Technical Report

How to Configure NVIDIA GPU K1 and K2 Cards with Citrix XenDesktop 7.6 and vSphere 6.0 in FlexPod Express with Cisco C-Series Servers

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1 Executive Summary

Server virtualization is a mainstream practice in current IT infrastructure deployments. The infrastructure of a virtualized environment typically includes compute nodes (physical servers), switches, and a storage array system. The majority of virtualized environments also use shared storage and shared switches. In addition to the virtualization of standard business applications, video clusters are now making the jump to the virtualized world with the advent of powerful graphics processing cards (GPUs) and drivers provided by hypervisor companies. NVIDIA is a major player in this movement, and NVIDIA GPU cards now have drivers available for VMware vSphere and Citrix XenServer.

Cisco has developed firmware to support NVIDIA GPU cards in C series M4 servers, and Citrix XenDesktop has virtual desktop infrastructure (VDI) software to accommodate GPU cards in a shared VDI environment. The files processed by these VDI video clients are typically very large in size. NetApp provides superior storage for CIFS access of these large input files. NetApp® systems also allow you to use CIFS storage for the VDI software and storage requirements of this environment.

Graphics display users tend to be small groups that use a portion of the overall virtualized server environment. The FlexPod® Express converged platform is positioned for the remote office/branch office (ROBO) market, the small to medium-sized business market, or small user base solutions. FlexPod Express is composed of the Cisco Unified Computing System (Cisco UCS) mini B series or C series servers, Cisco Nexus switches, and NetApp FAS2552 series storage. FlexPod Express fulfills the requirement for a small user base for GPU users, the need to process large files, and the need for server performance with drivers to support NVIDIA GPU offload graphics card positions in this reference architecture.

1.1 Reference Architecture Objectives

This reference architecture describes how to configure NetApp storage and NVIDIA GPU cards in a FlexPod Express system so that it accommodates your video VDI requirements. In addition, it shows how to add a Cisco UCS rack mount server into a Cisco UCS Mini blade server environment. This reference architecture uses vSphere 6.0u1 on a Cisco UCS Mini with a C240 M4 rack server, two Cisco Nexus 9000 series switches, and a NetApp FAS2552 under the FlexPod Express converged infrastructure umbrella.

This technical report is a how-to document. Therefore, we assume that the reader is familiar with the architecture, design, infrastructure, and VDI configuration of a FlexPod Express system. To learn more about these subjects, see the Cisco validated design (CVD) document FlexPod Express with Cisco UCS Mini and Citrix XenDesktop 7.6 with Cisco Nexus 9000 Series, and VMware vSphere 5.5 Update 2. This CVD covers Cisco UCS servers, Cisco Nexus 9000 switches, and the NetApp FAS2500 series product line in detail. In addition, this CVD covers VDI load testing and VDI configuration on a FlexPod Express configuration.

The hardware and software infrastructure described in this CVD was used to conduct the NVIDIA validation and to create this technical report. This proven infrastructure provides step-by-step instructions on configuring NVIDIA GPU cards in a FlexPod Express configuration.

2 Introduction

Built on more than five years of innovation, FlexPod has evolved to meet the changing needs of our customers and has helped drive their success. Specifically, FlexPod Express provides a rich set of data management features and clustering for scale-out, operational efficiency, and nondisruptive operations. This combination offers you one of the most compelling value propositions in the industry. The IT landscape is undergoing a fundamental shift to IT as a service, a model that requires a pool of compute, network, and storage to serve a wide range of applications and deliver a wide range of services. Innovations such as FlexPod Express are fueling this transformation.

2.1 Outstanding Performance

For this reference architecture, we used a FAS2552 with four SSD drives and 20 SAS drives in one internal DS2246 shelf. This configuration provides outstanding performance for CIFS and for large data access. The FAS2552 is a superior storage array for ROBO or small to medium businesses, and it also provides ample performance for a VDI environment. The NetApp FAS2552, when matched with a Cisco UCS converged infrastructure with Cisco Nexus data switches, provides the performance required for NVIDIA GPU environments.

2.2 Solution Summary

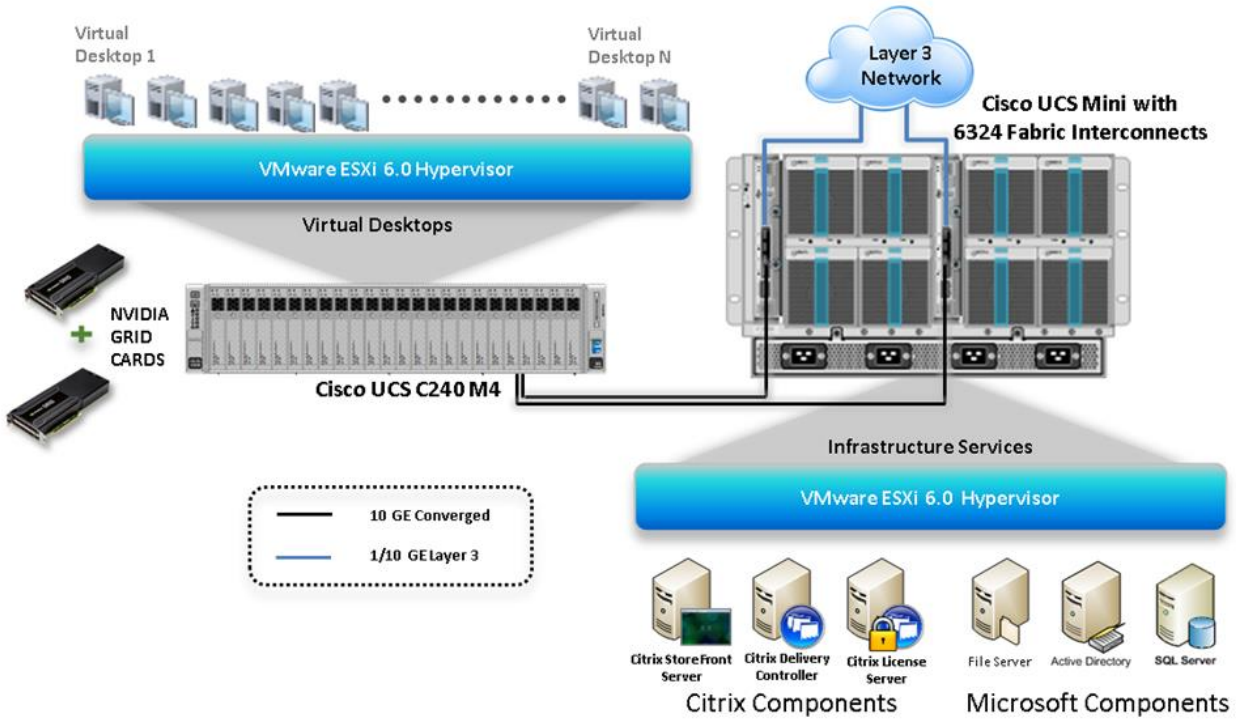
This solution is a converged infrastructure with full redundancy that is based on the following hardware and software:

- One NetApp FAS2552HA two-node storage cluster with NetApp Flash Pool™ intelligent data caching
- Two Cisco Nexus 9372 switches for data
- One Cisco UCS Mini chassis with 6324 fabric interconnects
- One Cisco UCS C240 rack mount server with an NVIDIA GPU card
- VMware vSphere ESXi 6.0
- vCenter Server Appliance 6.0
- Windows 2012 Server for the virtual machines (VMs)
- NetApp clustered Data ONTAP® 8.3.1
- NetApp Virtual Storage Console (VSC) 6.0 plug-in for vCenter

3 Solution Configuration

Figure 1 provides an overview of the solution configuration.

Figure 1) Reference architecture (graphic provided by Cisco).



3.1 Hardware Components of Solution

- One NetApp FAS2552 with four SSD drives (Flash Pool) and 20 SAS drives
- One Cisco UCS C240-M4 rack server (two Intel Xeon processor E5-2660 v3 CPUs at 2.60GHz) with 256GB of memory (16 GB x 16 DIMMs at 2133MHz) and a hypervisor host
- Cisco UCS VIC1227 mLOM
- Two Cisco Nexus 9372 switches (access switches)
- Two Cisco UCS 6324 fabric interconnects through Cisco UCS Mini
- 12 x 600GB SAS disks at 10,000 rpm
- NVIDIA GRID K1 and K2 cards

3.2 Software Components of Solution

- Cisco UCS firmware 3.0(2d)
- VMware ESXi 6.0 for VDI hosts
- Citrix XenApp/XenDesktop 7.6 with Feature Pack 3
- Microsoft Windows 7 SP1 64-bit
- NetApp VSC 6.0

3.3 Configure NetApp FAS2552

The following sections describe the configuration of the NetApp FAS2552 data storage system.

Cluster Setup in ONTAP

The FAS2552 is set up and configured with the NetApp System Setup tool. See the NetApp System Setup documentation (installation and setup instructions) to automatically create the storage cluster and configure the storage nodes, the root aggregates, and the initial storage configuration.

Storage Networking Configuration

This section describes the configuration of storage networking based on ONTAP®.

Set Auto-Revert on Cluster Management

To set the `auto-revert` parameter on the cluster management interface, run the following command:

```
network interface modify –vserver <<var_clustername>> -lif cluster_mgmt –auto-revert true
```

Failover Group Management in ONTAP

Logical interfaces (LIFs) and ports have roles, and different ports are used for management, storage, data motion, and fault tolerance. Roles include cluster management and node management: cluster for traffic between nodes and intercluster for NetApp SnapMirror® replication to a separate cluster and for data. From a solution perspective, data LIFs are further classified by how they are used by servers and applications and whether they are on private, nonroutable networks; corporate internal routable networks; or a DMZ.

The NetApp cluster connects to these various networks by using data ports. Data LIFs must use a specific set of ports on each node for traffic to be routed properly. Some LIFs, such as cluster management and data LIFs for NFS and CIFS, can fail over between ports within the same node or between nodes, so that traffic continues without interruption if a cable is unplugged or a node fails. Failover groups control to which ports a LIF can fail over. If failover groups are not set up or are set up incorrectly, LIFs can fail over to a port on the wrong network and cause a loss of connectivity.

Best Practices

- All data ports should be members of an appropriate failover group.
- All data LIFs should be associated with an appropriate failover group.
- To keep network connectivity as standardized as possible, use the same port on each node for the same purpose.

1. Create a management port failover group.

```
network interface failover-groups create –vserver <<var_clustername>> -failover-group fg-cluster-mgmt -targets <<var_node01>>:e0a, <<var_node02>>:e0a
```

2. Assign the management port failover group to the cluster management LIF.

```
network interface modify –vserver <<var_clustername>> -lif cluster_mgmt –failover-group fg-cluster-mgmt
```

Failover Group Node Management in ONTAP

Create a management port failover group

```
network interface failover-groups create –vserver <<var_clustername>> -failover-group fg-node-mgmt-01 -targets <<var_node01>>:e0M, <<var_node01>>:e0a
network interface failover-groups create –vserver <<var_clustername>> -failover-group fg-node-mgmt-02 -targets <<var_node02>>:e0M, <<var_node02>>:e0a
```

Assign Node Management Failover Groups to Node Management LIFs

Assign the management port failover group to the cluster management LIF.

```
network interface modify -vserver <<var_clustername>> -lif <<var_node01>>_mgmt1 -auto-revert true -failover-group fg-node-mgmt-01
network interface modify –vserver <<var_clustername>> -lif <<var_node02>>_mgmt1 –auto-revert true –failover-group fg-node-mgmt-02
```

Service Processor Network Interface Setup

Assign a static IPv4 address to the service processor on each node.

```
system service-processor network modify –node <<var_node01>> -address-family IPv4 –enable true –dhcp none –ip-address <<var_node01_sp_ip>> -netmask <<var_node01_sp_mask>> -gateway <<var_node01_sp_gateway>>

system service-processor network modify –node <<var_node02>> -address-family IPv4 –enable true –dhcp none –ip-address <<var_node02_sp_ip>> -netmask <<var_node02_sp_mask>> -gateway <<var_node02_sp_gateway>>
```

Note: The service processor IP addresses should be in the same subnet as the node management IP addresses.

Disable Flow Control on 10GbE and UTA2 Ports

Best Practice

- NetApp recommends disabling flow control on all of the 10GbE and UTA2 ports that are connected to external devices.

To disable flow control, run the following commands:

```
network port modify -node <<var_node02>> -port e0c,e0d,e0e,e0f -flowcontrol-admin none
Warning: Changing the network port settings will cause a several second interruption in carrier.
Do you want to continue? {y|n}: y
```

```
network port show –fields flowcontrol-admin
```

Disable Unused FCoE Ports

To disable unused switchless cluster interconnect FCoE ports, run the following commands:

```
fcp adapter modify -node <<var_node01>> -adapter 0e –state down
fcp adapter modify -node <<var_node01>> -adapter 0f –state down
fcp adapter modify -node <<var_node02>> -adapter 0e –state down
fcp adapter modify -node <<var_node02>> -adapter 0f –state down
fcp adapter show –fields state
```

Network Time Protocol in ONTAP

To configure time synchronization on the cluster, complete the following steps:

1. Set the time zone for the cluster.

```
timezone <<var_timezone>>
```

Note: For example, the time zone in the Eastern United States is America/New_York.

2. Set the date for the cluster.

```
date <ccyymmddhhmm.ss>
```

Note: The format for the date is <[Century][Year][Month][Day][Hour][Minute].[Second]>: for example, 201309081735.17.

3. Configure the Network Time Protocol servers for the cluster.

```
cluster time-service ntp server create -server <<var_global_ntp_server_ip>>
```

Simple Network Management Protocol in ONTAP

To configure the Simple Network Management Protocol (SNMP), complete the following steps:

1. Configure basic SNMP information, such as the location and contact. When polled, this information is visible as the sysLocation and sysContact variables in SNMP.

```
snmp contact <<var_snmp_contact>>
snmp location "<<var_snmp_location>>"
snmp init 1
options snmp.enable on
```

2. Configure SNMP traps to send to remote hosts, such as a DFM server or another fault management system.

```
snmp traphost add <<var_oncommand_server_fqdn>>
```

SNMPv1 in ONTAP

To configure SNMPv1, set the shared, secret plain-text password, which is called a community.

```
snmp community add ro <<var_snmp_community>>
```

Note: Use the `delete all` command with caution. If community strings are used for other monitoring products, the `delete all` command removes them.

SNMPv3 in ONTAP

SNMPv3 requires that a user be defined and configured for authentication. To configure SNMPv3, complete the following steps:

1. Create a user called `snmpv3user`.

```
security login create -username snmpv3user -authmethod usm -application snmp
```

2. Enter the authoritative entity's engine ID and select `md5` as the authentication protocol.
3. Run the `security snmpusers` command to view the engine ID.
4. When prompted, enter an eight-character minimum-length password for the authentication protocol.
5. Select `des` as the privacy protocol.
6. When prompted, enter an eight-character minimum-length password for the privacy protocol.

