Abstract
This document describes the features of NetApp® HCI and NetApp ONTAP® storage that are relevant for Citrix Virtual Apps and Desktops running in a VMware vSphere environment. It discusses design considerations, best practices, sizing guidelines, and more.
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1 Executive Summary

Digital workspaces play an important role in the digital transformation journey of any enterprise. A digital workspace offers a unified, consistent user experience that can be accessed from any location. Users can access everything they need for work in a single interface, on the premises or in the cloud. A portable workspace allows users to work with any device they choose, which makes it attractive to the new generation of workers.

NetApp® HCI offers several models for hosting Citrix Virtual Apps and Desktops, including graphics processing unit (GPU) models targeted for the latest Windows 10 applications and 3D graphics workstation applications from Autodesk, Dassault systems, Siemens, and more.

NetApp HCI is a hybrid cloud infrastructure that can grow with business demands and can be easily repurposed as business needs change. And NetApp HCI storage provides powerful storage efficiency features such as global deduplication, compression, and thin provisioning.

The file services available in NetApp ONTAP® offer your team elegant solutions for the home directories, user profiles, and file shares, which can easily grow beyond traditional sizing limits. ONTAP includes easy-to-use NetApp Snapshot™ technology that enables self-service file recovery for end users. Adaptive quality-of-service (QoS) features allow you to automatically scale a throughput ceiling or floor to volume size, while maintaining the ratio of IOPS to TBs/GBs as the size of the volume changes.

NetApp HCI and ONTAP easily integrate into your existing automation framework. ONTAP has Ansible modules, PowerShell modules, and RESTful APIs for integration with other automation tools. Both products include many enterprise security features and monitoring options.

Citrix delivers software with flexible consumption and deployment models to meet your business needs, while the Citrix Director tool provides insights for the help desk.

2 Solution Overview

Today’s mobile workforce wants to work from any location using their device of choice, which creates a significant challenge for administrators trying to keep up with security and management for these devices. Citrix Virtual Apps and Desktops (Previously known as XenApp and XenDesktop) delivers fully functional virtual Windows desktops, Linux desktops, and applications that employees need to remain productive.

Citrix App Layering simplifies application and OS management by allowing administrators to manage apps, user profile data, and operating systems as individual layers. With this unique technology, IT can efficiently and securely deliver apps and desktops on the premises or from leading public cloud vendors. The Citrix App Layering technology containerizes desktop apps as virtual disks for streamlined delivery to end users. With user layers, administrators can easily deliver a persistent desktop experience to users. This system also delivers cost savings because of the efficiency of a pooled desktop environment.

Citrix High Definition eXperience (HDX) technology on Citrix Virtual Apps and Desktops gives users the best possible experience, whether on a local network, a mobile network, or a high-latency, wide-area network.

Citrix HDX 3D Pro optimizes the performance of professional-grade, graphics-intensive 3D applications for Windows and Linux virtual desktops. Slow-rendering graphics due to network lag are no longer an issue. Visually lossless deep compression enables users to collaborate in real time on pixel-perfect images.

With NetApp HCI, you don’t need a dedicated environment for a virtual desktop infrastructure (VDI). It can coexist with other workloads running on a cluster. Storage performance is guaranteed with min, max, and burst QoS policies. The NetApp HCI compute cluster can grow from two nodes to the maximum number of clusters supported by VMware vCenter.
2.1 Target Audience

The target audience for this solution includes the following groups:

- Field consultants to help with design decisions for Citrix Virtual Apps and Desktops
- Executives and sales engineers to understand the value of the solution
- Professional services and IT managers to understand and identify the components of the solution
- Partners to assist customers who face similar challenges

2.2 Solution Technology

Citrix Virtual Apps and Desktops components are segregated into several layers, as shown in Figure 1.

Figure 1) Citrix layers.

Users accessing from on-premises locations (internal users) or from remote locations (external users) belong to the user layer. They access virtual apps and desktops using the StoreFront available on the access layer. External users connect to the StoreFront with the Citrix Gateway residing in a DMZ to provide secure access.

The delivery controller, which brokers user connections to desktops, resides in the control layer, along with other infrastructure components like the domain controller, database server, and license server.
These components are typically deployed as virtual machines (VMs) on VMware vSphere with NetApp HCI.

The resource layer contains the VMs on which the virtual delivery agent (VDA) is installed. It includes:

- Server OS where applications are hosted
- Server OS for remote desktop sessions
- Single-session desktop OS on which applications are hosted
- Desktop OS for virtual desktops
- Existing physical machines that require remote access

NetApp HCI belongs to the hardware layer, which provides compute, storage, memory, networking, and GPU resources, as well as the VMware hypervisor.

NetApp HCI consists of a mix of storage nodes and compute nodes. In the NetApp H410 series, the storage and compute nodes are half-width blades that are located on a 2U chassis. H610S is a 1U storage node that provides up to 100,000 IOPS per node. H610C is a 2U compute node that contains two scalable, first-generation Intel processors and two NVIDIA Tesla M10 cards. H615C is a 1U compute node that contains scalable second-generation Intel processors and a GPU with three NVIDIA Tesla T4 cards with the flexibility to run compute workloads in addition to graphics.

NetApp HCI provides the NetApp Deployment Engine (NDE) to automate the deployment and initial configuration of storage node clusters and compute clusters in a VMware vSphere environment.

Figure 2 shows the technical components of the solution.

Figure 2) Solution architecture.

Citrix Director is a monitoring and troubleshooting console for helpdesk users and administrators. Citrix Studio is the primary management tool for managing Citrix Virtual Apps and Desktops.

The complete on-premises deployment, access, control, and resource layer resides on top of NetApp HCI in the hardware layer. As part of a hybrid-cloud deployment model, some parts of the resource layer can reside with the public cloud provider. For example, you can host Linux VMs on Amazon Web Services (AWS), or you can run multisession Windows 10 apps on Microsoft Azure.
In the Citrix Cloud deployment model, the access and control layer can be hosted on Citrix Cloud with resources on NetApp HCI, connected to Citrix Cloud by using NetApp SANtricity® Cloud Connector.

