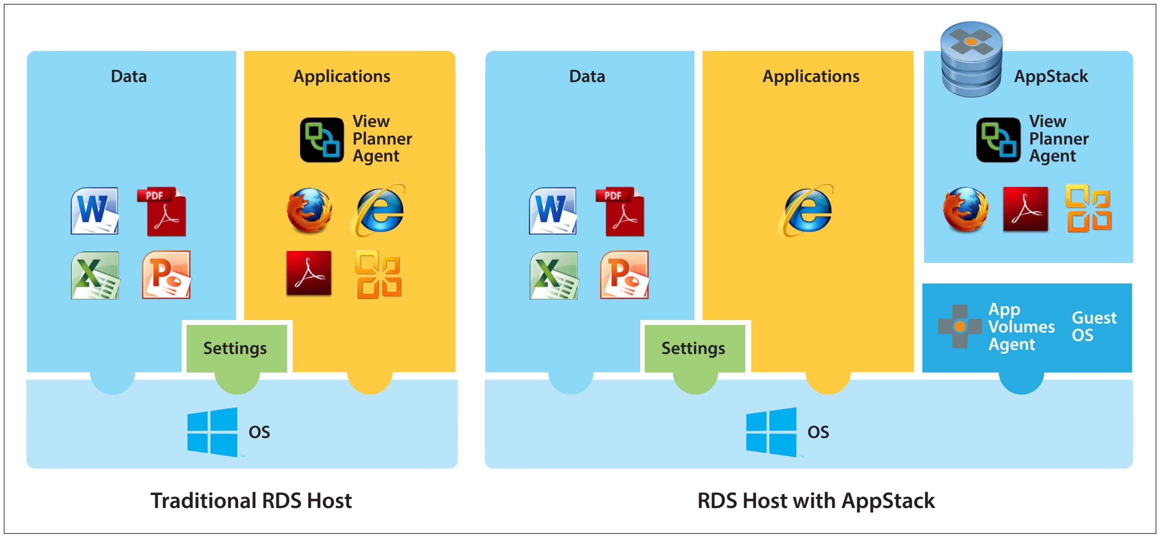


Figure 38: RDSH Test Images

Each image was optimized with the VMware OS Optimization tool.

ATTRIBUTE	TRADITIONAL RDSH	RDSH WITH APPSTACK
Desktop OS	Windows 2012 R2	Windows 2012 R2
VM hardware	v9	v9
CPU	8 (8 x 1 core)	8 (8 x 1 core)
Memory	32768 MB	32768 MB
Memory reserved	0 MB	0 MB
Video RAM	128 MB	128 MB
3D graphics	Off	Off
NICs	1	1
Virtual network adapter	VMXNet3 Adapter	VMXNet3 Adapter
Virtual SCSI controller 0	Paravirtual	Paravirtual
Virtual disk – VMDK 1	70 GB (OS C:\)	70 GB (OS C:\)
Virtual disk – VMDK 2	70 GB (View Planner Data E:\)	70 GB (View Planner Data E:\)
Virtual floppy drive	Removed	Removed
Virtual CD/DVD drive	Removed	Removed
Traditional Apps	• Adobe Acrobat 10.1.4 • Firefox 7.01 • Internet Explorer 10 • Office 2010 SP2 • View Planner 3.5 agent	Internet Explorer 10
AppStack		1 (6.2 GB)
AppStack Apps		• Adobe Acrobat 10.1.4 • Firefox 7.01 • Office 2010 • View Planner 3.5 agent
App Volumes Agent		2.6.0 build 3106
VMware Tools	9.4.11 – build 2400950	9.4.11 – build 2400950
VMware View Agent	6.0.2 – build 2331487	6.0.2 – build 2331487

Table 9: RDSH Virtual Machine Specifications with and Without AppStacks

Each RDSH server had a primary OS disk and a secondary 70 GB thin disk with View Planner 3.5 data files. Both images were cloned from the same base OS template and had the same OS optimizations applied. A third clone was used as a clean image to provision the AppStacks.

Each AppStack was stored on the same datastore as the RDSH servers.

The *Win2012-RDSH* AppStack was provisioned to the clean desktop and had Adobe Reader, Firefox, Office 2010, and View Planner installed. The size of the finished AppStack was 14.1 GB. This AppStack was assigned to the AD machines for the *RDSH with AppStack* View desktop pool.

Figure 39: RDSH – Departmental AppStack Used in Testing

View Planner Test Results

Five iterations of View Planner medium workload were executed on the Traditional Apps RDSH pool and on the AppStack RDSH pool. During each iteration, the desktops executed operations to simulate 130 RDSH sessions per host with 100 percent concurrency. The operations were interactive (Group A), I/O Operations (Group B), and background load (Group C). Group A and B operations determine the QoS of the desktop and are responsible for ensuring that the end-user experience is satisfactory. The View Planner passing marks are Group A < 1 second, Group B < 6 seconds.

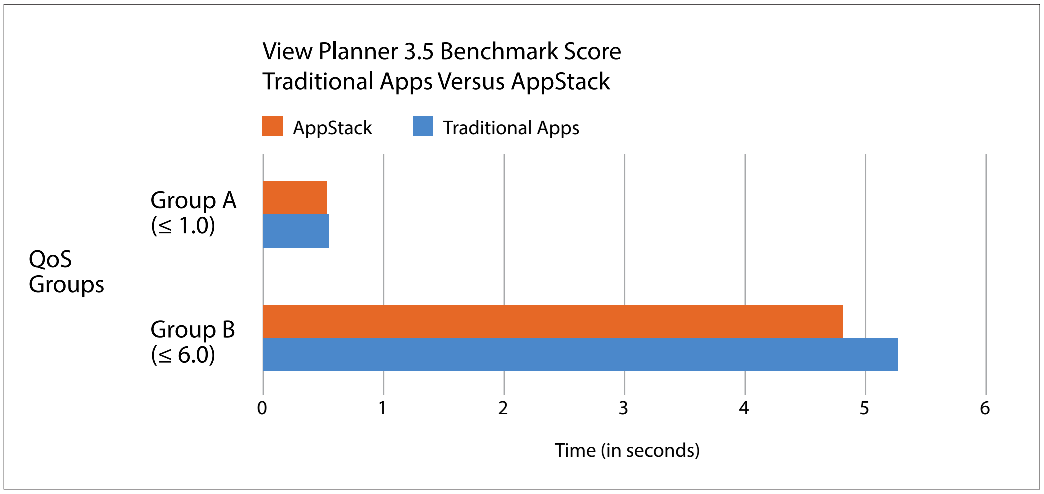


Figure 40: RDSH Workload Test – View Planner Score Comparison

Each RDSH pool met Group A and Group B requirements and passed the View Planner benchmark test. Traditional Apps and AppStack both scored 0.56 in the Group A score, but AppStack trumped Traditional Apps in the Group B score of 4.83 versus 5.27.

In the individual View Planner application operations, the AppStack RDSH pool scored lower latencies in 18 of the 25 Group A operations, 5 of the 10 Group B operations, and 2 of the 3 Group C operations.

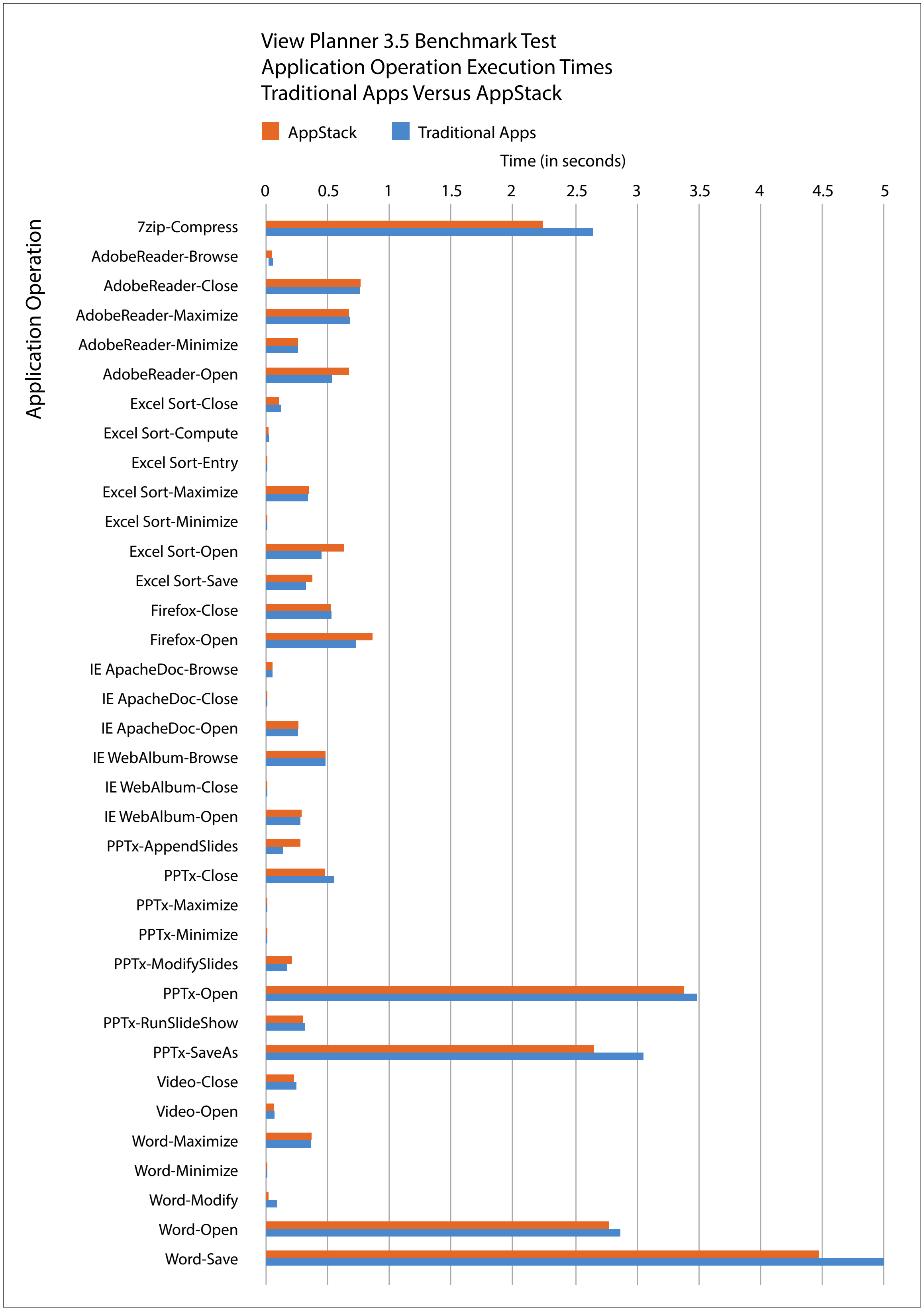


Figure 41: RDSH Workload Test – View Planner Latency Comparison

Metrics were collected from the ESXi hosts with a sample interval of 20 seconds. A comparison of CPU usage for the clusters from the RDSH AppStack and RDSH Traditional Apps pools produced the graph in Figure 42.

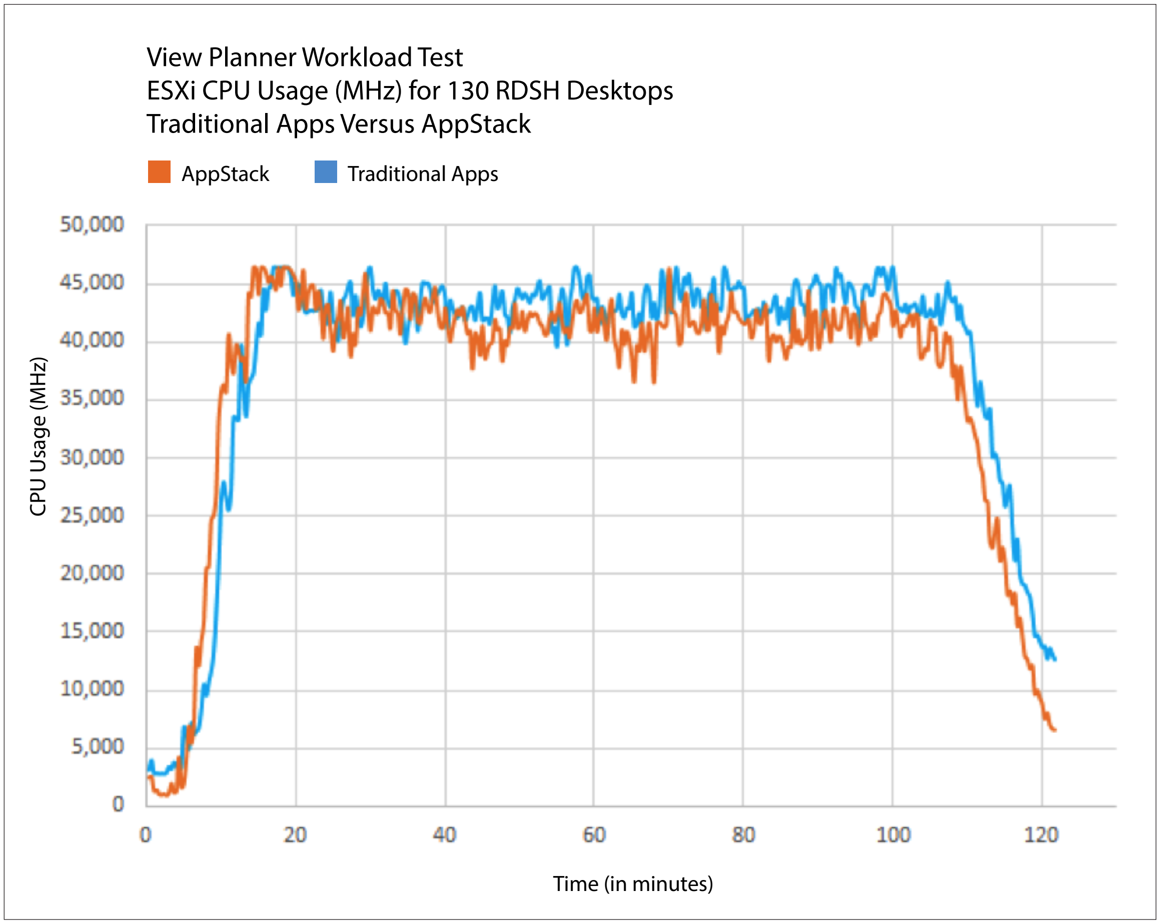


Figure 42: RDSH Workload Test – ESXi CPU Usage (MHz) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average CPU Usage (MHz)	43,537	41,318
Maximum CPU Usage (MHz)	46,399	46,315

Table 10: RDSH Workload Test – ESXi CPU Usage (MHz) Metrics

METRIC	RDSH TRADITIONAL APPS		RDSH WITH APPSTACK	
	Average	Maximum	Average	Maximum
CPU Usage (MHz)	43,537	46,399	41,318	46,315
Memory Usage (Consumed)	101	104	115	118
Memory Usage (Active)	47	72	47	74
Storage Reads per second	9	501	109	901
Storage Writes per second	371	756	354	1,254
Storage Read Rate (KB per second)	418	11,903	3,151	25,955
Storage Write Rate (KB per second)	7,901	22,053	6,467	82,861
Network Rx (KB per second)	93	294	98	387
Network Tx (KB per second)	508	1,545	532	1,412
Network Read Rate (KB per second)	418	11,903	3,151	25,955
Network Write Rate (KB per second)	7,901	22,053	6,467	82,861

Table 11: RDSH Workload Test – ESXi Metrics Summary

Summary of View Planner Workload Test Results

RDSH and RDSH with AppStack both comfortably passed the View Planner benchmark test for this configuration. The AppStack pool achieved slightly better results for Group B (storage I/O operations). In summary:

- The AppStack pool had a 5 percent lower average CPU usage than the Traditional Apps pool during workload.
- The AppStack pool showed more host memory consumed than Traditional Apps. Active memory was the same for both pools.
- The RDSH AppStack pool had more reads and slightly fewer (5 percent) average writes per second than the Traditional Apps desktop pool.
- The AppStack pool had a 5 percent higher average network receive rate (Rx) and a 4 percent average network transmission rate (Tx) than the RDSH AppStack pool.

Horizon Writable Volumes Test

The purpose of this test was to determine the IOPS requirement for writable volumes (profile data) under user login and workload testing.

Two ESXi hosts were provisioned, each with a pool of 100 linked-clone virtual desktops. One of the ESXi hosts was assigned a second datastore in which 100 writable volumes were created for user profile data.

Two AD groups were created, each with 100 users. The writable volumes were assigned to one of the AD groups.

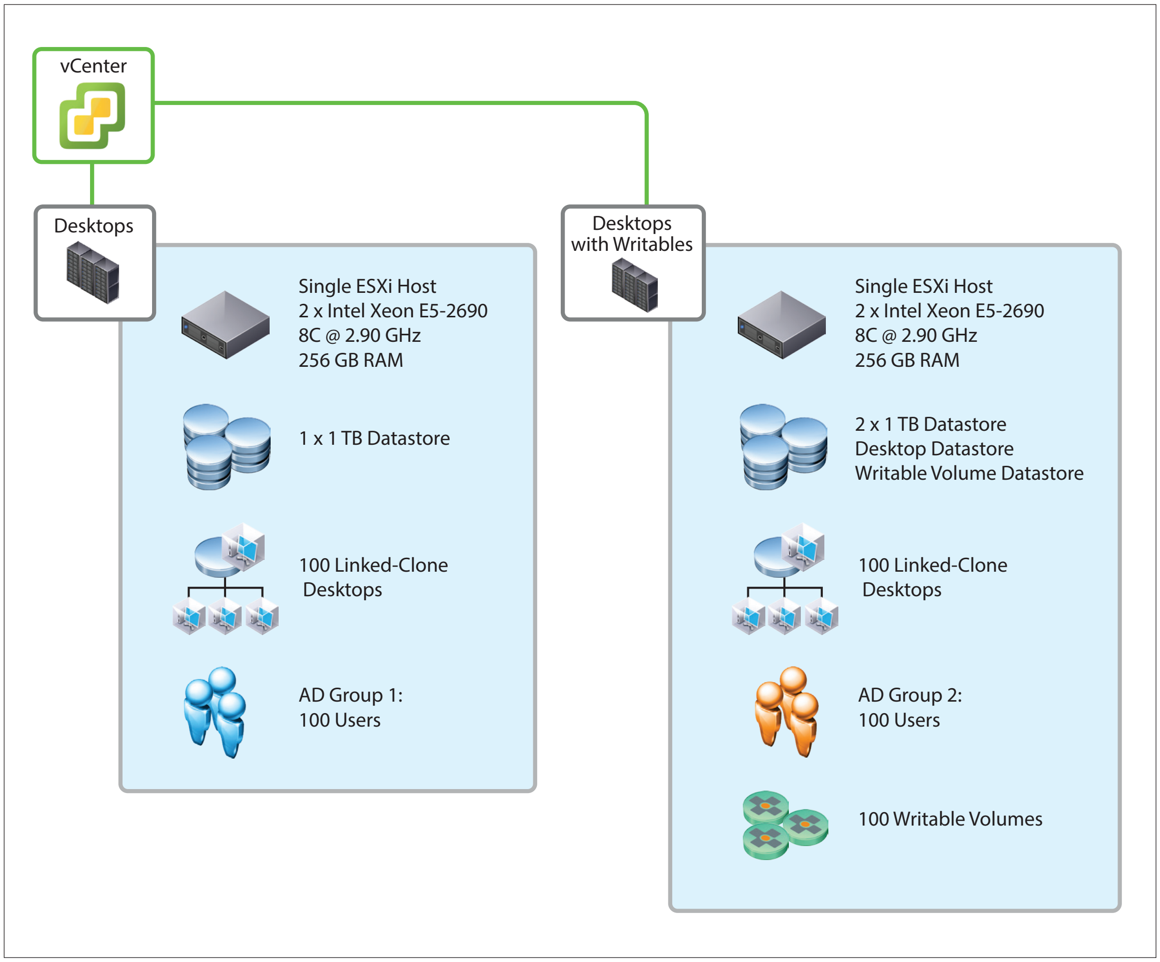


Figure 43: Linked-Clone Pools with and Without Writable Volumes

View Planner 3.5 was used to drive a medium workload on each linked-clone pool. The application latency results from both test runs are shown in Figure 44.

With writable volumes, the average increase in application latencies was 0.08 seconds, with a maximum observed difference of 0.48 seconds for one application task.

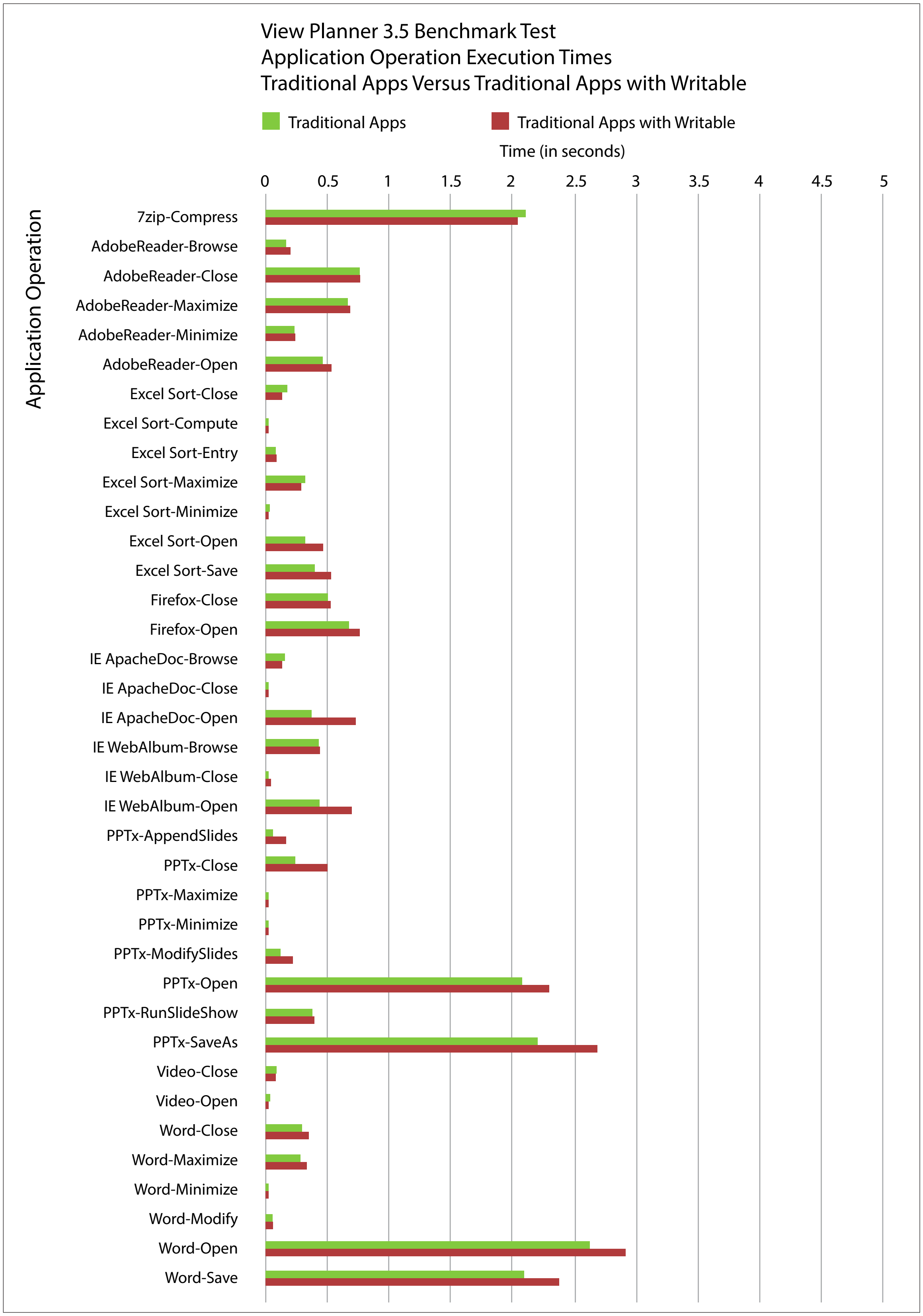


Figure 44: Writable Volumes Workload Test – View Planner Latency Comparison

Table 12 compares ESXi performance metrics for a pool of virtual desktops with and without writable volumes. The pool with writable volumes shows a slight increase in CPU usage (3 percent on average) but no difference in average memory consumed or average active memory usage.