AutoSupport HTTPS in ONTAP

NetApp AutoSupport® sends support summary information to NetApp through HTTPS. To configure AutoSupport, run the following command:

```
system node autosupport modify -node * -state enable –mail-hosts <<var_mailhost>> -transport
https -support enable -noteto <<var_storage_admin_email>>
```

Cisco Discovery Protocol in ONTAP

To enable the Cisco Discovery Protocol (CDP) on the NetApp storage controllers, run the following command:

```
node run -node * options cdpd.enable on
```

Note: To be effective, CDP must also be enabled on directly connected networking equipment such as switches and routers.

Create Jumbo Frame MTU Broadcast Domain in ONTAP

You can enable jumbo frames for data network VLANs if the switch supports it.

Best Practice
• NetApp recommends using jumbo frames or MTU 9000 for the data network.

To create a data broadcast domain with an MTU of 9000 on Data ONTAP, run the following command:

```
broadcast-domain create -broadcast-domain Data -mtu 9000
```

Move 10GbE Data Ports to Data Broadcast Domain

To move the 10GbE data ports to the data broadcast domain, run the following commands:

```
broadcast-domain remove-ports -broadcast-domain Default -ports <<var_node01>>:e0c,
<<var_node01>>:e0d,<<var_node02>>:e0c,<<var_node02>>:e0d
broadcast-domain add-ports -broadcast-domain Data -ports <<var_node01>>:e0c,<<var_node01>>:e0d,
<<var_node02>>:e0c,<<var_node02>>:e0d
broadcast-domain show
network port show –fields mtu
```

VLANs in ONTAP

1. Create NFS VLAN ports and add them to the data broadcast domain.

```
network port vlan create –node <<var_node01>> -vlan-name e0c-<<var_nfs_vlan_id>>
network port vlan create –node <<var_node01>> -vlan-name e0d-<<var_nfs_vlan_id>>
network port vlan create –node <<var_node02>> -vlan-name e0c-<<var_nfs_vlan_id>>
network port vlan create –node <<var_node02>> -vlan-name e0d-<<var_nfs_vlan_id>>
broadcast-domain add-ports -broadcast-domain Data -ports <<var_node01>>:e0c-<<var_nfs_vlan_id>>,
<<var_node01>>:e0d-<<var_nfs_vlan_id>>,<<var_node02>>:e0c-<<var_nfs_vlan_id>>,
<<var_node02>>:e0d-<<var_nfs_vlan_id>>
```

2. Create iSCSI VLAN ports and add them to the data broadcast domain.

```
network port vlan create –node <<var_node01>> -vlan-name e0c-<<var_iscsi_vlan_A_id>>
network port vlan create –node <<var_node01>> -vlan-name e0d-<<var_iscsi_vlan_B_id>>
network port vlan create –node <<var_node02>> -vlan-name e0c-<<var_iscsi_vlan_A_id>>
network port vlan create –node <<var_node02>> -vlan-name e0d-<<var_iscsi_vlan_B_id>>
broadcast-domain add-ports -broadcast-domain Data -ports <<var_node01>>:e0c-
<<var_iscsi_vlan_A_id>>,<<var_node01>>:e0d-<<var_iscsi_vlan_B_id>>,<<var_node02>>:e0c-
<<var_iscsi_vlan_A_id>>,<<var_node02>>:e0d-<<var_iscsi_vlan_B_id>>
```

3.4 NetApp Storage Configuration for VMware ESXi 6.0 Infrastructure and VDA Virtual Machines

Aggregates in ONTAP

Best Practices
• Create an aggregate RAID group size of 16 to 20 SAS drives. • Create one large data partition aggregate per storage node when possible. Size limitations might require multiple aggregates.

To create new aggregates, complete the following steps:

1. Run the following commands:

```
aggr create -aggregate aggr1_node01 -nodes <<var_node01>> -diskcount <<var_num_disks>>
aggr create -aggregate aggr1_node02 -nodes <<var_node02>> -diskcount <<var_num_disks>>
```

Note: Retain at least one disk (select the largest disk) in the configuration as a spare. A best practice is to have at least one spare for each disk type and size.

Note: Start with five disks initially; you can add disks to an aggregate when additional storage is required. Note that with a FAS2552 or FAS2554 in this configuration, you might need to create an aggregate with all but one remaining disk (spare) assigned to the controller.

Note: The aggregate cannot be created until disk zeroing completes. Run the `aggr show` command to display the aggregate creation status. Do not proceed until both `aggr1_node1` and `aggr1_node2` are online.

2. Disable NetApp Snapshot® copies for the two data aggregates that were recently created.

```
node run <<var_node01>> aggr options aggr1_node01 nosnap on
node run <<var_node02>> aggr options aggr1_node02 nosnap on
```

3. Delete any existing Snapshot copies for the two data aggregates.

```
node run <<var_node01>> snap delete –A –a –f aggr1_node01
node run <<var_node02>> snap delete –A –a –f aggr1_node02
```

4. Rename the root aggregate on node 01 to match the naming convention for this aggregate on node 02.

```
aggr show
aggr rename –aggregate aggr0 –newname <<var_node01_rootaggrname>>
```

Storage Virtual Machines

To create an infrastructure storage virtual machine (SVM; called Vserver in the command interface), complete the following steps:

1. Run the `vserver create` command.

```
vserver create –vserver Infra-SVM –rootvolume rootvol –aggregate aggr1_node01 –rootvolume-
security-style unix
```

2. Select the `vserver` data protocols to configure, leaving `nfs`, `fcp`, and `iscsi`.

```
vserver remove-protocols –vserver Infra-SVM -protocols cifs,ndmp
```

3. Add the two data aggregates to the `Infra-SVM` aggregate list for NetApp Virtual Console.

```
vserver modify –vserver Infra-SVM –aggr-list aggr1_node01,aggr1_node02
```

4. Enable and run the NFS protocol in the `Infra-SVM vserver`.

```
nfs create -vserver Infra-SVM -udp disabled
```

5. Turn on the `SVM vstorage` parameter for the NetApp NFS VAAI plug-in.

```
vserver nfs modify –vserver Infra-SVM –vstorage enabled
vserver nfs show
```

Create Load-Sharing Mirror of SVM Root Volume in ONTAP

To create a load-sharing mirror of the SVM root volume in ONTAP, complete the following steps:

1. Create a volume to be the load-sharing mirror of the infrastructure SVM root volume on each node.

```
volume create –vserver Infra-SVM –volume rootvol_m01 –aggregate aggr1_node01 –size 1GB –type DP
volume create –vserver Infra-SVM –volume rootvol_m02 –aggregate aggr1_node02 –size 1GB –type DP
```

2. Create a job schedule to update the root volume mirror relationships every 15 minutes.

```
job schedule interval create -name 15min –minutes 15
```

3. Create the mirroring relationships.

```
snapmirror create –source-path //Infra-SVM/rootvol –destination-path //Infra-SVM/rootvol_m01 –
type LS -schedule 15min
snapmirror create –source-path //Infra-SVM/rootvol –destination-path //Infra-SVM/rootvol_m02 –
type LS -schedule 15min
```

4. Initialize the mirroring relationships.

```
snapmirror initialize-ls-set –source-path //Infra-SVM/rootvol
snapmirror show
```

Fibre Channel Protocol Service in ONTAP

Create the Fibre Channel Protocol (FCP) service on each SVM. This command also starts the FCP service and sets the FCP worldwide node name (WWNN) for the SVM.

```
fcp create -vserver Infra-SVM
fcp show
```

iSCSI Service in ONTAP

To create the iSCSI service on each SVM, start the iSCSI service, and set the iSCSI qualified name (IQN) for the SVM, run the following commands:

```
iscsi create -vserver Infra-SVM
iscsi show
```

HTTPS Access in ONTAP

To configure secure access to the storage controller, complete the following steps:

1. Increase the privilege level to access the certificate commands.

```
set -privilege diag
Do you want to continue? {y|n}: y
```

2. Generally, a self-signed certificate is already in place. Verify the certificate by running the following command:

```
security certificate show
```

3. For each SVM shown, the certificate common name must match the DNS fully qualified domain name (FQDN) of the SVM. Delete the four default certificates and replace them with either self-signed certificates or certificates from a certificate authority (CA). To delete the default certificates, run the following commands:

```
security certificate delete [TAB] …
Example: security certificate delete -vserver Infra-SVM -common-name Infra-SVM -ca Infra-SVM -
type server -serial 552429A6
```

Note: Deleting expired certificates before creating new certificates is a best practice. Run the `security certificate delete` command to delete expired certificates. In the following command, use TAB completion to select and delete each default certificate.

4. To generate and install self-signed certificates, run the following commands as one-time commands. Generate a server certificate for the infra-SVM and the cluster SVM. Again, use TAB completion to aid in completing these commands.

```
security certificate create [TAB] …
Example: security certificate create -common-name infra-svm.ciscorobo.com -type  server -size
2048 -country US -state "California" -locality "San Jose" -organization "Cisco" -unit "UCS" -
email-addr "abc@cisco.com" -expire-days 365 -protocol SSL -hash-function SHA256 -vserver Infra-
SVM
```

5. To access the values for the parameters required in the following step, run the `security certificate show` command.
6. Enable each certificate that was just created by using the `–server-enabled true` and `–client-enabled false` parameters. Again use TAB completion.

```
security ssl modify [TAB] …
Example: security ssl modify -vserver clus -server-enabled true -client-enabled false -ca
clus.ciscorobo.com -serial 55243646 -common-name clus.ciscorobo.com
```

7. Configure and enable SSL and HTTPS access and disable HTTP access.

```
system services web modify -external true -sslv3-enabled true
Warning: Modifying the cluster configuration will cause pending web service requests to be
         interrupted as the web servers are restarted.
Do you want to continue {y|n}: y
system services firewall policy delete -policy mgmt -service http –vserver <<var_clustername>>
```

Note: It is normal for some of these commands to return an error message stating that the entry does not exist.

8. Change back to the normal admin privilege level and allow SVM log access from the web.

```
set –privilege admin
vserver services web modify –name spi|ontapi|compat –vserver * -enabled true
```

NFS Export Policies in ONTAP

To configure NFS on the SVM, complete the following steps:

1. Create a new rule for each ESXi host in the default export policy. For each ESXi host being created, assign a rule. Each host has its own rule index. Your first ESXi host has rule index 1, your second ESXi host has rule index 2, and so on.

```
vserver export-policy rule create –vserver Infra-SVM -policyname default –ruleindex 1 –protocol
nfs -clientmatch <<var_esxi_host1_nfs_ip>> -rorule sys –rwrule sys -superuser sys –allow-suid
false
vserver export-policy rule create –vserver Infra-SVM -policyname default –ruleindex 2 –protocol
nfs -clientmatch <<var_esxi_host2_nfs_ip>> -rorule sys –rwrule sys -superuser sys –allow-suid
false
```

```
vserver export-policy rule show
```

2. Assign the FlexPod export policy to the infrastructure SVM root volume.

```
volume modify –vserver Infra-SVM –volume rootvol –policy default
```

NFS FlexVol Volumes in ONTAP

Best Practices
• Create a minimum of two volumes per storage node. • Group similar data on each volume for better deduplication ratios. • Set auto-grow on the volumes. • Set the Delete Oldest Snapshot parameter when running low on space on a volume. • Use thin provisioning on volumes when possible. • Set up reallocation jobs to run against each volume on all storage nodes, with the exception of root volumes. • Never reallocate an aggregate unless you are directed to do so by NetApp Global Support.

Deduplication with FlexVol Volumes

Table 1) Deduplication recommendations.

Resource	Recommended Deduplication	Reason
vDisk	Yes	OS data can be deduplicated.
Write cache	No	Log files and page files are temporary, transient data. Therefore, do not enable deduplication on these volumes. Doing so wastes storage resources.
Personal vDisk	Yes	Use deduplication on the same applications between users.
User data and profile	Yes	Use deduplication on user data and profiles.

To create a NetApp FlexVol® volume, you must provide the volume's name, size, and the aggregate on which it exists.

```
volume create -vserver Infra-SVM -volume infra_datastore_1 -aggregate aggr1_node02 -size 500GB -
state online -policy default -junction-path /infra_datastore_1 -space-guarantee none -percent-
snapshot-space 0

volume create -vserver Infra-SVM -volume infra_swap -aggregate aggr1_node01 -size 100GB -state
online -policy default -junction-path /infra_swap -space-guarantee none -percent-snapshot-space 0
-snapshot-policy none

volume create -vserver Infra-SVM -volume esxi_boot -aggregate aggr1_node01 -size 100GB -state
online -policy default -space-guarantee none -percent-snapshot-space 0

snapmirror update-ls-set -source-path //Infra-SVM/rootvol
```

iSCSI LUNs for Boot from SAN

Best Practices

• NetApp recommends the following network configuration best practices:
  - Enable jumbo frames on the iSCSI networks.
  - Set flow control to none.
  - Disable spanning tree on the switch ports connected to NetApp storage ports.
• Create two iSCSI VLANs for iSCSI fabric A and iSCSI fabric B.
• Set the iSCSI boot LUN's ID to 0.

ONTAP iSCSI Configuration

To configure iSCSI on ONTAP, complete the following steps:

1. Add an iSCSI license.
2. Add the iSCSI protocol to the SVM.
3. Enable the iSCSI service.
4. Create iSCSI VLANs.
5. Create iSCSI LIFs.
6. Create volumes.
7. Create the boot LUNs within the volumes.
8. Create the igroups with the host IQNs.
9. Map the LUN to the igroup and set the LUN ID to 0 (LUN masking).