2.3 Use Case Summary
This solution can be applied to the following use cases:

- Freedom of choice for end-user devices
- Increased security of end devices
- Policy-based access control for user data
- Ease of management for multiple operating system versions
- Space-efficient storage solution for VDI
- High availability of file shares for user data
- Hosted application solution, including for graphics-intensive applications
- Remote access to existing graphics workstations

3 NetApp HCI
NetApp HCI is a hybrid cloud infrastructure that consists of a mix of storage nodes and compute nodes. It is available in either a two-rack unit or single-rack unit format, depending on the model. The installation and configuration required to deploy VMs are automated with the NDE. Compute clusters are managed with VMware vCenter, and storage clusters are managed by using the vCenter Plug-in deployed with NDE. A management VM called the mNode is deployed as part of NDE.

NetApp HCI handles the following functions:

- Version upgrades
- Pushing events to vCenter
- vCenter Plug-In management
- A VPN tunnel for support
- The NetApp Active IQ® collector
- The extension of NetApp Cloud Services to on the premises, enabling a hybrid cloud infrastructure

Figure 3) HCI components.
3.1 Storage Nodes

Storage nodes are available with either a half-width or full-width rack unit size. A minimum of four storage nodes is required to begin with, and a cluster can expand to up to 40 nodes. A storage cluster can be shared across multiple compute clusters. All the storage nodes contain a cache controller to improve write performance. A single node provides either 50K or 100K IOPS at a 4K block size.

NetApp HCI storage nodes run NetApp Element® software, which provides minimum, maximum, and burst QoS limits. The storage cluster supports a mix of storage nodes, although one storage node cannot exceed one-third of total capacity.

3.2 Compute Nodes

Compute nodes are available in half-width, full-width, and two rack-unit sizes. The H410C and H610C are based on scalable Intel Skylake processors. The H615C is based on second-generation scalable Intel Cascade Lake processors. There are two compute models that contain GPUs: the H610C contains two NVIDIA M10 cards and the H615C contains three NVIDIA T4 cards.

Figure 4) Front view of H615C.

The NVIDIA T4 has 40 RT cores that provide the computation power needed to deliver real-time ray tracing. The same server model used by designers and engineers can now also be used by artists to create photorealistic imagery that features light bouncing off surfaces just as it would in real life. This RTX-capable GPU produces real-time ray tracing performance of up to five Giga Rays per second. The NVIDIA T4, when combined with Quadro Virtual Data Center Workstation (Quadro vDWS) software, enables artists to create photorealistic designs with accurate shadows, reflections, and refractions on any device from any location.

Tensor cores enable you to run deep learning inferencing workloads. When running these workloads, an NVIDIA T4 powered with Quadro vDWS can perform up to 25 times faster than a VM driven by a CPU-only server. A NetApp H615C with three NVIDIA T4 cards in one rack unit is an ideal solution for graphics and compute-intensive workloads.

Figure 5 lists NVIDIA GPU cards and compares their features.
The M10 GPU remains the best TCO solution for knowledge-worker use cases. However, the T4 makes a great alternative when IT wants to standardize on a GPU that can be used across multiple use cases, such as virtual workstations, graphics performance, real-time interactive rendering, and inferencing. With the T4, IT can take advantage of the same GPU resources to run mixed workloads—for example, running VDI during the day and repurposing the resources to run compute workloads at night.

The compute node H610C is two rack units in size; the H615C is one rack unit in size and consumes less power. The H615C supports H.264 and H.265 (High Efficiency Video Coding [HEVC]) 4:4:4 encoding and decoding. It also supports a VP9 decoder, which is becoming more mainstream; even the WebM container package served by YouTube uses the VP9 codec for video.

The number of nodes in a compute cluster is dictated by VMware; currently, it is 64. Mixing different models of compute nodes in a cluster is supported when Enhanced vMotion Compatibility (EVC) is enabled. For GPU nodes with default graphics settings (virtual shared graphics mode), compute models can be mixed in a cluster.

4 NVIDIA Licensing

When using a NetApp HCI H610C or H615C, the license for the GPU must be procured from NVIDIA partners that are authorized to resell the licenses. You can find NVIDIA partners with the partner locator. Search for competencies such as virtual GPU (vGPU) or Tesla.

NVIDIA vGPU software is available in four editions:

- NVIDIA GRID Virtual PC (GRID vPC)
- NVIDIA GRID Virtual Applications (GRID vApps)
- NVIDIA Quadro Virtual Data Center Workstation (Quadro vDWS)
- NVIDIA Virtual ComputeServer (NVIDIA vCS)
4.1 GRID Virtual PC
This product is ideal for users who want a virtual desktop that provides a great user experience for Microsoft Windows applications, browsers, and high-definition video. The NVIDIA GRID Virtual PC delivers a native experience in a virtual environment, allowing you to run all your PC applications at full performance.

4.2 GRID Virtual Applications
GRID vApps are for organizations deploying a Remote Desktop Session Host (RDSH) or other app-streaming or session-based solutions. Designed to deliver Microsoft Windows applications at full performance, Windows Server-hosted RDSH desktops are also supported by GRID vApps.

4.3 Quadro Virtual Data Center Workstation
This edition is ideal for mainstream and high-end designers who use powerful 3D content creation applications like Dassault CATIA, SOLIDWORKS, 3DExcite, Siemens NX, PTC Creo, Schlumberger Petrel, or Autodesk Maya. NVIDIA Quadro vDWS allows users to access their professional graphics applications with full features and performance anywhere on any device.

4.4 NVIDIA Virtual ComputeServer
Many organizations run compute-intensive server workloads such as artificial intelligence (AI), deep learning (DL), and data science. For these use cases, NVIDIA vCS software virtualizes the NVIDIA GPU, which accelerates compute-intensive server workloads with features such as error correction code, page retirement, peer-to-peer over NVLink, and multi-vGPU.

Note: A Quadro vDWS license enables you to use GRID vPC and NVIDIA vCS.

5 GPU Usage with VMware vSphere
VMware vSphere became a trusted platform for virtualization by effectively using underlying resources and providing high availability for applications. The latest GPU driver can be downloaded from the NVIDIA site and installed on a vSphere host.

Note: You can use VMware Update Manager to deploy NVIDIA vGPU software on multiple hosts. Use the offline bundle .zip files to create a baseline of the type Host Extension.

VMs consume GPU resources in one of the following ways:
- Virtual Dedicated Graphics (vDGA)
- Virtual Shared Graphics (vSGA)
- Virtual Shared Passthrough Graphics (NVIDIA vGPU)

5.1 Virtual Dedicated Graphics
A VM has complete access to the GPU using the PCI passthrough option with direct I/O. However, certain vSphere features, such as snapshots, vMotion, and so on are not supported. The VM performs at a native level.