	POOL 1 – TRADITIONAL DESKTOPS		POOL 2 – DESKTOPS WITH WRITABLE VOLUMES (DESKTOP DATASTORE)		POOL 2 – DESKTOPS WITH WRITABLE VOLUMES (WRITABLE VOLUMES DATASTORE)	
	Average	Maximum	Average	Maximum	Average	Maximum
CPU usage (MHz)	31,583 MHz	44,499 MHz	32,549 MHz	46,399 MHz		
Memory usage (consumed)	213 GB	213 GB	213 GB	213 GB		
Memory usage (active)	44 GB	79 GB	44 GB	77 GB		
Storage reads per second	769	6,172	756	6,844	9	249
Storage writes per second	379	1,660	318	1,674	124	593
Storage read rate (KBps)	814	15,809	694	16,246	240	5220
Storage write rate (KBps)	2,613	24,748	1,674	9,621	1,107	14,810

Table 12: Workload Testing – Linked Clones with and Without Writable Volume

Operations Testing

One hundred writable volumes were created from the App Volumes Manager console. The writable volume VMDKs are thin-provisioned and stored in the same datastore as the writable volumes template VMDK. It took just under 10 minutes to create the 100 writable volumes, with 806 maximum reads per second and 858 maximum writes per second.

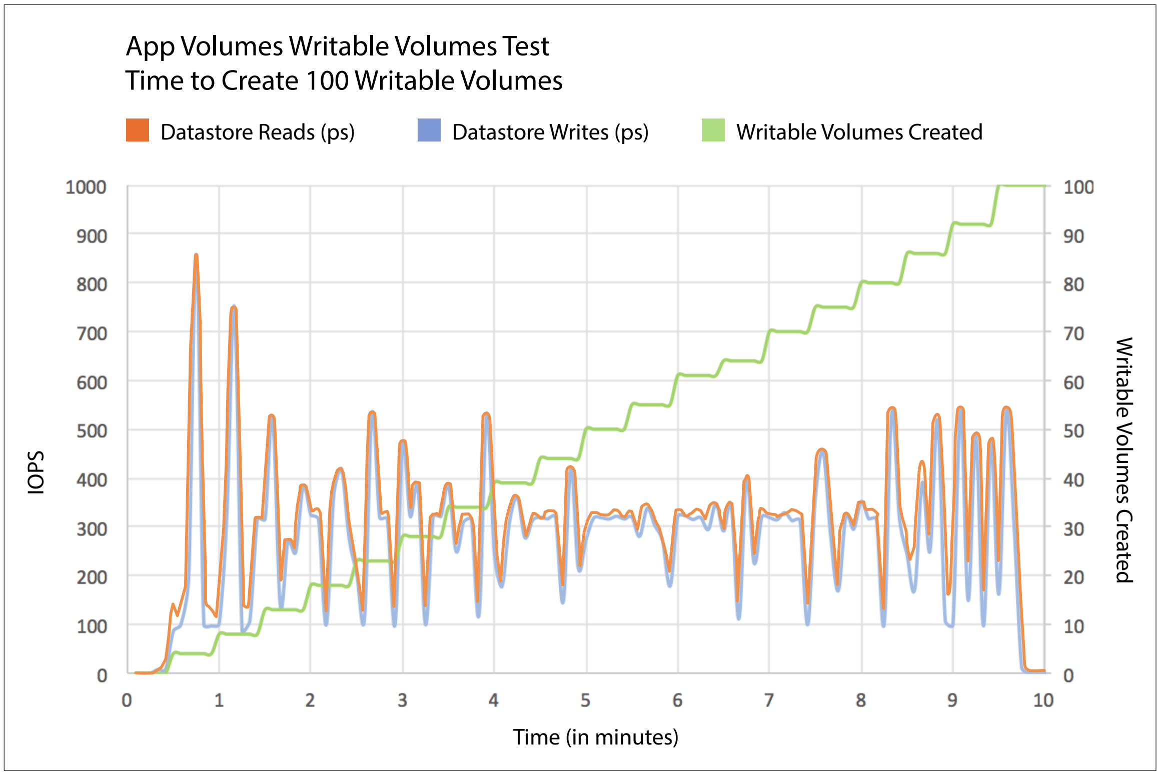


Figure 45: Time to Create Writable Volumes Against IOPS

	AVERAGE	MAXIMUM
Reads per second	305	806
Writes per second	296	858
Read rate (KBps)	16,062	49,490
Write rate (KBps)	12,028	46,275

Table 13: Datastore Metrics for Creation of 100 Writable Volumes

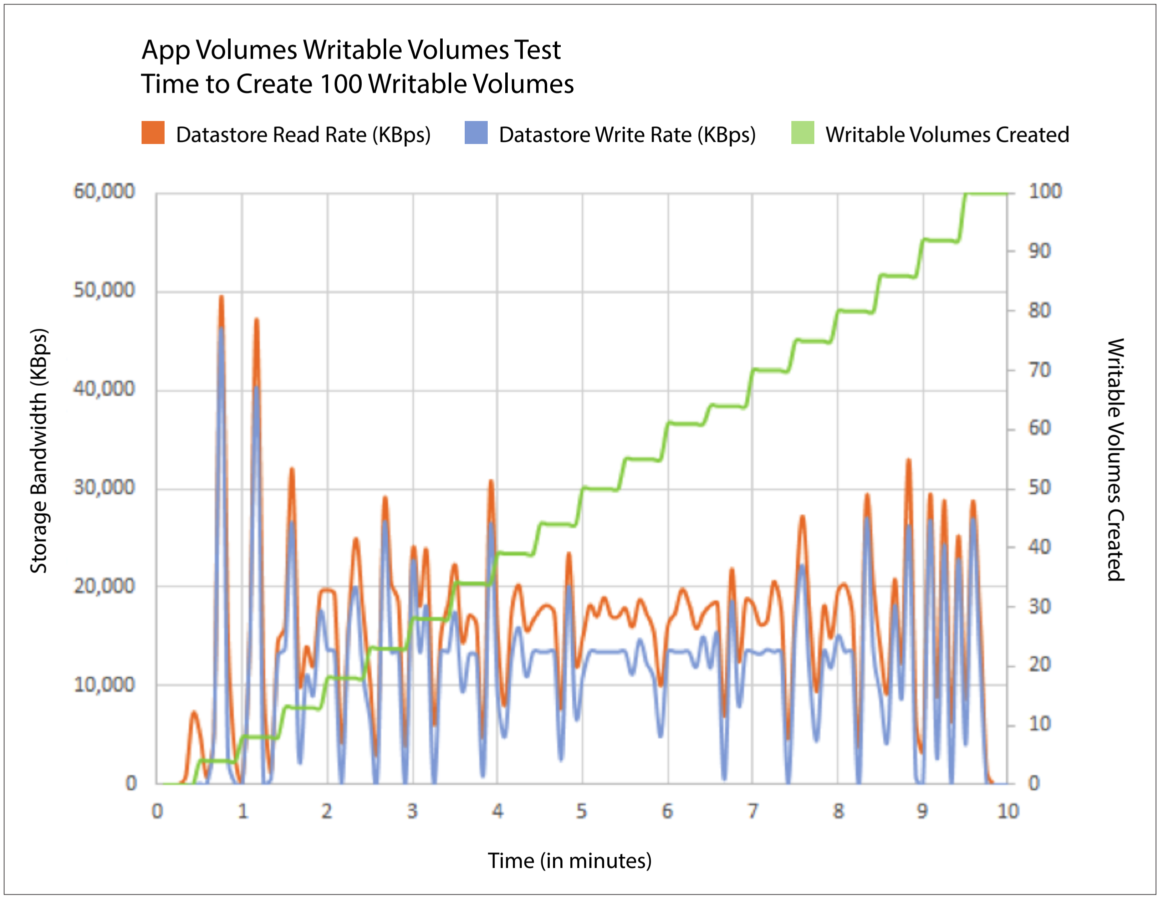


Figure 46: Time to Create Writable Volumes Against Write Rate

Writable Volumes Test Findings

Using writable volumes for profile data did not introduce significant CPU or memory overhead on the ESXi host. There was a small penalty in application response times, but this was an average of 0.08 seconds across all View Planner workload operations.

The maximum IOPS for a single writable volume was 2.5 reads and 6 writes during workload testing, including login.

System Configuration

The following section describes the virtual infrastructure sizing and configuration.

vCenter Server

vCenter Server manages the ESXi hosts, vSphere clusters, virtual networking, Virtual SAN and local datastores, and the provisioning of virtual machines. For automated testing with View Planner, a single vCenter Server can manage both the management cluster and the desktop clusters. In production implementations, however, VMware recommends deploying an additional vCenter Server to separate the management of server and desktop workloads. Ideally, a vCenter Server running on an existing vSphere platform manages the management block, and another vCenter Server running in the management block manages the desktop block.

The vCenter Server was sized to accommodate server workloads and up to 2,000 virtual desktops. For concurrent provisioning and high availability, deploy multiple vCenter Servers.

ATTRIBUTE	DESCRIPTION
OS	Windows Server 2012 R2
vCPU	4 vCPUs
vRAM	24 GB
Storage	100 GB

Table 14: vCenter Server Configuration

vSphere Cluster Configuration

Table 15 lists the vSphere clusters.

CLUSTER	NUMBER OF HOSTS	DESCRIPTION	HA	DRS
Management	2	Contains all server workload virtual machines.	Enabled (default settings)	Enabled (default settings)
Desktop	7	Contains linked-clone virtual desktops created by View 700 users and 100 virtual machines per host		Enabled (default settings)
RDSH	2	Contains all RDSH servers 260 users and 32 sessions per RDSH		

Table 15: vSphere Clusters

ESXi Configuration

This architecture used standard rack mount servers with dual-socket Intel Xeon 8-core, E5 2.9 GHz, E5 v2 12c 2.7 GHz CPUs, and 256 GB RAM with ESXi version 5.5. The RDSH and management servers used the 2.9 GHz hosts, and the virtual desktop cluster used the 2.7 GHz hosts.

VMware performance and system tests were used to size the hosts for this reference architecture.

In testing RDSH and virtual desktops, the same View Planner medium workload tests were run on each pool.

CPU Sizing – Virtual SAN and Virtual Desktops

DESKTOP PERFORMANCE METRIC	RECORDED VALUE
Average number of CPUs per physical desktop system	1
Average CPU utilization per physical desktop system	350 MHz
vCPU overhead	10%
ATTRIBUTE	**SPECIFICATION**
Number of CPUs (sockets) per host	2
Number of cores per CPU	12
GHz per CPU core	2.7 GHz
Total GHz per CPU	32.4 GHz
Total CPU GHz per host	64.8 GHz
Virtual SAN overhead	10%
Proposed maximum host CPU utilization	80%
Available CPU GHz per host	46.65 GHz
Virtual machines per host	~100

Table 16: ESXi CPU Sizing – Virtual SAN and Linked Clones

CPU Sizing – RDSH Hosts

Based on VMware testing and experience from field deployments, a CPU over-commitment of 2:1 is recommended. This specification means that a two-CPU, eight-core host with 16 physical cores can support up four vCPU RDSH hosts on a single ESXi server—approximately 32–35 RDSH medium workload sessions (more than eight users per core).

The View Planner medium workload passed for 130 sessions per ESXi host, and even for 140 users per host, although CPU was at 100 percent usage for some sustained intervals during the 140-session test run. This reference architecture focuses on the 130 session results, to compare the performance characteristics of AppStacks to Traditional Apps.

ATTRIBUTE	SPECIFICATION
CPUs per desktop	1
Average CPU utilization per desktop	350 MHz
vCPU overhead	10%
Number of CPUs (sockets) per ESXi	2
Number of cores per ESXi CPU	8
GHz per ESXi CPU core	2.9 GHz
Total GHz per ESXi CPU	23.2 GHz
Total CPU GHz per ESXi	46.4 GHz
Proposed maximum host CPU utilization	80%
Available CPU GHz per ESXi	37.12 GHz

Table 17: ESXi CPU Sizing – RDSH Servers

Memory Sizing – Virtual SAN and Virtual Desktops

Each desktop was allocated 2 GB RAM, with no over-commitment and no memory reserved. In View deployments, most Windows 7 x86 virtual desktops have between 1–2 GB RAM.

ATTRIBUTE	SPECIFICATION
Total amount of RAM per virtual desktop	2048 MB
Memory reservation	0%
Display resolution	1920 x 1600 (1 monitor)
Memory overhead per virtual desktop	41 MB
Total RAM required for desktop virtual machines	204 GB
Virtual SAN memory overhead	5 GB[1]
Amount of memory required per host	209 GB
Proposed maximum host memory usage	80%
Total amount of RAM per host	256 GB

Table 18: ESXi Memory Sizing – Virtual SAN and Linked Clones

1. This is a liberal estimate, based on the number of disks in the test configuration (single disk group 6 MDDs).

Memory Sizing – RDSH Servers

RDSH workloads vary in memory requirements, depending on the application workload, ranging from approximately 500 MB to 1 GB. For the medium workload testing, 1 GB was allocated with the expectation that usage would be lower—512 MB RAM per session could have been adequate.

ATTRIBUTE	SPECIFICATION
Total amount of RAM per RDSH session	512 MB
Total number of sessions per RDSH server	32
Total RAM required per RDSH server	16 GB
Number of RDSH sessions per ESXi host	4
Memory overhead per virtual desktop session	41 MB
Total RAM required per ESXi host	64 GB
Minimum RAM required per host (including overhead)	97 GB
Total RAM allocated per RDSH server (1 GB per session plus overhead)	129 GB
Proposed maximum host memory usage	80%
Total amount of RAM per host	256 GB

Table 19: ESXi Memory Sizing – RDSH Servers

Network Configuration

A single vSphere Distributed Switch (vDS) was created for virtual networking between the management and desktop clusters. Each ESXi had two 10GbE uplinks, each to a separate Dell 10GbE switch for resiliency.

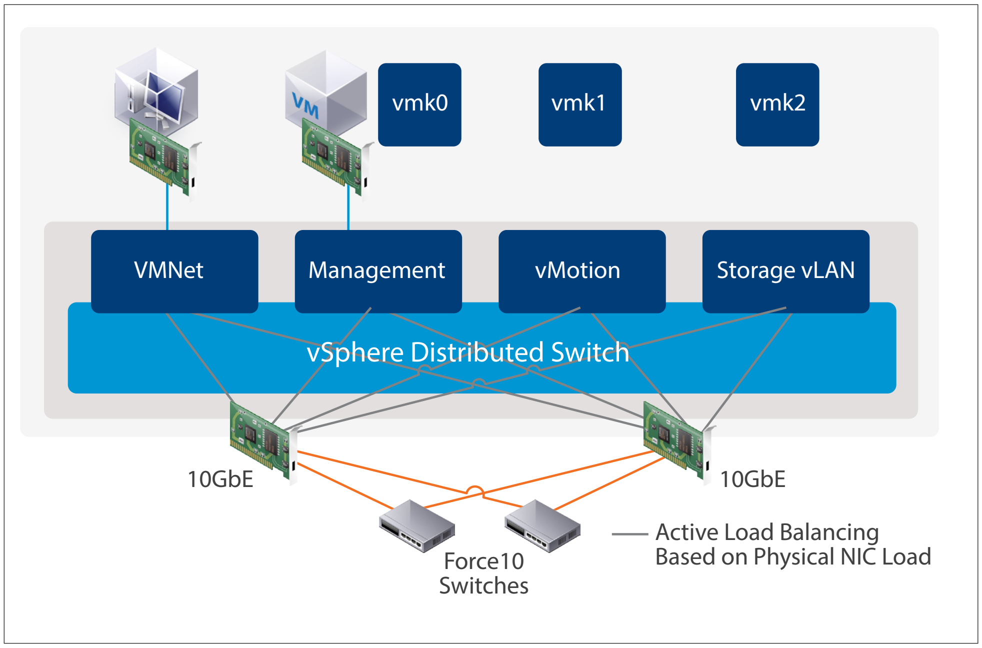


Figure 47: vDS Configuration

Four VLANs were used for network traffic, with a port group created for each VLAN on the vDS. The virtual machine port groups were:

- **dvPG-Management** – Network for ESXi management
- **dvPG-VMNET** – Network for virtual machines
- **dvPG-Storage** – Network for Virtual SAN traffic
- **dvPG-vMotion** – Network for VMware vSphere vMotion® traffic for migrating running virtual machines to other ESXi hosts

Network I/O Control (NIOC) was enabled on the vDS to ensure that all tenants received their fair share of network I/O resources. Jumbo frames were configured on physical and virtual switches for vSphere vMotion and storage traffic.

PROPERTY	SETTING	DEFAULT	REVISED
General	Port binding	Static	–
Policies: Security	Promiscuous mode	Reject	–
	MAC address changes	Accept	Reject
	Forged transmits	Accept	Reject
Policies: Traffic Shaping	Status	Disabled	–
Policies: Teaming and Failover	Load balancing	Route based on the originating virtual port ID	Route based on physical NIC load
	Failover detection	Caution Link Status only	–
	Notify switches	Yes	–
Policies: Resource Allocation	Network I/O Control	Disabled	Enabled
Advanced	Maximum MTU	1500	9000

Table 20: vDS Configuration

View

View provides access to and management of virtual desktops, RDSH desktops, and RDSH applications. In this reference architecture, View was sized and configured to provision 700 stateless desktops and 260 RDSH desktops.

A View virtual desktop is accessed from a Horizon Client installed on an end-user device, which connects to View security servers for external access or View Connection Servers for internal access.

- View Connection Servers broker View connections to RDSH sessions and desktops running on vSphere ESXi hosts.
- View Administrator and vCenter Server provide ESXi host and virtual machine management functions.
- View Composer provides linked-clone management.
- App Volumes provides application delivery.
- vRealize Operations is responsible for health and performance monitoring.

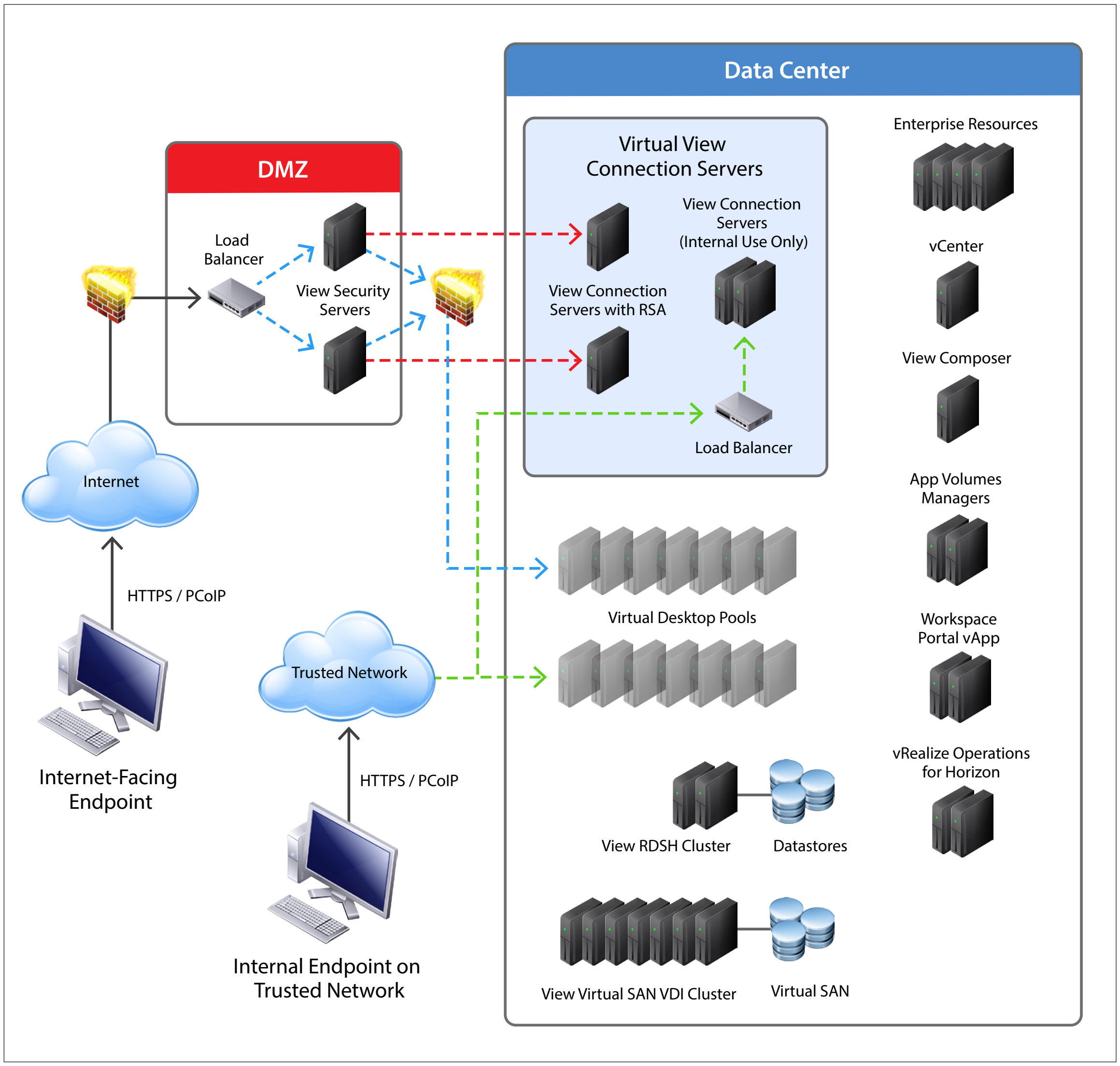


Figure 48: View Configuration

View Connection Servers handle AD authentication and broker connections to virtual desktops and RDSH desktops over PCoIP. For external users, the View security server forwards PCoIP traffic to the desktop session. For internal users, the client is connected directly to the desktop session.

