NetApp Verified Architecture

NetApp HCI for End-User Computing with VMware

NVA Deployment

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Abstract

VMware End-User Computing with NetApp® HCI is a prevalidated, best-practice, data center architecture for deploying virtual desktop workloads at an enterprise scale. This document describes deploying the solution at production scale in a reliable and risk-free manner.

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1 Executive Summary

Technology continues to shape our everyday lives and, because end-user demands are increasing, digital transformation is a priority for most enterprises. Regardless of where you are on your journey, NetApp can help you by providing solutions that deliver business results for your end users.

Digital Transformation (DX) is about enabling you to solve traditional problems in different ways by using digital technology; this transformation leads to a better digital solution for your organization.

NetApp® is committed to delivering digital transformation solutions. Specifically, this solution is focused on how you can deploy an end-user compute solution using the VMware Horizon environment on NetApp HCI. The minimum starting point for this solution is an environment with:

- Virtualized compute – NetApp HCI compute running ESXi.
- Pooled storage – NetApp HCI storage running NetApp® Element® software
- Management plane – Element Plug-in for VMware vCenter Server

With this solution, your business can easily meet rapidly changing needs and you can accelerate your business outcomes. The NetApp HCI solution delivers predictable performance for all desktops, databases, and applications in your end-user compute environment. It has a highly flexible and efficient architecture that is simple to deploy, manage, and scale.

The NetApp HCI solution is designed to:

- Host multiple workloads and applications.
- Be easily scalable for either computer or storage.
- Provide management, monitoring, and reporting tools as needed.
- Provide quality of service (QoS) for all tenants.

2 The Big Picture: VMware Private Cloud on NetApp HCI

Moving to the private cloud is a journey. Most organizations want to start small and grow their environment over time. NetApp has developed, in collaboration with VMware, two documents that describe how to deploy the NetApp HCI Private Cloud with VMware Private. These documents are the VMware Validated Design (VVD) for NetApp HCI and the NetApp HCI for VMware Private Cloud NVA. These documents provide guidelines, best practices, and deployment information for a VMware private cloud, using the VMware vRealize suite of products and VMware NSX, with NetApp HCI.

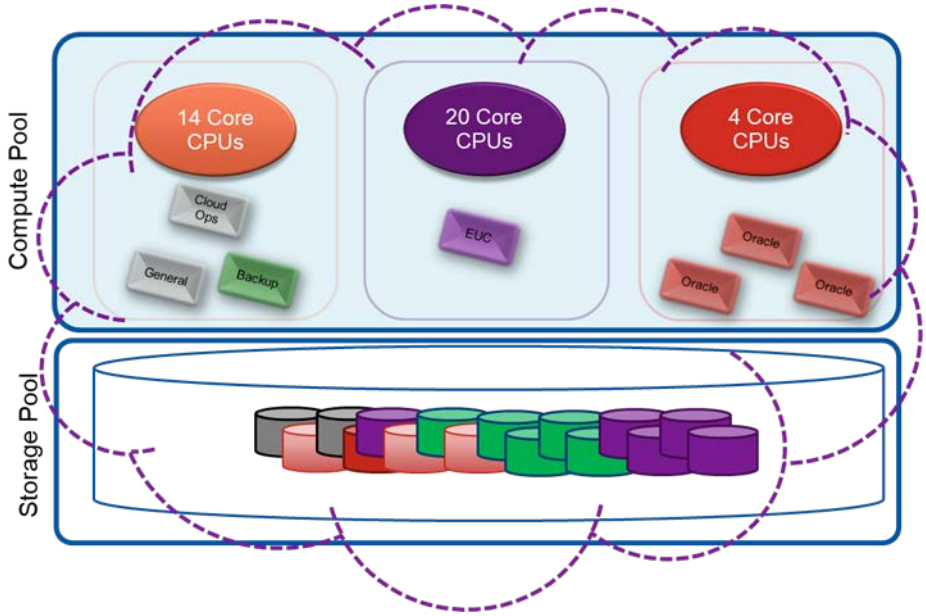
When you are using a private cloud, you might want to automate parts of the environment. With tools such as vRealize Automation self-service, you can provision virtual machines (VMs) from a predefined catalog and quickly provision applications. For example, engineering VMs can be delivered as an OVA file (template) from VMware and then deployed in the vSphere environment. The goal is a solution that offers microsegmentation of resources, provides extensive IT automation, and enables you to integrate your application workloads that are running in a private cloud.

Another objective when deploying and operating in a private cloud is increased agility or the ability to quickly deploy more applications or workloads. With NetApp HCI, you can easily deploy and support any workload or use case. Figure 1 shows how the compute and storage resources are distributed for a superior level of resource-sharing capabilities. This capability is similar to hyperscalers such as Amazon Web Services (AWS), Azure, and Google Cloud.

With this infrastructure, you can deploy the application or workload to run on the desired CPUs and move that application as your needs evolve. The storage that holds the data does not have to move and can be grown independently from the compute environment. The NetApp Data Fabric also enables you to connect your private cloud ecosystem on NetApp HCI to hyperscalers to deliver a hybrid multicloud experience.

For more information about the NetApp Data Fabric, see What Is Hybrid Multicloud Experience?

Figure 1) VMware private cloud on NetApp HCI.



For more information about NetApp HCI and VMware Private Cloud, see the VMware Private Cloud on NetApp HCI NVA Design Guide.

2.1 NetApp HCI VMware Private Cloud

If you are seeking the flexibility of a private cloud and the portability of a hybrid cloud infrastructure, the NetApp HCI VMware private cloud offers various benefits. It combines industry best practices with the VMware vSphere hypervisor. The NetApp HCI VMware private cloud delivers features and capabilities that first-generation hyperconverged infrastructure vendors did not offer. It is predictable, flexible, scalable, and provides simple administration and deployment. It is also integrated with the NetApp Data Fabric.

Predictable

Delivering predictable performance is one of the biggest challenges when you are managing a private cloud infrastructure, especially when you are faced with increasing applications and workloads. Dedicated platforms and massive overprovisioning are not economically viable. However, when multiple applications share infrastructures, one application might interfere with the performance of another.

The NetApp HCI VMware private cloud solution alleviates this concern through its design choices and technology innovation. First, the compute and storage are separate and scale independently. On the compute side, workloads can be segmented into different compute clusters that are managed by the same tools. If the monitoring tools determine extra compute is needed, you can easily add resources.

On the storage side, the NetApp Element software implements quality of service (QoS) which applies limits and enables granular control of each application and volume. Element software also eliminates noisy neighbors and satisfies performance SLAs. All applications can be deployed and operated on a shared platform, with predictable performance.

Flexible and Scalable

Workload planning is not an exact science. Business needs change constantly, applications evolve, and IT organizations are expected to keep pace. Administrators need solutions that can scale, are easy to manage, and provide dynamic flexibility. The NetApp HCI VMware private cloud enables independent on-demand scaling and rebalancing of compute and storage resources. It offers online resource migration, providing a public cloud-like experience for private cloud users.

NetApp HCI scales compute and storage resources independently. Independent scaling enables the environment to add extra resources to only those areas that need them. This type of scaling helps avoid costly and inefficient overprovisioning and simplifies capacity and performance planning.

With the NetApp HCI VMware private cloud, licensing costs can also be reduced. It can mix-and-match compute configurations to match application needs. The architectural design choices that are available can help you to confidently scale on your terms. These features make NetApp HCI a viable solution for core data center applications and platforms.

Simple

Automating all routine tasks is a priority for the IT community because it mitigates the risk of user error, and releases resources to focus on more interesting, higher-value projects. The NetApp HCI VMware private cloud enables IT departments to become more agile and responsive by simplifying deployment and ongoing management.

The VMware vCenter plug-in simplifies management in an intuitive way. Also, the NetApp HCI VMware private cloud solution uses a robust suite of APIs to promote integration with higher-level management, orchestration, backup, and disaster recovery tools.

NetApp Storage Portfolio and the NetApp Data Fabric

Several private cloud solutions involve the introduction of a silo of resources into an existing data center. They do not have the portfolio to offer best-in-class technologies. NetApp can deliver a multitude of storage technologies designed to meet your application and workload needs. Also, all of the different storage products can operate in the NetApp Data Fabric.

NetApp has invested heavily in the Data Fabric, offering enhanced data portability, visibility, and protection of workloads whether they reside on-premises, in near-cloud storage, or in a public cloud. The Data Fabric removes lock-in and provides you with a new set of choices. It enables the full potential of your data to be unleashed across cloud environments.

3 NetApp HCI and VMware End-User Computing Architecture

This combination of technologies from NetApp and VMware gives you the benefit of the end-user computing ecosystem. This document details the design decisions that we made to deploy VMware End-User Computing on NetApp HCI.

NetApp HCI is a hybrid cloud infrastructure solution capable of transforming and empowering organizations to move faster, drive operational efficiencies, and reduce costs. NetApp HCI is designed to run multiple applications and to deliver predictable performance—features that enterprises and their customers demand. NetApp HCI enables the independent scaling of compute and storage resources, making sure that systems are right-sized. VMware Horizon can rapidly provision desktops and required applications in minutes, eliminating the complex management of traditional architectures. Integration into the NetApp Data Fabric means that you can easily integrate your infrastructure with the cloud and the required data services.

NetApp HCI releases you from the limitations of current infrastructure solutions which are often complex and are unable to consolidate all workloads. These restrictions can force you to scale in ways that strand

resources and throttle the performance required by next-generation applications. With VMware Horizon on NetApp HCI, you can provision your compute and storage to quickly deploy on virtual desktops and applications. The infrastructure can then be scaled as needs change.