To configure vDGA, follow these steps:
1. In the Hardware section, click PCI Devices and then click Passthrough-Enabled Devices.
2. Edit VM Settings and add the PCI device.

3. When the GPU is configured for vDGA mode, the Graphics Devices list shows the Active Type as Direct.
Before vSphere 6.7 update 2, vDGA was the only option of the three (vDGA, vSGA, or vGPU) listed that enabled the VM to access multiple GPUs. An NVIDIA vGPU driver is optional on the vSphere host. However, an OS driver is required inside the VM. An NVIDIA license server should be available to check licenses in and out. Without a license, only a very limited feature set is available.

Table 1) vDGA: H610C compared to H615C.

<table>
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<tr>
<th>Feature</th>
<th>H610C</th>
<th>H615C</th>
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</thead>
<tbody>
<tr>
<td>Maximum number of passthrough devices per server</td>
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<td>3</td>
</tr>
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</table>

5.2 Virtual Shared Graphics

Virtual Shared Graphics is the default mode enabled on VMware vSphere. NVIDIA vGPU software is required on the vSphere host to use hardware-based rendering. When a GPU is not present, it uses CPU cycles to provide software-based rendering. To use virtual shared graphics, enable 3D support and install VMware Tools on the VM.
The VMware device driver provides limited support for DirectX and OpenGL. There is also limited support for 4K monitors. Frame buffer memory is limited to 2GB.

H610C and H615C nodes can be part of the same vSphere cluster with Virtual Shared Graphics mode when Enhanced vMotion Compatibility (EVC) is enabled.

**Note:** vDGA uses PCI passthrough for a GPU card to a given VM. vDGA is not recommended because it does not support many vSphere features and provides low resource utilization. vSGA enables multiple VMs to leverage physical GPUs installed locally in the ESXi hosts to provide hardware-accelerated 3D graphics. vSGA is not recommended because graphics API support is limited and only some versions of DirectX and OpenGL are supported. Additionally, there is no Compute Unified Device Architecture (CUDA) support for vSGA. With vSGA, the VDI instance relies on the VMware vSGA driver, which receives access through an Xorg server running on the hypervisor. This is suboptimal from a performance standpoint. With vGPU, NVIDIA technology is used throughout, and a VDI instance gets the closest possible parity to running a native NVIDIA driver.

### 5.3 Virtual Shared Passthrough Graphics

Virtual Shared Passthrough Graphics provides better utilization of GPU resources because each VM has its own dedicated frame buffer. However, the GPU compute, encoder, decoder, and so on are shared. In
a manner similar to a hypervisor sharing resources with VMs, NVIDIA GRID software manages the resource scheduling of GPU requests from a VM.

Figure 7) NVIDIA vGPU architecture.

To use Virtual Shared Passthrough Graphics mode, the host graphics setting must be changed to Shared Direct mode, as shown in the following screenshot.

In VM Settings, add Shared PCI Device and choose the required vGPU profile (Table 2) based on the frame buffer. You must reserve memory to enable direct access for the PCI device.
<table>
<thead>
<tr>
<th>Virtual GPU Type</th>
<th>Intended Use Case</th>
<th>Frame Buffer (MB)</th>
<th>Virtual Display Heads</th>
<th>Maximum Resolution per Display Head</th>
<th>Maximum vGPUs per GPU</th>
<th>Maximum vGPUs per H615C/H610C Server</th>
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<td>512</td>
<td>2</td>
<td>2560x1600</td>
<td>64</td>
<td>128</td>
<td>Quadro vDWS</td>
</tr>
<tr>
<td>M10-2B</td>
<td>Virtual desktops</td>
<td>2048</td>
<td>2</td>
<td>4096x2160</td>
<td>16</td>
<td>32</td>
<td>GRID vPC or Quadro vDWS</td>
</tr>
<tr>
<td>M10-2B4</td>
<td>Virtual desktops</td>
<td>2048</td>
<td>4</td>
<td>2560x1600</td>
<td>16</td>
<td>32</td>
<td>GRID vPC or Quadro vDWS</td>
</tr>
<tr>
<td>M10-1B</td>
<td>Virtual desktops</td>
<td>1024</td>
<td>4</td>
<td>2560x1600</td>
<td>32</td>
<td>64</td>
<td>GRID vPC or Quadro vDWS</td>
</tr>
<tr>
<td>M10-1B4</td>
<td>Virtual desktops</td>
<td>1024</td>
<td>1</td>
<td>4096x2160</td>
<td>32</td>
<td>64</td>
<td>GRID vPC or Quadro vDWS</td>
</tr>
<tr>
<td>M10-0B</td>
<td>Virtual desktops</td>
<td>512</td>
<td>2</td>
<td>2560x1600</td>
<td>64</td>
<td>128</td>
<td>GRID vPC or Quadro vDWS</td>
</tr>
<tr>
<td>M10-8A</td>
<td>Virtual applications</td>
<td>8192</td>
<td>1</td>
<td>1280x1024</td>
<td>4</td>
<td>8</td>
<td>GRID vApps</td>
</tr>
<tr>
<td>M10-4A</td>
<td>Virtual applications</td>
<td>4096</td>
<td>1</td>
<td>1280x1024</td>
<td>8</td>
<td>16</td>
<td>GRID vApps</td>
</tr>
<tr>
<td>M10-2A</td>
<td>Virtual applications</td>
<td>2048</td>
<td>1</td>
<td>1280x1024</td>
<td>16</td>
<td>32</td>
<td>GRID vApps</td>
</tr>
<tr>
<td>M10-1A</td>
<td>Virtual applications</td>
<td>1024</td>
<td>1</td>
<td>1280x1024</td>
<td>32</td>
<td>64</td>
<td>GRID vApps</td>
</tr>
</tbody>
</table>
Note: For NVIDIA vGPU mode, do not enable 3D support on the VM. For more information, see the NVIDIA vGPU User Guide.

GRID vPC (profiles typically end with B) is used for virtual desktops, and GRID vApps (profiles end with A) is used for hosted apps. Most of the Q profiles (Quadro vDWS) support up to four 4K resolution monitors, which provides an enhanced user experience for image editing tools and support for professional graphics workloads.