If a desktop is not available, View Connection Server can automatically provision additional desktops through vCenter Server. Entitling users or a group to preconfigured pools of desktops in View Administrator enables automatic provisioning. View Composer minimizes storage requirements by using linked clones for virtual desktops.

View Connection Servers and security servers are installed in the management block. A View pod can support up to seven View Connection Servers, not to exceed 10,000 concurrent sessions, and up to four View security servers per View Connection Server.

The recommended deployment is one vCenter Server per desktop block, along with a single instance of View Composer. View Composer can be installed in standalone mode or on a vCenter Server.

COMPONENT	QUANTITY	OS	vCPU	VRAM	HDD
View Connection Server	4 (2 internal, 2 external)	Windows 2012 R2	4	16	50 GB
View security server	2 (2 per external View Connection Server)	Windows 2012 R2	4	16	40 GB
View Composer	1	Windows 2012 R2	4	16	40 GB

Table 21: View VM Hardware Specifications

View Global Policies and Settings

Workspace was the delegated authentication mechanism for View. The SAML authenticator was set to the externally facing fully qualified domain name (FQDN) of the Workspace Gateway load balancer IP address.

View Accelerator was enabled with a 2 GB host cache. The default number of View Composer and vCenter provisioning and maintenance operations was increased from the default values to the settings below.

ATTRIBUTE	SPECIFICATION
Description	View vCenter Server
Connect using SSL	Yes
vCenter port	443
View Composer port	18443
Enable View Composer	Yes
Advanced settings: • Maximum Concurrent vCenter Provisioning Operations • Maximum Concurrent Power Operations • Maximum Concurrent View Composer Maintenance Operations • Maximum Concurrent View Composer Provisioning Operations	 30 50 30 30
Storage settings: • Enable View Storage Accelerator • Default Host Cache Size	 √ 2048 MB

Table 22: View vCenter Settings

View Manager Pool Settings

Two desktop pools were created in the View Administrator, one for linked clones and one for RDSH servers.

Linked-Clone Desktop Pool

An automated floating desktop pool with 700 Windows 7 linked-clone desktops was provisioned with View Composer to enable load testing. No persistent disk or disposable disks were used. Replica and OS disks were stored on the Virtual SAN datastore. The default settings were used for the advanced storage options.

The following View Manager pool settings were used for the *Linked-Clone* pool.

ATTRIBUTE	SPECIFICATION
Pool Type	Automated Pool
User Assignment	Floating
Pool Definition – vCenter Server	Linked Clones
Pool ID	Desktops
Display Name	Desktops
View Folder	/
Remote Desktop Power Policy	Take no power action
Auto Logoff Time	Never
User Reset Allowed	False
Multi-Session Allowed	False
Delete on Logoff	Never
Display Protocol	PCoIP
Allow Protocol Override	False
Maximum Number of Monitors	1
Maximum Resolution	1920 x 1200
HTML Access	Not selected
Flash Quality Level	Do not control
Flash Throttling Level	Disabled
Enable Provisioning	Enabled
Stop Provisioning on error	Enabled
Provision all desktops up-front	Enabled
Disposable File Redirection	Do not redirect
Use VMware Virtual SAN	Enabled
Use View Storage Accelerator	Selected

ATTRIBUTE	SPECIFICATION
Disk Types	OS disks
Reclaim VM disk space	N/A
Regenerate Storage Accelerator after	7 days
Reclaim VM Disk Space	N/A
Use QuickPrep	Enabled

Table 23: View Linked-Clone Pool Settings

RDSH Desktop Pool

Eight Windows servers were cloned from the same template and configured as RDSH session hosts. An RDSH farm was created using the RDSH servers and used to back the RDSH desktop pool in View.

PCoIP was configured as the connection protocol for the 260 desktop sessions. All other pool and farm configuration options were left at default.

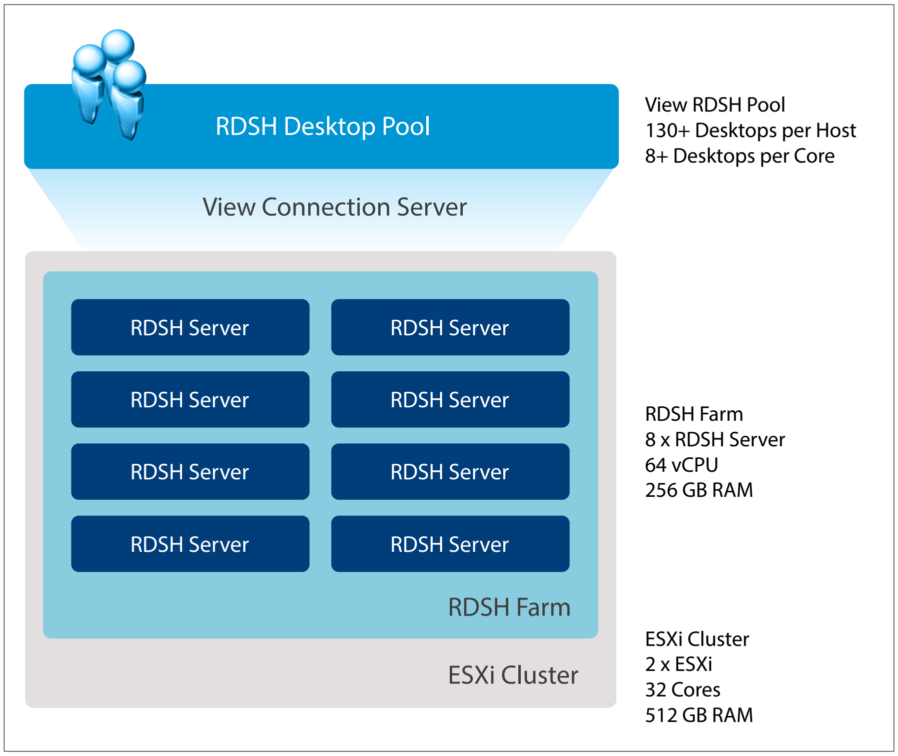


Figure 49: RDSH Farm

App Volumes

App Volumes presents applications, data files, environment settings to View virtual desktops and RDSH servers as read-only containers known as AppStacks. AppStacks are assigned from the Web-based App Volumes Manager, which is also integrated with Active Directory for application entitlements. AppStacks are stored in shared volumes accessible by a pool of desktops running the App Volumes Agent. App Volumes Manager delivers the AppStacks to the desktop or to the chosen user or group. For end users, applications delivered by App Volumes appear and perform as if they were natively installed. Applications follow users across sessions and devices. Data can also optionally follow that user. IT can update or replace applications in real time and can also quickly remove assigned applications. App Volumes also allows user data (profile, settings, files, and user-installed apps) to be stored in a container known as a writable volume, which can move with the user.

The App Volumes deployment configuration and relevant network ports are shown in Figure 50.

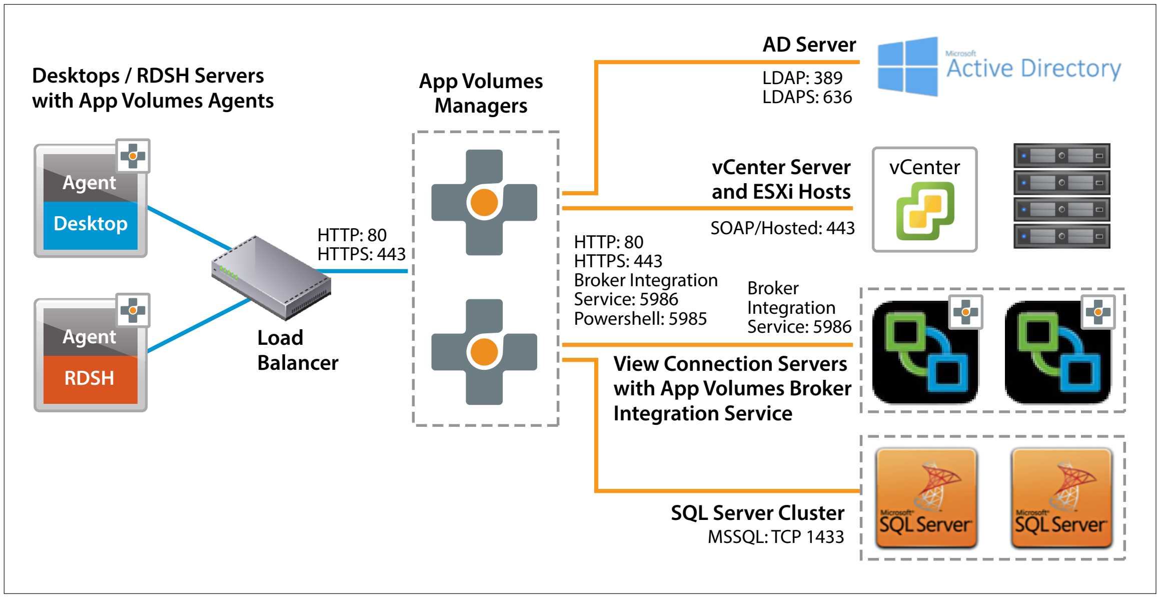


Figure 50: App Volumes Deployment

The App Volumes deployment consists of the following components:

- **App Volumes Manager** – A Windows server used to administer configuration, provisioning, and assignment of AppStacks and writable volumes. It also serves as a broker for AppStack and writable volume assignment during desktop or RDSH server startup or login.
- **App Volumes Agent** – Software installed on all desktops and RDSH servers that runs as a service. It uses a filter driver to handle application calls and file system redirects to AppStacks and writable volumes.
- **App Volumes Broker Integration Service** – An optional component that can be installed on each View Connection Server to reduce user login time for View desktop pools by attaching volumes to virtual machines prior to user login. The broker was installed for testing.
- **Active Directory** – App Volumes uses Active Directory to assign AppStacks to user or computer accounts or AD groups. An AppStack cannot be attached to a computer and a logged-in user simultaneously—only one is possible at a time, and machine accounts take precedence. Writable volumes are assigned to an AD user account or AD group, one writable volume per user.
- **SQL Server** – App Volumes Manager is stateless and stores all configuration information in a remote SQL database in which each App Volumes Agent machine is cataloged by an identifier and BIOS_UUID. The BIOS_UUID matches the one used in the vCenter database. A clustered SQL Server is recommended for production deployments.

- **vCenter and ESXi hosts** – App Volumes Manager connects to vCenter and uses BIOS_UUID for all VM reconfigure operations. Through Direct Connect, it is possible to bypass vCenter and issue mount commands directly to the ESXi host to speed up operations. Direct Connect was enabled throughout testing.
- **Load Balancer** – A load balancer can be introduced for production deployments to distribute HTTP and HTTPS requests efficiently across two or more App Volumes Manager servers.

App Volumes Manager has a default timeout of 3 minutes for VM reconfigure operations. This value was found to be insufficient for some of the more intensive tests, such as boot storm testing. The VM reconfigure task timeout was increased to 600 for testing by creating a new environment variable *CV_RECONFIG_TIMEOUT* on *each* App Volumes Manager server and restarting the App Volumes Manager service. This was the only change made from the default settings.

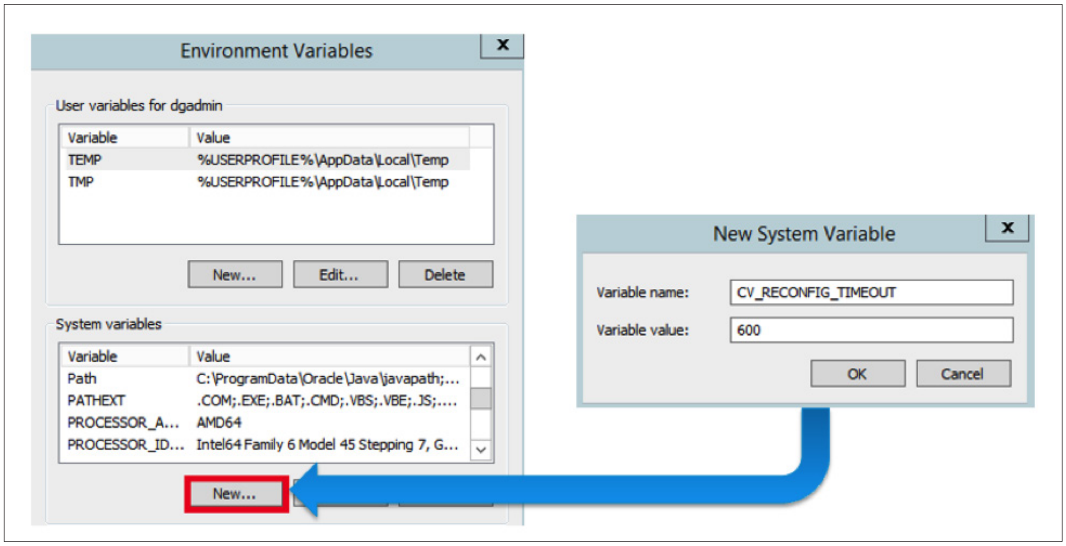


Figure 51: Reconfiguring the App Volumes Manager Timeout

Storage for Virtual SAN

Virtual SAN was used as storage for the linked-clone desktop pool.

Each ESXi host in the desktop cluster had the same configuration, and all disks were presented directly to the ESXi host and not configured in a RAID group.

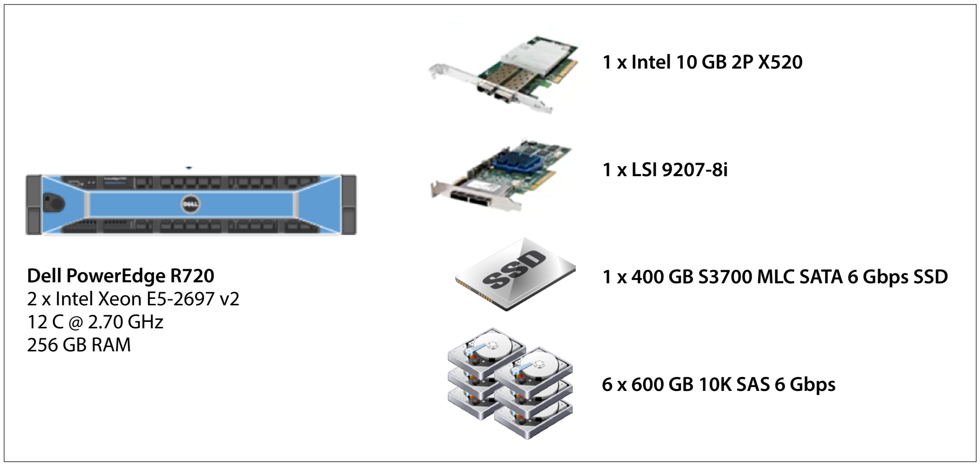


Figure 52: Virtual SAN Cluster ESXi Configuration

A single disk group was created on each ESXi, using one Intel S3700 400 GB SSD and six 600 GB HP 10 K SAS disks. This configuration was validated for a medium or office worker View Planner workload. For heavier workloads, 15 K disks are recommended, and additional disk groups per server might be required.

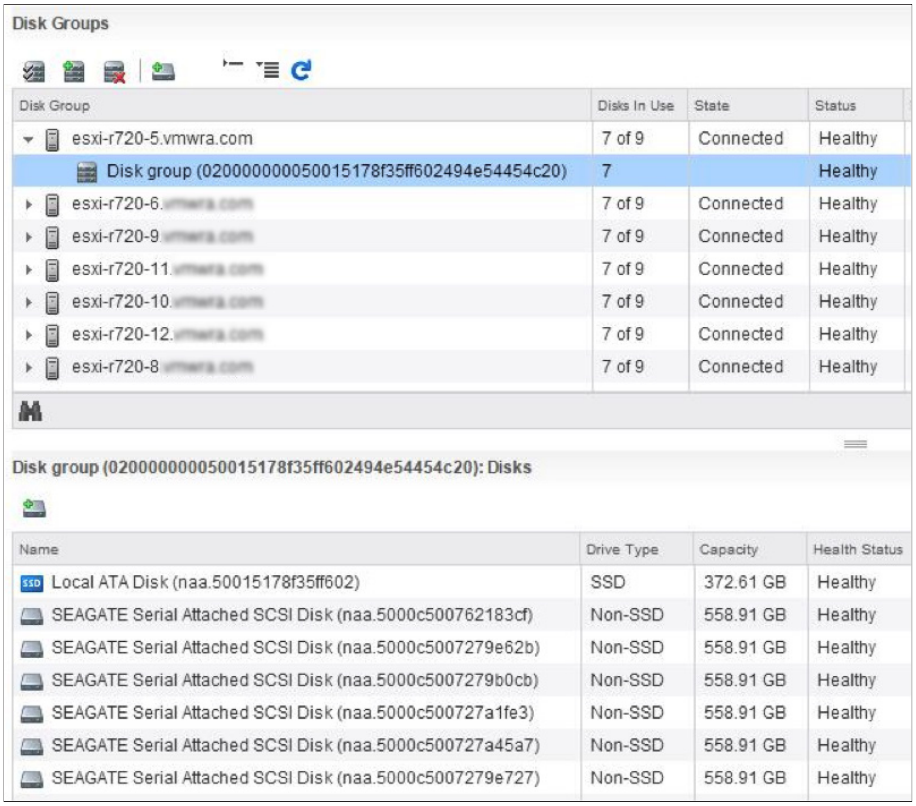


Figure 53: Virtual SAN Disk Group

Collectively, the seven disk groups combined to form a Virtual SAN datastore of 22.92 TB.

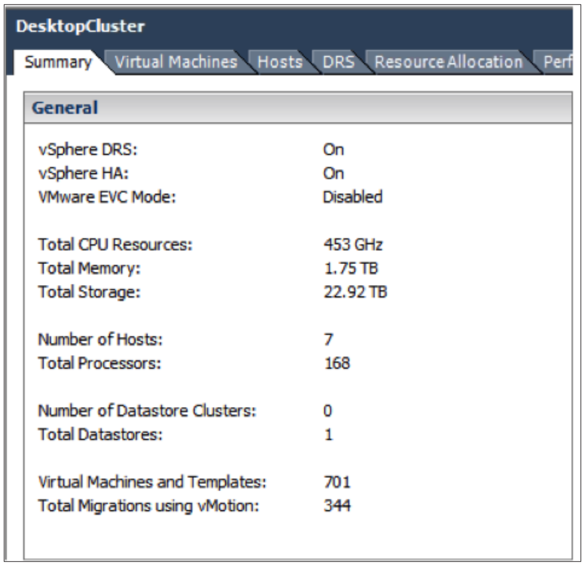


Figure 54: Virtual SAN Cluster Resources

Virtual SAN Sizing

The recommended sizing for the SSD is 10 percent of the total consumed storage capacity, excluding FTT. For a pool of 700 linked-clone desktops that is expected to use 5 GB of disk space per virtual desktop, the figures would be:

10% (700 x 5) = 350 GB flash per cluster

For this particular configuration, the minimum recommended SSD size is 50 GB per host. Only magnetic disks count toward cluster capacity. The formula for cluster capacity is:

Num_hosts x Num_disk_groups x Num_disks_per_group x disk_size

For the test configuration, the formula for usable capacity was:

7 x 1 x 6 x 558 GB = 22.92 TB

Objects and Components

Each virtual machine deployed to a Virtual SAN datastore consists of the following set of objects.

VIRTUAL SAN OBJECTS	OBJECT TYPE
VM Name Homespace	VMX file, VM logs, CBRC digest
Virtual Disk File	OS disk, AppStack VMDK, writable volumes
Virtual Disk Snapshots	VM Snapshot, AppStack Redo log (when assigned, VM is powered on)
VM Swap	(When VM is powered on)

Table 24: Virtual SAN Objects and Components

Each object consists of components, the number of which is determined by the storage policy. vSphere can set availability, capacity, and performance policies for each virtual machine deployed on the Virtual SAN datastore.

VIRTUAL SAN STORAGE POLICY CAPABILITIES	DESCRIPTION
Number of disks striped per object	Number of HDDs across which each VM is striped
Flash read cache reservation (%)	SSD capacity reserved as read cache for the virtual machine object
Number of failures to tolerate (FTT)	Number of host, disk, or network failures a virtual machine object can tolerate. Maximum FTT=3
Object space reservation	Percentage of the logical size of the object reserved, expressed as a percentage of the logical size of the object

Table 25: Virtual SAN Storage Policy Capabilities

To satisfy storage policy object availability requirements, Virtual SAN can maintain multiple copies or replicas of the virtual machine objects. The FTT value determines the number of replicas that are created. For n failures tolerated, $n+1$ copies of the virtual machine object are created, and $2n+1$ hosts with storage are required.

Virtual SAN witnesses are part of every storage object that has an FTT value greater than 0. A witness does not contain data, but it serves as a tiebreaker during availability decisions in the Virtual SAN cluster. Table 26 lists the number of replicas, witnesses, and components required to maintain availability.

NUMBER OF FAILURES TO TOLERATE	COMPONENT COUNT	NUMBER OF HOSTS NEEDED	COMPONENT TYPES
0	1	1	1 Replica
1	3	3	2 Replicas plus 1 Witness
2	5	5	3 Replicas plus 2 Witnesses
3	7	7	4 Replicas plus 3 Witnesses

Table 26: Virtual SAN FTT Requirements

View has predefined storage policies that can be leveraged when a new desktop pool is created. Different types of desktop pool take different storage policies with varying capabilities.

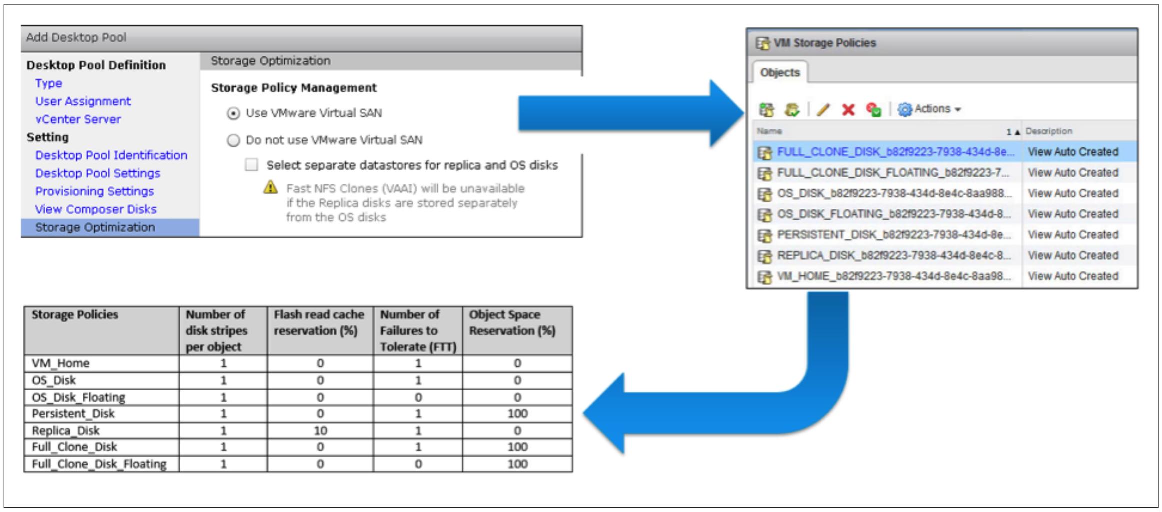


Figure 55: View Virtual SAN Storage Policy Integration

For View, a *replica* disk is a critical virtual machine that all linked clones in a linked-clone desktop pool point to for their OS reads. View replicas have their own storage policy of FTT=1, which results in two Virtual SAN replicas of the VMDK and a witness component.