To complete these nine steps, the following commands are required:

The steps to add a licensed are displayed.

```
cluster setup
Enter an additional license key []:<<var_fcp_license>>
```

1. Select the SVM data protocols to configure, leaving `nfs`, `fcp`, and `iscsi`.

```
vserver remove-protocols –vserver Infra-SVM -protocols cifs,ndmp
```

2. To enable the iSCSI service, run the following commands. These commands create the iSCSI service on each SVM, start the iSCSI service, and set the iSCSI IQN for the SVM.

```
iscsi create -vserver Infra-SVM
iscsi show
```

3. Create iSCSI VLAN ports and add them to the data broadcast domain.

```
network port vlan create –node <<var_node01>> -vlan-name e0c-<<var_iscsi_vlan_A_id>>
network port vlan create –node <<var_node01>> -vlan-name e0d-<<var_iscsi_vlan_B_id>>
network port vlan create –node <<var_node02>> -vlan-name e0c-<<var_iscsi_vlan_A_id>>
network port vlan create –node <<var_node02>> -vlan-name e0d-<<var_iscsi_vlan_B_id>>
broadcast-domain add-ports -broadcast-domain Data -ports <<var_node01>>:e0c-
<<var_iscsi_vlan_A_id>>,<<var_node01>>:e0d-<<var_iscsi_vlan_B_id>>,<<var_node02>>:e0c-
<<var_iscsi_vlan_A_id>>,<<var_node02>>:e0d-<<var_iscsi_vlan_B_id>>
```

4. Create four iSCSI LIFs, two on each node.

```
network interface create -vserver Infra-SVM -lif iscsi_lif01a -role data -data-protocol iscsi -
home-node <<var_node01>> -home-port e0c-<<var_iscsi_vlan_A_id>> -address
<<var_node01_iscsi_lif01a_ip>> -netmask <<var_node01_iscsi_lif01a_mask>> -status-admin up –
failover-policy disabled –firewall-policy data –auto-revert false

network interface create -vserver Infra-SVM -lif iscsi_lif01b -role data -data-protocol iscsi -
home-node <<var_node01>> -home-port e0d-<<var_iscsi_vlan_B_id>> -address
```

```
<<var_node01_iscsi_lif01b_ip>> -netmask <<var_node01_iscsi_lif01b_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false

network interface create -vserver Infra-SVM -lif iscsi_lif02a -role data -data-protocol iscsi -
home-node <<var_node02>> -home-port e0c-<<var_iscsi_vlan_A_id>> -address
<<var_node02_iscsi_lif01a_ip>> -netmask <<var_node02_iscsi_lif01a_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false

network interface create -vserver Infra-SVM -lif iscsi_lif02b -role data -data-protocol iscsi -
home-node <<var_node02>> -home-port e0d-<<var_iscsi_vlan_B_id>> -address
<<var_node02_iscsi_lif01b_ip>> -netmask <<var_node02_iscsi_lif01b_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false

network interface show
```

5. The following information is required to create a FlexVol volume: the volume's name, size, and the aggregate on which it exists. Create two VMware datastore volumes and a server boot volume. Also, update the SVM root volume load-sharing mirrors to make the NFS mounts accessible.

```
volume create -vserver Infra-SVM -volume infra_datastore_1 -aggregate aggr1_node02 -size 500GB -
state online -policy default -junction-path /infra_datastore_1 -space-guarantee none -percent-
snapshot-space 0

volume create -vserver Infra-SVM -volume infra_swap -aggregate aggr1_node01 -size 100GB -state
online -policy default -junction-path /infra_swap -space-guarantee none -percent-snapshot-space 0
-snapshot-policy none

volume create -vserver Infra-SVM -volume esxi_boot -aggregate aggr1_node01 -size 100GB -state
online -policy default -space-guarantee none -percent-snapshot-space 0

snapmirror update-ls-set -source-path //Infra-SVM/rootvol
```

6. Create the boot LUNs. Repeat this step for each of the iSCSI LUNs required.

```
lun create -vserver Infra-SVM -volume esxi_boot -lun VM-Host-Infra-01 -size 10GB -ostype vmware -
space-reserve disabled
lun create -vserver Infra-SVM -volume esxi_boot -lun VM-Host-Infra-02 -size 10GB -ostype vmware -
space-reserve disabled
```

7. Create the igroups with IQNs.

```
igroup create -vserver Infra-SVM -igroup Boot01 -protocol iscsi -ostype vmware -portset <portset
name> -initiator IQN1, IQN2, IQN3, etc.
```

8. Map the LUNs to igroups and set the LUN ID to 0.

```
Lun map -vserver Infra-SVM -path <path of LUN> -volume <volname> -qtree <qtreename> -lun
<lunname> -igroup Boot01 -lun-id 0
```

Deduplication in ONTAP

To enable deduplication on the appropriate volumes, run the following commands:

```
volume efficiency on -vserver Infra-SVM -volume infra_datastore_1
volume efficiency on -vserver Infra-SVM -volume esxi_boot
```

LIF Creation in ONTAP

Best Practices
• Each NFS datastore should have a data LIF for every node in the cluster. • When you create a new SVM, add one LIF per protocol per node.

FCP LIF in ONTAP

Create four FCoE LIFs, two on each node.

```
network interface create -vserver Infra-SVM -lif fcp_lif01a -role data -data-protocol fcp -home-
node <<var_node01>> -home-port 0c -status-admin up -failover-policy disabled -auto-revert false

network interface create -vserver Infra-SVM -lif fcp_lif01b -role data -data-protocol fcp -home-
node <<var_node01>> -home-port 0d -status-admin up -failover-policy disabled -auto-revert false

network interface create -vserver Infra-SVM -lif fcp_lif02a -role data -data-protocol fcp -home-
node <<var_node02>> -home-port 0c -status-admin up -failover-policy disabled -auto-revert false

network interface create -vserver Infra-SVM -lif fcp_lif02b -role data -data-protocol fcp -home-
node <<var_node02>> -home-port 0d -status-admin up -failover-policy disabled -auto-revert false
```

Create iSCSI LIFs for Data Access in ONTAP

Create four iSCSI LIFs, two on each node.

```
network interface create -vserver Infra-SVM -lif iscsi_lif01a -role data -data-protocol iscsi -
home-node <<var_node01>> -home-port e0c-<<var_iscsi_vlan_A_id>> -address
<<var_node01_iscsi_lif01a_ip>> -netmask <<var_node01_iscsi_lif01a_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false

network interface create -vserver Infra-SVM -lif iscsi_lif01b -role data -data-protocol iscsi -
home-node <<var_node01>> -home-port e0d-<<var_iscsi_vlan_B_id>> -address
<<var_node01_iscsi_lif01b_ip>> -netmask <<var_node01_iscsi_lif01b_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false

network interface create -vserver Infra-SVM -lif iscsi_lif02a -role data -data-protocol iscsi -
home-node <<var_node02>> -home-port e0c-<<var_iscsi_vlan_A_id>> -address
<<var_node02_iscsi_lif01a_ip>> -netmask <<var_node02_iscsi_lif01a_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false

network interface create -vserver Infra-SVM -lif iscsi_lif02b -role data -data-protocol iscsi -
home-node <<var_node02>> -home-port e0d-<<var_iscsi_vlan_B_id>> -address
<<var_node02_iscsi_lif01b_ip>> -netmask <<var_node02_iscsi_lif01b_mask>> -status-admin up -
failover-policy disabled -firewall-policy data -auto-revert false
network interface show
```

NAS Failover Groups in ONTAP

Create an NFS port failover group.

```
network interface failover-groups create -vserver Infra-SVM -failover-group fg-nfs-
<<var_nfs_vlan_id>> -targets <<var_node01>>:e0c-<<var_nfs_vlan_id>>,<<var_node01>>:e0d-
<<var_nfs_vlan_id>>,<<var_node02>>:e0c-<<var_nfs_vlan_id>>,<<var_node02>>:e0d-<<var_nfs_vlan_id>>

network interface failover-groups show
```

NFS LIF in ONTAP

Best Practices

- Create one NetApp LIF per VMware datastore.
- Pin NFS VMkernel ports to one fabric (A or B) in VMware vSwitch, VMware vDS, or Cisco Nexus 1000V.

Create an NFS LIF.

```
network interface create -vserver Infra-SVM -lif nfs_infra_swap -role data -data-protocol nfs -
home-node <<var_node01>> -home-port e0d-<<var_nfs_vlan_id>> -address
<<var_node01_nfs_lif_infra_swap_ip>> -netmask <<var_node01_nfs_lif_infra_swap_mask>> -status-
admin up -failover-policy broadcast-domain-wide -firewall-policy data -auto-revert true -
failover-group fg-nfs-<<var_nfs_vlan_id>>

network interface create -vserver Infra-SVM -lif nfs_infra_datastore_1 -role data -data-protocol
nfs -home-node <<var_node02>> -home-port e0d-<<var_nfs_vlan_id>> -address
```

```
<<var_node02_nfs_lif_infra_datastore_1_ip>> -netmask
<<var_node02_nfs_lif_infra_datastore_1_mask>> -status-admin up –failover-policy broadcast-domain-
wide –firewall-policy data –auto-revert true –failover-group fg-nfs-<<var_nfs_vlan_id>>

network interface show
```

LIF Migration

NFS and CIFS LIFs can be migrated, but iSCSI LIFs cannot. If you install NetApp Flash Cache™ intelligent data caching, you might need the I/O expansion module (IOXM) to add another 10GbE card. If you use IOXM, you must connect the high-availability (HA) pair with a fiber cable.

Best Practice
• Use 10GbE for cluster interconnection and data networks. NetApp recommends 1GbE for management networks. Make sure you have enough 10GbE cards and ports.

Add Infrastructure SVM Administrator

To add the infrastructure SVM administrator and SVM administration LIF in the out-of-band management network, run the following commands:

```
network interface create –vserver Infra-SVM –lif vsmgmt –role data –data-protocol none –home-node
<<var_node02>> -home-port  e0a –address <<var_vserver_mgmt_ip>> -netmask
<<var_vserver_mgmt_mask>> -status-admin up –failover-policy broadcast-domain-wide –firewall-
policy mgmt –auto-revert true –failover-group fg-cluster-mgmt
```

Note: The SVM management IP indicated here should be in the same subnet as the storage cluster management IP.

1. Create a default route for the SVM management interface to reach the outside world.

```
network route create –vserver Infra-SVM -destination 0.0.0.0/0 –gateway
<<var_vserver_mgmt_gateway>>
Network route show
```

2. Set a password for the SVM `vsadmin` user and unlock the user.

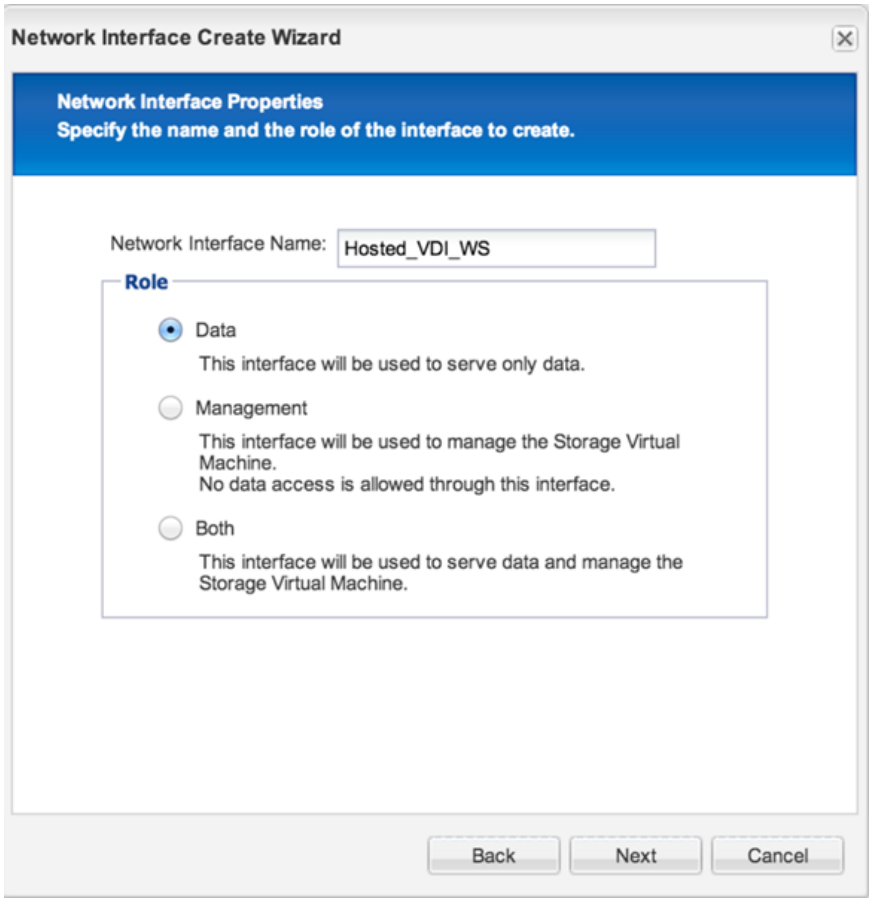
```
security login password –username vsadmin –vserver Infra-SVM
Enter a new password:  <<var_password>>
Enter it again:  <<var_password>>

security login unlock –username vsadmin –vserver Infra-SVM
```

NetApp Storage Configuration for Citrix Provisioning Services Write Cache Datastores

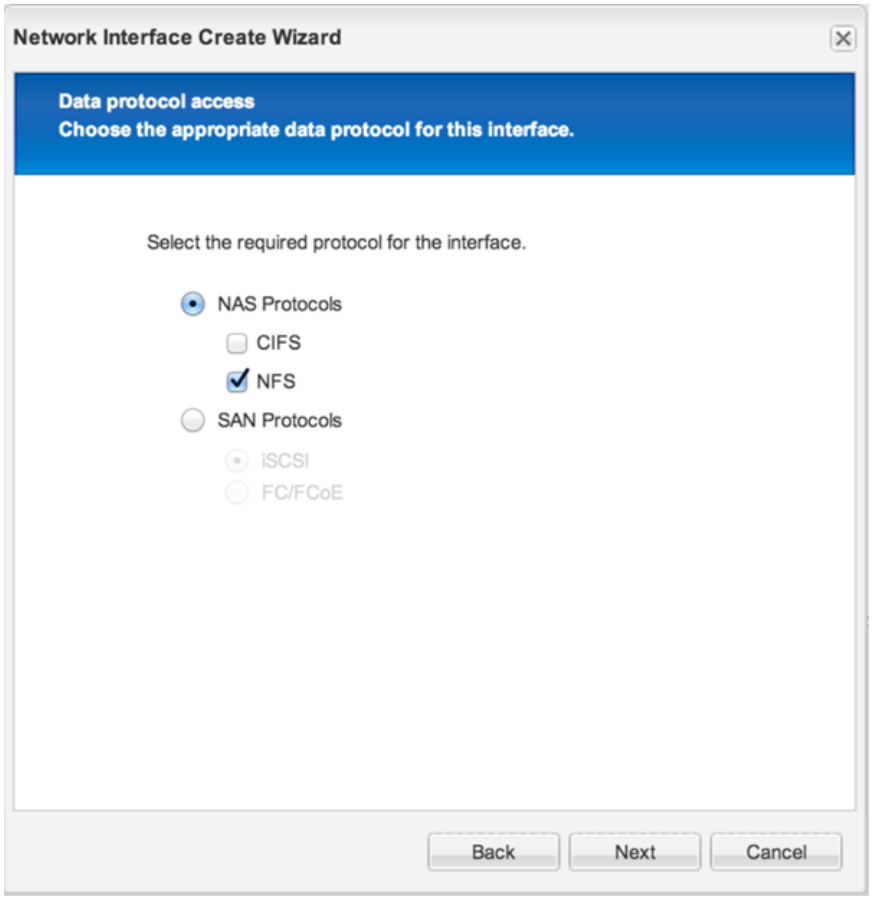
Create Storage Volumes for Provisioning Services vDisks

To create the network interface with NetApp OnCommand® System Manager, complete these steps:

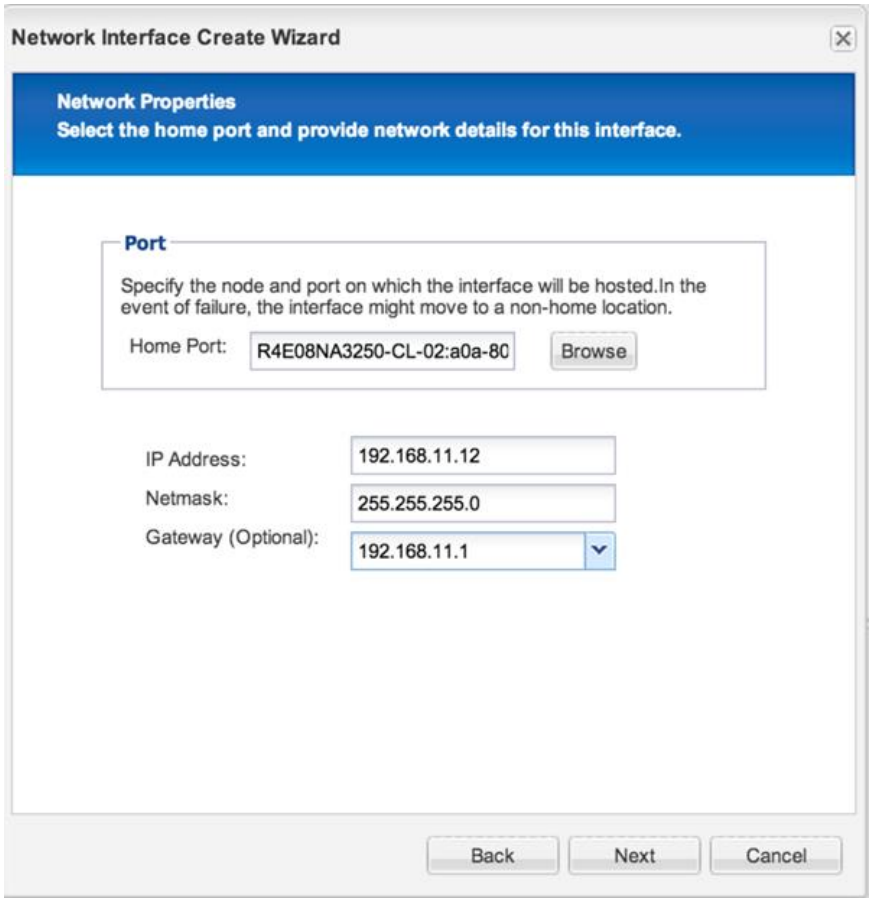
1. Log in to ONTAP in System Manager.
2. On the SVM `Hosted_VDI`, select Configuration > Network Interface.
3. Click Create to start the Network Interface Create wizard. Click Next.
4. Enter `Hosted_VDI_WS` for the network interface name. Select Data and click Next.