3.1 VMware End-User Computing

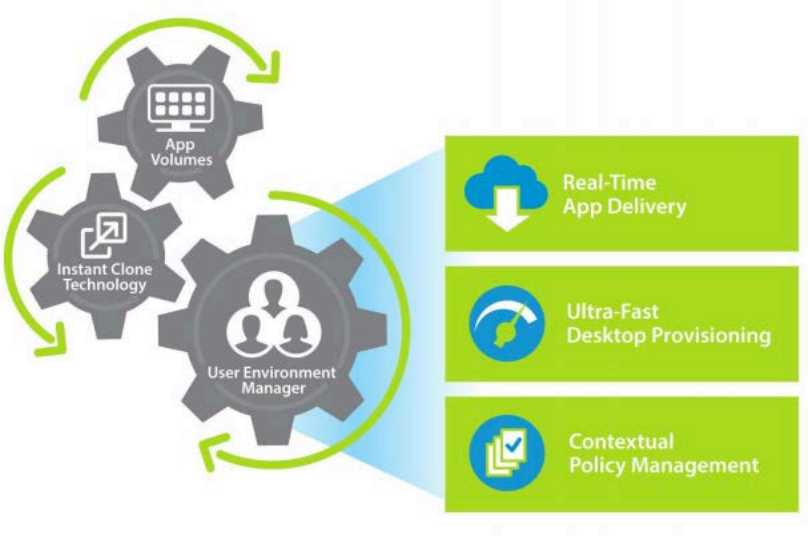
Horizon is tightly integrated with the NetApp HCI solution. This integration provides a seamless turnkey solution, eliminating the need to build, test, and support disparate storage, virtualization, and networking products.

Horizon provides you with access to all of their virtual desktops, applications, and online services through a single digital workspace. You can quickly transform static desktops into secure, digital workspaces that can be delivered on demand. It's also possible to provision virtual or remote desktops and applications through a single virtual desktop infrastructure (VDI) and app virtualization platform. This feature enables you to streamline management and easily assign permissions for your end users.

Figure 2 shows the VMware Horizon Just-In-Time Management Platform (JMP) technology, which enables you to perform:

- Ultrafast desktop or remote desktop session host provisioning with instant clones.
- Real-time application delivery with application volumes.
- Contextual policy management with User Environment Manager (UEM).

Figure 2) VMware Horizon JMP technology.



Horizon Instant Clone, App Volumes, and UEM are all part of Horizon 7 Enterprise edition, which also includes other components such as:

- vRealize Operations Manager for performance monitoring of desktop and application dynamic disk pools.
- vRealize Log Insight for centralized log collection and analysis.
- VMware NSX for vSphere for software defined networking, securing desktops with microsegmentation, and edge services such as a load balancer and Dynamic Host Configuration Protocol (DHCP).

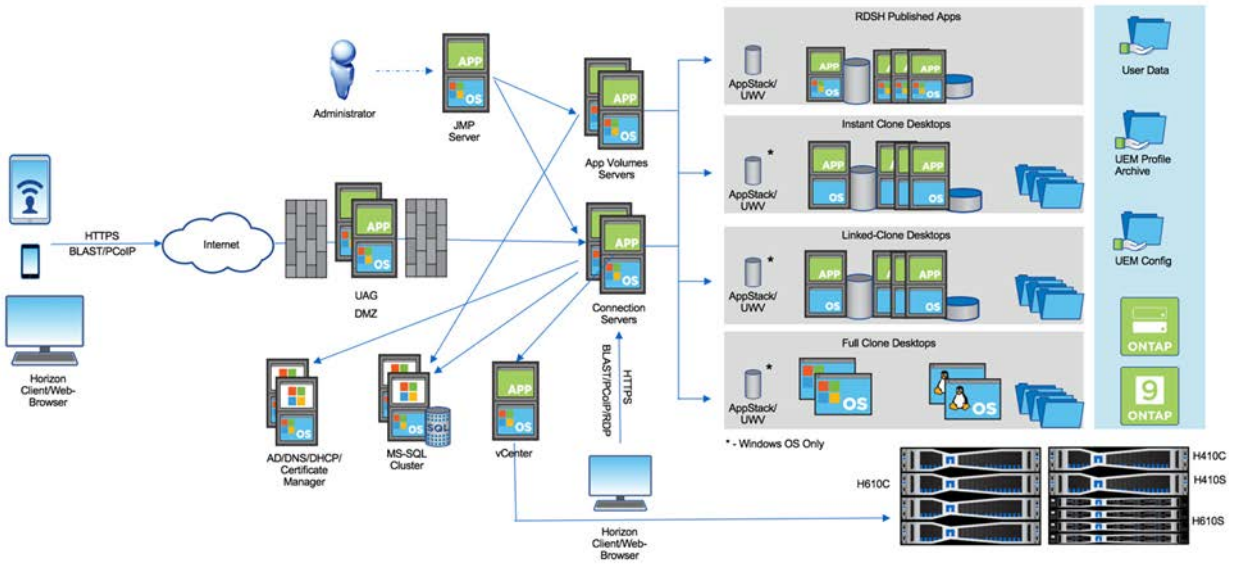
4 Solution Overview

This solution takes the VMware Horizon View 7 product and runs it on top of the NetApp HCI, enabling you to deploy virtual desktops and applications. It supports infrastructure on the same platform and you can scale the platform to meet demand. The starting point for this solution is a deployed and operational NetApp HCI environment consisting of at least the following:

- VMware ESXi 6.5 or higher
- Storage dynamic disk pools with free capacity, NetApp HCI storage, and possibly FAS or AFF
- Management plane, in this report we assume VMware Horizon and vCenter Server

For further information about deploying and running the private cloud, see the NetApp Verified Architecture for VMware Private Cloud.

Figure 3) NVA for VMware private cloud.



Key components of this solution include:

- NetApp HCI: Enables the compute or storage platform to expand or shrink based on the demand. Storage provides features such as global deduplication, compression, and thin provisioning.
- VMware Horizon Instant Clone: This feature reduces the number of desktop images that you must manage and provides faster cloning times for end users.
- App Volumes: App Volumes provides a common set of applications and enables you to install policy-based applications on your own by using writable volumes. User profiles and application settings are managed by a user environment manager, which enables you to maintain the same settings when you move them between machines.
- Just-In-Time Management Platform (JMP): VMware Horizon 7 provides JMP technology that allows you to provision a desktop in seconds, including application provisioning. JMP uses the VMware Horizon 7 Instant Cloning feature, application provisioning with AppStacks, and profile management using User Environment Manager.
- vRealize Operations Manager and vRealize Log Insight: This solution includes centralized monitoring with vRealize Operations Manager and vRealize Log Insight.

4.1 Target Audience

The target audience for the solution includes the following groups:

- Field consultants to help with design decisions in the VMware End-User compute environment.
- Executives and sales engineers to understand the value of the solution.
- NetApp Professional Services and IT managers to understand and identify the components of the solution.
- Partners to learn and assist the customers who face similar challenges.

4.2 NetApp HCI Use Cases

In addition to the previously mentioned benefits, there are various use cases for which the NetApp HCI solution is ideal. If you are designing end-user compute environments, including hardware accelerated graphics applications, and considering workload consolidation, NetApp HCI is architected to deliver exceptional value.

4.3 Private Cloud

NetApp HCI is an optimal foundation for an enterprise private cloud model, whether you choose OpenStack, VMware, or a solution developed in-house. This flexibility is because NetApp HCI uses native Element software APIs that enable the on-demand provisioning of workloads through storage drivers and management plug-ins.

For example, NetApp HCI integrates with VMware Virtual Volumes (VVols), enabling VMware administrators to achieve the most granular control over storage performance on a per-VM basis. You can set minimum, maximum, and burst IOPS levels, confirming exact amounts of capacity and performance for even the most sensitive VMs. You can change capacity and performance dynamically without migrating data or affecting system performance.

4.4 End-User Computing

NetApp HCI is optimal for end-user computing (EUC) environments because capacity and performance are allocated independently for every virtual desktop and every application. The allocations can be easily adjusted as workloads shift or requirements change. If an application needs more performance, the initial configuration can become a bottleneck, but NetApp HCI eliminates the penalty for underestimating requirements. Modification of the QoS policies can easily change the settings for minimum, maximum, and burst, and the new settings take effect immediately.

4.5 Workload Consolidation

NetApp HCI eliminates workload silos, enabling you to predictably run multiple applications on the same infrastructure. Traditionally, when multiple applications share infrastructures, all performance resources, both IOPS and bandwidth, are freely available to all applications across the shared resources. Without a more precise resource allocation, one application or “noisy neighbor” can easily consume an unfair share of the resources, leaving little available for others. This first-come, first-served allocation methodology can have a negative effect on the other applications on the system.

Performance expectations on an application-by-application basis are unpredictable. One misbehaving application can cripple the entire system. To keep these variances in check, you must constantly monitor and manage which applications share resources. Often, alleviating resource contention requires that either the “noisy neighbor” or the unhappy customer is migrated to a new system.

The NetApp HCI QoS settings eliminate resource contention and the variable application performance that is caused by noisy neighbors. Each volume on the system is assigned its own minimum, maximum,

and burst settings for predictable performance each application. This feature is important for avoiding the capacity sprawl and low utilization issues that are common in today's hyper converged infrastructures.

4.6 Solution Use Case Summary

This solution applies to the following use cases:

- On-demand desktop and application deployment for end users
- User profile management self-service for end users
- Ease of management for security patches
- Integration with an existing private cloud
- Secure multitenant infrastructure for enterprises

5 Technology Components

This section covers the technology components that we used to validate the End-User Computing on NetApp HCI.

5.1 Hardware Components

Table 1 and Table 2 show the physical and virtual hardware components that we used for the solution. The hardware components that are used in any particular implementation of the solution might vary based on your requirements.

Table 1) Physical hardware components.

Component	Count	Description
NetApp HCI compute nodes (resource block)	2	H410C
NetApp HCI compute nodes (management block)	2	H500E
NetApp HCI storage nodes	4	H500S
Cisco Nexus 9000 switch	2	iSCSI/VM/vMotion
1Gb switch	1	Intelligent Platform Management Interface (IPMI)/Management

Table 2) Virtual hardware components.