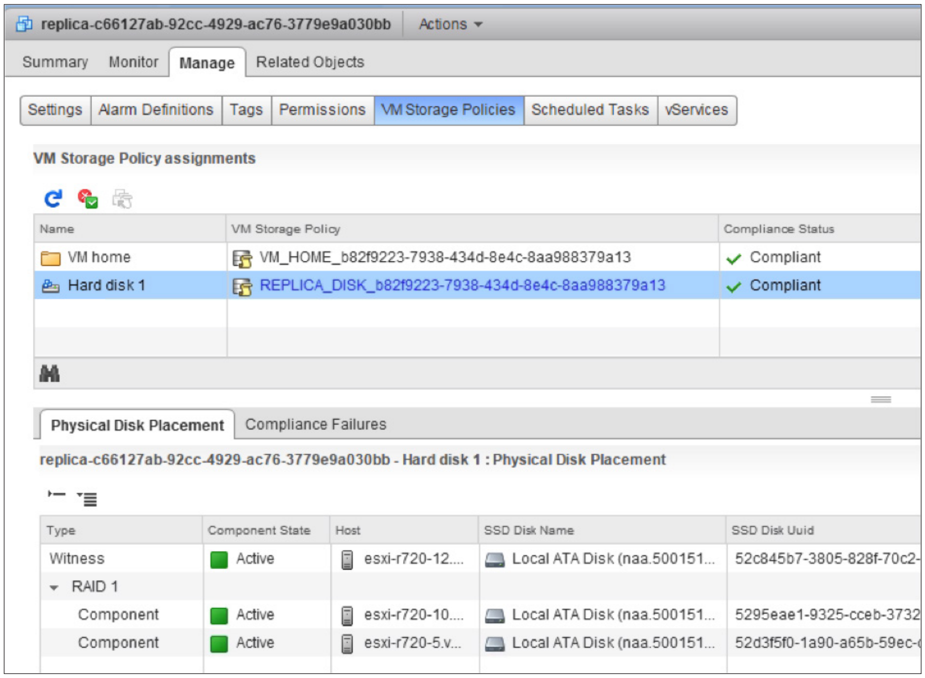


Figure 56: Virtual SAN Failures to Tolerate – Replica Disk

In a pool of floating linked clones, FTT=0 for the virtual desktop OS disks. This setting provides no redundancy but consumes the minimum amount of disk space. In the event of a hardware failure, the virtual desktop becomes unavailable, but a user can log in to an available virtual machine within a matter of seconds and have access to profile data through writable volumes or View Persona.

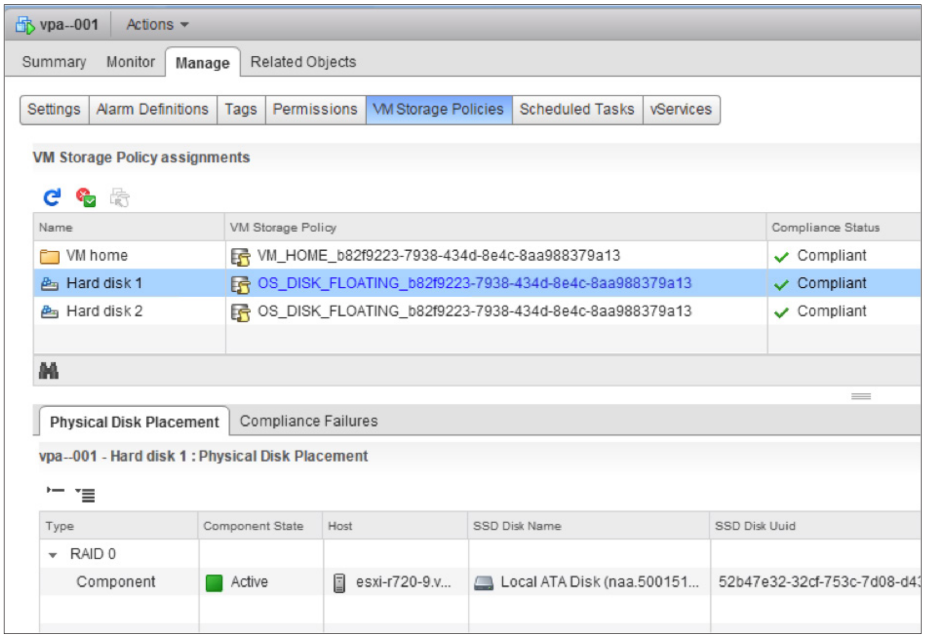


Figure 57: Virtual SAN Failures to Tolerate – Floating Linked-Clone OS Disk

The number of objects per virtual machine, in addition to their performance and availability requirements, dictates the number of components to be created. Virtual SAN supports a maximum of 3,000 components per host, and 100 virtual machines per ESXi.

App Volumes AppStacks and writable volumes contribute to the number of components per host. The default storage policy for Virtual SAN objects is FTT=1, as shown below. It applies to all AppStacks and writable volumes created on the Virtual SAN datastore.

```
/~ # esxcli vsan policy getdefault
Policy Class     Policy Value
------------     -------------------------------------------------------------
Cluster          ((“hostFailuresToTolerate” i1))
Vdisk            ((“hostFailuresToTolerate” i1))
vmnamespace      ((“hostFailuresToTolerate” i1))
vmswap           ((“hostFailuresToTolerate” i1) (“forceProvisioning” i1))
/~ #
```

AppStacks are mounted on each desktop as independent, non-persistent disks. The resulting redo log shows three components per AppStack mounted on each desktop. For example, 700 desktops x 5 AppStacks x 3 components = 10,500 components per cluster.

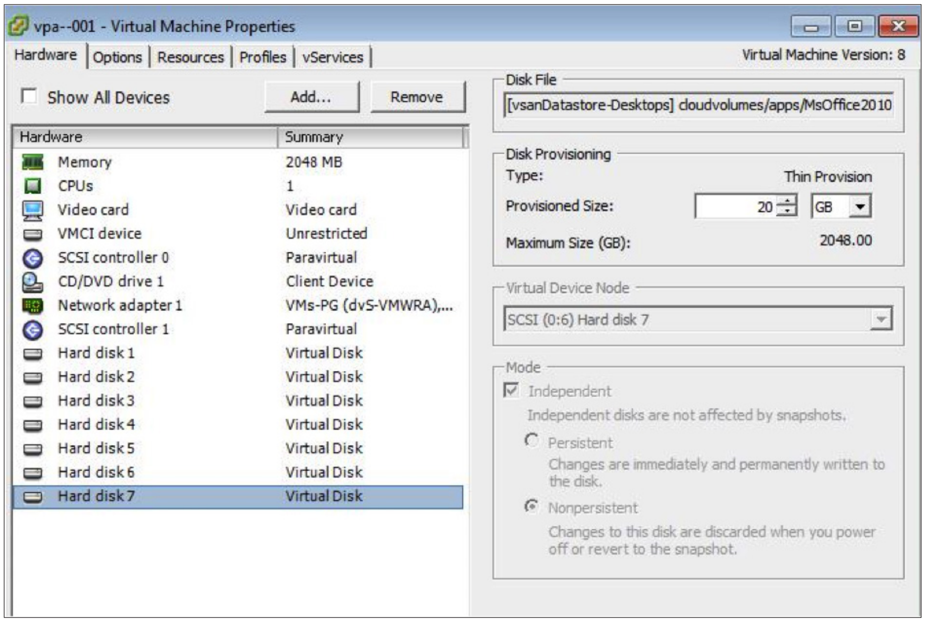


Figure 58: Desktop with App Volumes AppStack Attached

Writable volumes are persistent. This results in just three components per writable volume. For example, 700 virtual desktops with writable volumes attached = 2,100 components per cluster.

The maximum number of AppStacks and writable volumes that can be assigned to desktops on Virtual SAN can be derived from the default Virtual SAN storage policies in View and the type of desktop pool deployed.

USER ASSIGNMENT	VIRTUAL MACHINE TYPE	DISPOSABLE DISK	PERSISTENT DISK	COMPONENTS	MAXIMUM NUMBER OF APPSTACKS OR WRITABLE VOLUMES PER DESKTOP
Floating	Linked Clone	N	N	Replica 9 Desktop 9	6 AppStacks or 5 AppStacks plus 1 writable volume
Floating	Linked Clone	Y	N	Replica 9 Desktop 11	6 AppStacks or 5 AppStacks plus 1 writable volume
Dedicated	Linked Clone	Y	Y	Replica 9 Desktop 24	1 AppStack or 1 writable volume
Dedicated	Linked Clone	N	Y	Replica 9 Desktop 18	3 AppStacks or 2 AppStacks plus 1 writable volume
Dedicated	Linked Clone	Y	N	Replica 9 Desktop 21	2 AppStacks or 1 AppStack plus 1 writable volume
Floating	Full Clone			Desktop 7	7 AppStacks or 6 AppStacks plus 1 writable volume
Dedicated	Full Clone			Desktop 9	6 AppStacks or 5 AppStacks plus 1 writable volume

Table 27: Maximum Number of App Volumes AppStacks or Writable Volumes per View Pool Type

Note: Adjusting the default Storage Policy-Based Management policies alters the component counts listed in Table 27.

Taking the test configuration as an example, 700 floating linked-clone virtual desktops were provisioned, with no disposable disk and no persistent disk.

The total number of components for the pool of 700 virtual machines is:

replica (9) + linked clones (700 x 9) = 6309 per cluster

```
/vcenter.vmwra.com/RA-DC/computers> vsan.check_limits DesktopCluster/
+------------------------+---------------------+-------------------------+
| Host | RDT | Disks |
+------------------------+---------------------+-------------------------+
| esxi-r720-5.vmwra.com | Assocs: 2869/20000 | Components: 901/3000 |
| | Sockets: 1565/10000 | naa.5000c500762183cf: 3% |
| | Clients: 517 | naa.5000c5007279b0cb: 3% |
| | Owners: 519 | naa.5000c5007279e727: 3% |
| | | naa.5000c500727a1fe3: 3% |
| | | naa.5000c5007279e62b: 3% |
| | | naa.50015178f35ff602: 0% |
| | | naa.5000c500727a45a7: 3% |
| esxi-r720-6.vmwra.com | Assocs: 2815/20000 | Components: 900/3000 |
| | Sockets: 1577/10000 | naa.5000c500727622e7: 3% |
| | Clients: 502 | naa.5000c500761f128b: 5% |
| | Owners: 500 | naa.50015178f360b5f9: 0% |
| | | naa.5000c50076218b33: 3% |
| | | naa.5000c50072742703: 3% |
| | | naa.5000c500727a3f6f: 3% |
| | | naa.5000c5007621cf53: 3% |
| esxi-r720-9.vmwra.com | Assocs: 2699/20000 | Components: 902/3000 |
| | Sockets: 1485/10000 | naa.5000c50072762077: 3% |
| | Clients: 472 | naa.5000c5007279fed7: 3% |
| | Owners: 477 | naa.50015178f35f55fb: 0% |
| | | naa.5000c50072761167: 3% |
| | | naa.5000c50076217437: 3% |
| | | naa.5000c5007279e77b: 4% |
| | | naa.5000c5007273311b: 3% |
| esxi-r720-11.vmwra.com | Assocs: 2881/20000 | Components: 902/3000 |
| | Sockets: 1587/10000 | naa.50015178f35ffb0d: 0% |
| | Clients: 522 | naa.5000c5007621de4f: 3% |
| | Owners: 516 | naa.5000c5007275fd07: 3% |
| | | naa.5000c5007279e5c3: 3% |
| | | naa.5000c50076217477: 3% |
```

```
|  |  | naa.5000c50072740beb: 3% |
|  |  | naa.5000c500727625bb: 3% |
| esxi-r720-10.vmwra.com | Assocs: 2926/20000 | Components: 901/3000 |
|  | Sockets: 1602/10000 | naa.5000c5007621cb13: 4% |
|  | Clients: 542 | naa.50015178f3604b1e: 0% |
|  | Owners: 526 | naa.5000c500727a269b: 5% |
|  |  | naa.5000c500727607c3: 2% |
|  |  | naa.5000c500727a1e8b: 4% |
|  |  | naa.5000c500762184b7: 3% |
|  |  | naa.5000c5007279bf7f: 3% |
| esxi-r720-12.vmwra.com | Assocs: 2658/20000 | Components: 901/3000 |
|  | Sockets: 1474/10000 | naa.5000c5007275ed5f: 3% |
|  | Clients: 462 | naa.5000c5007272dc5b: 4% |
|  | Owners: 463 | naa.5000c5007622dfd7: 3% |
|  |  | naa.5000c5007621bccb: 3% |
|  |  | naa.5000c5007273461f: 4% |
|  |  | naa.5000c50076209fd3: 4% |
|  |  | naa.50015178f360b772: 0% |
| esxi-r720-8.vmwra.com | Assocs: 2810/20000 | Components: 902/3000 |
|  | Sockets: 1552/10000 | naa.5000c5007621d30b: 3% |
|  | Clients: 497 | naa.5000c5007275fbcb: 4% |
|  | Owners: 502 | naa.5000c5007622410b: 3% |
|  |  | naa.50015178f35f6b76: 0% |
|  |  | naa.5000c5007272dd6b: 3% |
|  |  | naa.5000c500727a30ab: 3% |
|  |  | naa.5000c500727a178b: 4% |
+------------------------+---------------------+--------------------------+
```

Based on this example, the maximum number of AppStacks and writable volumes that the configuration can accommodate is six AppStacks or five AppStacks plus one writable volume. Table 28 presents further details.

ITEM	DESCRIPTION	NUMBER OF COMPONENTS
Desktop pool	View replica (9) + linked clones (9=700 x 9)	6,309
App Volumes folder and subdirectories	\\vmfs\volumes\vsanDatastore\cloudvolumes\...	3
AppStack	5 AppStack VMDKs (5 x 3) plus AppStack redo log (700 x 15)	10,515
Writable volume	700 desktops x writable volume components (3)	2,100
AppStack template	1 x default AppStack template	3
Writable volume template	3 x default AppStack template	9
Total components	Cluster Host	18,939 2,705

Table 28: Linked-Clone Pool (No Disposable or Persistent Disk) with Maximum AppStacks

The total number of components per cluster is 18,939, or approximately 2,705 components per ESXi, which falls inside the maximum threshold of 3,000.

```
/vcenter.vmwra.com/RA-DC/computers> vsan.check_limits DesktopCluster/
+------------------------+---------------------+---------------------------+
| Host   | RDT   | Disks   |
+------------------------+---------------------+---------------------------+
| esxi-r720-5.vmwra.com | Assocs: 7531/20000 | Components: 2706/3000 |
|   | Sockets: 4527/10000 | naa.5000c500762183cf: 5% |
|   | Clients: 958 | naa.5000c5007279b0cb: 5% |
|   | Owners: 1163 | naa.5000c5007279e727: 3% |
|   |   | naa.5000c500727a1fe3: 5% |
|   |   | naa.5000c5007279e62b: 6% |
|   |   | naa.50015178f35ff602: 0% |
|   |   | naa.5000c500727a45a7: 4% |
| esxi-r720-6.vmwra.com | Assocs: 7541/20000 | Components: 2709/3000 |
|   | Sockets: 4623/10000 | naa.5000c500727622e7: 4% |
|   | Clients: 1088 | naa.5000c500761f128b: 7% |
|   | Owners: 1104 | naa.50015178f360b5f9: 0% |
|   |   | naa.5000c50076218b33: 5% |
|   |   | naa.5000c50072742703: 5% |
|   |   | naa.5000c500727a3f6f: 5% |
```

```
| | | naa.5000c5007621cf53: 5% |
| esxi-r720-9.vmwra.com | Assocs: 7362/20000 | Components: 2704/3000 |
| | Sockets: 4520/10000 | naa.5000c50072762077: 4% |
| | Clients: 998 | naa.5000c5007279fed7: 5% |
| | Owners: 1086 | naa.50015178f35f55fb: 0% |
| | | naa.5000c50072761167: 4% |
| | | naa.5000c50076217437: 11% |
| | | naa.5000c5007279e77b: 5% |
| | | naa.5000c5007273311b: 6% |
| esxi-r720-11.vmwra.com | Assocs: 7548/20000 | Components: 2705/3000 |
| | Sockets: 4570/10000 | naa.50015178f35ffb0d: 0% |
| | Clients: 969 | naa.5000c5007621de4f: 4% |
| | Owners: 1148 | naa.5000c5007275fd07: 4% |
| | | naa.5000c5007279e5c3: 12% |
| | | naa.5000c50076217477: 4% |
| | | naa.5000c50072740beb: 5% |
| | | naa.5000c500727625bb: 5% |
| esxi-r720-10.vmwra.com | Assocs: 7113/20000 | Components: 2706/3000 |
| | Sockets: 4403/10000 | naa.5000c5007621cb13: 4% |
| | Clients: 939 | naa.50015178f3604b1e: 0% |
| | Owners: 1023 | naa.5000c500727a269b: 6% |
| | | naa.5000c500727607c3: 4% |
| | | naa.5000c500727a1e8b: 5% |
| | | naa.5000c500762184b7: 4% |
| | | naa.5000c5007279bf7f: 6% |
| esxi-r720-12.vmwra.com | Assocs: 7407/20000 | Components: 2704/3000 |
| | Sockets: 4525/10000 | naa.5000c5007275ed5f: 5% |
| | Clients: 1089 | naa.5000c5007272dc5b: 4% |
| | Owners: 1071 | naa.5000c5007622dfd7: 5% |
| | | naa.5000c5007621bccb: 5% |
| | | naa.5000c5007273461f: 4% |
| | | naa.5000c50076209fd3: 4% |
| | | naa.50015178f360b772: 0% |
| esxi-r720-8.vmwra.com | Assocs: 7510/20000 | Components: 2705/3000 |
| | Sockets: 4568/10000 | naa.5000c5007621d30b: 6% |
| | Clients: 1020 | naa.5000c5007275fbcb: 5% |
```

```
|   | Owners: 1118 | naa.5000c5007622410b: 5% |
|   |   | naa.50015178f35f6b76: 0% |
|   |   | naa.5000c5007272dd6b: 4% |
|   |   | naa.5000c500727a30ab: 5% |
|   |   | naa.5000c500727a178b: 4% |
+------------------------+---------------------+---------------------------+
```

Estimating Required Capacity

A capacity sizing exercise based on the View pool of 700 floating linked clones uses the following assumptions to arrive at the sizing figures shown in Table 29:

- Replica disk – 24 GB
- Memory – 2 GB per virtual desktop (no memory reserved)
- Virtual desktop log size – 10 MB
- Maximum virtual desktop growth delta file – 5 GB

ITEM	OBJECT	CALCULATION	SIZE (MB)
Replica disk	Replica OS Disk	*Master replica size x (FTT_ReplicaDisk+1)*	49,152
	Witness_ReplicaDisk	*FTT_ReplicaDisk x 2 MB*	2
Capacity required for replica disk			49,154 MB
Virtual desktops	VMSwap File (.vswp)	RAM_Size-MemoryReservation	2,048
	Suspend State File (.vmss)	RAM_Size	2,048
	Witness_OS_Disk	*FTT_OS_Disk_VMDK x 2 MB*	0
	Estimated Delta Growth		5,120
	VM_Log_file	*(FTT_VM_Home+1) x 10 MB*	20
	Witness_VM_Home	*(FTT_VM_Home+1) x 2 MB*	4
Capacity required per linked clone			9236
Capacity required for 700 linked clones			6,465,200 MB
Estimated capacity required			6,514,354 MB

Table 29: App Volumes Datastore Sizing

A liberal estimate for the required capacity is 6.51 TB. Reserving some memory and reducing the size of the swap file could further reduced this figure, but RAM was not reserved for testing, and the default virtual machine settings were used.

It is recommended to leave 30 percent free capacity across the Virtual SAN datastore to accommodate automatic rebuilds. It is possible to size for less capacity than this, but doing so can affect virtual SAN performance when datastore usage reaches 80 percent of capacity.

Storage for RDSH Hosts

Each ESXi host in the RDSH cluster used a local LSI Nytro WarpDrive 1.6 TB datastore for the duration of the testing. The RDSH servers and a copy of the AppStack were stored on each datastore.

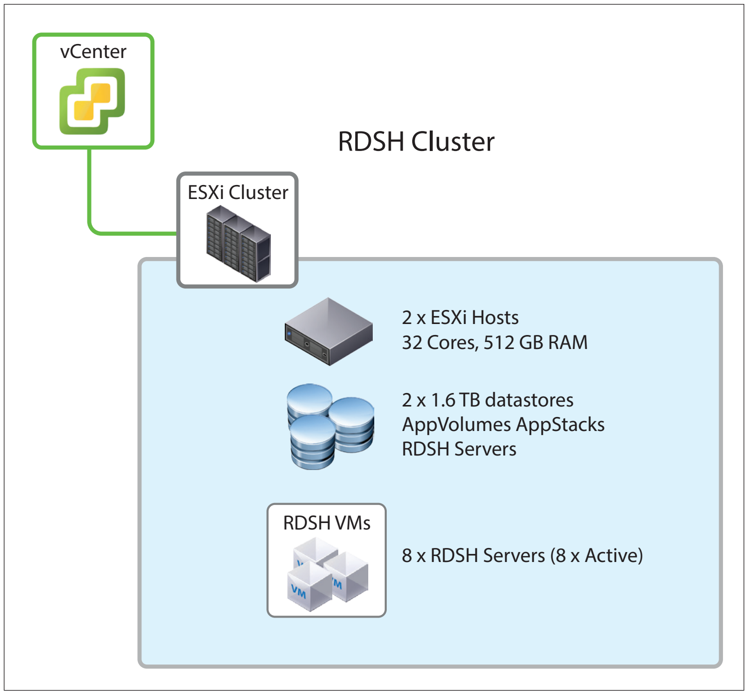


Figure 59: Desktop with an App Volumes AppStack Attached

Local storage facilitated a side-by-side performance analysis comparing Traditional Apps to AppStack apps. It was helpful in the sizing exercise, but it could not leverage VMware vSphere High Availability protection for the cluster. It also had the disadvantage of RDSH downtime for ESXi maintenance windows. Shared storage provides a more resilient solution for production deployments.

ATTRIBUTE	SPECIFICATION	DESCRIPTION
Number of RDSH servers per datastore	4	1.6 TB local datastores, offering 280,000 reads and 200,000 writes. Estimating 5 IOPS per hosted session, these datastores can comfortably support the IOPS requirements.
OS disk datastore size	At least 288 GB	Size is based on the following calculations: • Server size – 40 GB (Windows Server 2012 R2) • Swap file size – 32 GB • Log file size (maximum) – 10 MB • Minimum allocated datastore size – 288 GB *(4 virtual machines x (40960 + 32768 +10))*
Total number of datastores	2	2 datastores required for 8 RDSH servers
Hosts per datastore	1	Each host has access to its own local datastore

Table 30: RDSH Datastore Sizing

Active Directory Group Policies

The design uses organizational units (OU) created specifically for View desktops, RDSH servers, and custom Group Policy Objects (GPO) created for App Volumes. An OU is an Active Directory subdivision that contains users, groups, computers, or other OUs.