The NVIDIA T4 GPU supports multiple profiles. NVIDIA recommends the GRID vPC 1GB profile to deliver an optimal experience for standard knowledge workers:

- Heavy application use, including browsing; using email; and creating complex documents, presentations, and spreadsheets.
- Applications supported include Windows 10, Office productivity apps, streaming video, and multimedia using the latest web standards like WebGL.
- Up to four 2K (2560×1600) resolution monitors.

On the other hand, users with any of the following characteristics should be assigned a GRID vPC 2GB profile for advanced knowledge workers:

- Users with specific requirements such as multiple high-resolution monitors to handle larger files and higher-resolution media.
- Applications supported include Windows 10, Office productivity apps, video and multimedia, and industry-specific apps like Bloomberg, Thomson Reuters Eikon, and DICOM viewers.
- Up to two 4096x2160 resolution monitors.

Creative and technical professionals running applications like Dassault Systèmes CATIA, Autodesk Revit, Siemens NX, Petrel, and so on might need high frame buffers, depending on the workload and size of the models being manipulated.

For compute workloads such as AI, machine learning, and data science, NVIDIA recommends a minimum of 4GB of frame buffer, with larger frame buffers for larger models.
NVIDIA supports the same vGPU profiles that are available on a GPU (Table 3).

Table 3) NVIDIA T4 vGPU profiles on single GPU.

<table>
<thead>
<tr>
<th>Tesla T4</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T4-16Q</td>
<td>T4-8Q</td>
<td>T4-8Q</td>
<td>T4-8Q</td>
</tr>
<tr>
<td>T4-16Q</td>
<td>T4-4Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
</tr>
<tr>
<td>T4-8Q</td>
<td>T4-4Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
</tr>
<tr>
<td>T4-4Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
<td>T4-2Q</td>
</tr>
<tr>
<td>T4-2Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
</tr>
<tr>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
</tr>
<tr>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
</tr>
<tr>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
</tr>
<tr>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
</tr>
<tr>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
<td>T4-1Q</td>
</tr>
</tbody>
</table>
NVIDIA vGPU software does not support mixing profiles for a GPU accelerator with only one GPU. For example, if a VM with the 4Q profile is running on a GPU, it can only host another VM that has the same 4Q profile on the same GPU.

Table 4) Incorrect vGPU profile mix in single GPU.

<table>
<thead>
<tr>
<th>T4-4Q</th>
<th>T4-2Q</th>
<th>T4-2Q</th>
</tr>
</thead>
</table>

Because vGPU profiles on an H610C differ from the profiles on an H615C, a VM can't migrate from one host to another. Therefore, NetApp recommends having the same models in a cluster. If there is a strong need to mix the nodes in cluster, consider changing the GPU assignment policy to Group VMs on GPU. You need to have enough resources for a takeover if there is a node failure on either of the GPU nodes.

Table 5) vGPU - H610C compared to H615C.

<table>
<thead>
<tr>
<th>Frame Buffer</th>
<th>1xH610C (2XM10)</th>
<th>1xH615C (3xT4)</th>
<th>2xH615C (6xT4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GB</td>
<td>64</td>
<td>48</td>
<td>96</td>
</tr>
<tr>
<td>2GB</td>
<td>32</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>4GB</td>
<td>16</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

After the NVIDIA driver is installed on a VM, the VM console presents a blank screen for the vGPU profile. You must install VNC/Horizon Direct Connect prior to the NVIDIA driver to have console access.

VMware vSphere 6.7 Update 1 and later provides support for vMotion for VMs with NVIDIA vGPU profiles.
The H615C can host 50% more density for the same rack unit size and provide double the performance for most workloads.

6  Citrix Virtual Apps and Desktops

This section covers the components of Citrix Virtual Apps and Desktops.

New versions of Citrix Virtual Apps and Desktops are delivered every quarter. Each new version is supported for 6 months from its release date, and users are expected to upgrade the software every 3 to 6 months. If a longer support term is required, consider using the Long Term Service Release (LTSR) version. You can also use Citrix Cloud if you don’t want to deal with version upgrades.

6.1  Citrix Workspace App (Receiver Client)

The Citrix Workspace App, which replaces the Receiver client, is client software that runs on virtually any device and operating platform, including Windows, Mac, Linux, iOS, and Android. The app must be downloaded onto user endpoints to access graphics applications that are hosted in the data center. The Citrix Workspace App provides client-side functionality to secure, optimize, and transport information to and from the endpoint or host over Citrix HDX. Citrix HDX is a set of technologies built into the networking protocol to provide a high-definition user experience regardless of device, network, or location.

6.2  Citrix Gateway

Citrix Gateway, formerly known as NetScaler Unified Gateway, is an add-on component that provides secure access to virtual apps and desktops from remote locations. It can be deployed on the premises, or it can be consumed as a service from Citrix. It offers single sign-on access to web, virtual, cloud, and SaaS applications across multiple devices. It also supports multifactor authentication.

6.3  Citrix StoreFront

Citrix StoreFront is an enterprise app store that improves security and simplifies deployments, delivering a modern, unmatched near-native user experience across Citrix Receiver on any platform. StoreFront makes it easy to manage multisite and multiversion Citrix Virtual Apps and Desktops environments. Organizations can further customize with their own branding and deployments to meet specific business needs. Citrix StoreFront also enables mobility features for users to work with any device from any location.
6.4 Citrix Delivery Controller

The Citrix Delivery Controller is responsible for managing user access and brokering and optimizing connections. Controllers also provide machine creation services that use the hypervisor cloning feature to create desktop and server images. A site must have at least one delivery controller. After you install the initial controller, you can add more controllers when you create a site, or possibly later. Having additional controllers at a site provides redundancy and scalability to improve overall responsiveness.

The Controller’s broker service tracks which users are logged on and where, what session resources users have, and whether users need to reconnect to existing applications. The broker service executes PowerShell cmdlets and communicates with a broker agent on the VDAs over TCP port 80. It does not have the option to use TCP port 443.

The Monitor Service collects historical data and places it in the Monitor database. This service uses TCP port 80 or 443. Data from the Controller services is stored in the site database.

The Controller manages the state of desktops and starts and stops them based on demand and the administrative configuration. In some editions, the Controller allows you to install profile management to manage user personalization settings in virtualized or physical Windows environments.