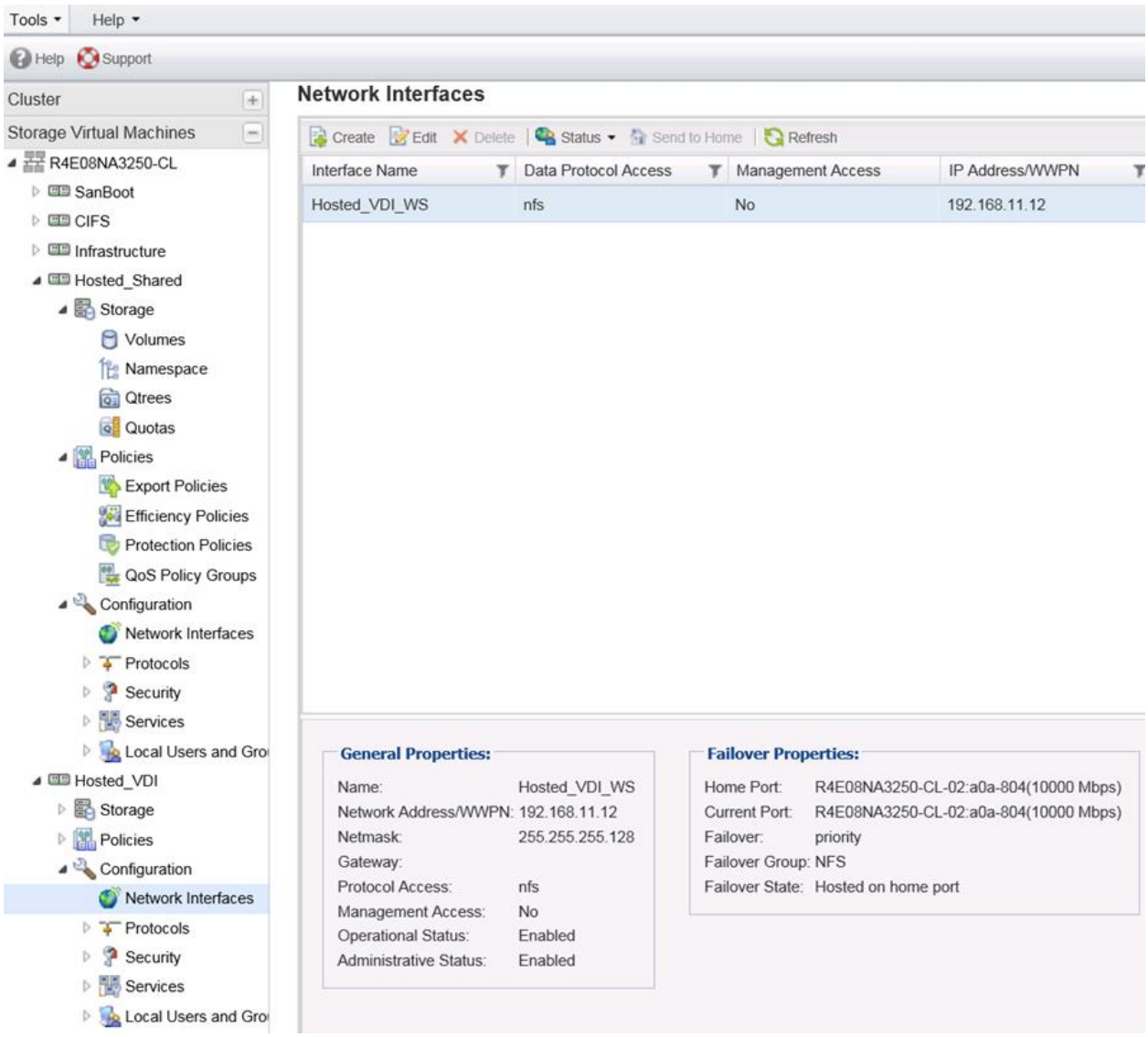
5. Set the protocol to NFS and click Next.



6. Select the home port for the network interface and enter the corresponding IP, netmask, and gateway details.



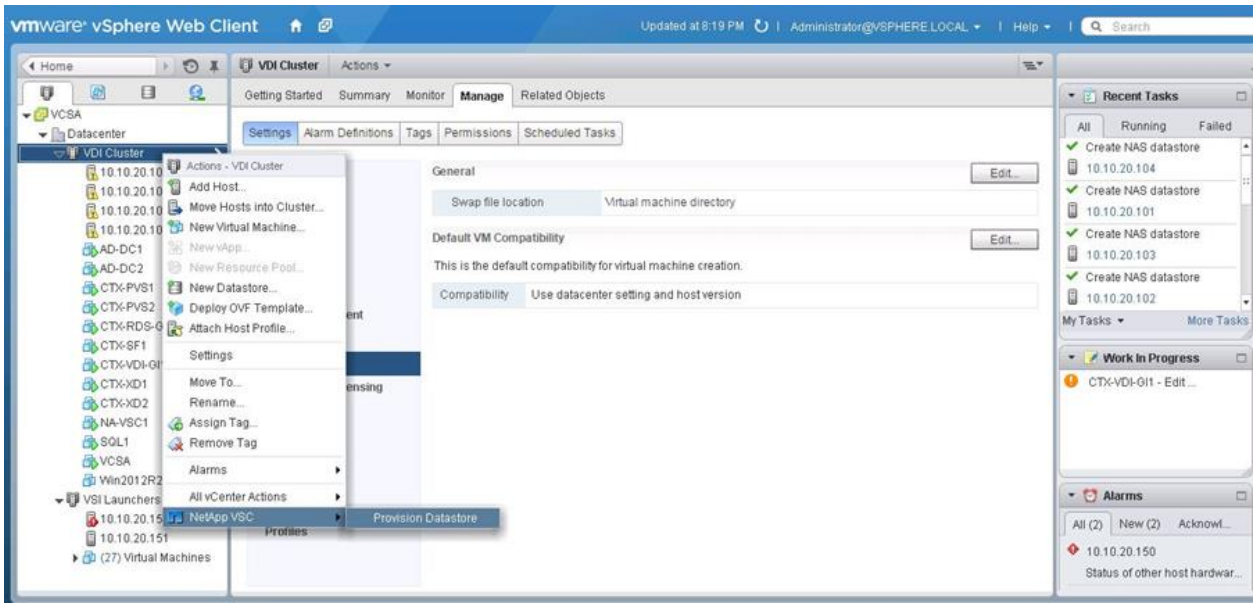
7. Review the details on the Summary page and click Next. The network interface is now available.



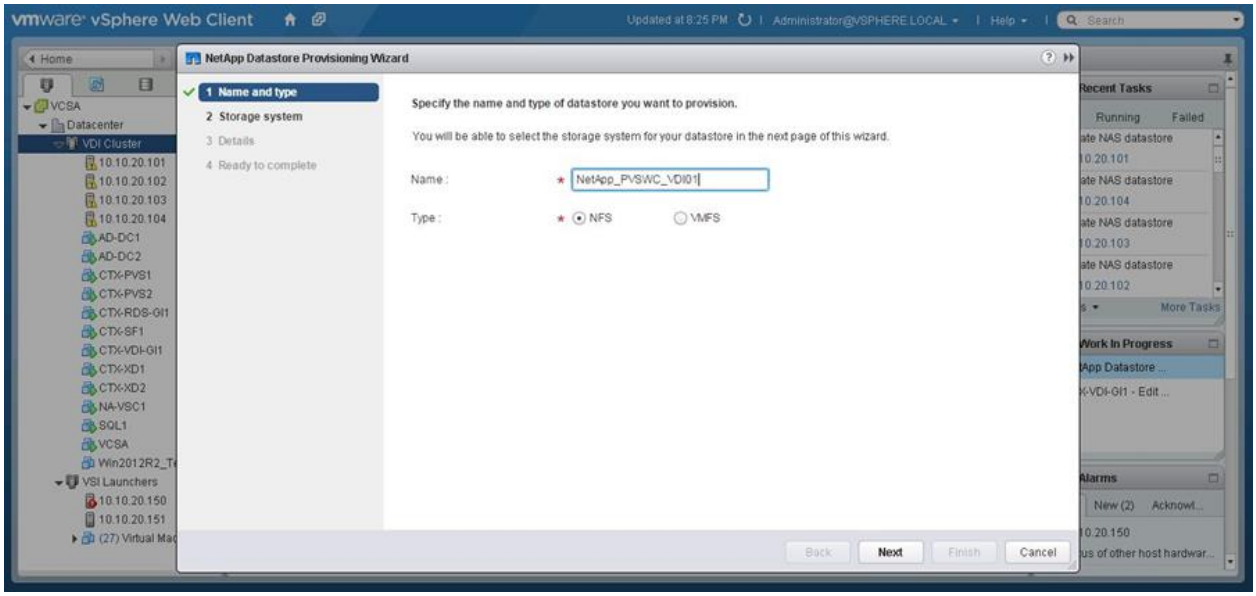
Create Volume for Write Cache Disks

Use NetApp VSC for VMware vSphere to create a volume for the write cache. The VSC applies best practices and makes the provisioning of storage repositories a much simpler operation than manual provisioning.

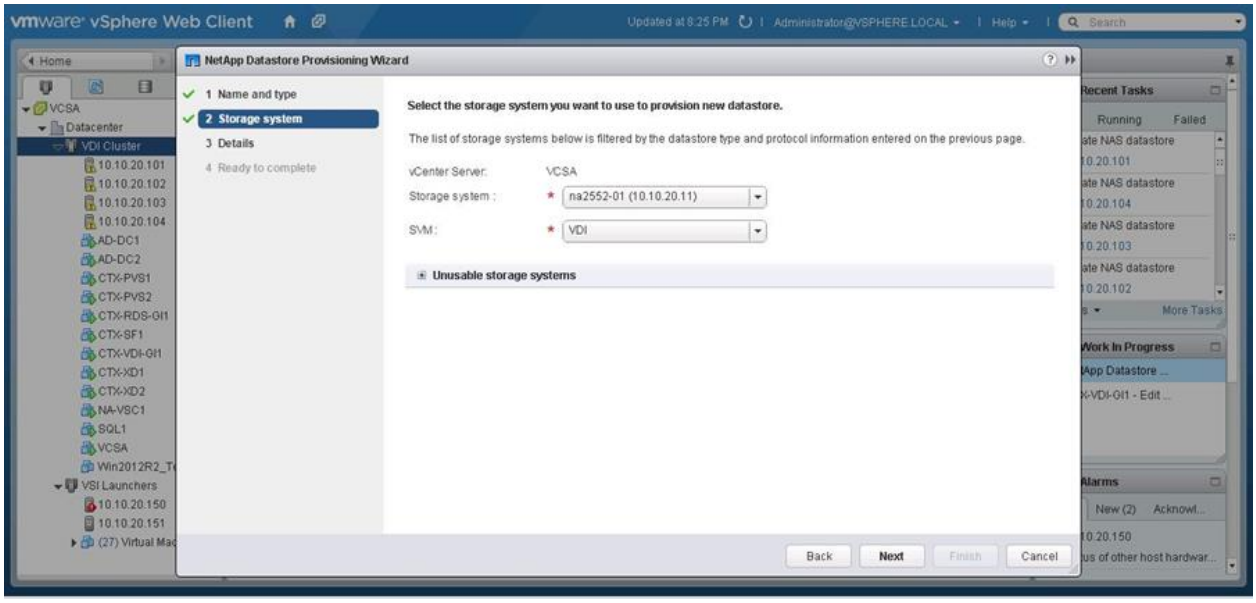
1. Install VSC. Build a separate Windows 2012 server and install the VSC vCenter plug-in on Windows 2012 server.
2. In vCenter, right-click the host for which you would like to provision the storage datastore and select NetApp VSC > Provision Datastores.



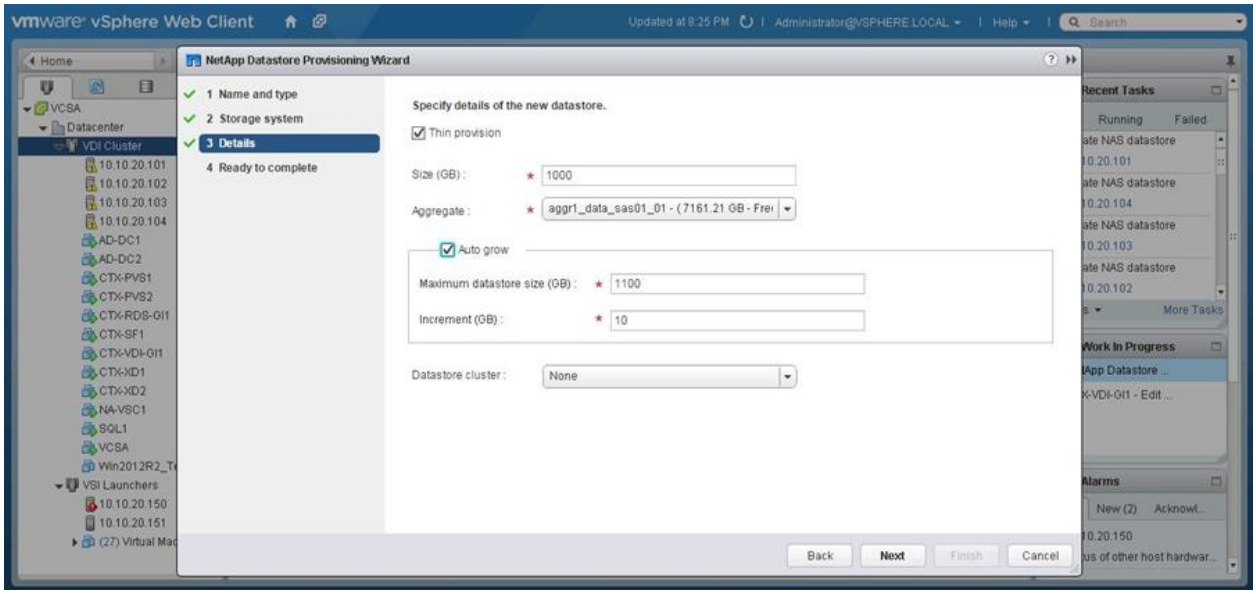
3. Enter the datastore name, choose NFS for Type, and click Next.