Dedicated OUs allow View policies to be applied through GPOs to all machines created dynamically by View. RDSH servers can also be added manually to an OU to apply RDSH-specific policies.

View has administrative templates for managing View virtual desktops and RDSH servers. Administrators can import these templates and use GPOs to apply them to the respective OUs. This method provides a straightforward and consistent way to manage policies specific to View virtual desktops and users.

For this reference architecture:

- The created OUs allowed management of users, virtual desktops, and RDSH servers.
- Virtual desktops were added automatically to the virtual desktops and App Volumes OU when provisioned by vCenter or View Composer.
- RDSH servers were added manually to the RDSH services and App Volumes OU when provisioned with vCenter.
- Group policies were applied to RDSH servers and virtual desktops for folder redirection, profile management, and PCoIP.
- RDSH servers and virtual desktops needed *Allow Log On Locally* and *Allow Log on Through Remote Desktop Services* to be set for the appropriate user groups.
- Group policy loopback processing was enabled to ensure that policies were applied to users accessing computers within the RDSH services or virtual desktop OUs.

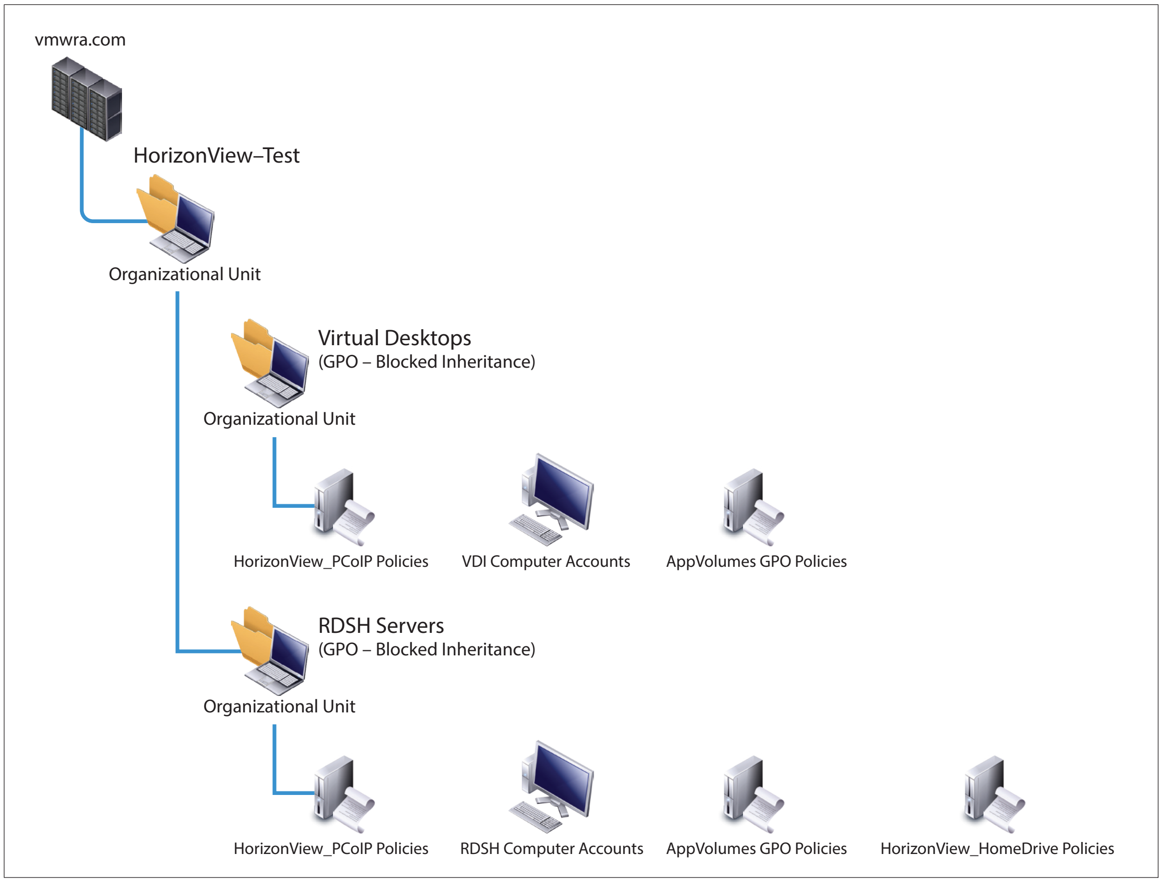


Figure 60: View with App Volumes Group Policies

PCoIP Group Policy

PCoIP is the default protocol for View desktops and applications. It can be configured with a Group Policy Administrative Template. Active Directory OUs were established for RDSH services and virtual desktops and a single PCoIP policy linked to both OUs.

PCoIP settings were modified for optimal performance and resource utilization, as shown in Figure 5.

HorizonView_PCoIP

Computer Configuration (Enabled)

Policies

Windows Settings

Administrative Templates

Policy definitions (ADMX files) retrieved from the local computer.

PCoIP Session Variables/Not Overridable Administrator Settings

Policy	Setting	Comment
Configure PCoIP image quality levels	Enabled	
See the Explain tab for example values.		
Set the Minimum Image Quality value (default value: 50):	40	
Set the Maximum Initial Image Quality value (default value: 90):	70	
Set the Maximum Frame Rate value (default value: 30):	30	
Use image settings from zero client if available (default value: disabled; not applicable for soft client)	Disabled	

Policy	Setting	Comment
Configure the maximum PCoIP session bandwidth	Enabled	
Set PCoIP session bandwidth in kilobits per second to:	4096	

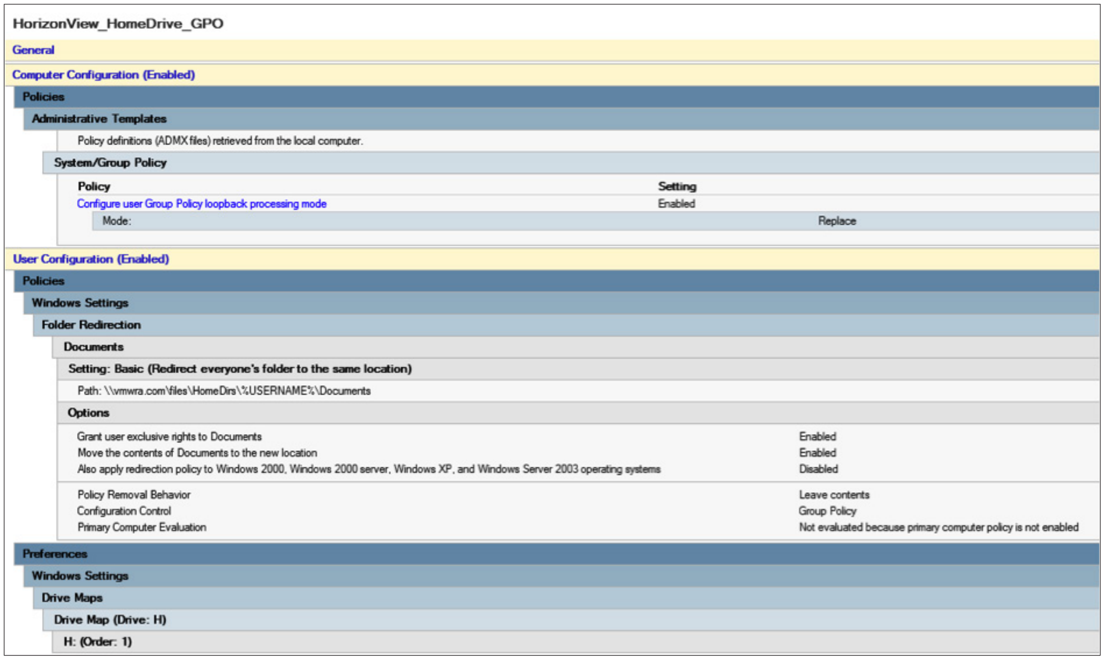
Policy	Setting	Comment
Configure the PCoIP session bandwidth floor	Enabled	
Set PCoIP session bandwidth floor in kilobits per second to:	128	

Policy	Setting	Comment
Enable access to a PCoIP session from a vSphere console	Enabled	
Enable/disable audio in the PCoIP session	Enabled	
Enable/disable microphone noise and DC offset filter in PCoIP session	Disabled	
Turn off Build-to-Lossless feature	Enabled	
Before turning off the Build-to-Lossless feature, please review the additional information in the Help section to understand what turning off this feature means. If you would like to turn off Build-to-Lossless, you must indicate your acceptance in the checkbox below. Otherwise, if you do not accept, the Build-to-Lossless feature will remain on.		
I accept to turn off the Build-to-Lossless feature.	Enabled	

Figure 61: PCoIP Group Policy

Persona and User Data

To provide a consistent user experience, it is imperative to maintain an unchanging desktop and application configuration across user sessions. This reference architecture used Microsoft RDSH profile (redirected to a network drive) for RDSH sessions.



HorizonView_HomeDrive_GPO

General

Computer Configuration (Enabled)

Policies

Administrative Templates

Policy definitions (ADMX files) retrieved from the local computer.

System/Group Policy

Policy	Setting	
Configure user Group Policy loopback processing mode	Enabled	
Mode:		Replace

User Configuration (Enabled)

Policies

Windows Settings

Folder Redirection

Documents

Setting: Basic (Redirect everyone's folder to the same location)

Path: \\vmwra.com\files\HomeDirs\%USERNAME%\Documents

Options

Grant user exclusive rights to Documents	Enabled
Move the contents of Documents to the new location	Enabled
Also apply redirection policy to Windows 2000, Windows 2000 server, Windows XP, and Windows Server 2003 operating systems	Disabled
Policy Removal Behavior	Leave contents
Configuration Control	Group Policy
Primary Computer Evaluation	Not evaluated because primary computer policy is not enabled

Preferences

Windows Settings

Drive Maps

Drive Map (Drive: H)

H: (Order: 1)

Figure 62: Redirection Group Policy

App Volumes Group Policy

App Volumes Agent is configured with a single App Volumes Manager name at install. This name can be the primary App Volumes Manager or the virtual IP address (VIP) for a pool of App Volumes Manager servers, if a load balancer is used.

Additional App Volumes Manager servers can be configured, to mitigate the result of a failure of the primary, and added to the client with

```
HKLM\CurrentControlSet\Services\svservice\Parameters
```

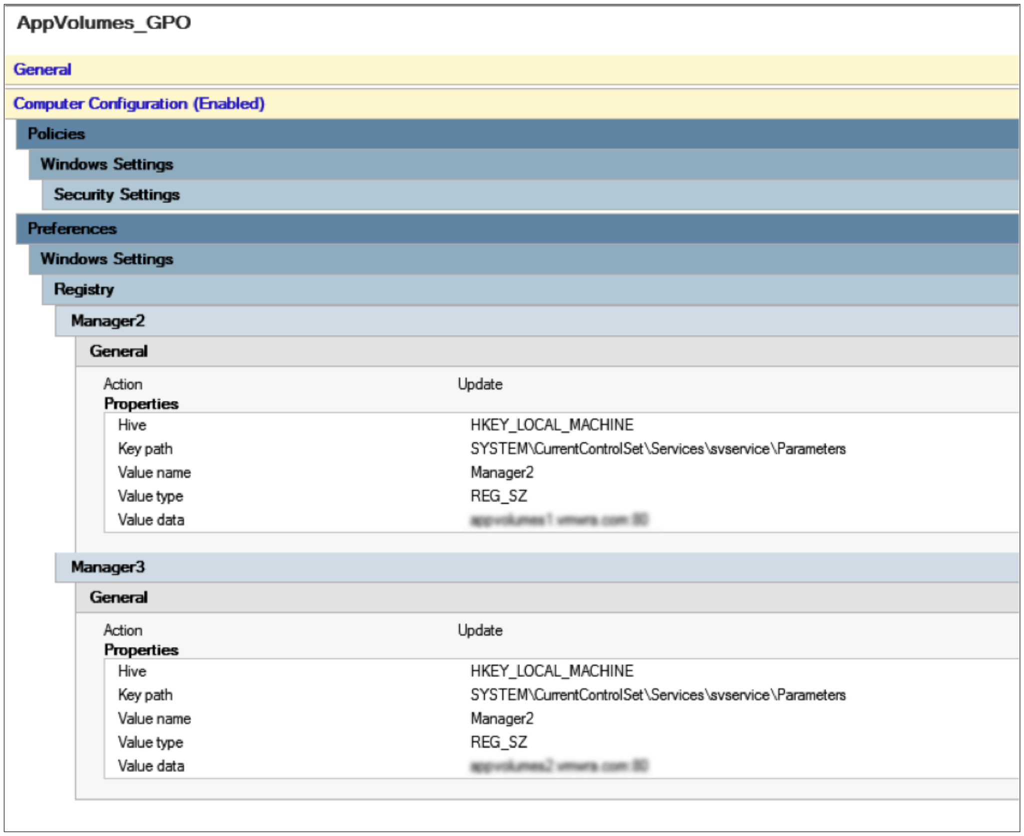


Figure 63: GPO to Add Multiple App Volumes Manager Servers

The following additional configuration GPOs can be edited in the Windows registry.

- Log and timing
  - *LogFileSizeInKB* – Size of the log file before rotating the log file. If undefined, the default is 5120 (5 MB).
  - *MaxDelayTimeOutS* – Maximum wait for a response, in seconds, from the App Volumes Manager. If 0, wait forever. The default is 2 minutes.
  - *ResolveTimeOutMs* – Number of milliseconds to wait for name resolution. If resolution takes longer than this timeout value, the action is canceled. The default is to wait for completion.
  - *ConnectTimeOutMs* – Number of milliseconds to wait for server connection requests. If the request takes longer than this timeout value, it is canceled. The default is 10 seconds.
  - *SendTimeOutMs* – Number of milliseconds to wait for sending requests. If the request takes longer than this timeout value, the send is canceled. The default is 30 seconds.

- *ReceiveTimeOutMs* – Number of milliseconds to wait for a response to a request. If the response takes longer than this timeout value, the request is canceled. The default is 5 minutes.
- *ProvisioningCompleteTimeOut* – Number of seconds to keep trying to contact the App Volumes Manager after provisioning is completed. The default is 120 seconds.
- *DomainNameWaitTimeOut* – Number of seconds to wait for the computer to resolve the Active Directory domain name during startup. On non-domain-joined machines, this can be set to 1 to allow for a faster login time. The default is 60 seconds.

• Volume behavior parameters

- *WaitForFirstVolumeOnly* – Number of seconds to wait for for the first volume to load. After the first volume is complete, the rest are handled in the background, and the login process is allowed to proceed. To wait for all volumes to load before releasing the login process, set this value to 0. The default is 1.
- *VolWaitTimeout* – Number of seconds to wait for a volume to be processed before ignoring the volume and proceeding with the login process. The default is 180.
- *VolDelayLoadTime* – Number of seconds to delay volume attachments after the login process. This value is ignored if a writable volume is used. Writable volumes must be attached before AppStacks. If the value is greater than VolWaitTimeout, it is reduced to the value of VolWaitTimeout. This setting can speed up login time by delaying the virtualizing of applications until after login is complete. The default is 0 (do not delay load time).

• Services, drivers, and general behavior parameters

- *RebootAfterDetach* – If set to 1, automatically reboots the system after a user logs off. The default is 0.
- *DisableAutoStartServices* – If set to 1, services do not automatically start on volumes after attach. The default is 0.
- *HidePopups* – If set to 1, `svservice.exe` does not generate popups. The default is 0.
- *DisableRunKeys* – If set to 1, applications in the Run key are not called. This setting applies to both AppStacks and writable volumes. The default is 0.

SQL Server

vCenter, View, App Volumes, and View Composer require database connectivity to store information. This reference architecture used a *Cluster In a Box* to create a MSCS SQL Server 2008 R2 failover cluster for resiliency. For production use, *Cluster Across Boxes* is recommended. SQL Server configuration specifications are listed in Table 31.

ATTRIBUTE	SPECIFICATION
Version	SQL Server 2008 R2 Standard
Virtual machine hardware	VMware Virtual Hardware version 9
OS	Windows Server 2008 R2 Standard
vCPU	4
vMemory	10 GB
vNICs	2 (1 x production, 1 x private network)
Virtual network adapter 1	VMXNet3 adapter
Virtual SCSI controller 0	LSI Logic SAS
Virtual disk – VMDK (scsi0:x)	Scsi0:1 Windows OS 40 GB
Virtual SCSI controller 1	LSI Logic SAS (bus sharing set to virtual)
Virtual disk – VMDK (scsi1:x)	• scsi1:0 Cluster Quorum 1 GB • scsi1:1 SQL Data 100 GB • scsi1:2 SQL Log 5 GB • scsi1:3 Cluster DTC 2 GB

Table 31: SQL Server Configuration

Windows File Services

View relies on file services to provide users with access to data. Two Windows file servers provide network shares for user data and RDSH profiles. Each file server is allocated a 100 GB disk.

Microsoft Distributed File System (DFS) is a highly available file services solution. The following table shows the DFS shares set up to replicate the data between the two file servers.

Note: Size file shares based on user quota and expected profile size.

ATTRIBUTE	SPECIFICATION
Number of file servers	2
VM hardware	VMware Virtual Hardware version 9
OS	Windows Server 2012 R2 (64-bit)
vCPU	4
vMemory	10 GB
vNICs	1
Virtual network adapter 1	VMXNet3 adapter
Virtual SCSI controller 0	LSI Logic Parallel
Virtual disk – VMDK	• 40 GB Windows OS • 100 GB data disk: - User home drives – \HomeDrives - RDSH profiles – \RDSHProfiles

Table 32: Windows File Services Configuration

vRealize Operations for Horizon

vRealize Operations for Horizon simplifies the management of VDI and provides end-to-end visibility into its health and performance. It presents data through alerts, in configurable dashboards, and on predefined pages in the user interface.

vRealize Operations for Horizon extends the functionality of vRealize Operations and enables IT administrators and help desk specialists to monitor and manage Horizon with View environments.

vRealize Operations for Horizon uses an adapter to pull data from View Connection Server and View Agent. The View adapter obtains the topology from the Horizon environment, collects metrics and other types of information from the desktops, and passes the information to vCenter Operations Manager.

Another vCenter Server adapter pulls data relating to vSphere, networking, storage, and virtual machine performance.

Out-of-the-box dashboards monitor the health of the Horizon infrastructure and components. Dashboards can be accessed from the Web-based vRealize Operations console.

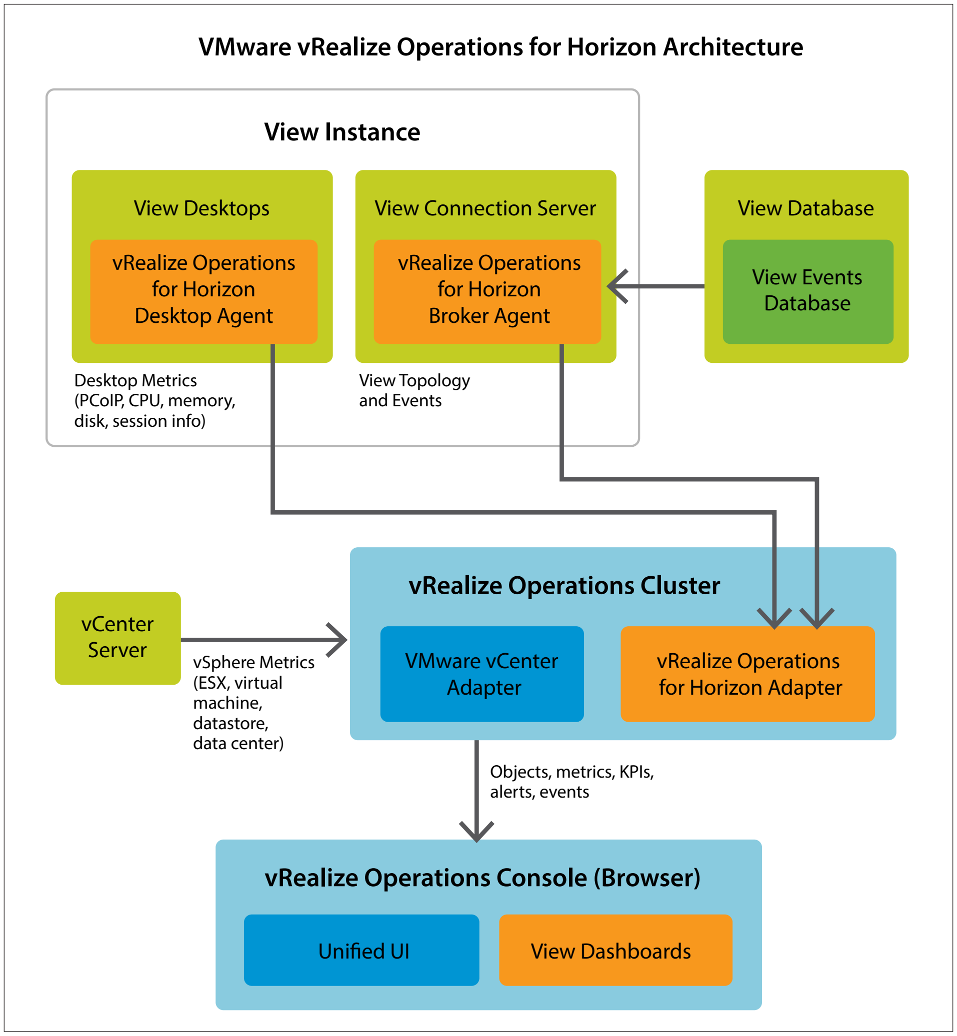


Figure 64: vRealize Operations for Horizon Architecture

vRealize Operations for Horizon consists of a SuSE Linux Enterprise 11 (64-bit) virtual appliance that supports 2,000 virtual desktops. The appliance collects data such as metrics, topology, and change events from vCenter Server and third-party sources. The Web UI appliance permits access to the analytics results and the Administration Portal to perform management tasks. An additional replica node is added to the vRealize Operations cluster for HA. It is also possible to add vRealize Operations nodes to the cluster for storage capacity.

ATTRIBUTE	SPECIFICATION
Number of vRealize appliances	2
VM hardware	VMware Virtual Hardware version 9
OS	SuSE Linux Enterprise 11 (64-bit)
vCPU	4
vMemory	16 GB
vNICs	1
Virtual network adapter 1	VMXNet3 adapter
Virtual SCSI controller 0	LSI Logic Parallel
Virtual disk – VMDK	266 GB disk

Table 33: vRealize Operations Specifications

Availability

The system is resilient in the event of a component system failure. The design does not cover a disaster recovery scenario in which the entire site is lost, but it does cover limited component failure.