6.5 Citrix Provisioning Service

Citrix Provisioning Services (PVS) is an optional component that can be used to deliver desktop or server images to physical machines as well as to VMs. It streams a shared disk image (vDisk) rather than copying images to individual machines. PVS enables organizations to reduce the number of disk images that they manage. All the write operations to the disk are redirected to a delta disk that is specific for each machine.

When a target device is turned on, it is set to boot from the network and communicate with a provisioning server. Unlike thin-client technology, processing takes place on the target device (step 1 in Figure 9).
The target device downloads the boot file from a provisioning server (step 2), and then the target device boots. Based on the device boot configuration settings, the appropriate vDisk is located and then mounted on the provisioning server (step 3). The software on that vDisk is streamed to the target device as needed. To the target device, it appears like a regular hard drive on the system.

Instead of immediately pulling all vDisk contents down to the target device as in traditional imaging deployment solutions, the data is brought across the network in real time as needed. This approach allows a target device to get a completely new operating system and set of software in the time it takes to reboot, without requiring a visit to a workstation. This approach dramatically decreases the amount of network bandwidth required by traditional disk imaging tools, making it possible to support a larger number of target devices on your network without affecting overall network performance.

6.6 Citrix Studio

Citrix Studio is the management console that enables you to configure and manage your Virtual Apps and Desktops deployment. This console eliminates the need for separate management consoles to manage delivery of applications and desktops. Citrix Studio provides wizards to guide you through environment setup, creating your workloads to host applications and desktops, and assigning applications and desktops to users. You can also use Studio to allocate and track Citrix licenses for your site.

Studio gets the information it displays from the broker service in the Controller by communicating over TCP port 80.
Citrix Studio allows you to define policies that can be centrally managed for your virtual apps and desktops. For any actions you take in Citrix Studio, the corresponding PowerShell command line is displayed to facilitate automation.

6.7 Citrix License Server

Citrix License Server manages your Citrix product licenses. It communicates with the Controller to manage licensing for each user's session and with Citrix Studio to allocate license files. You must create at least one license server to store and manage your license files.

6.8 Citrix Director

Citrix Director is a web-based tool that enables IT support and help desk teams to monitor an environment, troubleshoot issues before they become system-critical, and perform support tasks for end users. You can use one Director deployment to connect to and monitor multiple XenApp or XenDesktop Sites.

Citrix Director displays the following information:

- Real-time session data from the broker service in the Controller. This includes data that the broker service gets from the broker agent in the VDA.
- Historical site data from the monitor service in the Controller.
- Data about HDX traffic (also known as ICA traffic) captured by HDX Insight from the Citrix Gateway, if your deployment includes Citrix Gateway and your XenApp or XenDesktop edition includes HDX Insight.

You can also view and interact with a user's sessions through Citrix Director by using Windows Remote Assistance.
6.9 Virtual Delivery Agent

VDA is installed on each physical machine or VM in your site that you make available to users. The VDA enables a machine to register with the Controller, which makes the machine and resources it is hosting available to users. VDAs establish and manage the connection between the machine and the user device, verify that a Citrix license is available for the user or session, and apply whatever policies have been configured for the session.

The VDA communicates session information to the broker service in the Controller through the broker agent in the VDA. The broker agent hosts multiple plug-ins and collects real-time data. It communicates with the Controller over TCP port 80.

The acronym VDA is often used to refer to the agent as well as the machine on which it is installed.

VDAs are available for Windows Server and Windows desktop operating systems. VDAs for Windows Server operating systems allow multiple users to connect to the server at one time. VDAs for Windows desktop operating systems allow only one user to connect to the desktop at a time. Linux VDAs are also available.

6.10 Database

At least one Microsoft SQL Server database is required for every Virtual Apps and Desktops site to store configuration and session information. This database stores the data collected and managed by the services that make up the Controller. Install the database in your data center, and provide it with a persistent connection to the Controller. The site also uses a configuration logging database and a monitoring database. By default, those databases are installed in the same location as the site database, but you can change this.

6.11 File Shares

NetApp HCI provides file services by using NetApp ONTAP Select, which provides the following features useful for Citrix Virtual Apps and Desktops implementations:
- User home directories
- Storage virtual machines
- NetApp FlexGroup technology
- NetApp FabricPool technology
- NetApp Data Availability Services
- Adaptive QoS
- Deduplication
- Data protection features
  - NetApp RAID DP®
  - NetApp Snapshot™ copies
  - NetApp FlexClone® technology
  - NetApp SnapMirror® and SnapVault® technologies
- Self-restore from Snapshot copies

Citrix Virtual Apps and Desktops supports both Microsoft Windows and Linux environments. Therefore, ONTAP provides the SMB and NFS protocols with the secure multitenancy feature and the flexibility to use the same storage environment for multiple environments, such as test and production.

7 Technology Requirements

This section covers the technology requirements for the Citrix Virtual Apps and Desktops solution.

7.1 Hardware Requirements

Table 6 lists the hardware components that are required to implement the solution. The hardware components that are used in any particular implementation of the solution might vary based on customer requirements.

Table 6) Hardware requirements.

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetApp HCI H410C</td>
<td>2</td>
<td>Infrastructure components</td>
</tr>
<tr>
<td>NetApp HCI H410C</td>
<td>8</td>
<td>Resource for around 800 non-GPU virtual desktops and apps</td>
</tr>
<tr>
<td>NetApp HCI H410S</td>
<td>4</td>
<td>Storage cluster to provide block storage</td>
</tr>
<tr>
<td>NetApp HCI H610C</td>
<td>3</td>
<td>Host around 180 virtual desktops for knowledge workers</td>
</tr>
<tr>
<td>NetApp HCI H615C</td>
<td>2</td>
<td>Host around 24 Quadro virtual workstations</td>
</tr>
<tr>
<td>Mellanox SN2010</td>
<td>4</td>
<td>A 25Gb Ethernet switch</td>
</tr>
<tr>
<td>1Gb Ethernet switch</td>
<td>1</td>
<td>For Intelligent Platform Management Interface (IPMI) management</td>
</tr>
</tbody>
</table>

7.2 Software Requirements

Table 7 lists the software components that are required to implement the solution. The software components that are used in any particular implementation of the solution might vary based on customer requirements.
### Table 7) Software requirements.