Virtual Machine	Count	vCPU	RAM (GB)	VMDK (GB)	Port Group	Block
Active Directory	2	1	4	40	VM Network	Management
DHCP/Certificate Server	1	1	4	40	VM Network	Management
NVIDIA License Server	1	2	4	40	VM Network	Management
Management vCenter	1	8	24	500	HCI_Internal_vCenter_Network	Management
Resource vCenter	1	2	10	280	HCI_Internal_vCenter_Network	Management

Virtual Machine	Count	vCPU	RAM (GB)	VMDK (GB)	Port Group	Block
SQL Server	1	4	8	40 (OS) 100 (Data) 50 (Log)	VM Network	Management
NetApp ONTAP® Select	1	4	16	4096	VM Network	Management
HCI Storage management node	1	6	8	100	VM Network	Management
Horizon Connection Server	2	4	16	40	VM Network	Management
JMP Server	1	2	8	40	VM Network	Management
Unified Access Gateway	1	4	16	40	VM Network, Corp	Management
App Volumes Server	1	4	4	40	VM Network	Management
vRealize Log Insight	1	8	16	20,510,0.5	VM Network	Management
vRealize Operations Manager	1	8	32	20,250,4	VM Network	Management
Login VSI Data Server	1	2	4	50	VM Network	Management
Login VSI Launchers	13-40	2	4	40	VM Network	Management

5.2 Optional Software Components

Table 3 shows the software components that are optional to implement the solution. The software components that are used in any particular implementation of the solution might vary based on your requirements.

Table 3) Software requirements.

Software	Version
NetApp HCI NDE	1.4
VMware Horizon 7 Enterprise	7.6
VMware Identity Manager	3.3.0
VMware Horizon	7.6
VMware App Volumes	2.14.2
VMware NSX for vSphere	6.4.3

Software	Version
VMware vCenter	6.7 Update 1
VMware vSphere	6.7 Update 1
VMware vRealize Operation Manager	6.6.1
VMware vRealize Operations for Published Applications	6.5.1
VMware vRealize Orchestrator Plug-in for Horizon	1.4.0
VMware User Environment Manager	9.5.0
VMware vRealize Log Insight for vCenter Server	4.6.1

6 Deployment Procedures

Deploying the solution involves the following tasks:

- Deploy NetApp HCI using NDE
- Complete the predeployment checklist
- Deploy and configure resource blocks
- Deploy VMware vRealize Log Insight
- Deploy VMware vRealize Operations Manager
- Deploy and configure VMware Horizon 7 Instant Clones
- Deploy and configure VMware App Volumes
- Deploy and configure VMware Unified Environment Manager
- Deploy and configure JMP Server
- Configure VMware vRealize Operations Manager
- Integrate with VMware vRealize Log Insight
- (Optional) Integration with VMware vRealize Automation (private cloud)

6.1 NetApp HCI Deployment

To deploy NetApp HCI, complete the following steps:

1. Follow the installation and setup instructions here:
   https://library.netapp.com/ecm/ecm_download_file/ECMLP2850370
2. Review the procedures for setting up and using NetApp HCI 1.4:
   https://library.netapp.com/ecm/ecm_download_file/ECMLP2847696

   Note: If you don't have an existing ONTAP File Services, then you must deploy file services.

6.2 Predeployment Checklist

Gather the information in Table 4 before you continue:

Table 4) Predeployment checklist.

Item	Value
DNS server IPs	
NTP server IP	

Item	Value
Gateway address	
Subnet mask	
Management Block datastore names (To host VMware Horizon Servers, App Volumes, JMP Server)	
Resource Block datastore names (To host Virtual Desktops, AppStacks, User Writable Volumes)	
SQL Server connection information (The credential should have the appropriate rights to create a database and be a database owner)	
Secure Sockets Layer (SSL) certificates available? Keep it available for production use.	
Collected software license information?	
Created DNS entries for the components deploying?	

6.3 Deploy and Configure Resource Blocks

To deploy resource blocks, complete the following steps:

1. Deploy vRealize server on management block for the resource block.
   For more information, see the section “GUI Deployment of the vCenter Server Appliance and Platform Services Controller Appliance” in the vCenter Server Installation and Setup guide.
2. Deploy NSX Manager on management block for the resource block.\
3. For more information, see the NSX Installation Guide.
4. Based on your deployment scenario, add vSphere hosts to resource block vRealize server and assign datastores to the cluster.
5. Based on your deployment scenario, have port groups available for the VMs to use.

6.4 Deploy VMware vRealize Log Insight

To deploy VMware vRealize Log Insight, complete the following steps:

1. Based on your environment need, deploy the appropriate size of VM.

   For more information, see the “Installing vRealize Log Insight” section of the Getting Started guide:
   https://docs.vmware.com/en/vRealize-Log-Insight/4.6/com.vmware.log-insight.getting-started.doc
2. Configure the authentication.

   For more information, see the “Configuring Authentication” section of the Administration Guide:
   https://docs.vmware.com/en/vRealize-Log-Insight/4.6/com.vmware.log-insight.administration.doc
3. Assign the license.

   For more information, see the “Configuring vRealize Log Insight” section of the Administration Guide:
   https://docs.vmware.com/en/vRealize-Log-Insight/4.6/com.vmware.log-insight.administration.doc
4. Replace the SSL certificates.

   See the “Install a Custom SSL Certificate” section of the Administration Guide:
   https://docs.vmware.com/en/vRealize-Log-Insight/4.6/com.vmware.log-insight.administration.doc
5. Depending on your environment, add worker nodes to vRealize Log Insight Cluster.

For more information, see the “Managing vRealize Log Insight Clusters” section of the Administration Guide: https://docs.vmware.com/en/vRealize-Log-Insight/4.6/com.vmware.log-insight.administration.doc

6.5 Deploy VMware vRealize Operations Manager

To deploy VMware vRealize Operations Manager, complete the following steps:

1. Deploy OVA for creating vRealize Operations Manager cluster nodes.
2. For more information, see the “Installing vRealize Operations Manager” section in vRealize Opertations Manager vApp Deployment and Configuration Guide.

   Note: The number of nodes depends on the environment needs.
3. Start the New Installation wizard by visiting the appliance web address (which was provided using OVA deployment on previous step).

   For more information, see page 23 in vRealize Opertations Manager vApp Deployment and Configuration Guide.
4. Depending on your environment, add extra nodes (remote collector/master replica) to the cluster.

   For more information, see page 29 in vRealize Opertations Manager vApp Deployment and Configuration Guide.
5. Log in as Admin and the assign license key.

   For more information, see page 36 in vRealize Opertations Manager vApp Deployment and Configuration Guide.

6.6 Deploy and Configure VMware Horizon 7 Instant Clones

To deploy VMware Horizon, complete the following steps:

1. Install Horizon 7 on datastores that are available in the management block.

   For more information, see the instructions on the VMware Horizon 7 Installation page.

   Note: Skip Horizon Composer Database steps and Horizon Composer Installation steps unless you plan on using them.
2. Perform the Horizon 7 initial configuration.

   For more information, see the instructions on the VMware Horizon 7 Introduction page.

   Note: Register resource block vCenter Server with VMware Horizon. Skip steps related to composer unless you plan on using them.

6.7 Deploy and Configure VMware App Volumes Manager

To deploy VMware App Volumes, complete the following steps:

1. Install VMware App Volumes Manager. See the “Installing App Volumes” section at VMware App Volumes Installation Guide.

   Note: Based on environment need, deploy more App Volumes managers.
2. Configure VMware App Volumes Manager. See the “Configuring App Volumes Manager” section at VMware App Volumes Administration Guide.
3. Update the SSL Certificate. See the “Using SSL Certificates with App Volumes Manager” section at VMware App Volumes Administration Guide.

6.8 Deploy and Configure VMware User Environment Manager

To deploy VMware User Environment Manager, complete the following steps:

1. Create a UEM configuration file share and user profile archive file share.

Follow the instructions available at VMware User Environment Manager Deployed in 60 Minutes or Less.

2. Configure Windows Group Policy Objects (GPOs).

   Follow the instructions available at VMware User Environment Manager Deployed in 60 Minutes or Less.

3. Install UEM Management Console and configure.

   For more information, see Quick Start Tutorial for User Environment Manager.

6.9 Deploy and Configure JMP Server

To deploy a JMP Server, complete the following steps:

1. Create SQL Server Database and Login for JMP server host.

   For more information, see Create a SQL Server Database for JMP Server.

2. For SQL Server login for JMP server host, see Create a SQL Server Login for the JMP Server Host.
3. Install the JMP Server.

   For more information, see Install JMP Server.

4. Configure the JMP Server.

   For more information, see Configuring the JMP Server Instance.

6.10 Configure vRealize Operations Manager

To monitor VMware Horizon with vRealize Operations Manager, complete the following steps:

1. Install the vRealize Operations for Horizon Solution.

   For more information, see Installing and Configuring vRealize Operations for Horizon.

   Note: Install the Horizon Broker Agent on connection servers.

2. To monitor NetApp HCI with vRealize Operations manager, deploy the Blue Medora NetApp HCI plug-in.

   For more information, see VMware vRealize Operations Management Pack for NetApp HCI & SolidFire.

6.11 Integrate with vRealize Log Insight

To configure Horizon centralized logging with vRealize Log Insight, complete the following steps:

1. Install vRealize Log Insight Agent on the desktop template.

   For more information, see the appropriate section in Installing or Upgrading vRealize Log Insight Agents.

2. Install VMware Horizon View content pack for log insight.
   a. Download the content pack here: https://marketplace.vmware.com/resources/99407fe755ee11e78024005056a107c6/doc/ce2e437bf7484024beb86b7a990891da/VMware%20-%20Horizon%20View%20%20v3.3.vlcp.
   b. Install using the procedure provided in the Install a Content Pack from the Content Pack Marketplace.
3. Create Agent Group and provide appropriate filters to add the agents.