FAILURE POINT	REDUNDANCY
Workspace Portal virtual appliance	Multiple virtual appliances provide a highly available Workspace Portal solution. No load balancer is required.
View security server	At least two load-balanced View security servers are required for redundancy. If a server fails, users are disconnected from their session. User data is not lost, and a user can reconnect quickly. A third-party load balancer is required.
View Connection Server	At least two load-balanced View Connection Servers are required for redundancy. If a server fails, users are not disconnected from their session. A third-party load balancer is required.
View desktop	If a desktop fails, the user might lose data. A new desktop can be provisioned if the current desktop cannot be fixed. Alternatively, a pool of pre-provisioned desktops allows users to quickly connect to another desktop.
RDSH server	Users are disconnected from their session. View supports RDSH farms in which multiple RDSH servers are pooled for desktop or application access. Users can reconnect to a different RDSH server, but might have lost data.

FAILURE POINT	REDUNDANCY
vCenter Server	If vCenter Server fails, View is not affected. Virtual desktops can still be connected, but new desktops cannot be provisioned. Workloads are not balanced across clustered hosts. Desktops cannot be powered on or off. Desktops with AppStacks or writable volumes are unaffected.
ESXi host	If a virtual desktop host fails, the user loses connection to the desktop. The user can login to another available floating desktop or hosted session.
ESXi host: Virtual SAN node	If the ESXi host fails unexpectedly, any FTT=0 objects on the host are not available until ESXi is restored to service. If ESXi is unavailable for longer than the clomd timer setting (default is 60 minutes), rebuild kicks off for objects protected by distributed RAID (FTT>0).
View desktop cluster failure	If all hosts in a View desktop cluster lose connectivity or fail, users assigned to the desktop pools hosted on the affected cluster cannot access a virtual desktop until the cluster is restored.
Management cluster failure	The service is unavailable if the management cluster fails. Users directly accessing virtual desktops and RDSH servers are disconnected, but might lose services, such as printing, Active Directory, and user profile data.
App Volumes Manager	One or more App Volumes Managers work in active-active. If one fails, service is not affected. If both fail, desktops with attached AppStacks or writable volumes are not affected.
SQL Server	Two SQL Servers work as failover cluster. If one fails, the other takes over.

Table 34: Resiliency of Horizon Services

Conclusion

This reference architecture evaluated a deployment for 960 users on 700 linked-clone View desktops and 260 RDSH sessions. This deployment was supported by Horizon 6 Enterprise Edition, which includes App Volumes and Virtual SAN. Performance was similar to high-end physical computers, with rapid desktop provisioning and excellent user experience characteristics across a wide range of use cases and application delivery methods.

Extensive test results support the following conclusions:

- App Volumes improved the desktop consolidation ratio and reduces CPU and memory usage while providing satisfactory or better end-user experience.
- Storage provisioning and management required little effort, and performance was excellent with low latency from Virtual SAN, even under heavy load.
- Desktop maintenance, storage provisioning and management, and application delivery and patching required only minimal time and effort from one administrator for this large deployment.

The tests were carried out with a defined set of applications required for View Planner workload testing and a streamlined desktop template. Production deployments should employ thorough testing, including a proof-of-concept phase, because results can vary depending on the environment, application set, and hardware and software configurations. In particular, the following practical measures are highly recommended:

- For heavy workloads, use 15 K magnetic disk drives in the Virtual SAN capacity layer.
- Deploy AppStacks with multiple applications to reduce the number of associated Virtual SAN components.
- Increase the App Volumes reconfigure timeout value *CV_RECONFIG_TIMEOUT* from the default of 300. It was set to 600 for the tests reported here.

About the Author and Contributors

Donal Geary is a Desktop Virtualization Reference Architecture Engineer in the VMware End-User-Computing Group. He wishes to thank the following people for their contributions to the content and presentation of this paper:

• Stephane Asselin, Senior End-User-Computing Technical Enablement Architect, VMware

• Tristan Todd, End-User-Computing Technical Enablement Architect, VMware

• Gary Sloane, Consulting Editor, VMware

References

Optimization Guide for Windows 7 and Windows 8 Virtual Desktops in Horizon with View

Wikibon Server SAN 2012-2026

Setup for Failover Clustering and Microsoft Cluster Service

View Documentation

View Planner Resources

View Technical Resources

VMware App Volumes Documentation

VMware Desktop Virtualization Services

VMware End-User Computing Solutions

VMware Horizon 6 Documentation

VMware Virtual SAN Documentation

Appendix A: Linked Clones on Virtual SAN Tests

This appendix details the observed performance metrics for a side-by-side comparison for a View Planner medium workload test on a pool of 700 linked clones with Traditional Apps, a pool of linked clones with an AppStack, and a pool of linked clones with an AppStack and ThinApp packages. The following performance metrics are the average ESXi results from a cluster of seven ESXi servers.

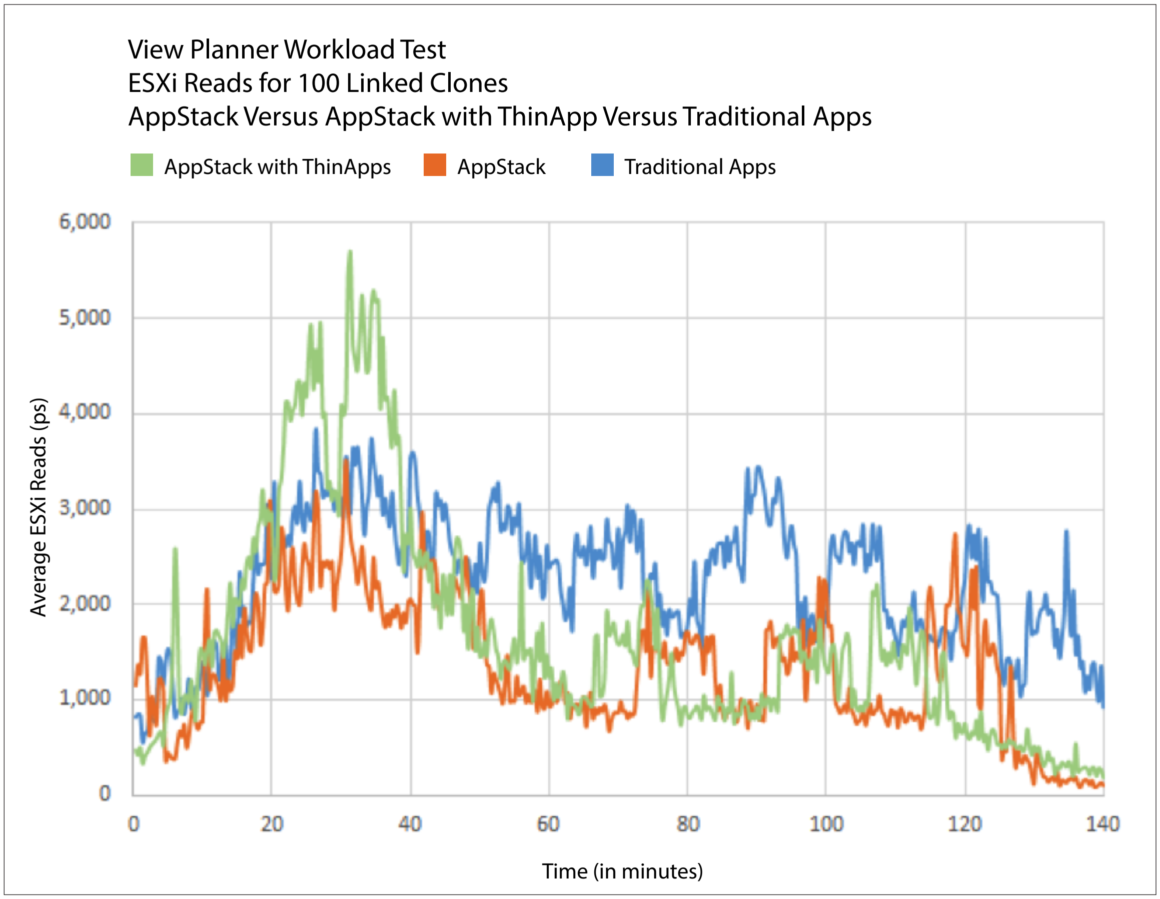


Figure 65: Linked-Clone Workload Test – ESXi Read Rate (KBps) Comparison

As shown in Figure 9, for the 40–100 minute period, with the workload running concurrently on 700 desktops, the storage performance statistics are:

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average read rate (KBps)	10,441	9,353	11,370
Maximum read rate (KBps)	19,888	26,963	34,743

Table 35: Linked-Clone Workload Test – ESXi Read Rate (KBps) Metrics

The AppStack desktop pool has 10 percent lower average read rate (KBps) and 30 percent higher maximum read rate (KBps) than the Traditional Apps desktop pool.

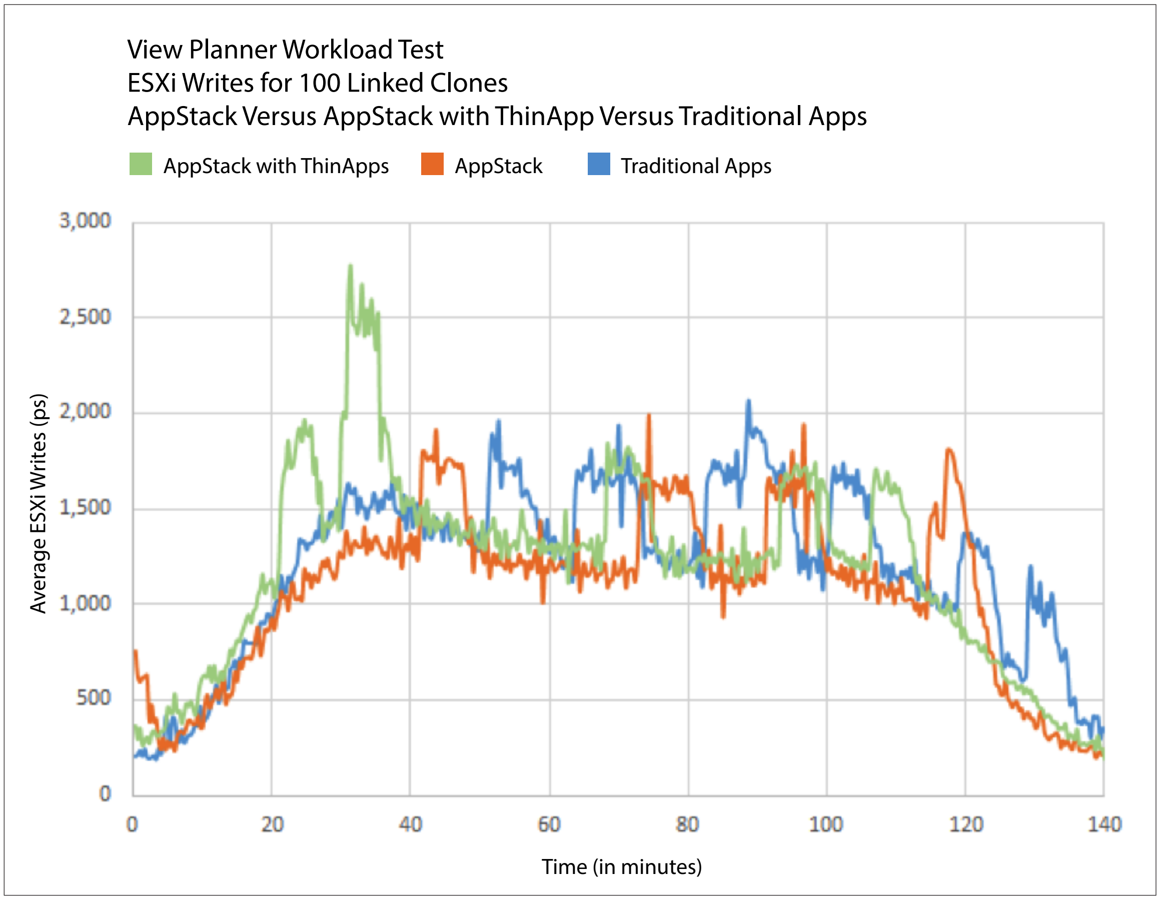


Figure 66: Linked-Clone Workload Test – ESXi Write Rate (KBps) Comparison

In the 40–100 minute period, with the workload running concurrently on 700 desktops, analysis of the storage performance statistics yields the following results:

	TRADITIONAL APPS	APPSTACK	APPSTACK WITH THINAPP
Average write (KBps)	12,146	10,163	12,222
Maximum write (KBps)	19,392	18,335	28,548

Table 36: Linked-Clone Workload Test – ESXi Write Rate (KBps) Metrics

Appendix B: RDSH Testing

This appendix details the observed performance metrics for a side-by-side comparison for a View Planner medium workload test carried out on a pool of 260 RDSH sessions with Traditional Apps and a pool of RDSH sessions with an AppStack. The performance metrics below are the average ESXi results from two ESXi servers.

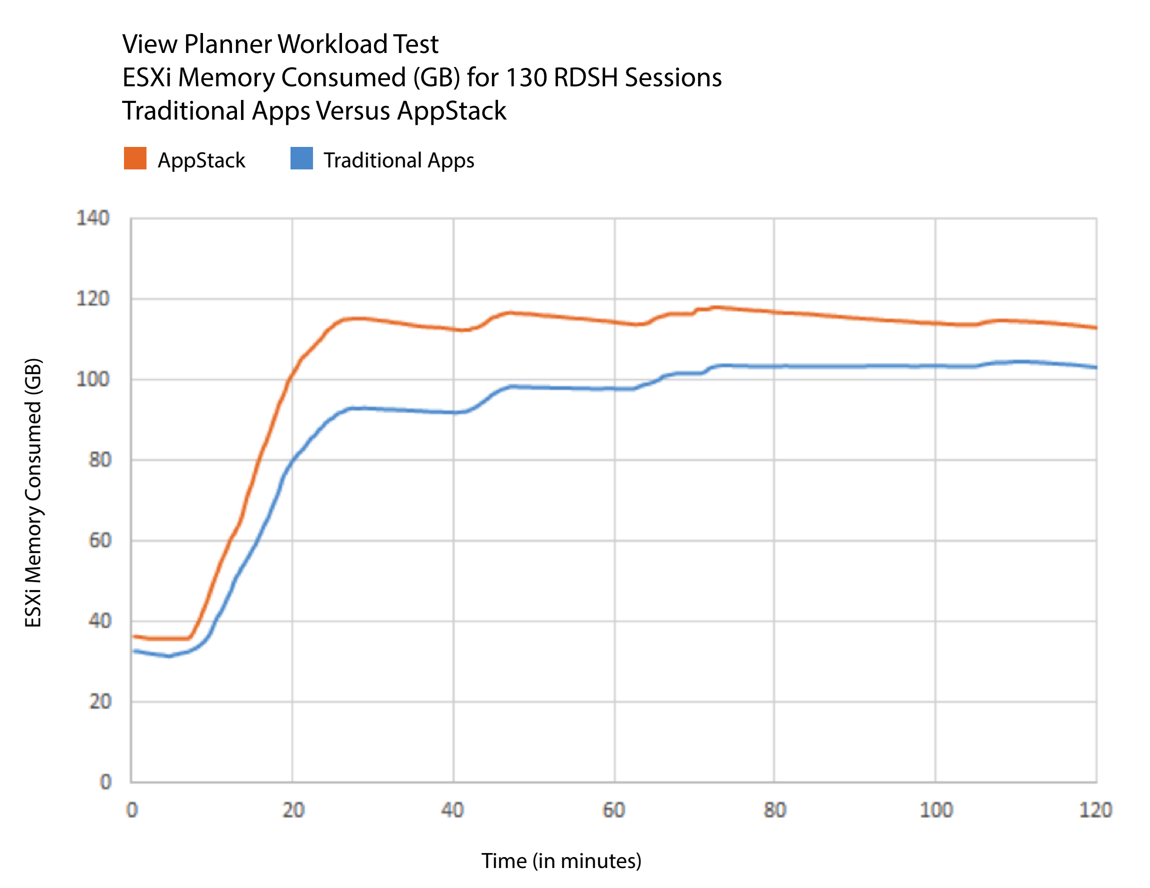


Figure 67: RDSH Workload Test – ESXi Memory Consumed (GB) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average memory consumed (GB)	101	115
Maximum memory consumed (GB)	104	118

Table 37: RDSH Workload Test – ESXi Memory Consumed (GB) Metrics

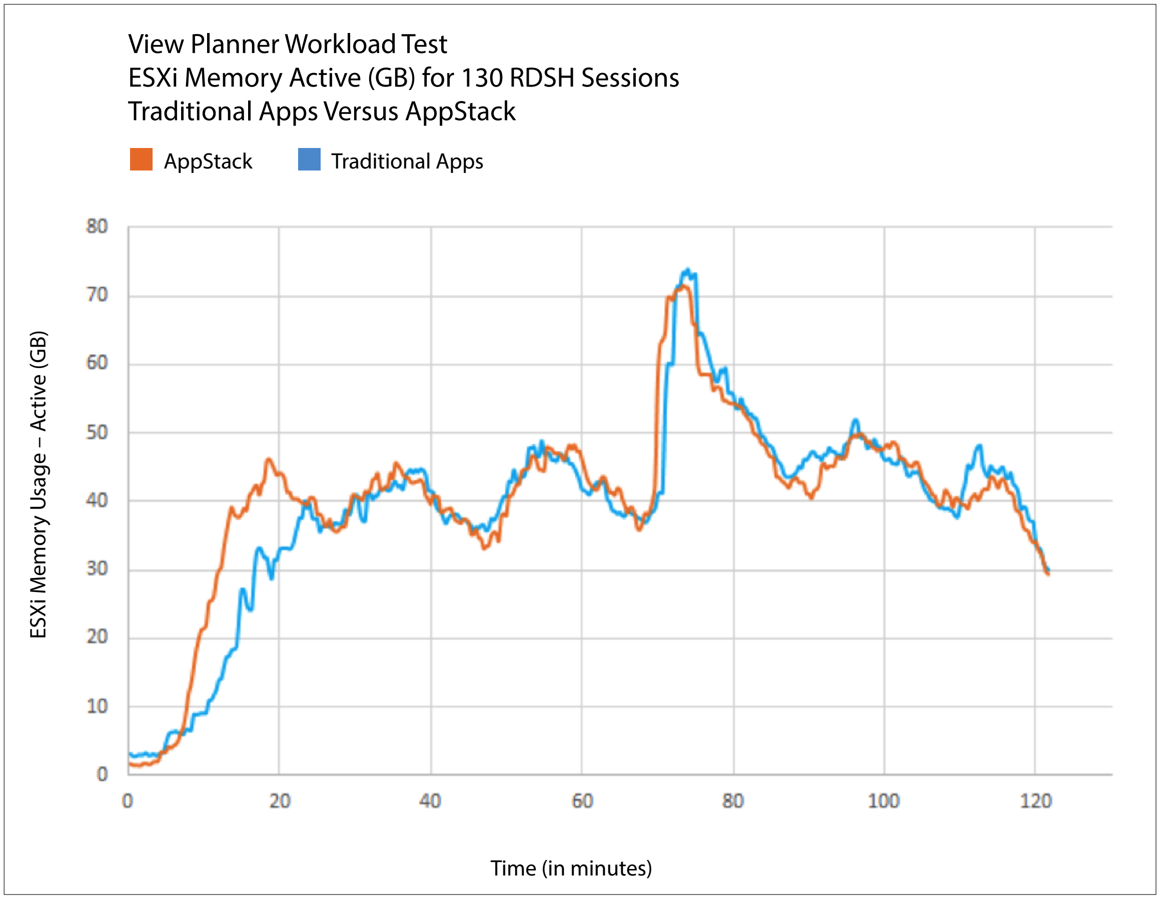


Figure 68: RDSH Workload Test – ESXi Memory Active (GB) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average memory active (GB)	47	47
Maximum memory active (GB)	72	74

Table 38: RDSH Workload Test – ESXi Memory Active (GB) Metrics

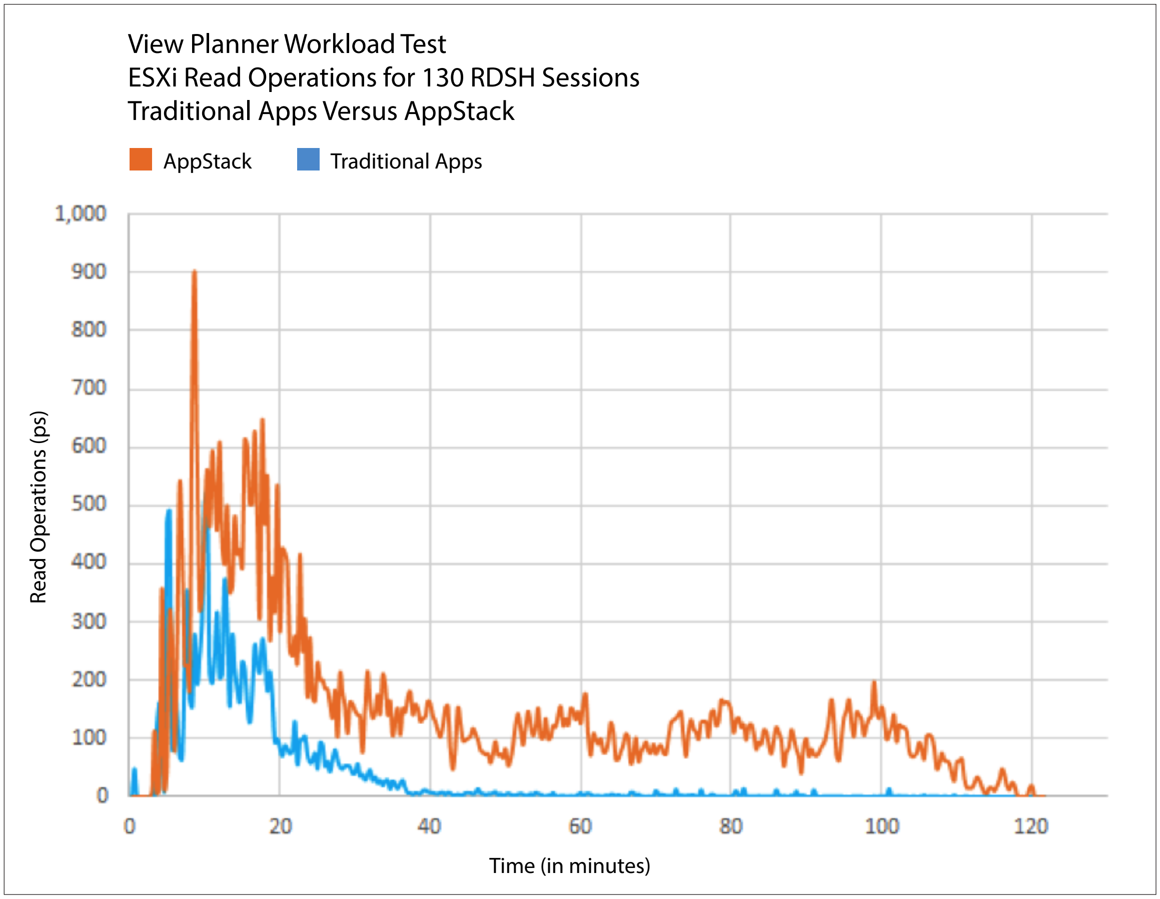


Figure 69: RDSH Workload Test – ESXi Storage Reads per Second Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average reads per second	9	109
Maximum reads per second	501	901