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetApp HCI NDE</td>
<td>1.7</td>
</tr>
<tr>
<td>NetApp ONTAP Select</td>
<td>9.7</td>
</tr>
<tr>
<td>Citrix Virtual Apps and Desktops (Premium Edition)</td>
<td>7 1909</td>
</tr>
<tr>
<td>NVIDIA vGPU Manager</td>
<td>9.1</td>
</tr>
<tr>
<td>Windows driver</td>
<td>430.46</td>
</tr>
<tr>
<td>Linux driver</td>
<td>431.79</td>
</tr>
<tr>
<td>Microsoft Windows Server</td>
<td>2016</td>
</tr>
<tr>
<td>VMware vSphere</td>
<td>6.7 Update 3</td>
</tr>
<tr>
<td>VMware vCenter</td>
<td>6.7 Update 3</td>
</tr>
<tr>
<td>SPECviewperf</td>
<td>13</td>
</tr>
<tr>
<td>Microsoft Windows</td>
<td>10 1903</td>
</tr>
</tbody>
</table>

### 8 Solution Verification

The sizing of Citrix Virtual Apps and Desktops with shared pass-through mode (vGPU) is decided by the vGPU profile listed in Table 2. The sizing for non-GPU workloads is calculated using the Citrix design methodology for the hardware layer. Table 8 shows the numbers for various NetApp HCI models for a Windows 10 heavy profile with real-time monitoring, antivirus enabled with Microsoft Office 2016, and hyper-threading enabled on the host.

### Table 8) NetApp HCI model parameters.

<table>
<thead>
<tr>
<th>Compute Model</th>
<th>Number of Processors</th>
<th>Number of Cores per Processor</th>
<th>Number of Virtual Desktops Supported per Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>H410C</td>
<td>2</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>H410C</td>
<td>2</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>H410C</td>
<td>2</td>
<td>14</td>
<td>64</td>
</tr>
<tr>
<td>H410C</td>
<td>2</td>
<td>20</td>
<td>91</td>
</tr>
<tr>
<td>H615C</td>
<td>2</td>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>H615C</td>
<td>2</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>H615C</td>
<td>2</td>
<td>16</td>
<td>73</td>
</tr>
<tr>
<td>H615C</td>
<td>2</td>
<td>24</td>
<td>110</td>
</tr>
</tbody>
</table>

A validation for 1,000 users with LoginVSI and the NVIDIA nVector tool will be available as a part of the deployment guide for both the MCS and PVS provisioning methods.

The Standard Performance Evaluation Corporation (SPEC) is a nonprofit corporation formed to establish, maintain, and endorse standardized benchmarks and tools. For graphics and workstation performance,
they have endorsed Application Performance Characterization (SPECapc) tools geared toward specific tools and required vendor licenses. Here is a sample list of SPECapc tools:

- SPECapc for 3ds Max 2015
- SPECapc for Maya 2017
- SPECapc for PTC Creo 3.0
- SPECapc for Siemens NX 9.0 and 10.0
- SPECapc for SolidWorks 2017

SPECviewperf and SPECworkstation both measure graphics performance based on professional applications. These benchmarks measure 3D graphics performance using the OpenGL and Direct X APIs. The benchmarks’ workloads, known as viewsets, represent graphics content and behavior from actual applications.

SPECviewperf is geared toward GPU cards. SPECworkstation also measures all key aspects of a workstation, such as CPU, memory, storage, and so on. The test duration for SPECworkstation is longer than for SPECviewperf.

Figure 12 shows the viewset of SPECviewperf 13.
Note: The 3ds Max and Showcase viewsets are not available when running 4K tests.

We performed the tests using the NVIDIA nVector toolset, which orchestrates the creation of VMs and client machines and sets the encoding options, executes the tests, and captures the performance data.

For every viewset, we performed the test with three VMs configured with the 16Q profile with the maximum frame buffer at full scale on a single NetApp HCI H615C server. We also used 12 VMs with the 4Q profile and the minimum frame buffer required for workloads at full scale on a single NetApp HCI H615C server.
For the 16Q profile test, we used a VM configuration of 18 vCPUs and 16GB of RAM. For the 12 VM test, we used a VM configuration of 6 vCPU and 16GB of RAM. In addition, we disabled the frame-rate limit. The client VM configuration is 4 vCPU, 4GB of RAM, and a GPU with the 1Q profile.

The Citrix policy applied to the GPUs is shown in Figure 13.

Figure 13) Citrix policy for GPU testing.

SPECviewperf measures the frame rate, or frames per second (FPS), at which a graphics card can render scenes across a wide variety of applications and usage models. Each viewset represents an application or usage model.

8.1 3ds Max (3dsmax-06)

The 3ds max viewset was created from traces of the graphics workload generated by Autodesk 3ds Max 2016. The styles of rendering in the viewset reflect those most commonly used in major markets, including realistic, shaded, and wireframe. Some less commonly used but interesting rendering models such as facets, graphite, and clay are also incorporated. The animations in the viewset are a combination of model spin and camera fly-through, depending on the model.

We performed the following viewset tests:

- Architectural model, shaded
- Architectural model, graphite
- Space model, wireframe
- Space model, clay
- Underwater model, wireframe
- Underwater model, shaded
- Hugh fish model, shaded
- Office model, realistic
- Office model, shaded
- Office model, realistic, with materials

For full details, see the SPEC page on the 3ds Max viewset.

Figure 14 is a sample screenshot captured during the test.

**Figure 14** 3ds Max sample.

8.2 **CATIA (catia-05)**

The catia-05 viewset was created from the traces of the graphics workload generated by the CATIA V6 R2012 application from Dassault Systèmes. Model sizes range from 5.1 to 21 million vertices.

The viewset includes numerous rendering modes supported by the application, including wireframe, antialiasing, shaded, shaded with edges, depth of field, and ambient occlusion.

Viewset tests included the following:

- Race car shaded with ambient occlusion and depth of field effect
- Race car shaded with pencil effect
- Race car shaded with ambient occlusion
- Airplane shaded with ambient occlusion and depth-of-field effect
- Airplane shaded with pencil effect
- Airplane shaded
- Airplane shaded with edges
• Airplane shaded with ambient occlusion
• SUV1 vehicle shaded with ground reflection and ambient occlusion
• SUV2 vehicle shaded with ground shadow
• SUV2 vehicle shaded with ground reflection and ambient occlusion
• Jet plane shaded with ground reflection and ambient occlusion
• Jet plane shaded with edges with ground reflection and ambient occlusion

Figure 15 shows a sample screenshot captured during the test.