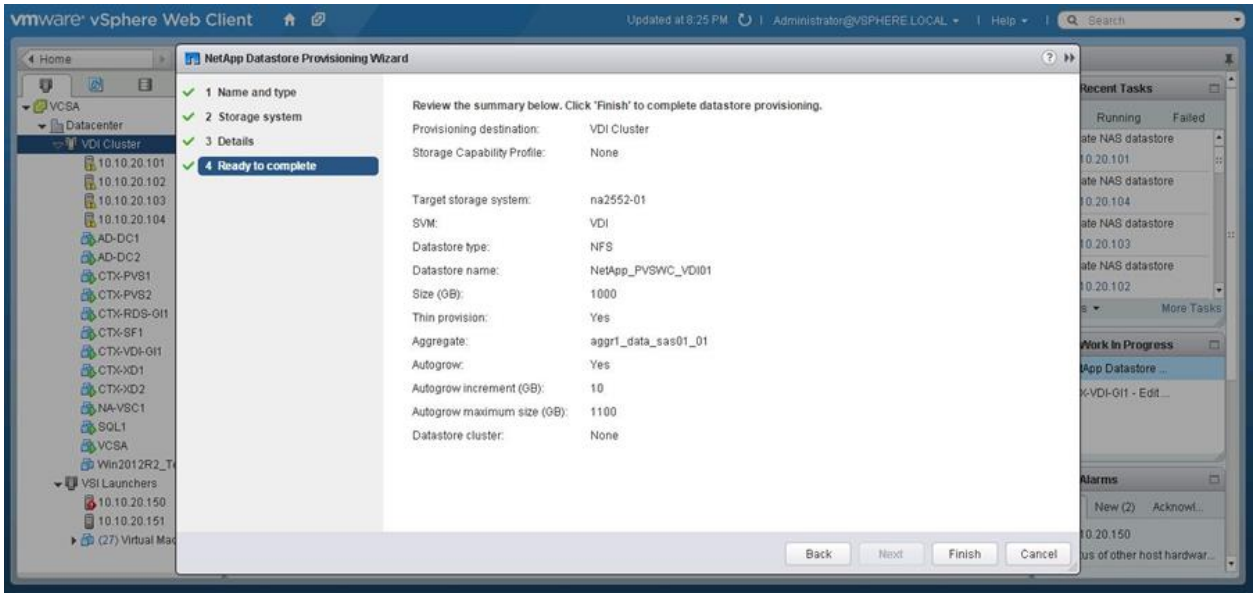
4. Choose the storage system and the SVM and click Next.



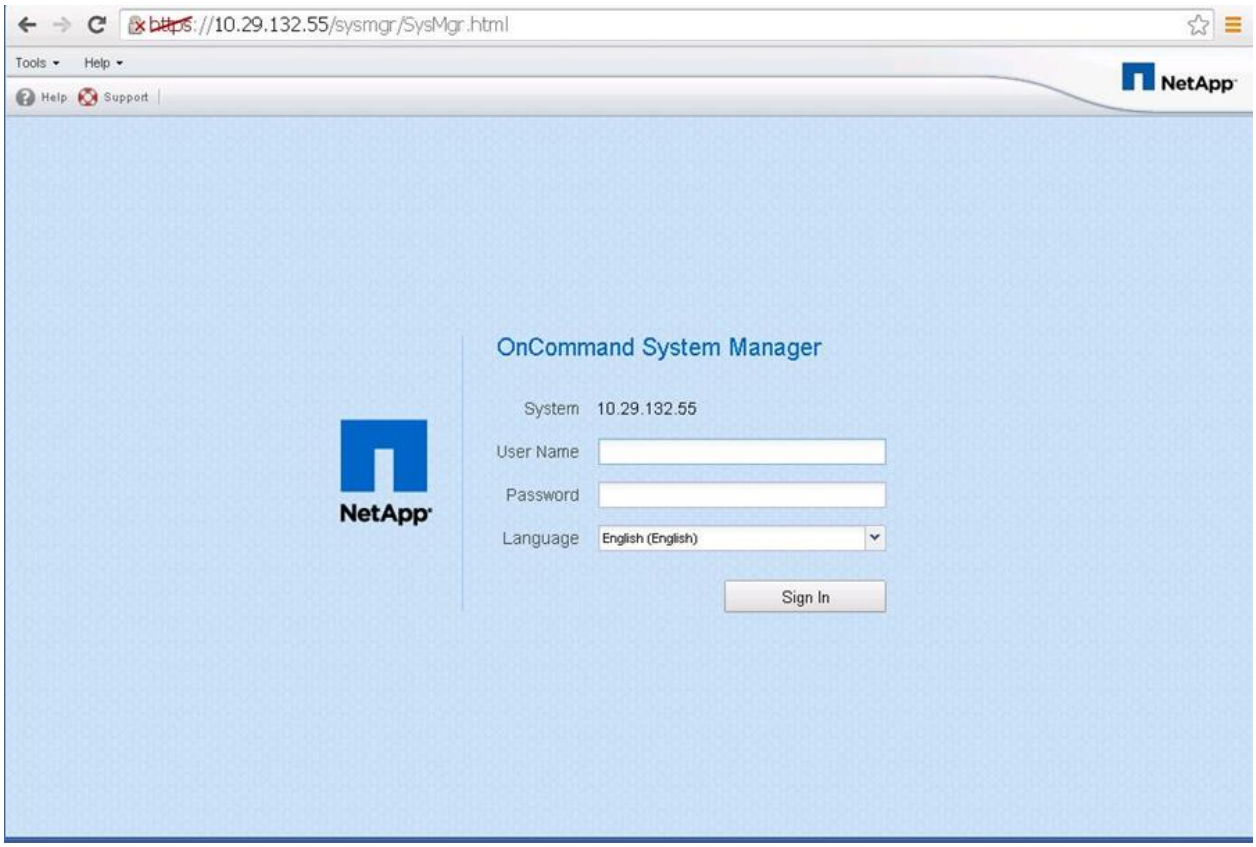
5. Select Thin Provision. Enter the size of the volume in GB and choose the aggregate containing the volume. Select Auto Grow and set the auto-grow maximum size and the auto-grow increment size in GB. If you have a VMware datastore cluster defined, then select the VMware datastore cluster and click Next.



6. Review your input on the Summary screen and, if correct, click Finish. Wait for a few moments until the storage volume and VMware datastore are created.

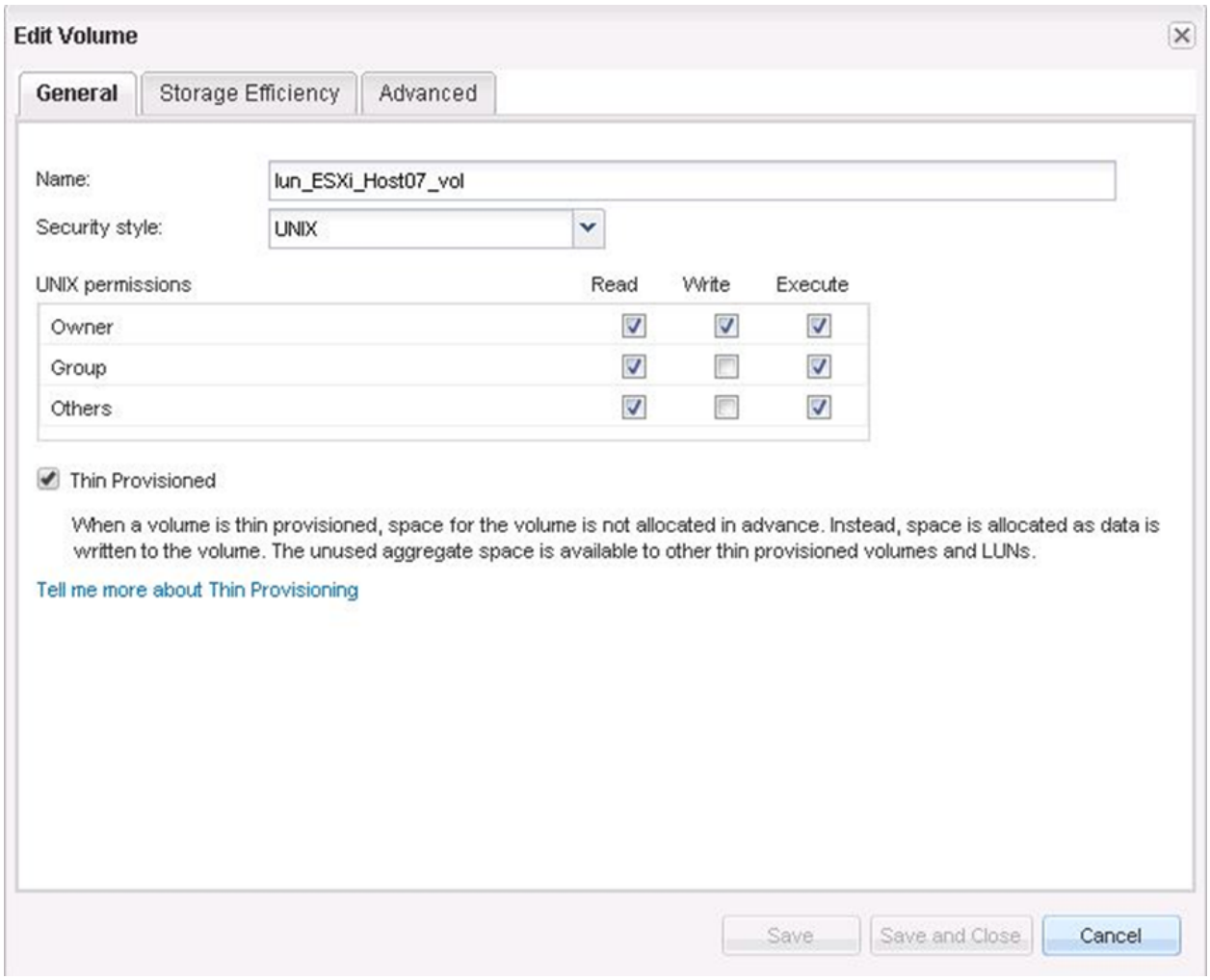


7. You must now launch the System Manager tool to finish the advance volume settings. In version 8.3, System Manager is built into clustered Data ONTAP inside the storage nodes. With your browser, connect to the cluster IP address. The System Manager login screen appears. Enter the administrator user name and password and click Sign In.

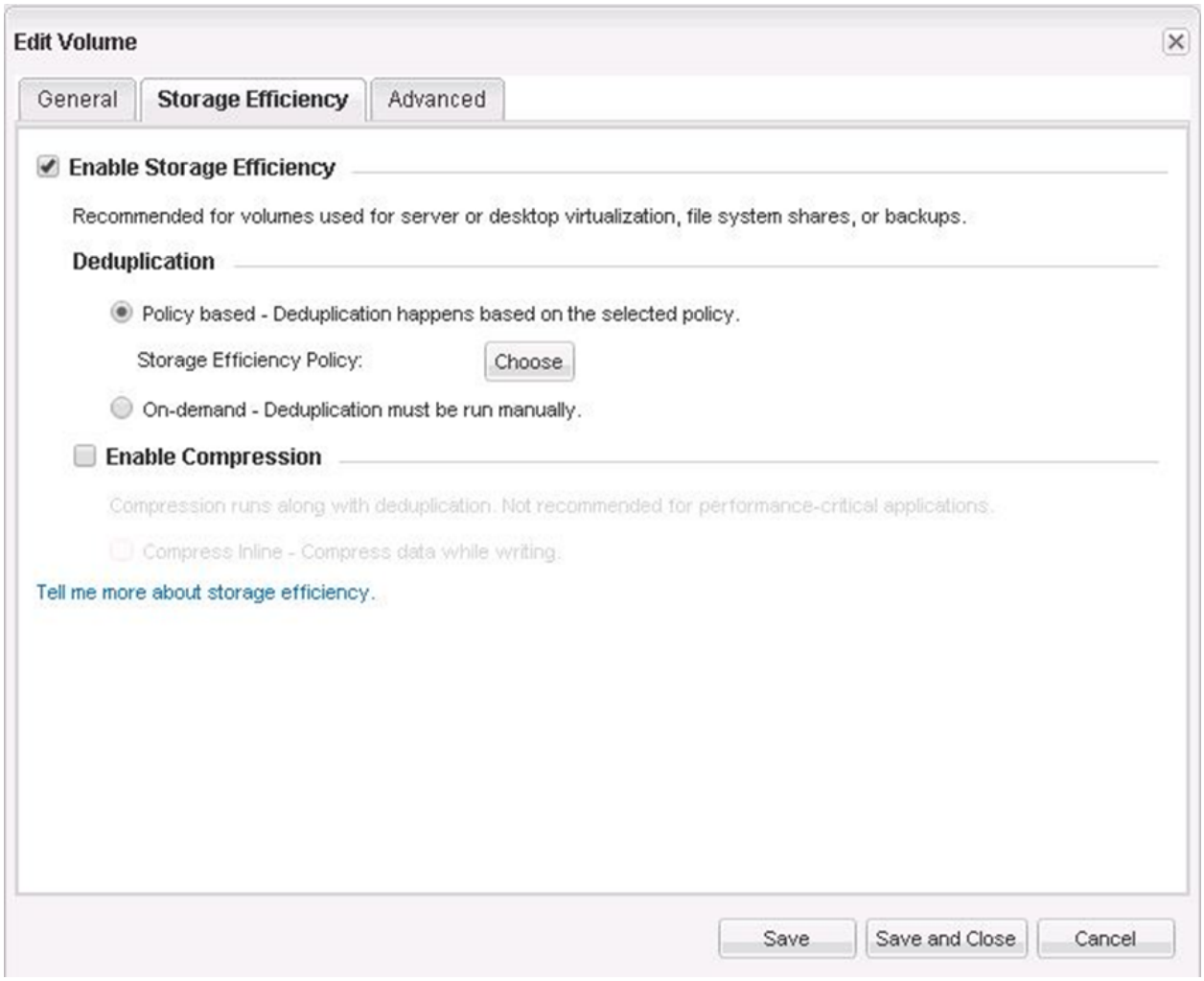


8. Sign in to the NetApp System Manager and click Storage Virtual Machine. Then select the storage submenu and volume submenu. Highlight the write cache volume by clicking the volume name in the