Table 39: RDSH Workload Test – ESXi Storage Reads per Second Metrics

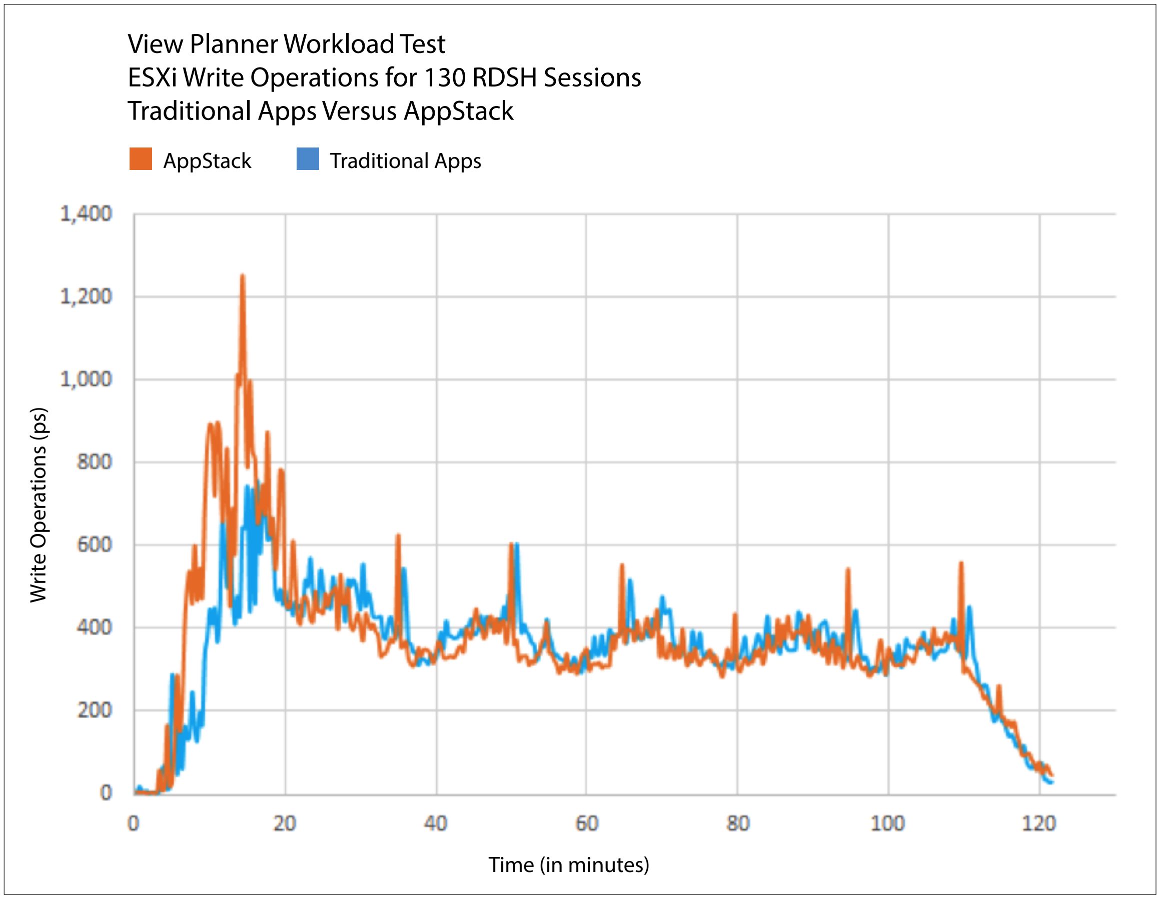


Figure 70: RDSH Workload Test – ESXi Storage Writes per Second Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average writes per second	371	354
Maximum writes per second	756	1,254

Table 40: RDSH Workload Test – ESXi Storage Writes per Second Metrics

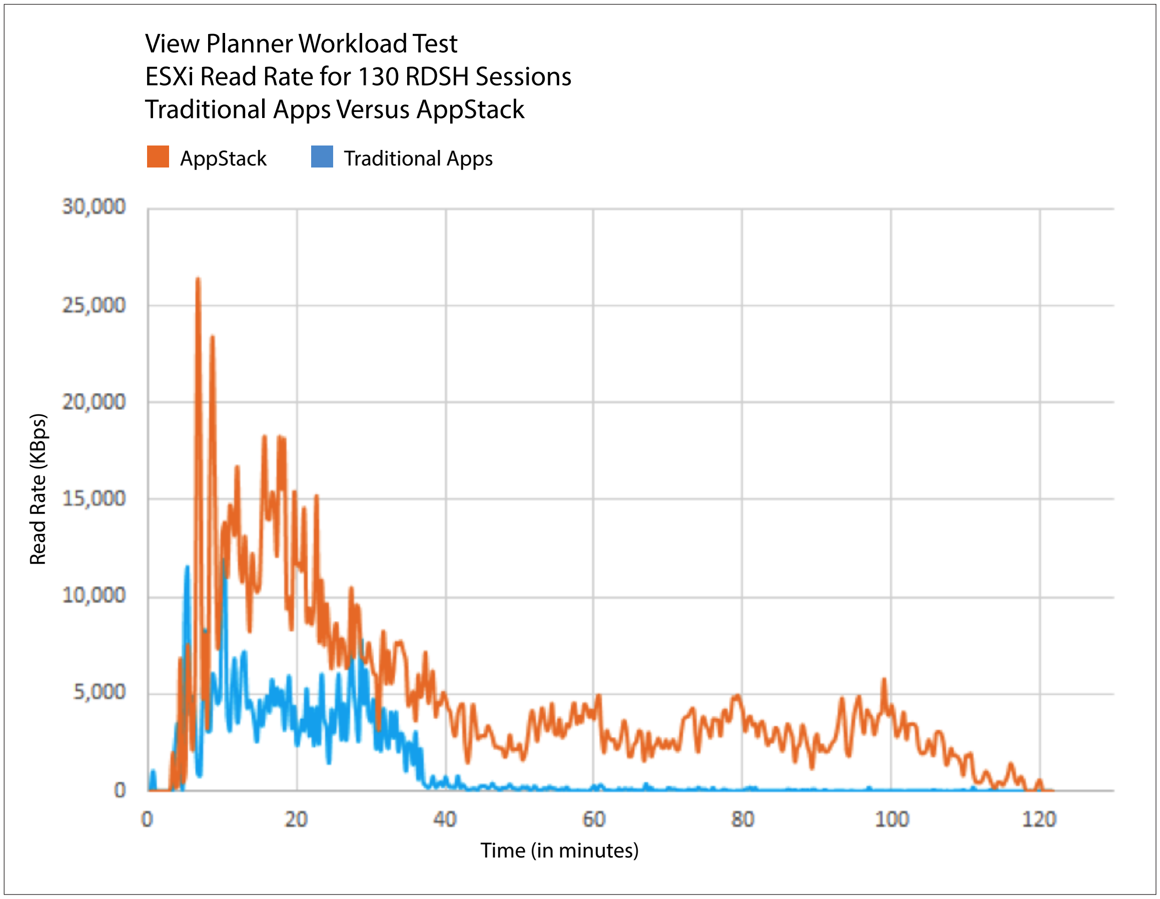


Figure 71: RDSH Workload Test – ESXi Read Rate (KBps) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average read rate (KBps)	418	3,151
Maximum read rate (KBps)	11,903	25,955

Table 41: RDSH Workload Test – ESXi Read Rate (KBps) Metrics

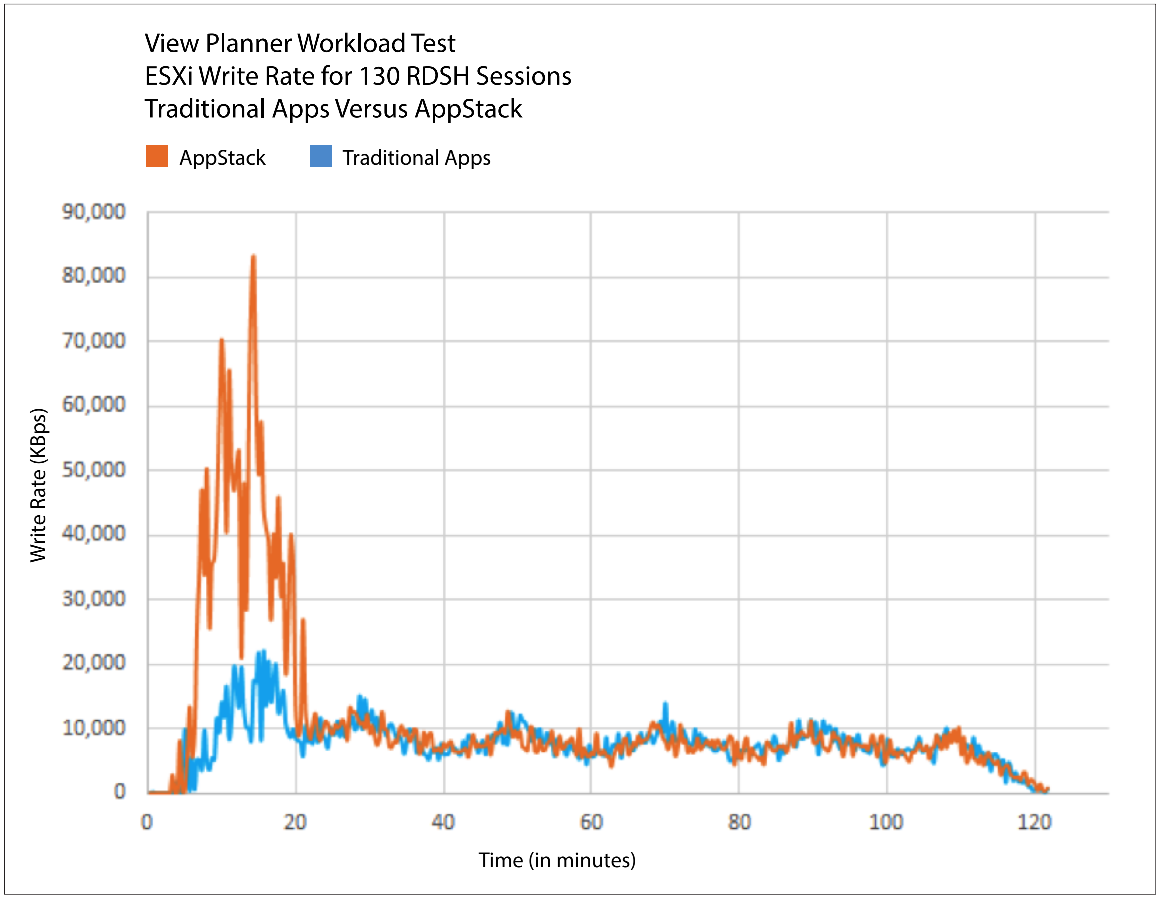


Figure 72: RDSH Workload Test – ESXi Write Rate (KBps) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average write rate (KBps)	7,901	6,467
Maximum write rate (KBps)	22,053	82,861

Table 42: RDSH Workload Test – ESXi Write Rate (KBps) Metrics

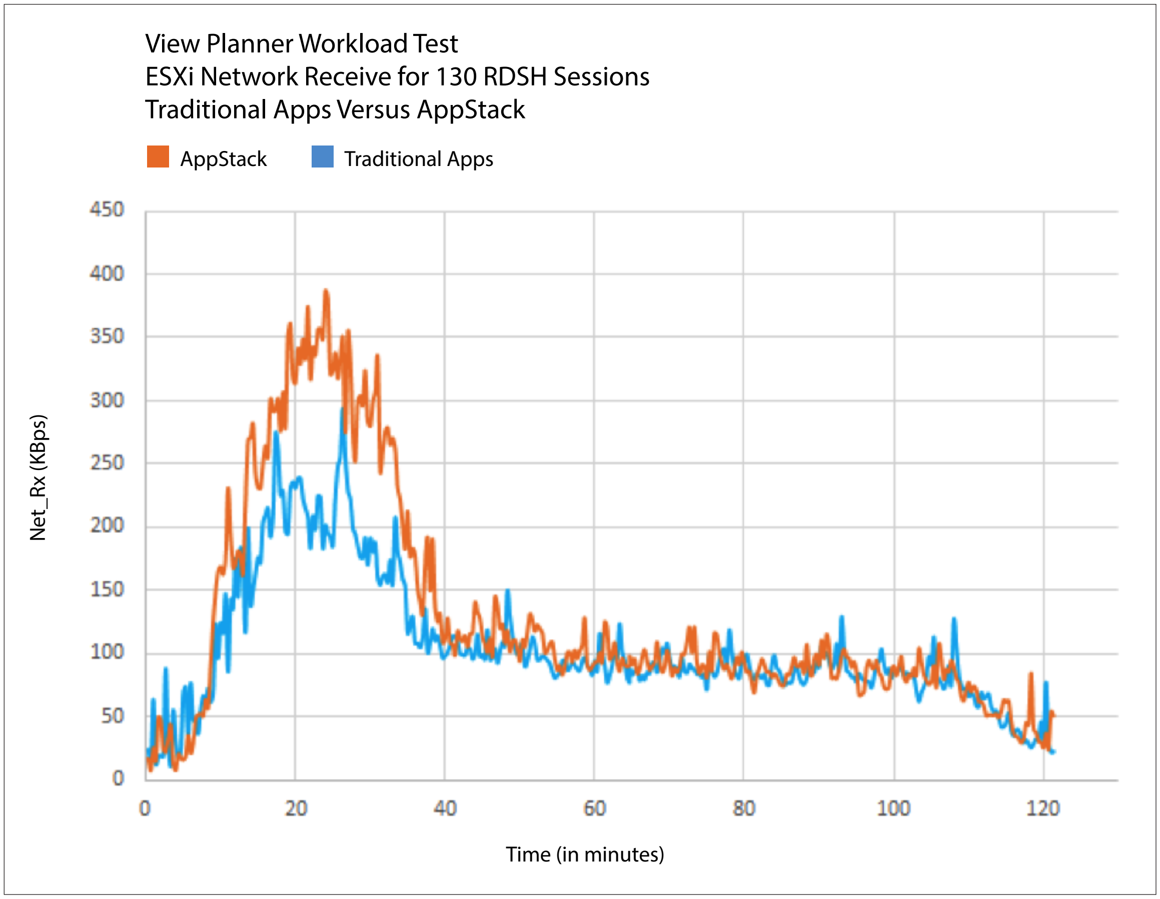


Figure 73: RDSH Workload Test – ESXi Network Receive Rate (KBps) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average network Rx (KBps)	93	98
Maximum network Rx (KBps)	294	387

Table 43: RDSH Workload Test – ESXi Network Receive Rate (KBps) Metrics

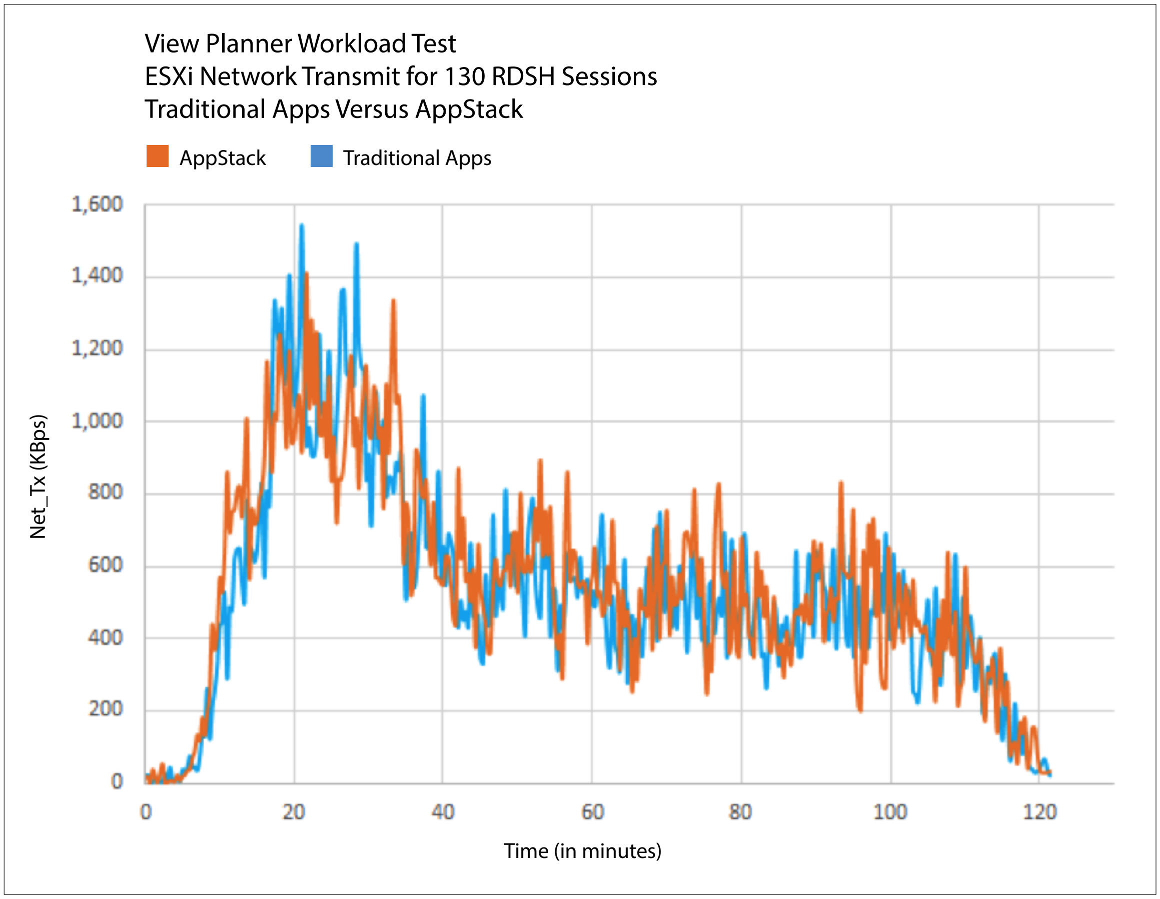


Figure 74: RDSH Workload Test – ESXi Network Transmit Rate (KBps) Comparison

	RDSH TRADITIONAL APPS	RDSH APPSTACK
Average network transmits (KBps)	508	532
Maximum network transmits (KBps)	1,545	1,412

Table 44: RDSH Workload Test – ESXi Network Transmit Rate (KBps) Metrics

Appendix C: Writable Volumes Test

This appendix details the observed performance metrics for a side-by-side comparison for a View Planner medium workload test carried out on a pool of 100 linked-clone desktops with and without an App Volumes writable volume attached for user profile data.

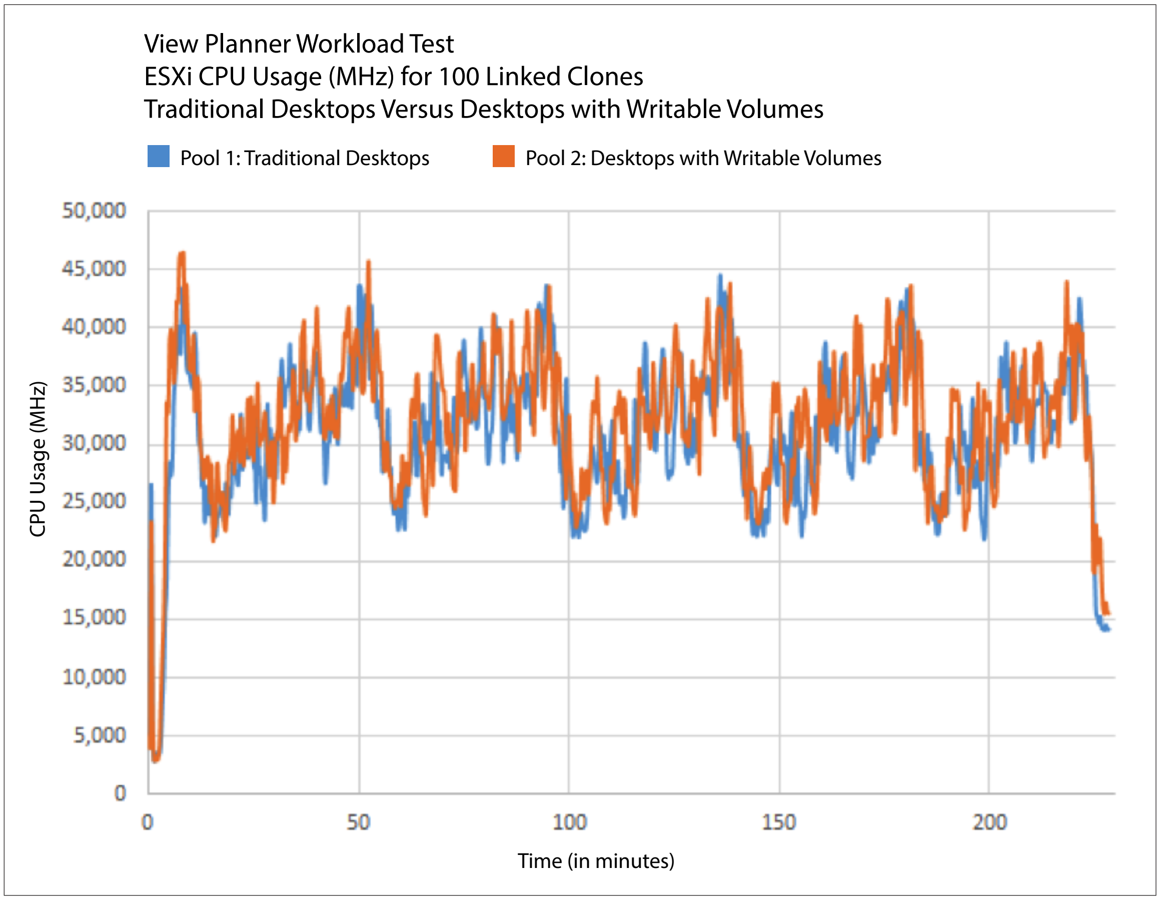


Figure 75: Writable Volumes Test – ESXi CPU Usage (MHz) Comparison

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOPS WITH WRITABLE VOLUMES
Average CPU MHz	31,583 MHz	32,549 MHz
Maximum CPU MHz	44,499 MHz	46,399 MHz

Table 45: Writable Volumes Test – ESXi CPU Usage (MHz) Metrics

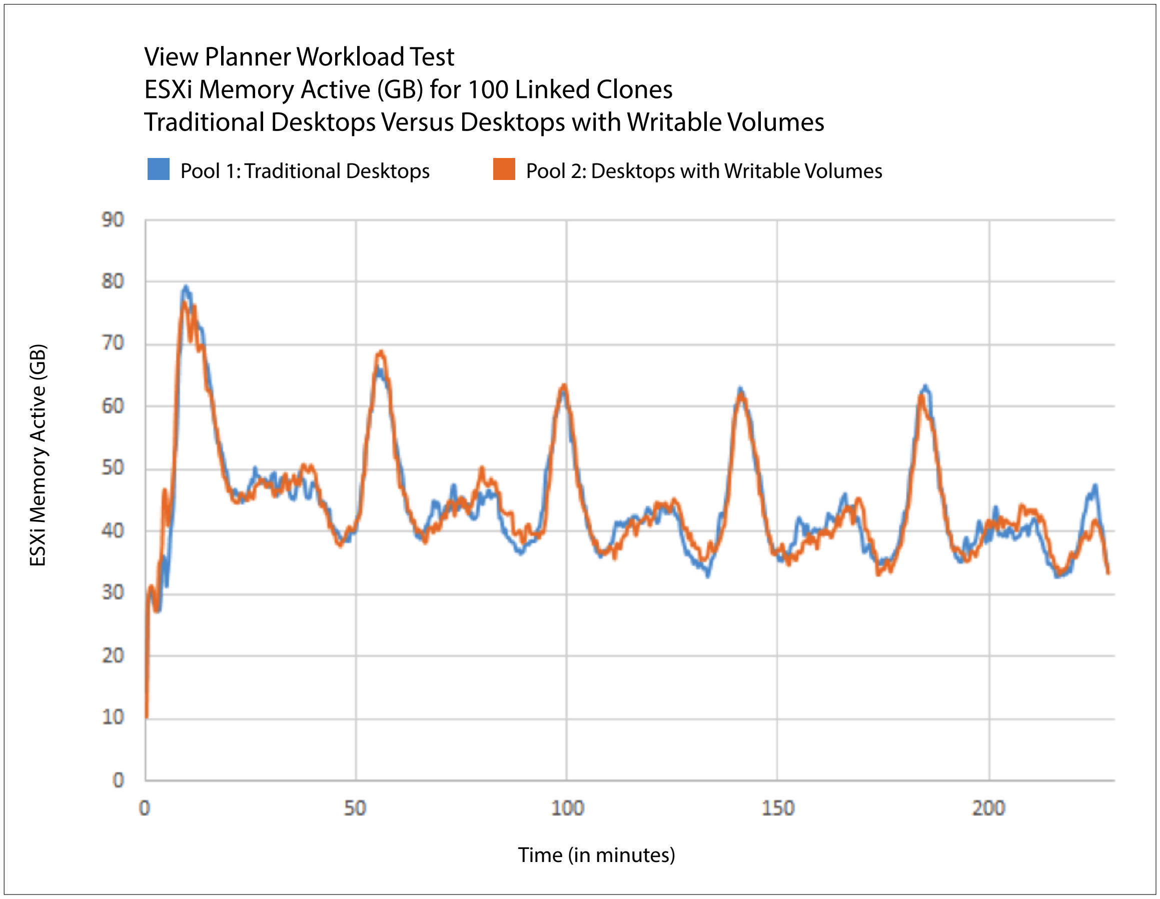


Figure 76: Writable Volumes Test – ESXi Memory Active (GB) Comparison

There was no difference in average active memory usage (44 GB). The maximum observed active memory was higher for the pool without a writable volume than for the pool with a writable volume.