   For more information, see Working with Centralized Agent Configurations and Agent Groups.

6.12 (Optional) Integrate with vRealize Automation

To integrate Horizon with vRealize Automation, complete the following steps:

1. Install vRealize Orchestrator Plug-in for Horizon.

For more information, see Install or Upgrade vRealize Orchestrator Plug-In for Horizon.

2. Configure the connection to Horizon Pod.

   For more information, see Configure the Connection to a Horizon Pod.

3. Configure the App Volumes Server.

   For more information, see Configure the App Volumes Server.

4. Expose Horizon Workflows in vRealize Automation.

   For more information, see Exposing vRealize Orchestrator Plug-in for Horizon Workflows in vRealize Automation.

7 Solution Verification

Login Virtual Session Indexer (Login VSI) is the industry standard load-simulation testing tool for measuring the performance and scalability of centralized Windows desktop environments, such as VDI and hosted applications. Login VSI is used for simulating a typical user activity using the virtual desktop. Login VSI is 100% vendor independent and works with standardized user workloads. This standardization makes all conclusions that are based on Login VSI test data objective, verifiable, and repeatable.

Figure 4 shows the Login VSI workloads that are provided out-of-the-box. You can also create custom workloads.

Figure 4) Login VSI workloads.

Workload Name	VSI Version	Apps Open	CPU Usage	Disk Reads	Disk Writes	IOPS	RAM	(v)CPU
Task Worker	4.1.x	2-7	70%	79%	77%	6	1GB	1(v)CPU
Office Worker	4.1.x	5-8	82%	90%	101%	8.1	1.5GB	1(v)CPU
Knowledge Worker	4.1.x	5-9	100%	100%	100%	8.5	1.5GB	2(v)CPU
Power Worker	4.1.x	8-12	119%	133%	123%	10.8	2GB	2(v)CPU+

For testing, we used the Knowledge Worker workload which is designed for two vCPU environments. This workload is well-balanced, intensive, and stresses the system smoothly, resulting in higher CPU, RAM, and I/O usage. This workload uses the following applications:

- Components of Microsoft Office (Word, Excel, Outlook, PowerPoint)
- Adobe Reader
- Freemind or Java
- Web Browser (Microsoft Edge or Internet Explorer)
- Photo Viewer
- Native Windows Apps (Notepad)

We performed a single-server test to identify the number of virtual desktops that can be hosted without excessive fine-tuning. Base Image contains a complete installation of Microsoft Office 2016, Login VSI Target Package, Horizon Agent including vRealize Operations NetApp Monitoring Agent, complete UEM, and App Volume Agent. We tested first with all components of JMP technologies, then we removed one component at a time and observed the affect this removal had on the results.

The hardware specification of the server that is used for testing is shown in Table 5.

Table 5) Hardware specification of server used for testing.

Item	Value
Model Number	NetApp HCI H410C-14020
Processor	Two Intel Xeon Scalable Processors (Also known as Skylake) Silver 4110 (8 core, 2.1 GHz, 11MB L3 Cache)
Memory	384GB

7.1 Login VSI Test with JMP Technologies

VMware Horizon Persistent Instant Clone dynamic disk pool, with App Volume for User Writable Volume and User profile archiving with UEM.

Table 6 shows the details used for the login VSI test with HT disabled.

Table 6) Login VSI test details (JMP technologies with HT disabled).

Test Case	Details
Test number	Test-01
Hyperthreading	Disabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone
Horizon Pool Size	45
App Volume Assignment	User Writable Volumes.
Login VSI Launchers	13

Login VSI Test Results (JMP Technologies and HT Disabled)

Table 7 shows the test results for the Login VSI test using all JMP technologies with HT disabled.

Table 7) Login VSI test results (JMP technologies and HT disabled).

Item	Value
Login VSI Max	41
Login VSI Base	1339ms

Figure 5 shows the virtual session index and its response time.

Figure 5) Login VSI chart results (JMP technologies and HT disabled).

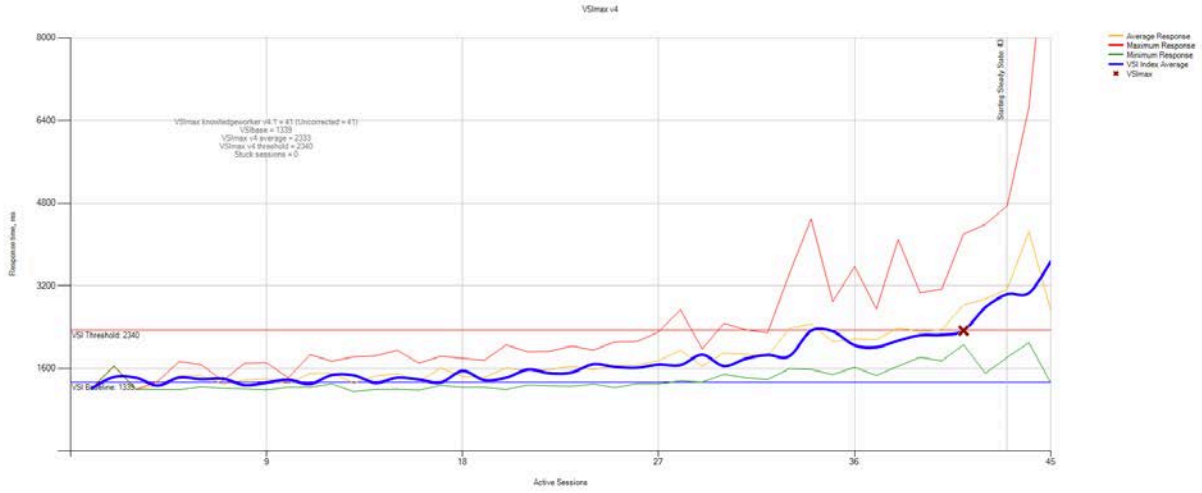


Figure 6 shows the corresponding physical CPU% utilities time which shows at the VSI maximum, the CPU utilization is around 80%.

Figure 6) Percentage of core utilization time (JMP technologies and HT disabled).

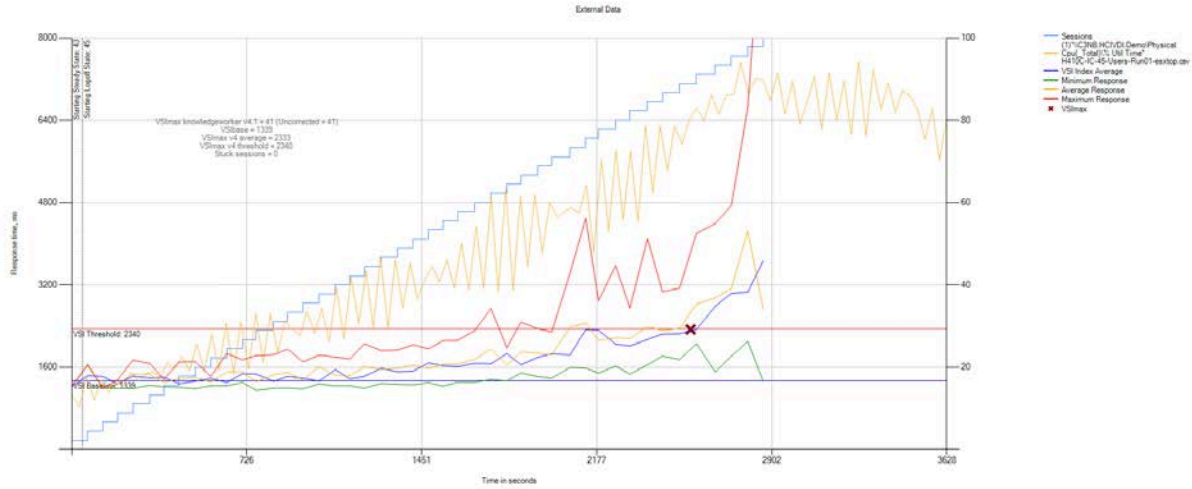


Figure 8 shows the test details for the Login VSI test using all JMP technologies with HT enabled.

Table 8) Login VSI test details (JMP Technologies and HT enabled).

Test Case	Details
Test number	Test-02
Hyperthreading	Enabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone
Horizon Pool Size	50
App Volume Assignment	User Writable Volumes.

Test Case	Details
Login VSI Launchers	13

Login VSI Test Results (JMP Technologies and HT Enabled)

Figure 9 shows the login VSI test results for all JMP technologies with HT enabled.

Table 9) Login VSI test results (JMP technologies and HT enabled).

Item	Value
Login VSI Max	47
Login VSI Base	2069ms

Figure 6 Login VSI chart shows the virtual session index and its response time.

Figure 7) Virtual session index and response time (JMP technologies and HT enabled).