Figure 15) CATIA sample.

8.3 Creo (creo-02)

The creo-02 viewset was created from traces of the graphics workload generated by the Creo 3 and Creo 4 applications from PTC. Model sizes range from 20 to 48 million vertices. The viewsets include numerous rendering modes supported by the application.

Viewset tests included the following:

• Worldcar in shaded mode, with environment mapped reflections, texture space bump mapping, image background, and screen-space ambient occlusion
• Worldcar in shaded mode, with reflections, bump mapping, image background, ambient occlusion, and 4x multisampled antialiasing
• Worldcar in shaded mode, with reflections, bump mapping, image background, ambient occlusion, and 8x multisampled antialiasing
• Worldcar in shaded mode
• Engine in shaded mode
• Motorcycle in shaded mode and 4x multisampled antialiasing
• Worldcar in shaded-with-edges mode and 4x multisampled antialiasing
• Engine in shaded-with-edges mode
• Motorcycle in shaded-with-edges mode
• Four bombers in shaded-with-edges mode and 8x multisampled antialiasing (traced from PTC Creo 4)
• Four engines in wireframe mode and 4x multisampled antialiasing
• Four bombers in wireframe mode (traced from PTC Creo 4)
• Worldcar in hidden-line mode
• Motorcycle in hidden-line mode and 8x multisampled antialiasing
• Engine in no-hidden-edge mode
• Four bombers in no-hidden-edge mode and 8x multisampled antialiasing (traced from PTC Creo 4)

Figure 16 is a sample screenshot from the test run.

Figure 16) Creo sample.

8.4 Energy (energy-02)

The energy-02 viewset is based on rendering techniques used by the open-source OpendTect seismic visualization application. In a manner similar to medical imaging such as MRI or CT, geophysical surveys generate image slices through the subsurface that are built into a 3D grid. Volume rendering provides a 2D projection of this 3D volumetric grid for further analysis and interpretation.

At every frame, the bounding cube faces of the volume are tessellated and rendered with a fragment shader that performs a ray cast from the eye position through the volume, accumulating transparently lit, color-mapped values. This process is continued until either the pixel becomes fully opaque or the volume is exited.

The voxel in the 3D grid is a single scalar value. A transfer function—simply a 1D lookup table—maps the 3D density value to color and alpha values. For lighting calculations, the gradients are computed on the fly using the central differences at each voxel. These state changes exercise various parts of the graphics subsystem. This viewset makes use of hardware support for 3D textures and therefore trilinear interpolation.
In addition to the volume rendering, the test includes both inline and crossline planes (slices in the X and Y planes). Also, for some subtests, horizons are present; these are geological strata boundaries of interest that are generated by exploration geophysicists and rendered using textured triangle strips.

The 3D datasets used in this viewset are real-world seismic datasets found at the SEG wiki. These datasets were translated from their native SEG-Y format and compressed using JPEG-2000.

We performed the following viewset tests:
- Blake Ridge volume (1307x95x1300) and horizons
- F3 Netherlands volume (950x450x462) and horizons
- Opunake volume (1949x731x1130)
- Blake Ridge volume (with animated clipping plane) and horizons
- F3 Netherlands volume (with animated clipping plane) and horizons
- Opunake volume (with animated clipping plane)

For the Energy viewset, the frame-buffer size affects the composite score significantly.

**Figure 17** Energy sample.

8.5 **Maya (maya-05)**

The maya-05 viewset was created from traces of the graphics workload generated by the Maya 2017 application from Autodesk.

This viewset includes numerous rendering modes supported by the application, including shaded mode, ambient occlusion, multisample antialiasing, and transparency. All tests are rendered using Viewport 2.0.

We performed the following viewset tests:
- Toy store, smooth shaded with wireframe on shaded mode, ambient occlusion, and 4x multisample antialiasing
- Toy store, wireframe mode and 8x multisample antialiasing
• Jungle escape, smooth shaded with hardware texture mode and ambient occlusion
• Jungle escape, smooth shaded with hardware texture mode
• Sven space, smooth shaded with hardware texture mode
• Sven space, smooth shaded, ambient occlusion, and 4x multisample antialiasing
• HSM satellite, smooth shaded and 8x multisample antialiasing
• Ship splash, smooth shaded with all lights
• Ship splash, wireframe mode and 4x multisample antialiasing
• Ship splash, smooth shaded with hardware texture mode, ambient occlusion, and 8x multisample antialiasing

Figure 18) Maya sample.

8.6 Medical (medical-02)

The medical-02 viewset uses the Tuvok rendering core of the ImageVis3D volume visualization program. It renders a 2D projection of a 3D volumetric grid. A typical 3D grid in this viewset is a group of 3D slices acquired by a scanner such as a CT or MRI machine.

Two rendering modes are represented: slice-based rendering and ray casting.

For slice-based rendering, a series of coplanar slices aligned with the current viewing angle are computed on the CPU. They are then sent to the graphics hardware for texturing and further calculations, such as transfer function lookup, lighting, and clipping to reveal internal structures. Finally, the slices are blended together before the image is displayed.

For ray casting, rays are cast through the volume, accumulating transparently lit, colored pixels until full opacity or the bounds of the volume are reached.

For both slice-based and ray-cast rendering, the volumes are potentially subdivided into 512x512x512 3D volumes. This technique, known as bricking, typically results in better rendering performance on a wider range of GPU hardware.
The voxel in the 3D grid is a single scalar value. A transfer function—either a 1D or a 2D lookup table—maps the 3D density value to color and alpha values. For 2D tables, the second axis is defined as the magnitude of the gradient at each sample. For lighting calculations, the gradients are computed on the fly using the central differences at each voxel. These state changes exercise various parts of the graphics subsystem. This viewset makes use of hardware support for 3D textures and therefore trilinear interpolation.

The following descriptions and weighting are for the four datasets in this viewset:

- A 4D heart dataset composed of multiple 3D volumes iterated over time. These were obtained from a phase-contrast MRI scanner. The 80MB dataset was contributed by the Department of Radiology at the Stanford School of Medicine and Lucile Packard Children's Hospital. Each volume consists of 256x256x32 16-bit samples.
- A stag beetle dataset provided by the Technical University of Vienna. The dataset size is 650MB and represents a workload with larger memory requirements. The volume consists of 832x832x494 16-bit samples.
- An MRI scan of the head of a member of the SPECgpc committee, who has released the data for use in SPECviewperf. The volume consists of 232x256x192 16-bit samples.
- A CT scan of the right upper thorax and arm of the same member of the SPECgpc committee, who has also released this data for use in SPECviewperf. The volume consists of 512x512x102 16-bit samples.