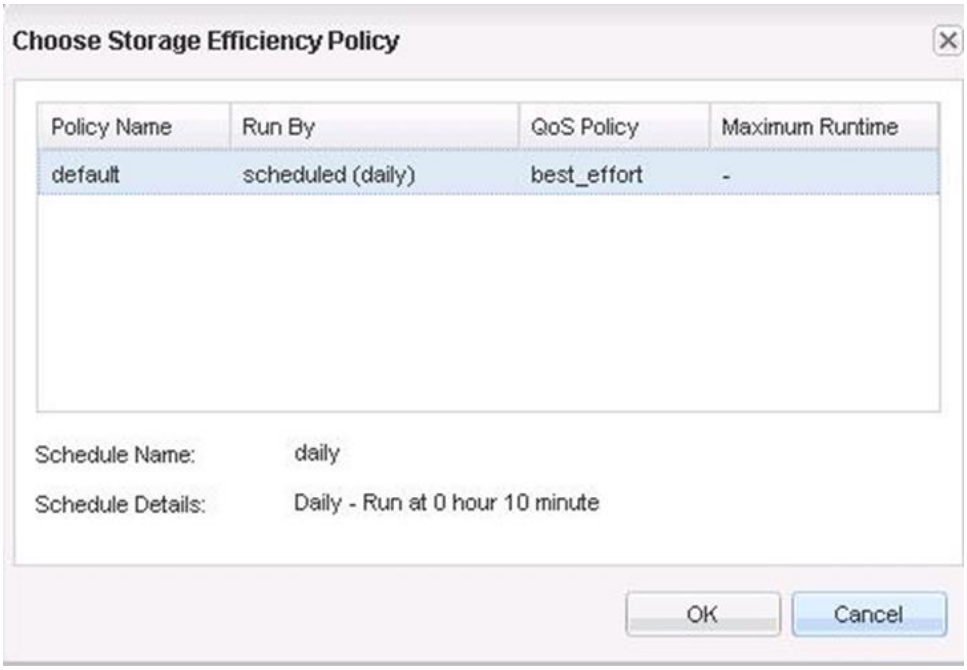
right window pane. Then click the Edit menu at the top. When the following screen appears, click the Storage Efficiency tab.



9. Select Enable Storage Efficiency and Policy Based – Deduplication Happens Based on the Selected Policy. Click Choose to set the storage efficiency policy.



10. Select the policy and click OK.



Deduplication on Write Cache Volumes

Best Practices
• Enable NetApp storage deduplication on write cache volumes. • Enable thin provisioning on the write cache volumes.

NetApp Storage Configuration for CIFS Shares

CIFS in ONTAP

Best Practices
• Use CIFS shares on the NetApp storage cluster instead of a Windows File Server VM. • Use CIFS shares on the NetApp storage cluster for VDI home directories, VDI profiles, and other VDI CIFS data.

User Home Data

Best Practices
• Use deduplication and compress end-user data files stored in home directories to obtain storage efficiency. NetApp recommends storing user data on the CIFS home directory on the NetApp storage cluster. • Use the Microsoft Distributed File System (DFS) to manage the CIFS shares. NetApp supports client DFS to locate directories and files. • Use the NetApp home directory share feature to minimize the number of shares on the system. • Use SMB3 for home directories.

User Profile Data

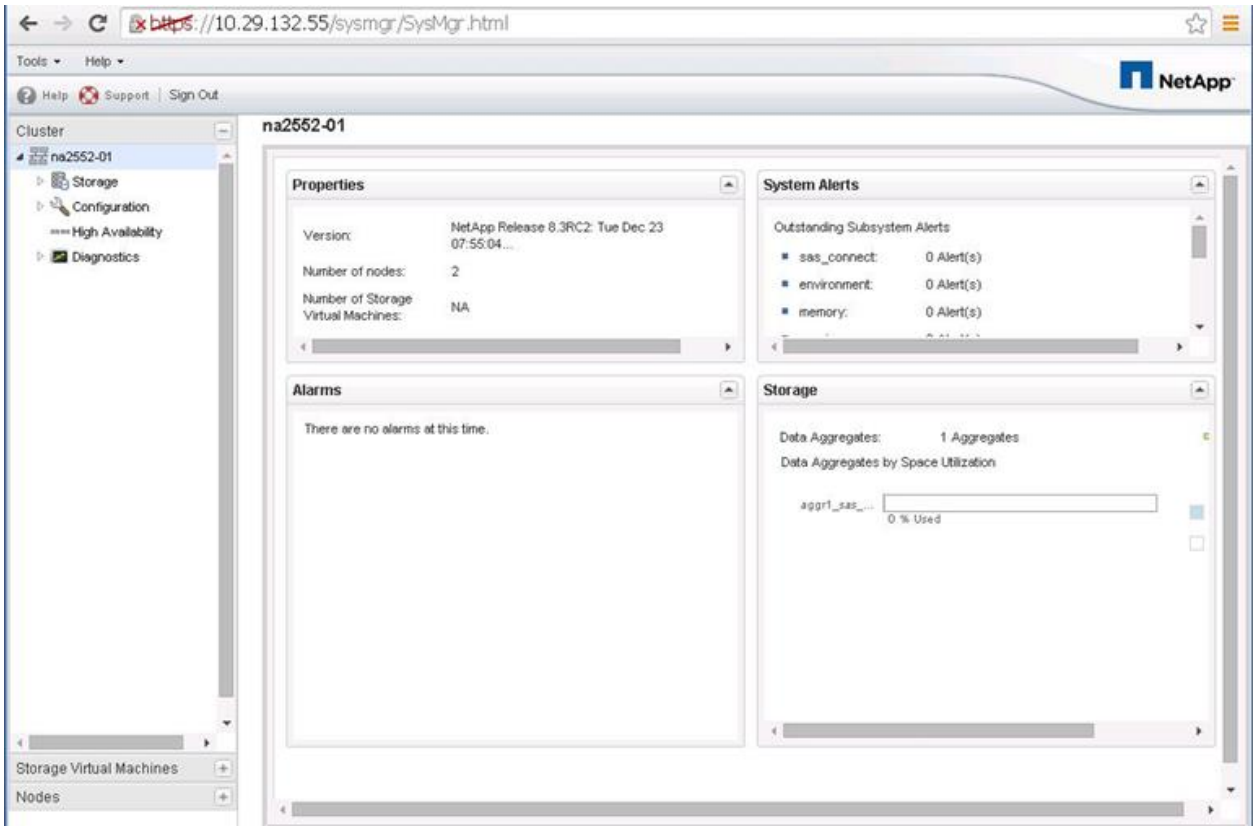
Best Practices
• NetApp recommends using a profile management solution such as Citrix User Profile Management or Liquidware Labs ProfileUnity to allow end users to customize their experience in a nonpersistent desktop environment. • Use redirected folders with a Microsoft Group Policy object (GPO). • Use SMB3 for the user profile share.

Profile Management

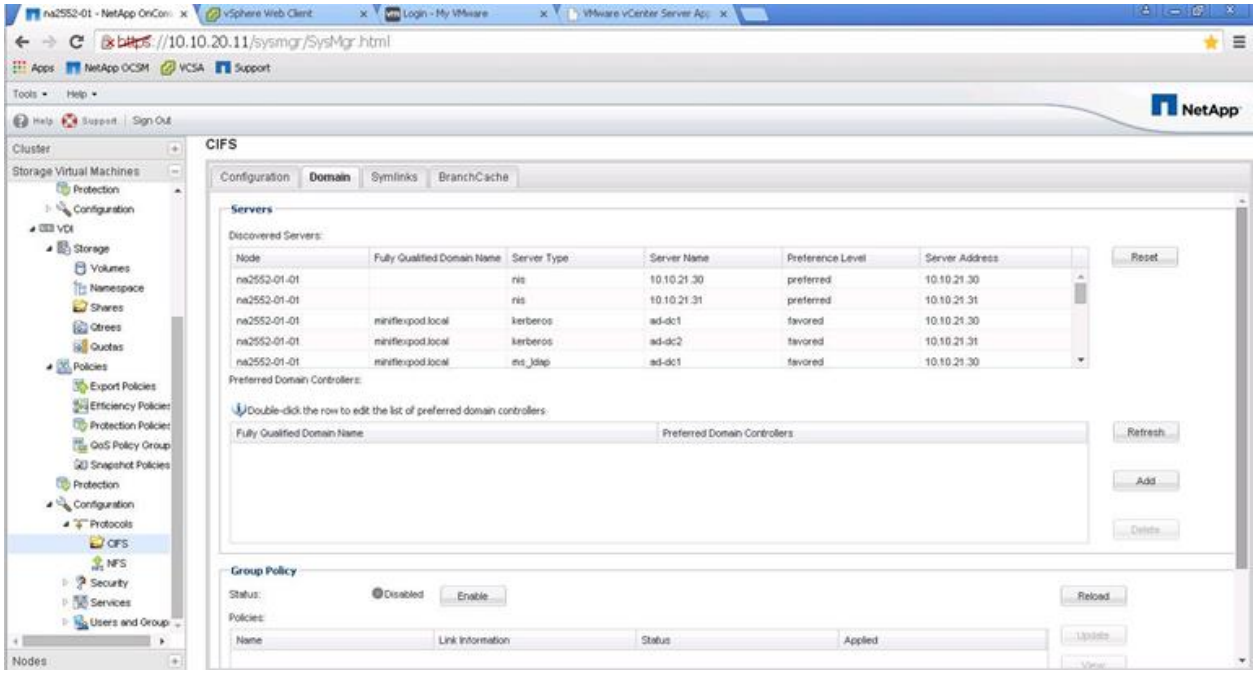
Best Practices
For faster login, NetApp recommends the following configurations: • A Flash Cache card in 8000 series models • A Flash Pool cache with a read cache allocated in 2500 series models • User profile management software to eliminate unnecessary file copying during login

CIFS Configuration

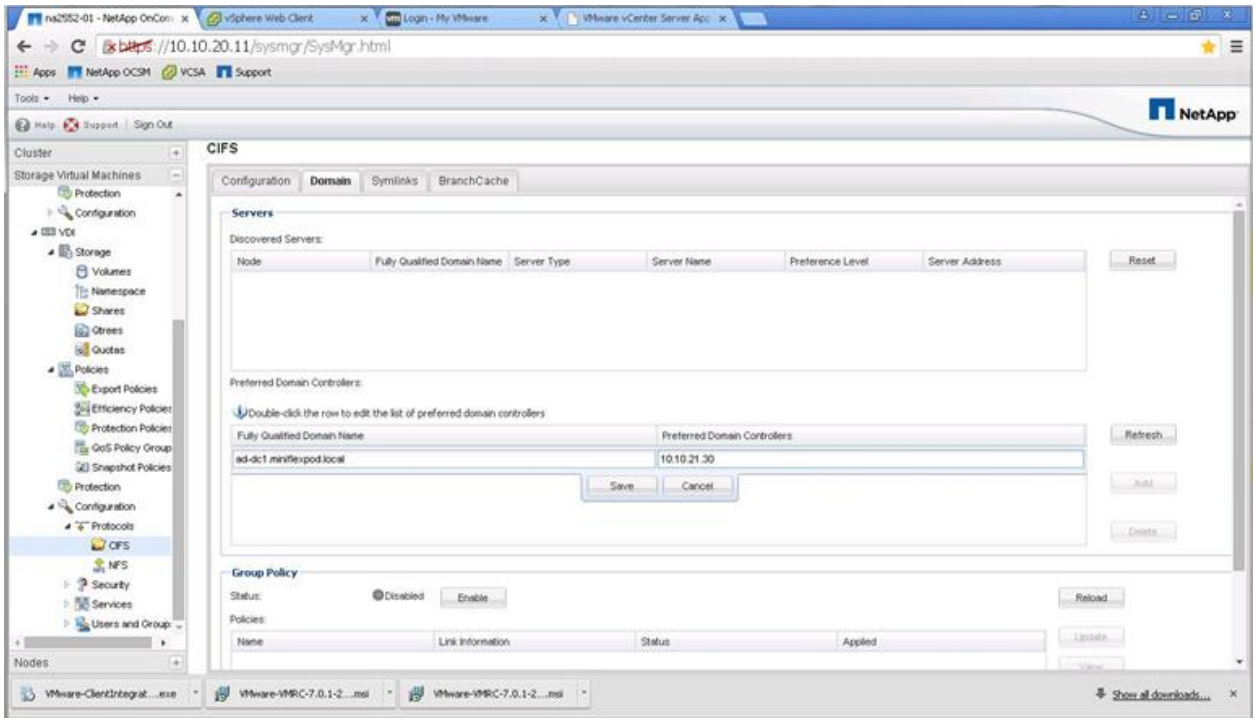
1. Before starting this step, add the CIFS licenses and enable the CIFS service. Sign in to the System Manager tool and go to the SVM menu.



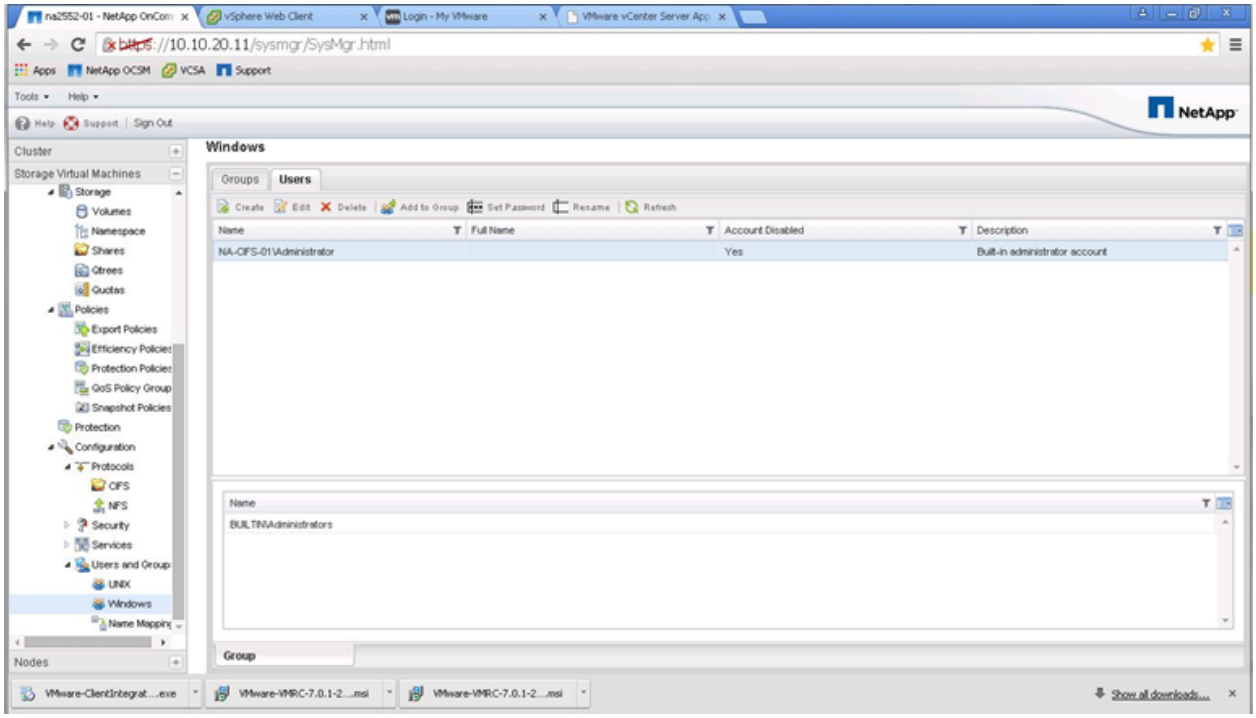
2. In the left window pane, select Configuration > Protocols > CIFS.