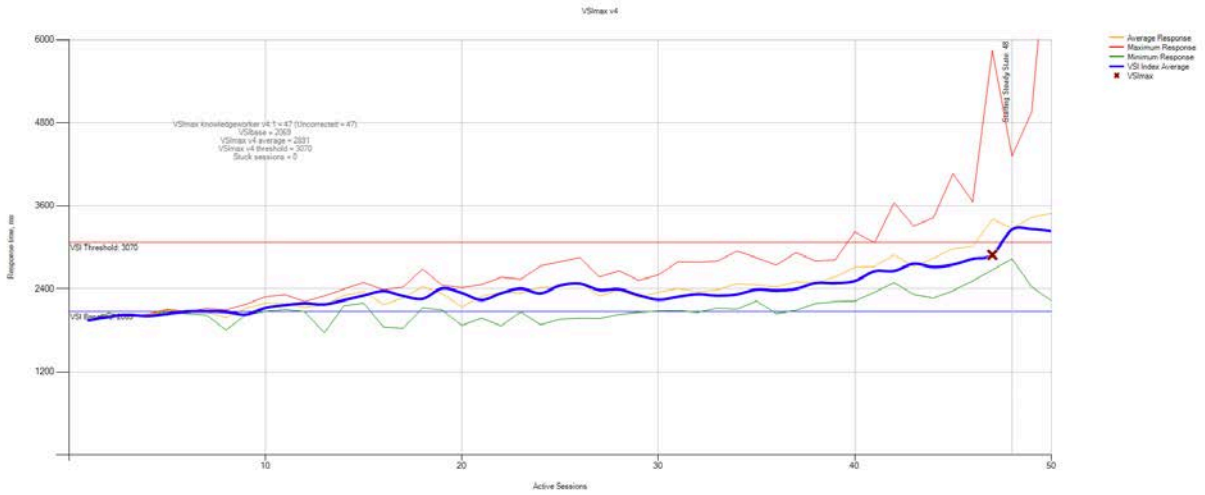
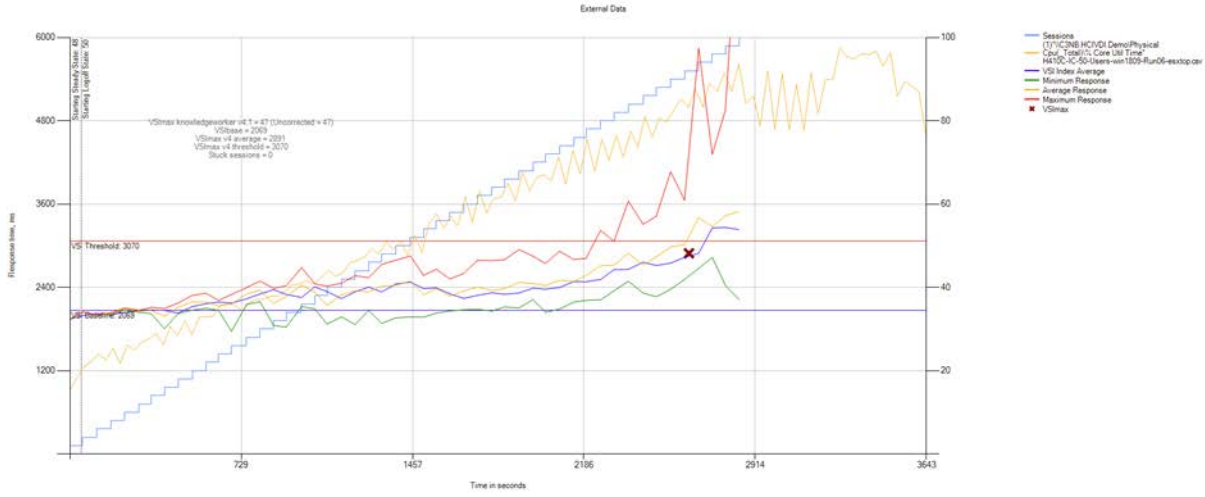


Figure 8 shows the %Core utilization time and session count.

Figure 8) Percentage of core utilization time and session count (JMP technologies and HT enabled).



7.2 Login VSI Test without App Volume Agent

VMware Horizon Persistent Instant Clone dynamic disk pool, without App Volumes Agent and User profile archiving with UEM.

Table 10 shows the test details for the login VSI test without using an App Volumes agent.

Table 10) Login VSI test details (no App Volumes agent).

Test Case	Details
Test number	Test-03
Hyperthreading	Enabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone
Horizon Pool Size	70
App Volume Assignment	Not Applicable
Login VSI Launchers	13

Login VSI Test Results (No App Volumes Agent)

Table 11 shows the test results for the login VSI test without App Volumes agent.

Table 11) Login VSI test results (no App Volumes agent).

Item	Value
Login VSI Max	62
Login VSI Base	1292ms

Figure 9 shows the Login VSI chart virtual session index and its response time.

Figure 9) Virtual session index and response time (no App Volumes agent).

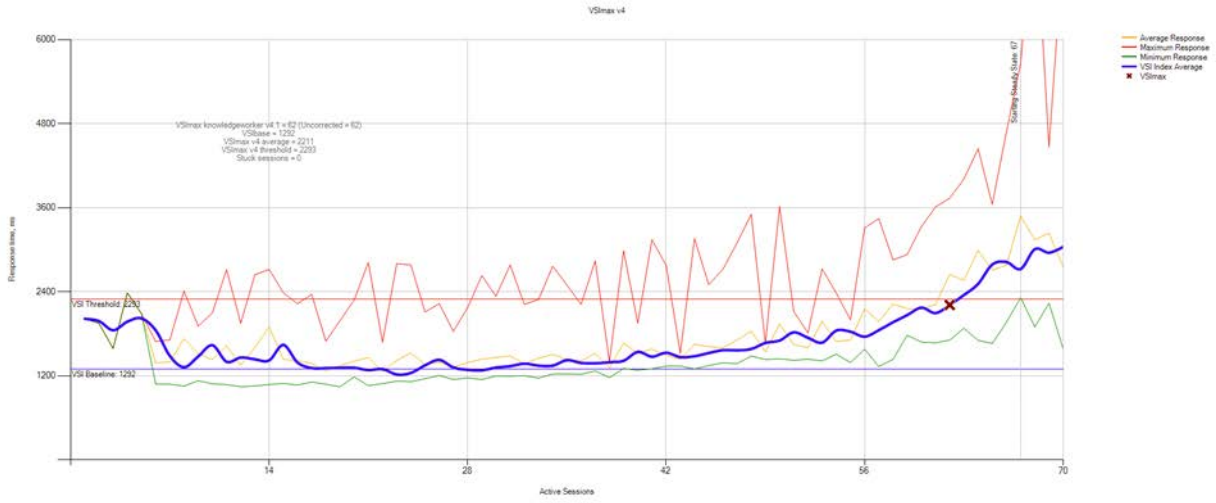
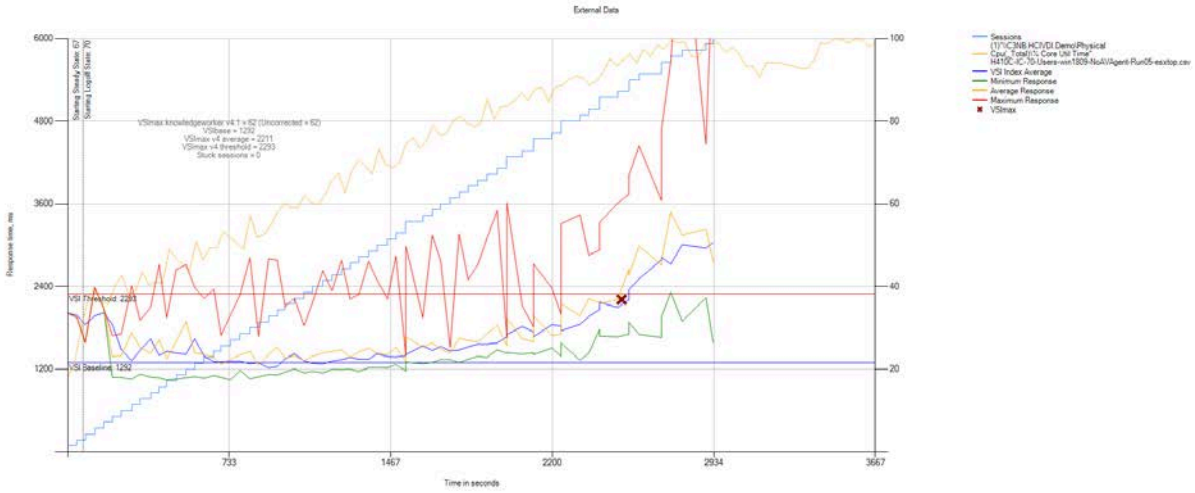


Figure 10 shows the corresponding %Core utilization time and sessions count.

Figure 10) Percentage of core utilization time and sessions count (no App Volumes agent).



7.3 Login VSI Test without App Volume Agent and with UEM Disabled

VMware Horizon Persistent Instant Clone dynamic disk pool, without App Volumes Agent and User profile archiving with UEM.

Table 12 shows the Login VSI test details with no App Volume agent and with UEM disabled.

Table 12) Login VSI test details (no App Volumes agent and UEM disabled).

Test Case	Details
Test number	Test-04
Hyperthreading	Enabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone
Horizon Pool Size	70
App Volume Assignment	Not Applicable
Login VSI Launchers	13

Login VSI Test Results (No App Volumes Agent and UEM Disabled)

Table 13 shows the Login VSI test results with no App Volume agent and UEM disabled.

Table 13) Login VSI test results (no App Volumes agent and UEM disabled).

Item	Value
Login VSI Max	62
Login VSI Base	1258ms

Figure 11 shows the virtual session index and its response time.

Figure 11) Virtual session index and response time (no App Volume agent and UEM disabled).