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOPS WITH WRITABLE VOLUMES
Average memory active	44 GB	44 GB
Maximum memory active	79 GB	77 GB

Table 46: Writable Volumes Test – ESXi Memory Active (GB) Metrics

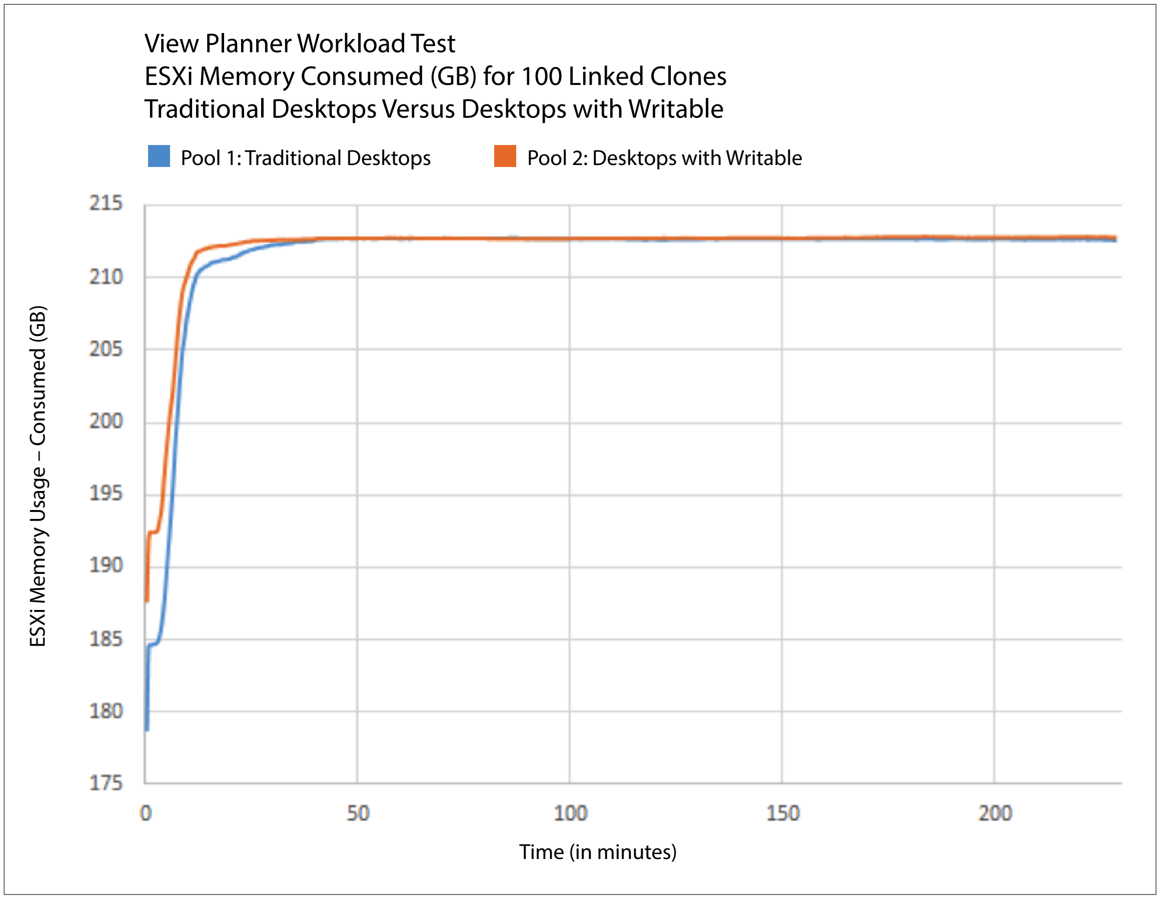


Figure 77: Writable Volumes Test – ESXi Memory Consumed (GB) Comparison

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOPS WITH WRITABLE VOLUMES
Average memory consumed	213 GB	213 GB
Maximum memory consumed	213 GB	213 GB

Table 47: Writable Volumes Test – ESXi Memory Consumed (GB) Metrics

There was no difference in average memory consumed.

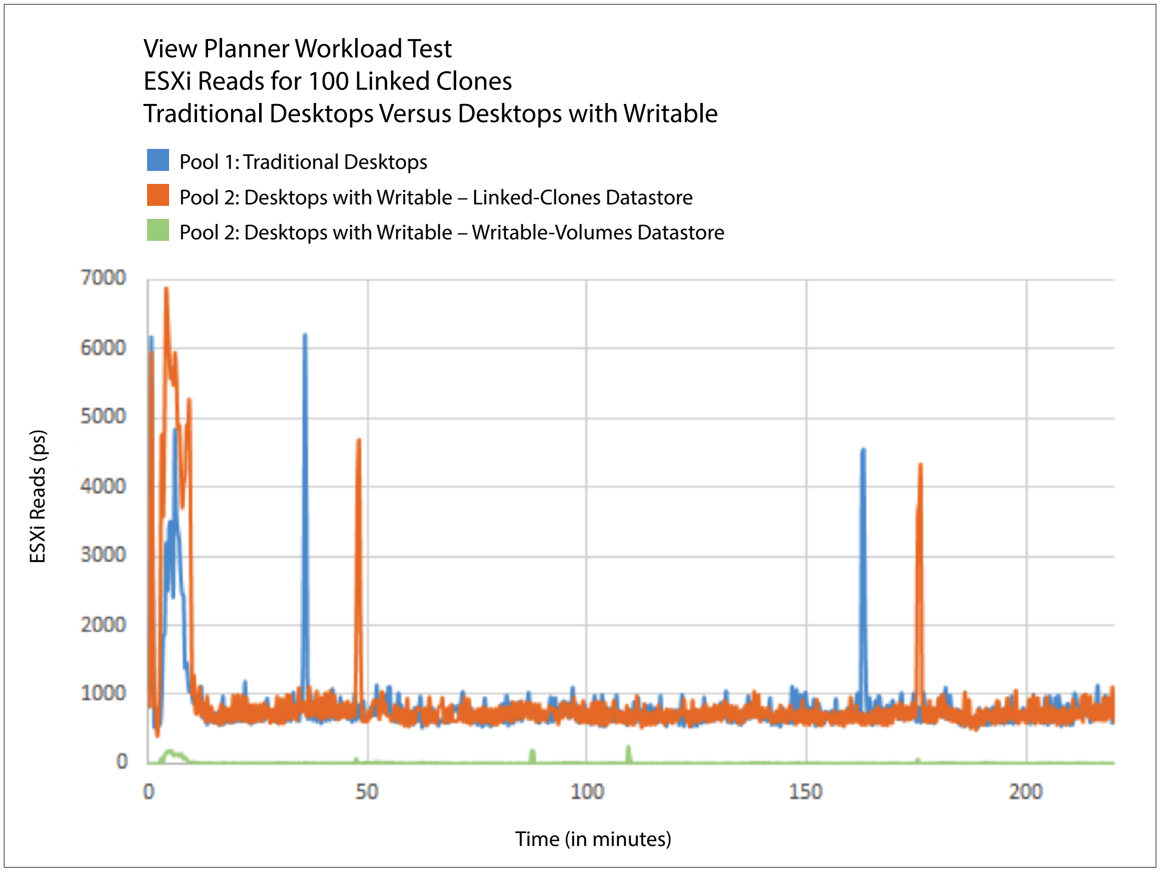


Figure 78: Writable Volumes Test – ESXi Reads per Second Comparison

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOP DATASTORE	POOL 2 – WRITABLE-VOLUMES DATASTORE
Average reads	769	756	9
Maximum reads	6,172	6,844	249

Table 48: Writable Volumes Test – ESXi Reads per Second Metrics

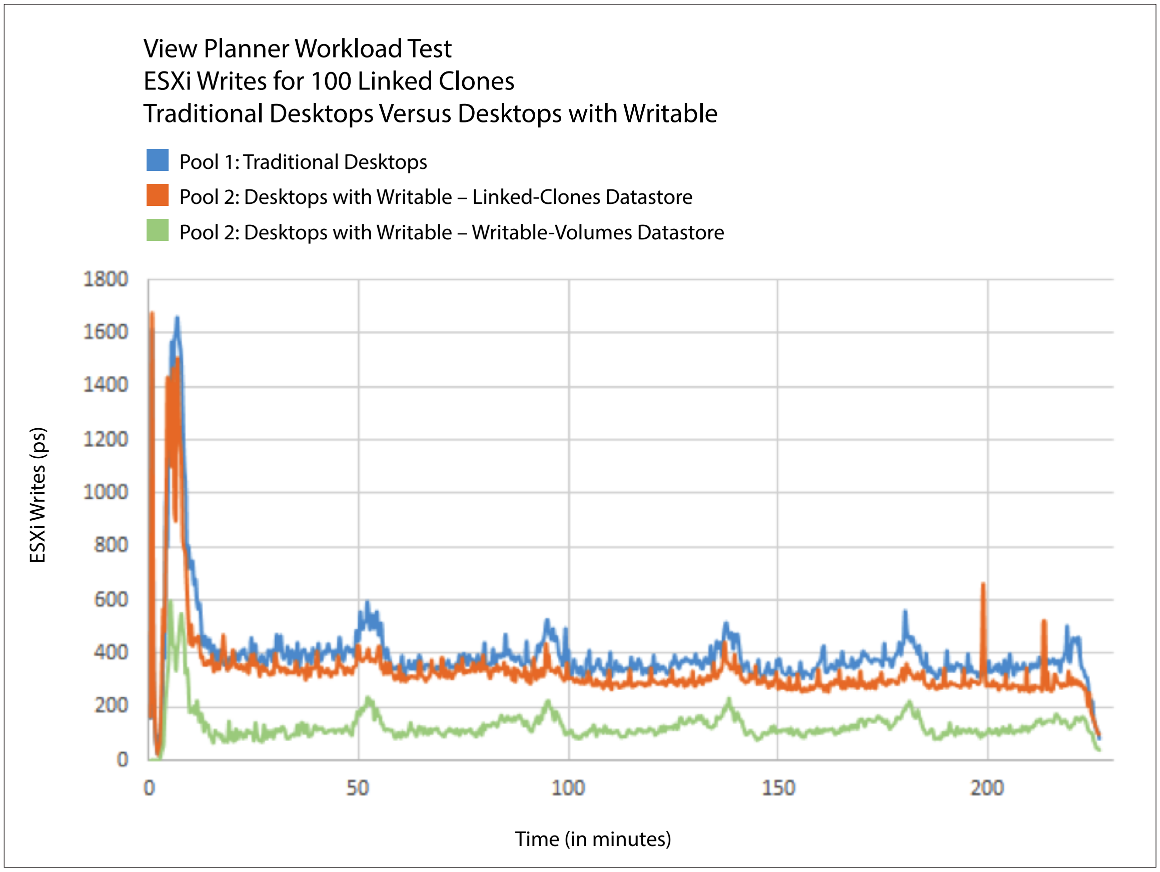


Figure 79: Writable Volumes Test – ESXi Writes per Second Comparison

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOP DATASTORE	POOL 2 – WRITABLE-VOLUMES DATASTORE
Average writes per second	379	318	124
Maximum writes per second	1,660	1,674	593

Table 49: Writable Volumes Test – ESXi Writes per Second Metrics

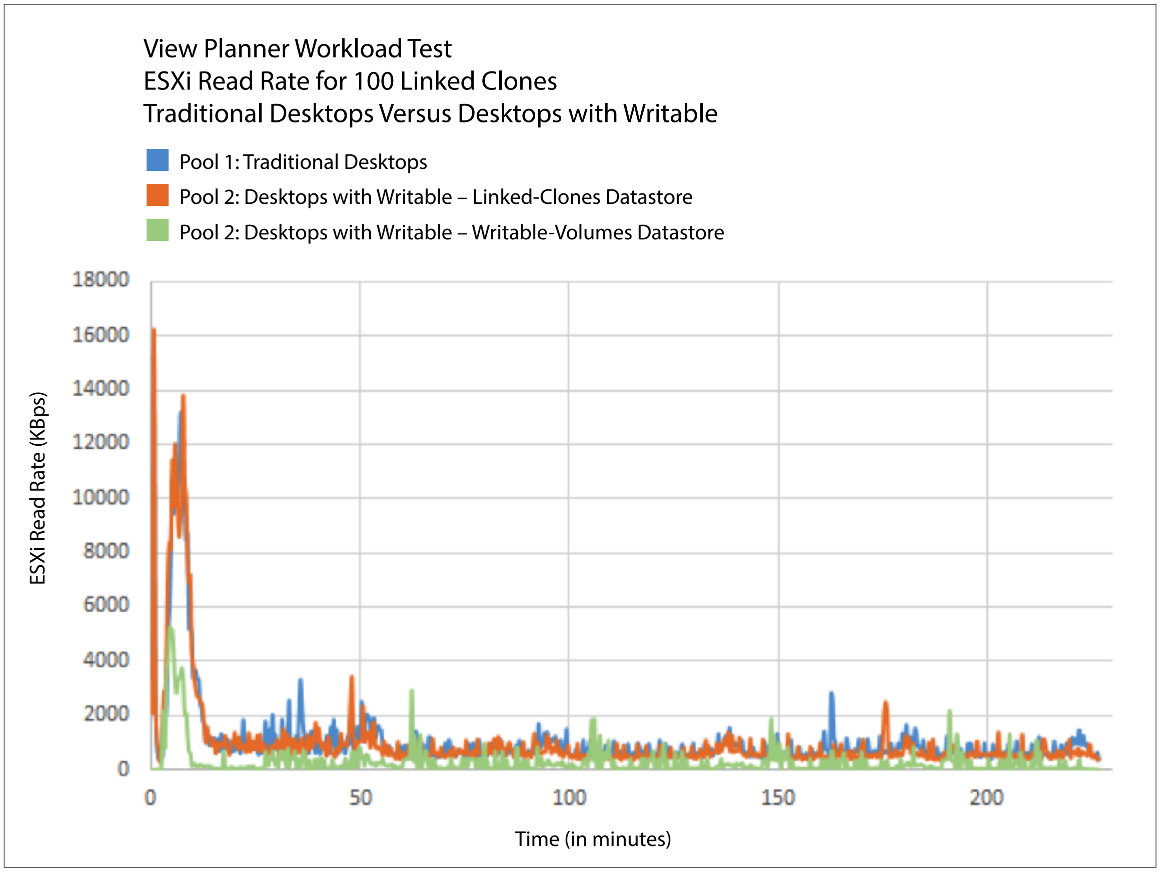


Figure 80: Writable Volumes Test – ESXi Read Rate (KBps) Comparison

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOP DATASTORE	POOL 2 – WRITABLE-VOLUMES DATASTORE
Average read rate (KBps)	814	694	240
Maximum read rate (KBps)	15,809	16,246	5,220

Table 50: Writable Volumes Test – ESXi Read Rate (KBps) Metrics

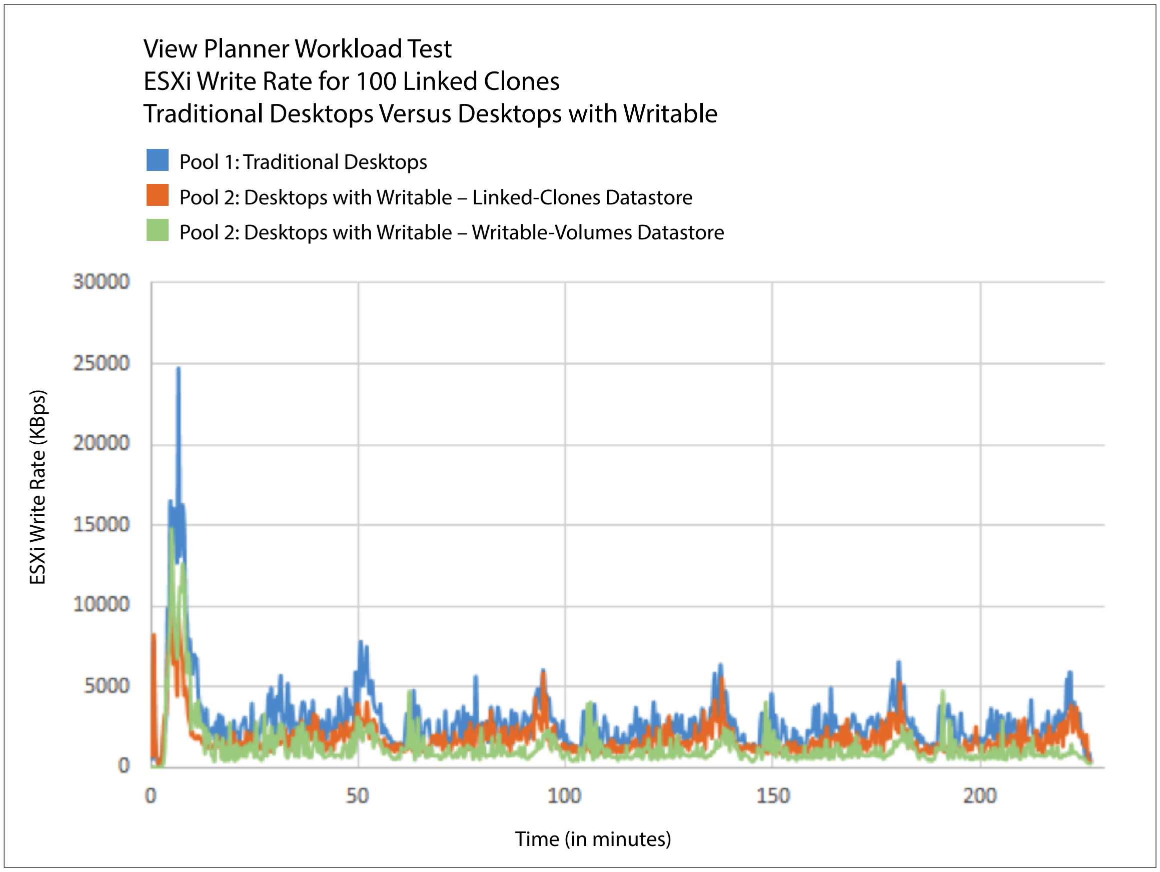


Figure 81: Writable Volumes Test – ESXi Write Rate (KBps) Comparison

	POOL 1 – TRADITIONAL DESKTOPS DATASTORE	POOL 2 – DESKTOP DATASTORE	POOL 2 – WRITABLE-VOLUMES DATASTORE
Average write rate (KBps)	2,613	1,674	1,107
Maximum write rate (KBps)	24,748	9,621	14,810

Table 51: Writable Volumes Test – ESXi Write Rate (KBps) Metrics

Appendix D: Bill of Materials

AREA	COMPONENT		QUANTITY
Server	Management: Dell PowerEdge R720		2
		Intel Xeon E5-2690 8C @ 2.90 GHz	2
		16 GB DIMMs	16
		LSI 9207_8i	1
		Intel Ethernet 10G 2P X520	1
		1 GB SD Card	1
	Desktops: Dell PowerEdge R720		7
		Intel Xeon E5-2697 v2 12C @ 2.70 GHz	2
		16 GB DIMMs	16
		LSI 9207_8i	1
		Intel Ethernet 10G 2P X520	1
		1 GB SD Card	1
		Intel 400 GB S3700 MLC SATA 6 Gbps SSD	1
		Dell 600 GB 10 K RPM 2.5in 6 Gbps SAS	6
	RDSH: Dell PowerEdge R720		2
		Intel Xeon E5-2690 8C @ 2.90 GHz	2
		16 GB DIMMs	16
		LSI 9207_8i	1
		LSI Nytro WarpDrive BLP4-1600 1.6 TB	1
		Intel Ethernet 10G 2P X520	1
		1 GB SD Card	1
Storage	Management: 1.5 TB NAS Datastore		1
	RDSH: 750 GB NAS Datastore		2
	Desktops: Virtual SAN Datastore 22.92 TB		1
Network	Dell Force10 S4810 10/40GbE		2

AREA	COMPONENT	QUANTITY
Software	Horizon Enterprise Edition	1,000 users
	Microsoft Windows 7 VDA	1,000 users
	Microsoft RDSH CAL	1,000 users
	Microsoft Windows 2012 R2	27
	Microsoft Windows 2008 R2	2
	Microsoft SQL Server 2008 R2	2

Table 52: Bill of Materials

VMware, Inc. 3401 Hillview Avenue Palo Alto CA 94304 USA Tel 877-486-9273 Fax 650-427-5001 www.vmware.com