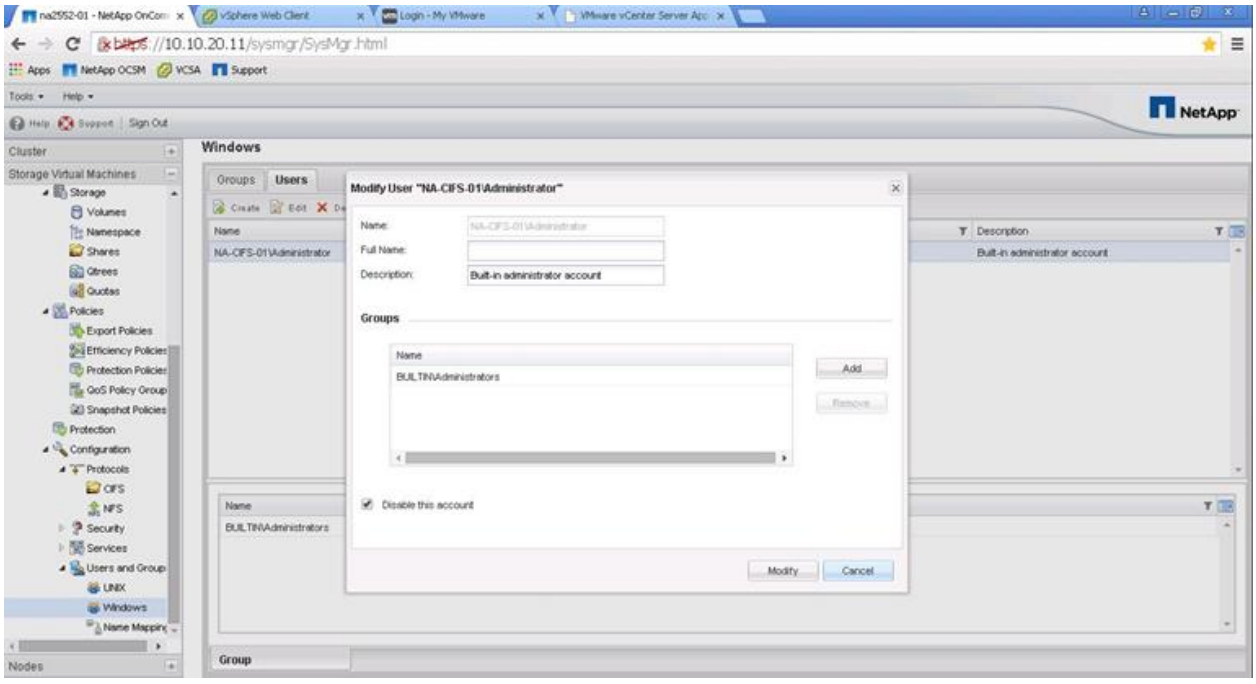
3. Configure preferred domain controllers by clicking the line in the Fully Domain Controllers window, Fully Qualified Domain Name column. Add the preferred domain controller IP address and FQDN and click Save. Repeat this step for each domain controller local to your site that you want on your preferred list.



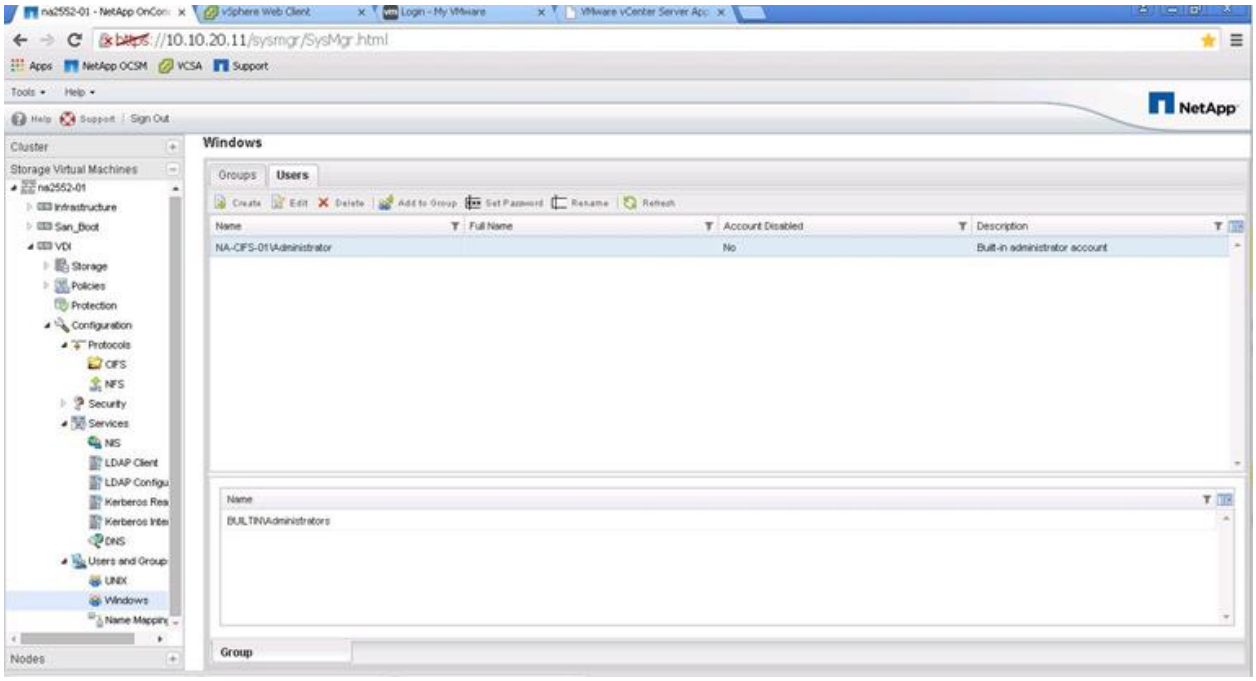
4. Enable the built-in administrator account by selecting Configuration > Users and Group > Windows. In the right window pane, click the local administrator account and click Edit.



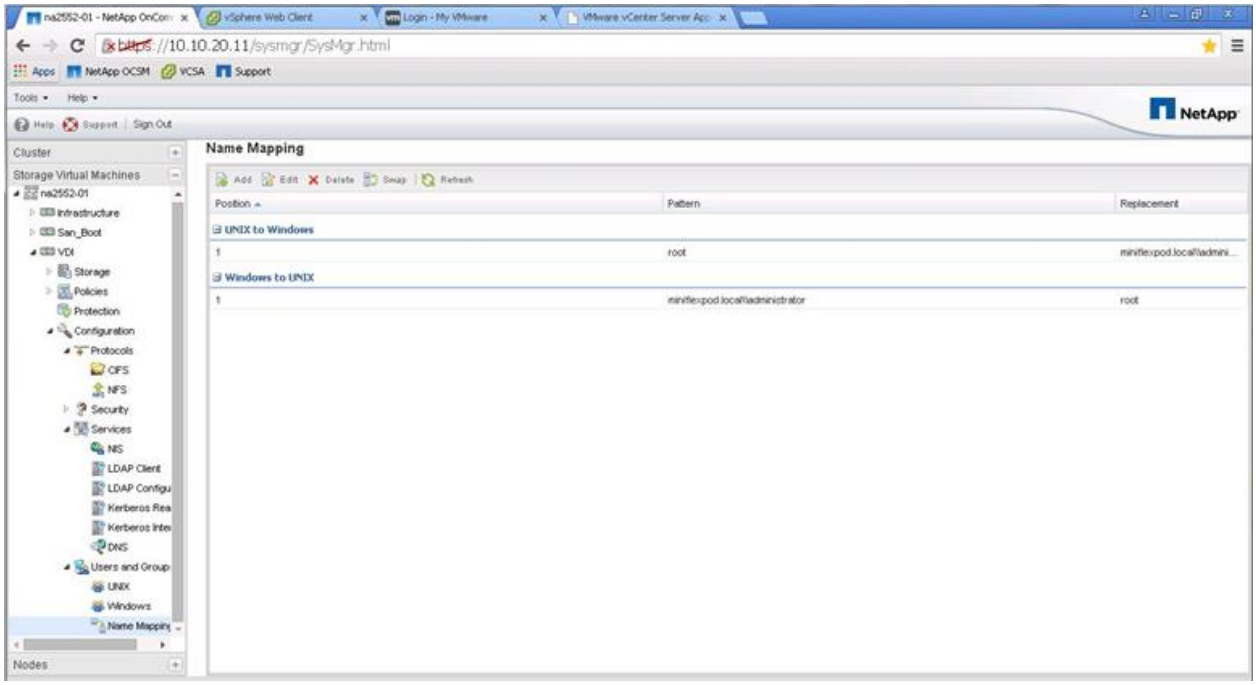
5. Deselect Disable this Account and click Modify.



6. Verify that the Account Disabled column is set to No.

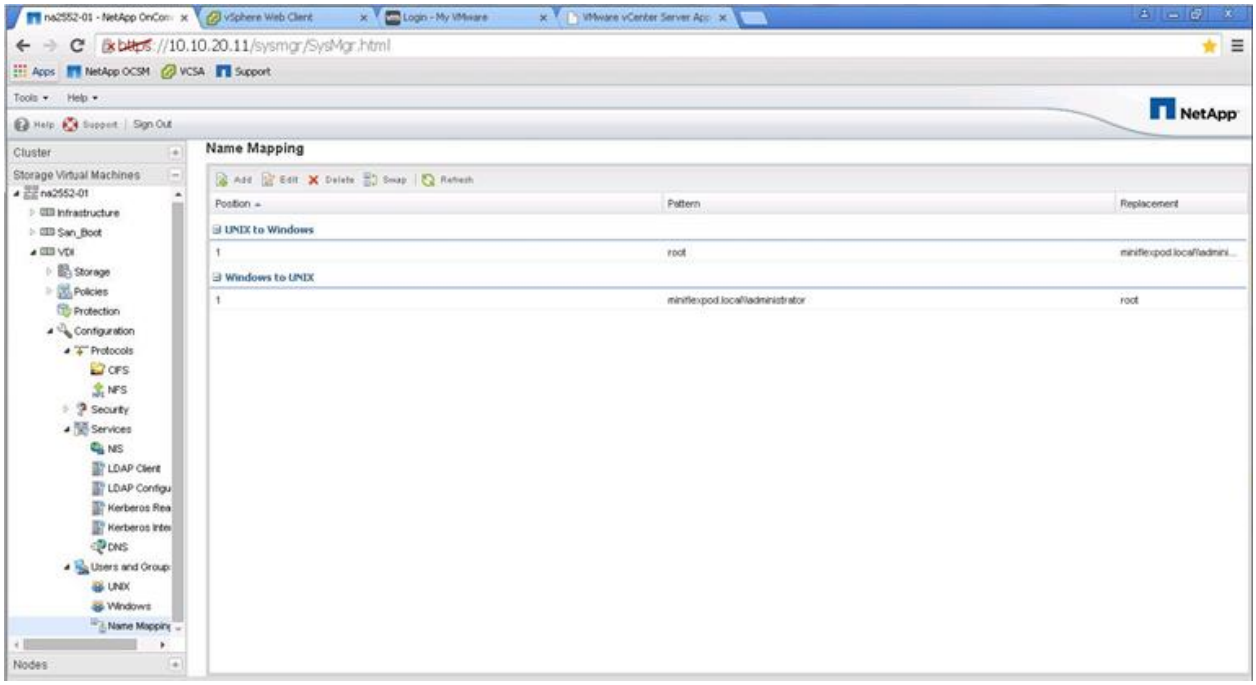


7. To configure Windows-to-UNIX and UNIX-to-Windows name mapping, select Configuration > Users and Groups > Name Mapping.



8. Click Add and then add the following:

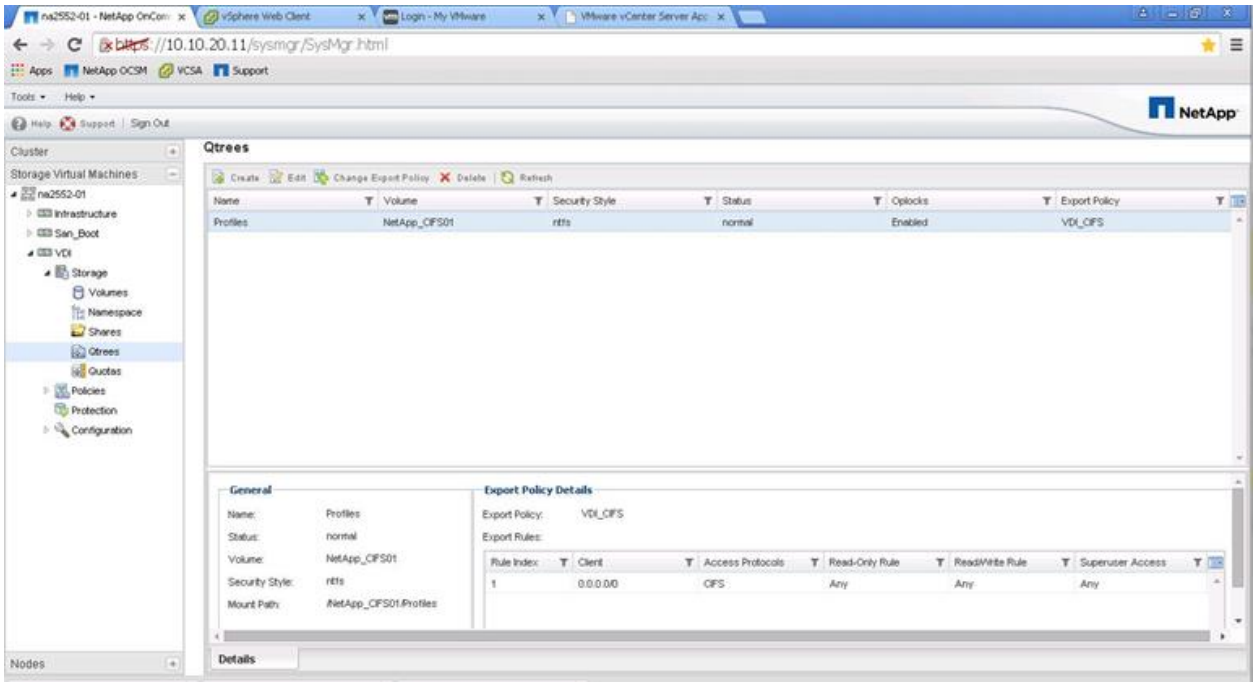
- UNIX to Windows: ID=1, pattern=root, replacement=domain administrator
- Windows to UNIX: ID=1, pattern=domain administrator, replacement=root