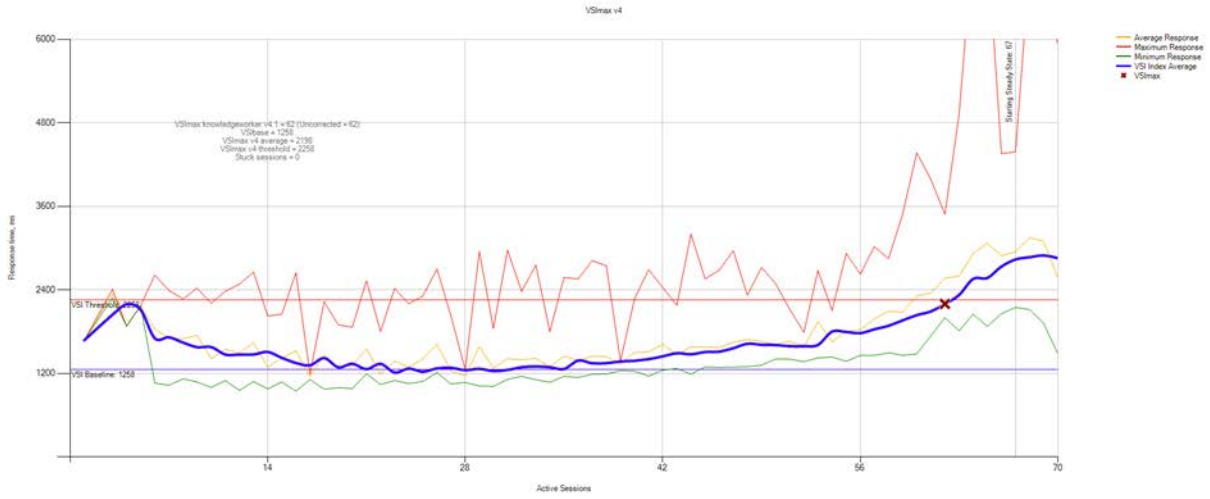
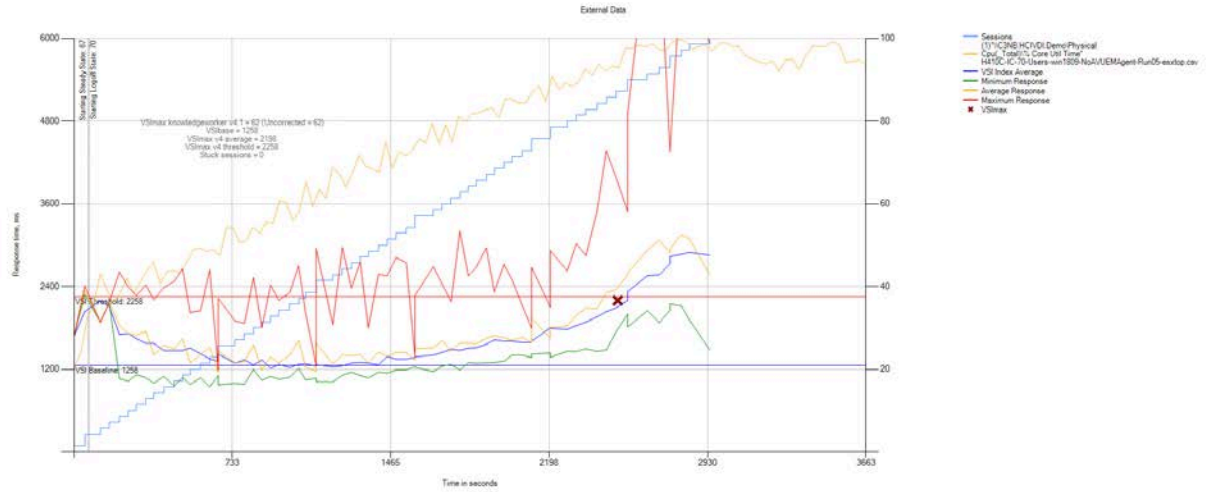


Figure 12 shows the corresponding %Core utilization time and sessions count.

Figure 12) Percentage of core utilization time and sessions count (no App Volume agent and UEM disabled).



In summary, we noticed approximately 14% extra user count when HT was enabled. Without App Volumes, we see the ratio of vCPU to physical CPU core of approximately 8:1 and with App volumes enabled, we noticed that the ratio dropped to around 5:1.

Note: The numbers might vary based on the Windows Image used, including the components installed on the machine.

Table 14) Login VSI overall test results.

Item	JMP (HT Off)	JMP (HT On)	No App Volume Agent	Instant Clone Alone
Login VSI Max	41	47	62	62
Login VSI Base	1339ms	2069ms	1292ms	1258ms

Item	JMP (HT Off)	JMP (HT On)	No App Volume Agent	Instant Clone Alone
Minimum number of servers required on given hardware model for 1000 users based on single-server test results.	25(+1 for HA)	22(+1 for HA)	17(+1 for HA)	17(+1 for HA)

7.4 Linear Scale Testing – Single Server

We used a different server model for linear scale testing validation. However, we used similar Windows Image as in our previous tests.

Table 15 shows the hardware specification of the servers that were used for linear scale testing. Table 16 shows the testing details used for linear scale testing on a single server.

Table 15) Hardware specification for linear scale testing.

Item	Value
Model Number	NetApp HCI H410C-25020
Processor	Two Intel Xeon Scalable Processors (Also known as Skylake) Gold 5120 (14 core, 2.2 GHz, 19.25MB L3 Cache)
Memory	512GB

Table 16) Test details (linear scale testing – one server).

Test Case	Details
Test number	Test-05
Hyperthreading	Enabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone
Horizon Pool Size	110
App Volume Assignment	Not Applicable
Login VSI Launchers	11

Login VSI Test Results (Linear Scale Testing – One Server)

Table 17 shows the login VSI test results for single server.

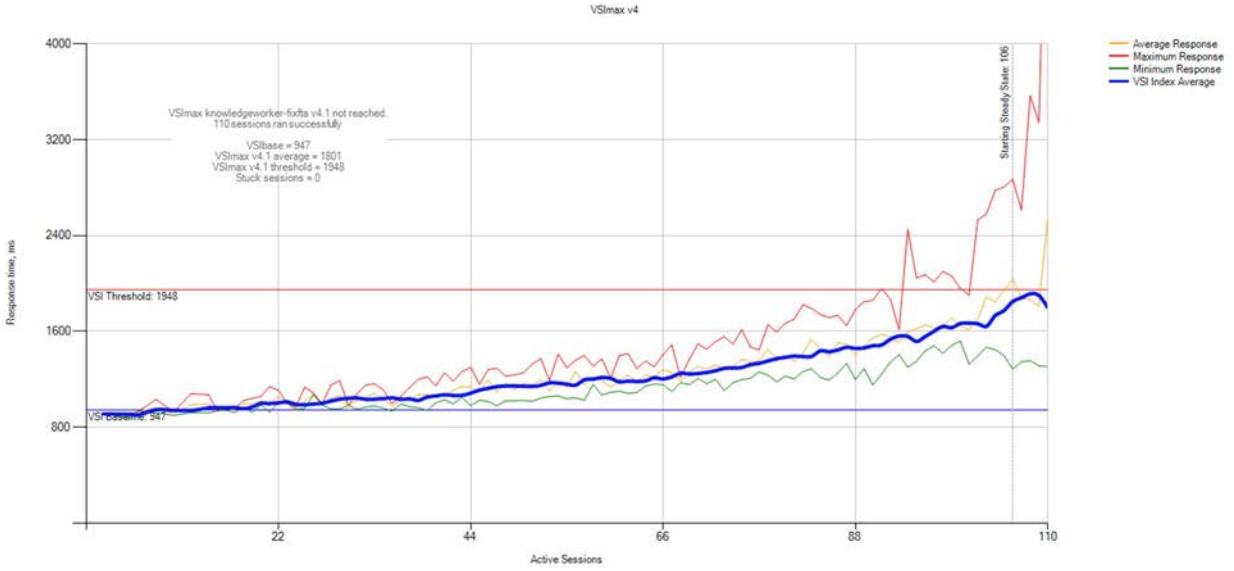
Table 17) Login VSI test results (linear scale testing – one server).

Item	Value
Login VSI Max	110

Login VSI Base	947ms

Figure 13 Login VSI chart shows the virtual session index and its response time.

Figure 13) Virtual session index and response time (linear scale testing - one server).



Note: The result shown in Table 18 is similar to our previous test result for single server.

Table 18) Linear scale test results for single server.

Item	H410C-14020	H410C-25020
Login VSI Max	62	110
Login VSI Base	1292ms	947ms
Number of Cores per socket	8	14
Memory Installed	384GB	512GB
vCPU/Core	7.75	7.86

7.5 Linear Scale Testing – Two Servers

The Horizon Pool size is increased to 220 and hosted on two H410C-25020 servers.

Table 19 shows the test details for linear scale testing with two servers.

Table 19) Test details (linear scale testing – two servers).

Test Case	Details
Test number	Test-06
Hyperthreading	Enabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone

Horizon Pool Size	220
App Volume Assignment	Not Applicable
Login VSI Launchers	11

Login VSI Test Results (Linear Scale Testing – Two Servers)

Table 20 shows the test results for two servers.

Table 20) Login VSI test results (linear scale testing - two servers).

Item	Value
Login VSI Max	220
Login VSI Base	926ms

Figure 14 Login VSI chart shows the virtual session index and its response time.

Figure 14) Virtual session index and response time (linear scale testing - two servers).

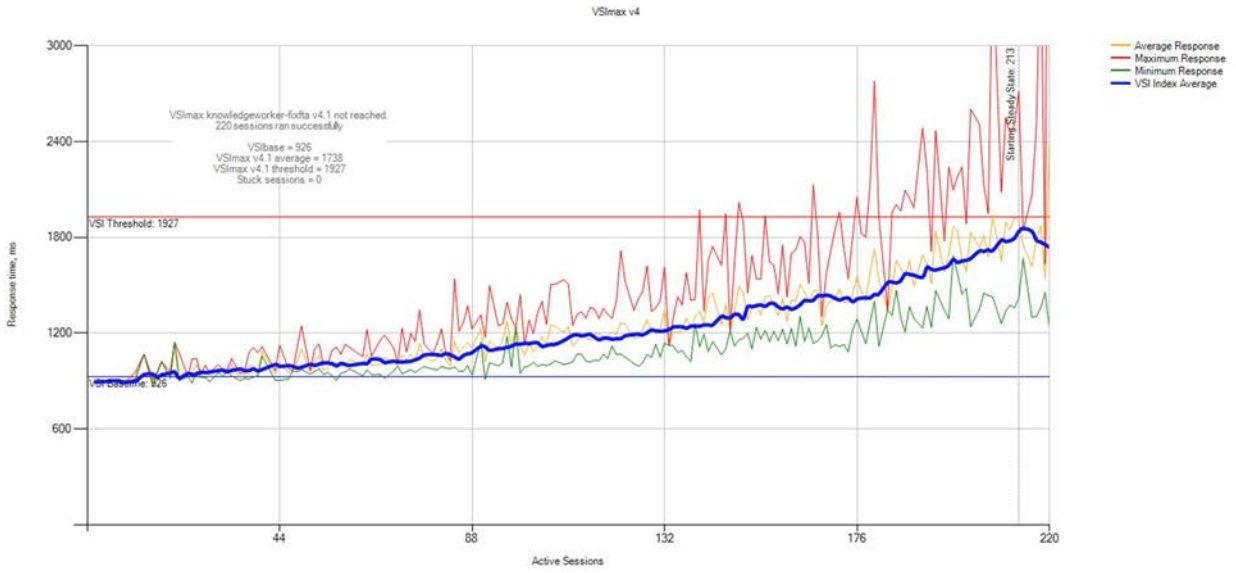


Table 21 displays results showing twice the test result of single server.