The tests in the viewset are derived from those four datasets as follows:

- 4D heart, 1D transfer function, slice-based rendering
- 4D heart, 1D transfer function, ray casting
- Stag beetle, 1D transfer function, slice-based rendering
- Stag beetle, 1D transfer function, ray casting
- Head MRI, 2D transfer, ray casting
- Head MRI, 2D transfer, ray casting, clipping plane
- Thorax CT, 2D transfer, ray casting
- Thorax CT, 2D transfer, ray casting, clipping plane

The Tuvok rendering core is licensed under the MIT open-source license; see the GitHub site for Tuvok for more information. Tuvok includes a Hilbert Curve implementation, which is copyright 1998, Rice University. Tuvok also includes LZ4, which is licensed under the BSD 2-Clause license.
8.7 Showcase (showcase-02)

The showcase-02 viewset was created from traces of Autodesk’s Showcase 2013 application. The model used in the viewset contains eight million vertices.

The viewset features DX rendering. Rendering modes included in the viewset include shading, projected shadows, and self-shadows.

The following tests were included in the viewset:

- Shaded with self-shadows
- Shaded with self-shadows and projected shadows
- Shaded
- Shaded with projected shadows
8.8 Siemens NX (snx-03)

The snx-03 viewset was created from traces of the graphics workload generated by the NX 8.0 application from Siemens PLM. Model sizes range from 7.15 to 8.45 million vertices.

The viewset includes numerous rendering modes supported by the application, including wireframe, antialiasing, shaded, shaded with edges, and studio mode.

**Viewset tests**

The following tests were included in the viewset:

- Powertrain in advanced studio mode
- Powertrain in shaded mode
- Powertrain in shaded-with-edges mode
- Powertrain in studio mode
- Powertrain in wireframe mode
- SUV in advanced studio mode
- SUV in shaded mode
- SUV in shaded-with-edges mode
- SUV in studio mode
- SUV in wireframe mode
8.9 SolidWorks (sw-04)

The sw-04 viewset was created from traces of Dassault Systèmes SolidWorks 2013 SP1 application. Models used in the viewset range in size from 2.1 to 21 million vertices.

The viewset includes numerous rendering modes supported by the application, including shaded mode, shaded with edges, ambient occlusion, shaders, and environment maps.

The following tests were included in the viewset:

- Vehicle in shaded mode—normal shader with environment cubemap
- Vehicle in shaded mode—bump parallax mapping with environment cubemap
- Vehicle in shaded mode—ambient occlusion enabled with normal shader and environment map
- Vehicle in shaded-with-edges mode—normal shader with environment cubemap
- Vehicle in wireframe mode
- Rally car in shaded mode—ambient occlusion enabled with normal shader and environment map
- Rally car in shaded mode—normal shader with environment cubemap
- Rally car in shaded-with-edges mode—normal shader with environment cubemap
- Tesla tower in shaded mode—ambient occlusion enabled with normal shader and environment map
- Tesla tower in shaded mode—normal shader with environment cubemap
- Tesla tower in shaded-with-edges mode—normal shader with environment cubemap
9 Conclusion

NetApp HCI provides the flexibility to start Citrix Virtual Apps and Desktops with a few nodes and grow as your needs increase. NetApp HCI storage offers storage saving by using global in-line deduplication, compression, and thin provisioning.

NetApp HCI min, max, and burst QoS features guarantee performance for your workloads. SMB file shares on ONTAP make it easier to set up user home folders and accommodate growth as demands increase.

NetApp HCI can be easily repurposed as workload demands change to provide a robust return on your investment. For more information, or to see a demonstration, contact your NetApp representative.

Where to Find Additional Information

To learn more about the information that is described in this document, review the following documents and/or websites.

NetApp
- NetApp HCI Theory of Operations
- VMware End-User Computing with NetApp HCI and NVIDIA GPUs
- NetApp HCI for End-User Computing with VMware and NVIDIA GPUs
- NetApp HCI for Virtual Desktop Infrastructure with VMware Horizon 7
• NetApp Cloud Services
  https://cloud.netapp.com/home

NVIDIA

• NVIDIA Tesla GPUs for virtualization

• NVIDIA GRID: Deployment Best Practices for the Digital Workspace

• Virtual Workstation 101

• NVIDIA Virtual GPU Packaging, Pricing and Licensing

• NVIDIA RTX

• NVIDIA T4 for Virtualization

• NVIDIA GRID Deployment Guide for Citrix XenDesktop 7.12 on VMware vSphere 6

• NVIDIA Management and Monitoring

• NVIDIA GPU Cloud
  https://ngc.nvidia.com/catalog/landing

Citrix

• Citrix Tech Zone
  https://docs.citrix.com/en-us/tech-zone

• Citrix Virtual Apps and Desktops

• Technical Overview of Citrix Application Layering

• Citrix VDI Handbook and Best Practices

• Citrix Virtual Apps and Desktops – Technical Overview

• Citrix Provisioning Services product overview
  https://docs.citrix.com/en-us/provisioning/7-15/overview.html

• Choosing the Provisioning Model for Image Management
  https://docs.citrix.com/en-us/tech-zone/design/design-decisions/image-management.html

• Citrix Blogs
  https://www.citrix.com/blogs/

• Citrix Cloud Services
  https://www.cloud.com/cloud-services.html

LakeSide
• GPU Assessment
  https://www.lakesidesoftware.com/assessments/nvidia

**Version History**

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<th>Version</th>
<th>Date</th>
<th>Document Version History</th>
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<td>Version 1.0</td>
<td>October 2019</td>
<td>Initial draft by Suresh Thoppay</td>
</tr>
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Appendix A: NVIDIA nVector Tool Configuration Information

The Config.JSON for the GPU tests is as follows:

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  "isdirectconnect": "0",
  "vditype": "XenDesktop",
  "broker": "cdc01.hcieuc.demo",
  "schedulingpolicy": "0x00",
  "gputype": "nvidia",
  "enduserlatency": "1"
}
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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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