Table 21) Linear scale test results for two servers.

Item	H410C-14020	H410C-25020 (1 Server)	H410C-25020 (2 Servers)
Login VSI Max	62	110	220
Login VSI Base	1292ms	947ms	926ms
Number of Cores per socket	8	14	14
Memory Installed	384GB	512GB	512GB

vCPU/Core	7.75	7.86	7.86

7.6 Linear Scale Testing – Four Servers

The Horizon Pool size is increased to 435 and hosted on four H410C-25020 servers.

Table 22 shows the test details for linear scale testing with four servers.

Table 22) Test details (linear scale testing – four servers).

Test Case	Details
Test number	Test-06
Hyperthreading	Enabled
Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – Dedicated User Assignment - Instant Clone
Horizon Pool Size	435
App Volume Assignment	Not Applicable
Login VSI Launchers	22

Login VSI Test Results

Table 23 shows the login VSI test results for linear scale testing with four servers.

Table 23) Login VSI test results (linear scale testing - four servers).

Item	Value
Login VSI Max	435
Login VSI Base	923ms

Figure 15 Login VSI chart shows the virtual session index and its response time.

Figure 15) Virtual session index and response time (linear scale testing – four servers).

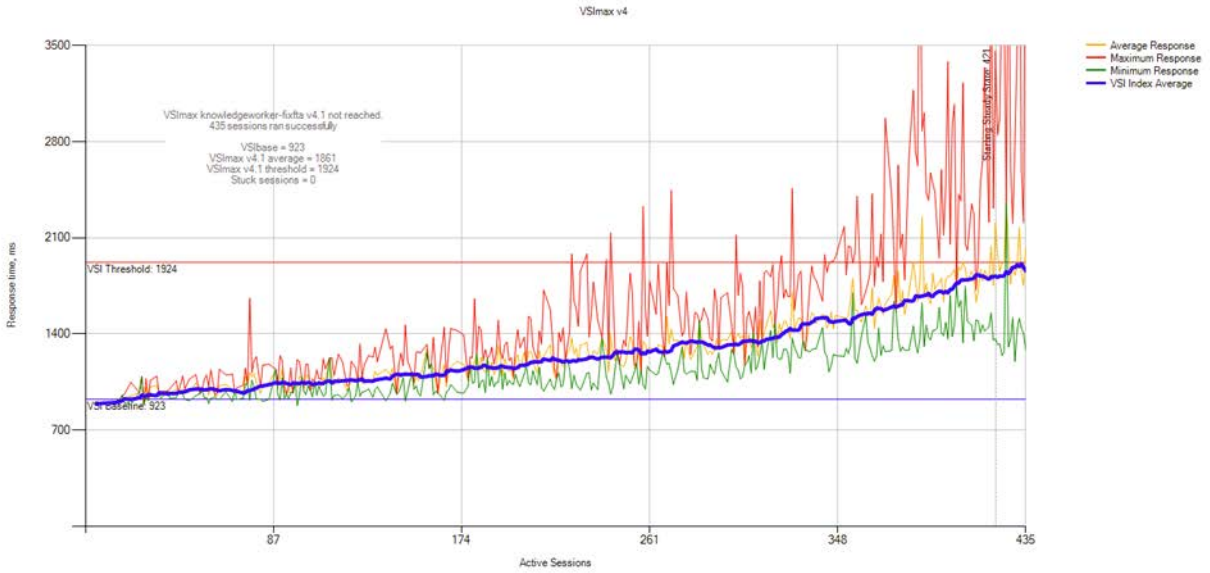


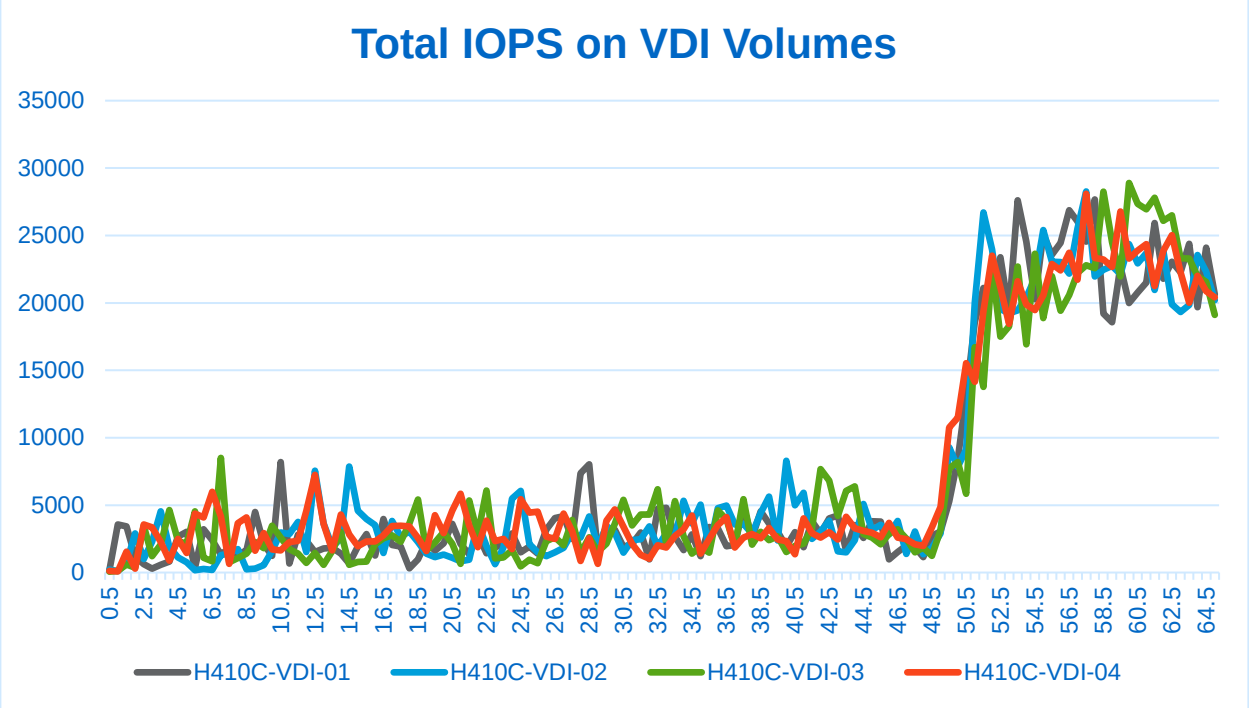
Table 24 shows that the final result deviates somewhat from the expected result. But, with this test, we started collecting metrics from NetApp HCI Storage and ESXTop data from vSphere using custom script.

Table 24) Linear scale overall test results.

Item	H410C-14020	H410C-25020 (1 Server)	H410C-25020 (2 Servers)	H410C-25020 (4 Servers)
Login VSI Max	62	110	220	435
Login VSI Base	1292ms	947ms	926ms	923ms
Number of Cores per socket	8	14	14	14
Memory Installed	384GB	512GB	512GB	512GB
vCPU/Core	7.75	7.86	7.86	7.77

Table 25 shows the total IOPS metrics collected for the datastore volumes that host the instant clone desktops.

Table 25) Total IOPS on VDI volumes.



The IOPS is steady and low during the login and workload simulations. The spike at the end is caused by the logout operations which cause instant clone to refresh the desktops.

The following script was used to collect metrics from NetApp HCI Storage:

```
sfmetrics.ps1
1   $nodestatsfile = 'C:\scripts\node-metrics.csv'
2   $volstatsfile = 'c:\scripts\volume-metrics.csv'
3
4
5   import-module solidfire
6   connect-sfcluster -target HCI-Cluster01 -user admin -password $password
7   1..130 | foreach-object {
8       get-sfnodestats | export-csv -path $nodestatsfile -append
9       get-sfvolume H410C* | get-sfvolumestats | export-csv -path $volstatsfile -append -NoTypeInformation
10      write-host $_
11      start-sleep 30
12  }
```

7.7 Linear Scale Testing – Eight Servers

The Horizon Pool size is increased to 900 and hosted on eight H410C-25020 servers.

Table 26 shows the testing details for linear scale testing on eight servers.

Table 26) Test details (linear scale testing – eight servers).

Test Case	Details
Test number	Test-07
Hyperthreading	Enabled

Virtual Desktop OS	Windows 10 1803 (with latest Windows updates)
Horizon Pool Type	Automated – dedicated user assignment - instant clone
Horizon Pool Size	900
App Volume Assignment	Not Applicable
Login VSI Launchers	40

Login VSI Test Results (Linear Scale Testing – Eight Servers)

Table 27 shows the login VSI results for linear scale testing with eight servers.

Table 27) Login VSI test results (linear scale testing – eight servers).

Item	Value
Login VSI Max	896
Login VSI Base	899ms

Figure 16 Login VSI chart shows the virtual session index and its response time.

Figure 16) Virtual session index and response time (linear scale testing - eight servers).

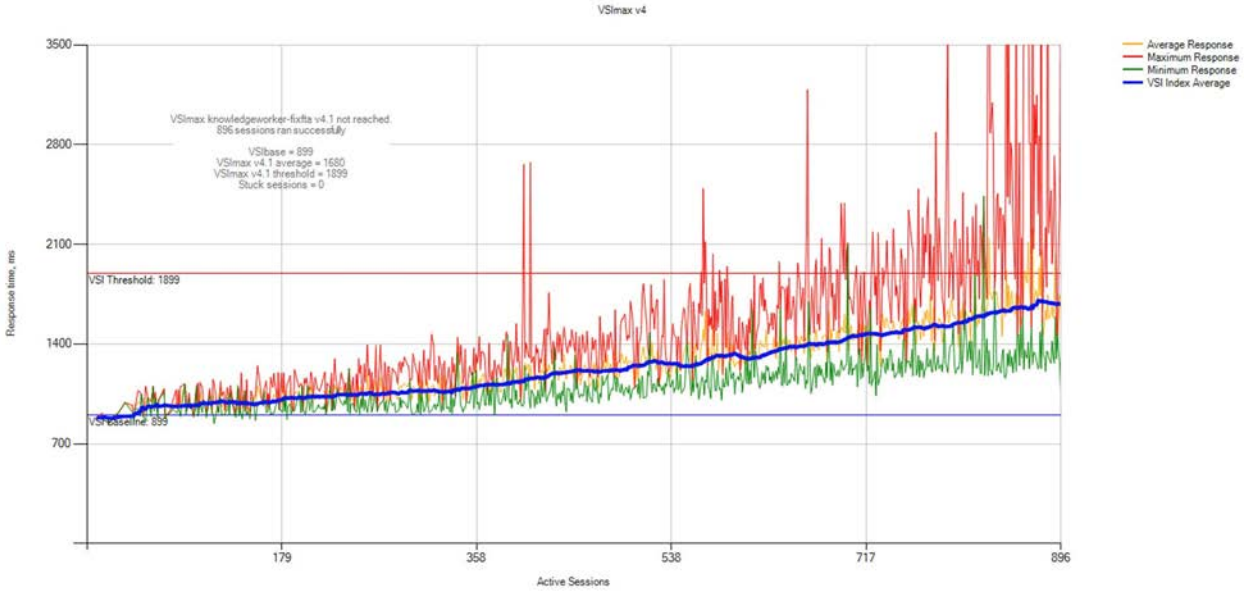


Table 28 shows reduced VSI Base for higher vCPU to core ratio as the number of servers increases.

Table 28) Reduced VSI base for higher vCPU to core ratio

Item	H410C-14020	H410C-25020 (1 Server)	H410C-25020 (2 Servers)	H410C-25020 (4 Servers)	H410C-25020 (8 Servers)
Login VSI Max	62	110	220	435	896
Login VSI Base	1292ms	947ms	926ms	923ms	899ms

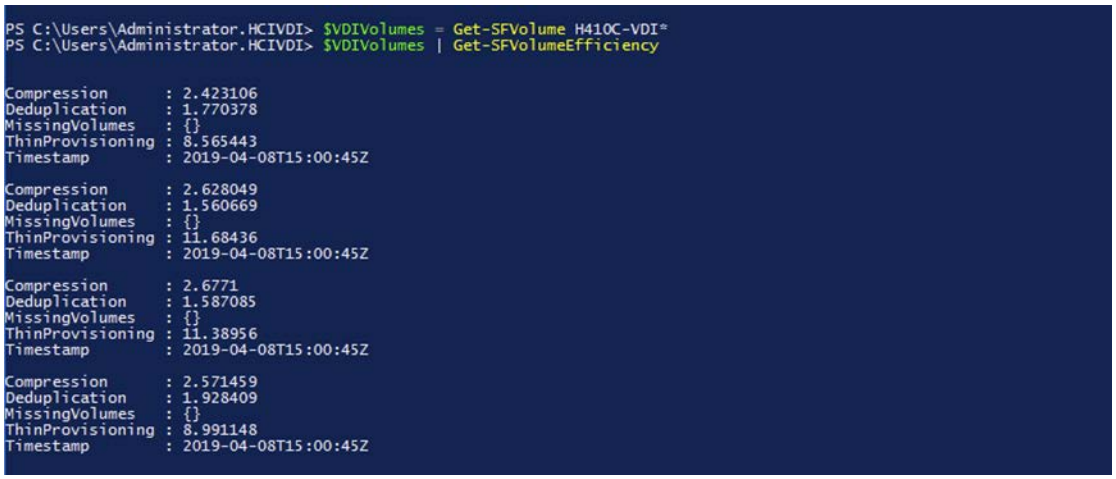
Item	H410C-14020	H410C-25020 (1 Server)	H410C-25020 (2 Servers)	H410C-25020 (4 Servers)	H410C-25020 (8 Servers)
Number of Cores per socket	8	14	14	14	14
Memory Installed per server	384GB	512GB	512GB	512GB	512GB
vCPU/Core	7.75	7.86	7.86	7.77	8

The VSI response time for various tests is summarized in Table 29.

Table 29) VSI response time.

VSI Response time (milliseconds)	H410C-14020	H410C-25020 (1 Server)	H410C-25020 (2 Servers)	H410C-25020 (4 Servers)	H410C-25020 (8 Servers)
@50 Sessions	1703	1143	987	999	935
@100 Sessions		1666	1138	1048	974
@150 Sessions			1290	1107	1005
@200 Sessions			1653	1157	1041
@250 Sessions				1265	1066
@300 Sessions				1325	1079
@350 Sessions				1500	1134
@400 Sessions				1724	1158
@450 Sessions					1218
@500 Sessions					1242
@550 Sessions					1273
@600 Sessions					1307
@650 Sessions					1402
@700 Sessions					1425
@750 Sessions					1458
@800 Sessions					1526
@850 Sessions					1583

Testing revealed a storage saving of 37x to 48x for thin provisioned virtual desktops with Horizon when storage was checked on NetApp SolidFire® Windows PowerShell module.



8 Conclusion

NetApp HCI enables you to easily expand clusters to meet growing demands. The global efficiency features of NetApp HCI such as compression, deduplication, and thin provisioning provide storage savings for VDI. You can consolidate different workloads, including VDI, on the same NetApp HCI cluster and control it with minimum, maximum, and burst QoS policies. If necessary, a NetApp HCI cluster can move the cold data to object store or can replicate it to any cloud.

Where to Find Additional Information

To learn more about the information described in this document, refer to the following documents and/or websites:

NetApp

- NetApp Product Documentation
  www.netapp.com/us/documentation/index.aspx
- NetApp HCI Documentation Center
  http://docs.netapp.com/hci/index.jsp
- NetApp Data Fabric
  www.netapp.com/us/info/what-is-data-fabric.aspx
- NetApp HCI Datasheet
  www.netapp.com/us/media/ds-3881.pdf
- NetApp HCI Technical Documentation
  http://docs.netapp.com/hci/index.jsp
- NetApp HCI Deployment Guide
  https://library.netapp.com/ecm/ecm_download_file/ECMLP2844053
- NetApp HCI Network Setup Guide
  www.netapp.com/us/media/tr-4679.pdf
- VMware vRealize Operations Management Pack for NetApp HCI and SolidFire
  https://bluemedora.com/resource/vmware-vrealize-operations-management-pack-for-netapp-hci-solidfire/
- NetApp SolidFire vRealize Orchestrator Plug-in
  https://github.com/solidfire/vrealize-orchestrator-plugin

- NetApp HCI Theory of Operations
  www.netapp.com/us/media/wp-7261.pdf
- NetApp Element Software
  https://www.netapp.com/us/products/data-management-software/element-os.aspx
- NetApp ONTAP Select
  www.netapp.com/us/products/data-management-software/ontap-select-sds.aspx
- NetApp Interoperability Matrix Tool
  https://mysupport.netapp.com/matrix/#welcome

VMware

- VMware Tech Zone
  https://techzone.vmware.com/
- Best Practices for Published Applications and Desktops in VMware Horizon Apps and VMware Horizon 7
  https://techzone.vmware.com/resource/best-practices-published-applications-and-desktops-vmware-horizon-apps-and-vmware-horizon-7
- App Volumes Deployment Considerations
  https://techzone.vmware.com/resource/app-volumes-deployment-considerations
- User Environment Manager Deployment Considerations Guide
  https://techzone.vmware.com/resource/user-environment-manager-deployment-considerations-guide
- VMware Workspace ONE and VMware Horizon 7 Enterprise Edition On-Premises Reference Architecture
  https://techzone.vmware.com/resource/vmware-workspace-one-and-vmware-horizon-7-enterprise-edition-premises-reference
- VMware Horizon 7 Sizing Limits and Recommendations
  https://kb.vmware.com/s/article/2150348
- VMware Configuration Maximums
  https://configmax.vmware.com/
- Reviewer's Guide for On-Premises VMware Identity Manager
  https://techzone.vmware.com/resource/reviewers-guide-premises-vmware-identity-manager
- Deployment and Design Considerations for VMware Mirage
  https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/techpaper/vmware-horizon-mirage-deployment-design-considerations.pdf
- Network Ports in VMware Horizon 7
  https://techzone.vmware.com/resource/network-ports-vmware-horizon-7
- Horizon for Linux FAQ
  www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/products/horizon/vmware-horizon-for-linux-faq.pdf
- vRealize Operations Manager 6.6.1 Sizing Guidelines
  https://kb.vmware.com/s/article/2150421
- Sizing the vRealize Log Insight Virtual Appliance
  https://docs.vmware.com/en/vRealize-Log-Insight/4.6/com.vmware.log-insight.getting-started.doc/GUID-284FC5F4-B832-47A7-912E-D407A760CAE4.html

Version History

Version	Date	Document Version History
Version 1.0	May 2019	Initial version

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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