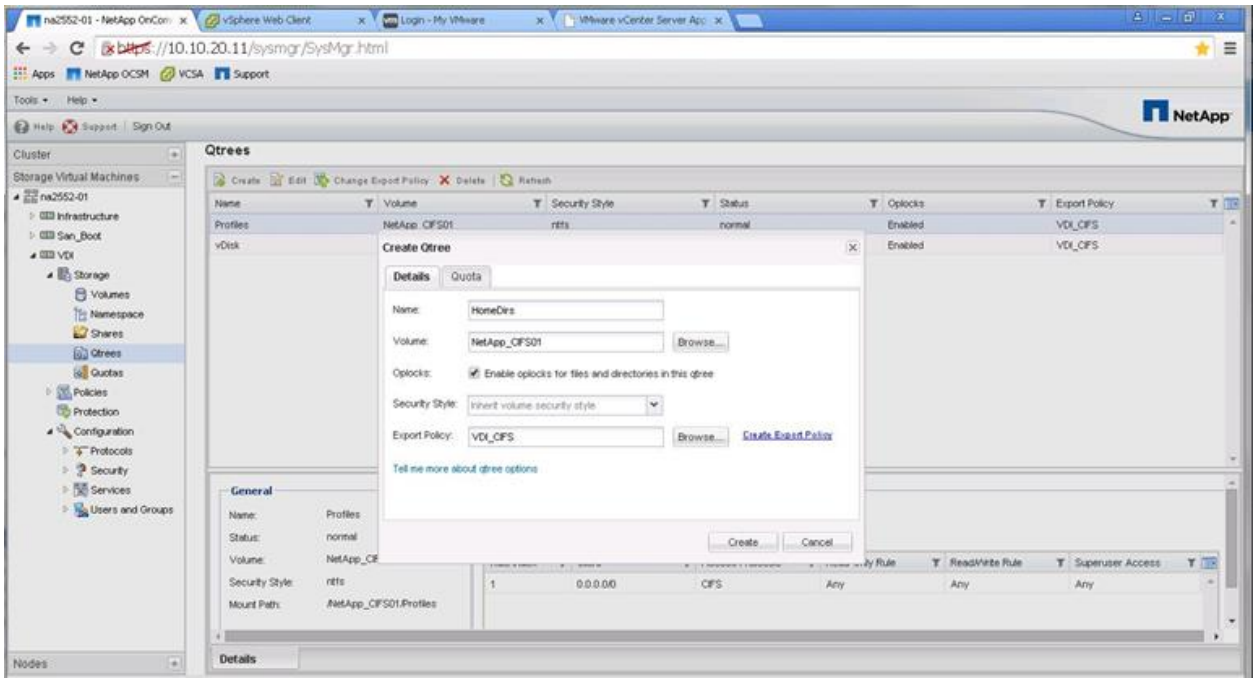
CIFS Shares and Qtrees

Creating Qtrees

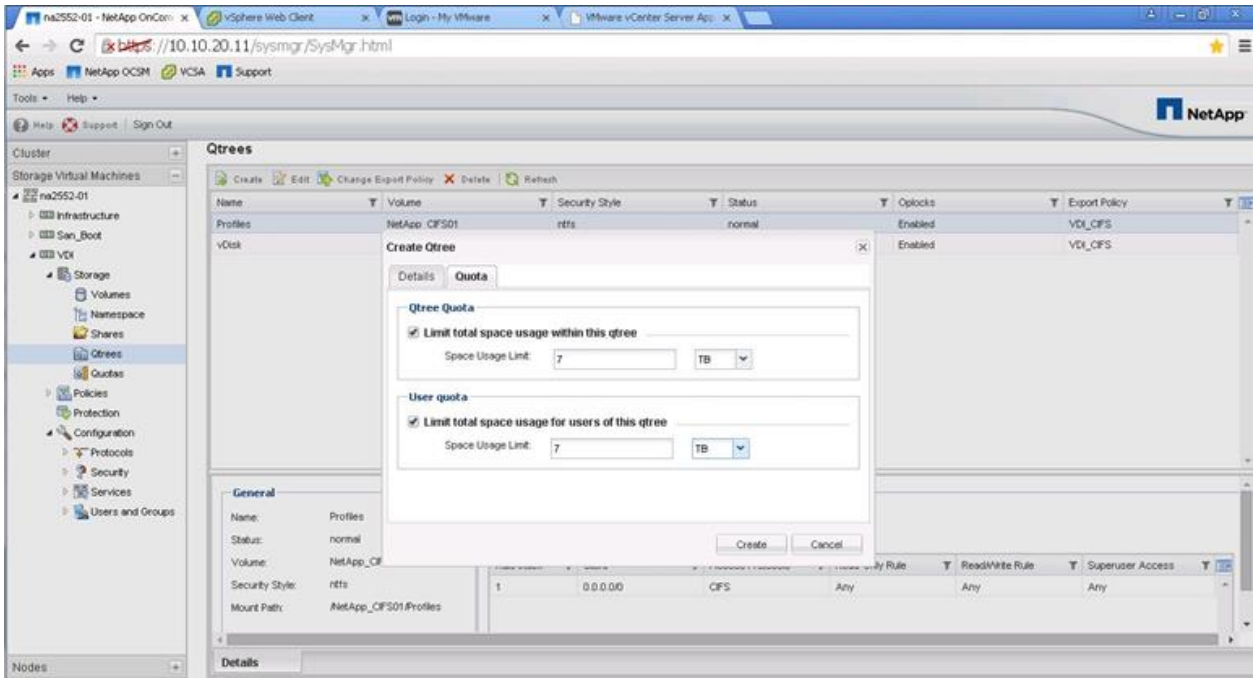
1. To create a qtree, sign in to the System Manager tool and go to the SVM menu. Select the SVM menu and then select the storage virtual machine (VDI > Storage > Qtrees). In the right window pane, click Create to create a qtree.

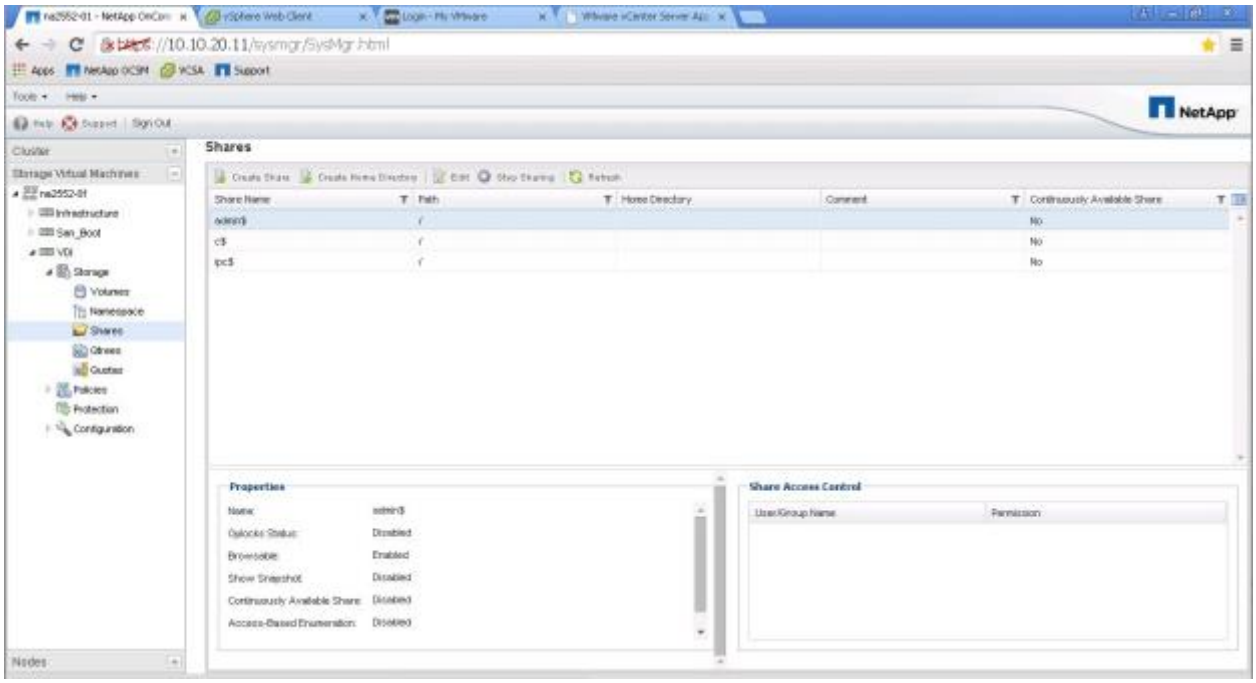


2. Enter the qtree (folder) name, choose the storage volume, select Enable Oplocks for Files and Directories in this Qtree, and enter the export policy. You can create the export policy prior to this step or by clicking the Create Export Policy link to the right. Then click the Quota tab.



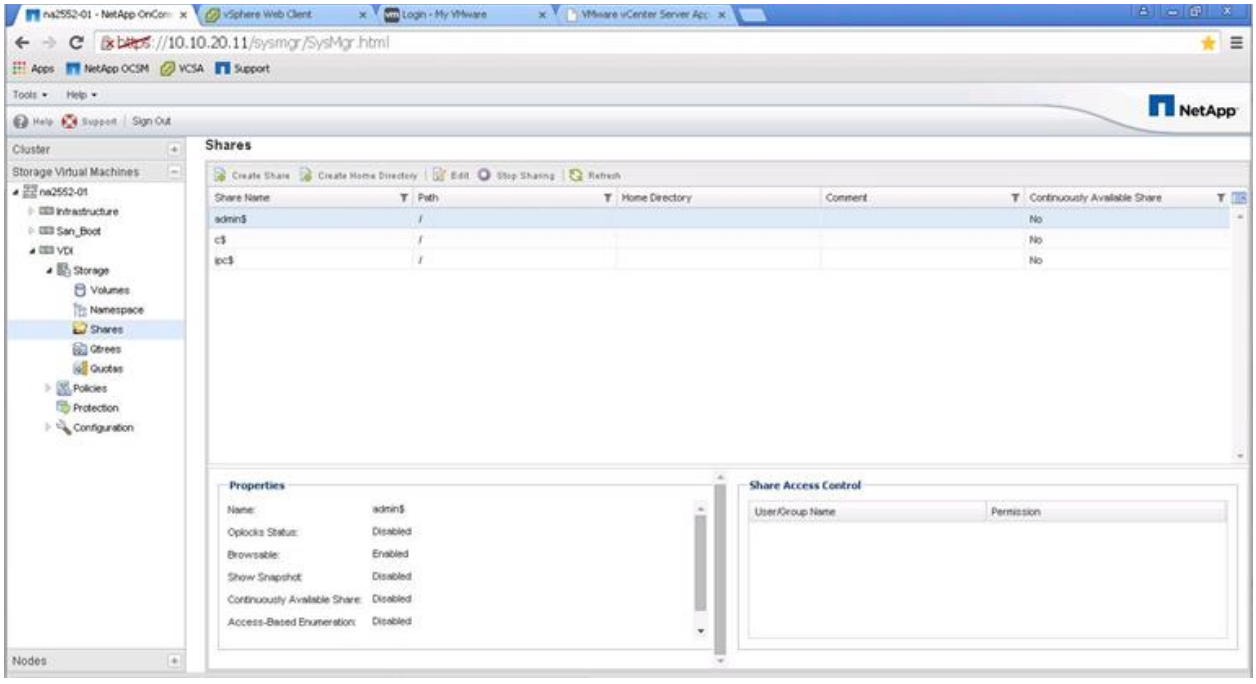
3. Run the Vserver Create command. Select Limit Total Space Usage Within this Qtree and enter the space usage limit in TB or GB. Then select Limit Total Space Usage for Users of This Qtree and enter the space usage limit in TB or GB. Click Create.



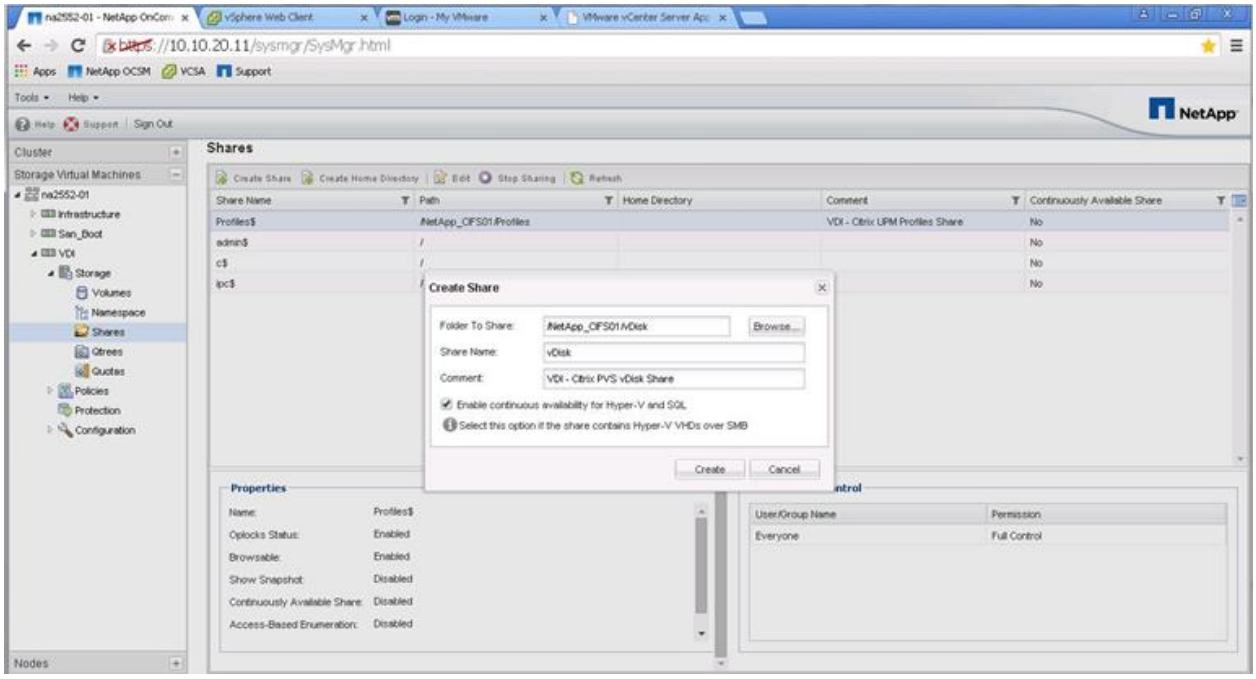


Creating CIFS Shares

1. Within System Manager, click the SVM menu. Select the SVM and then select Storage > Shares in the left window pane. Click Create Share to create the CIFS share.



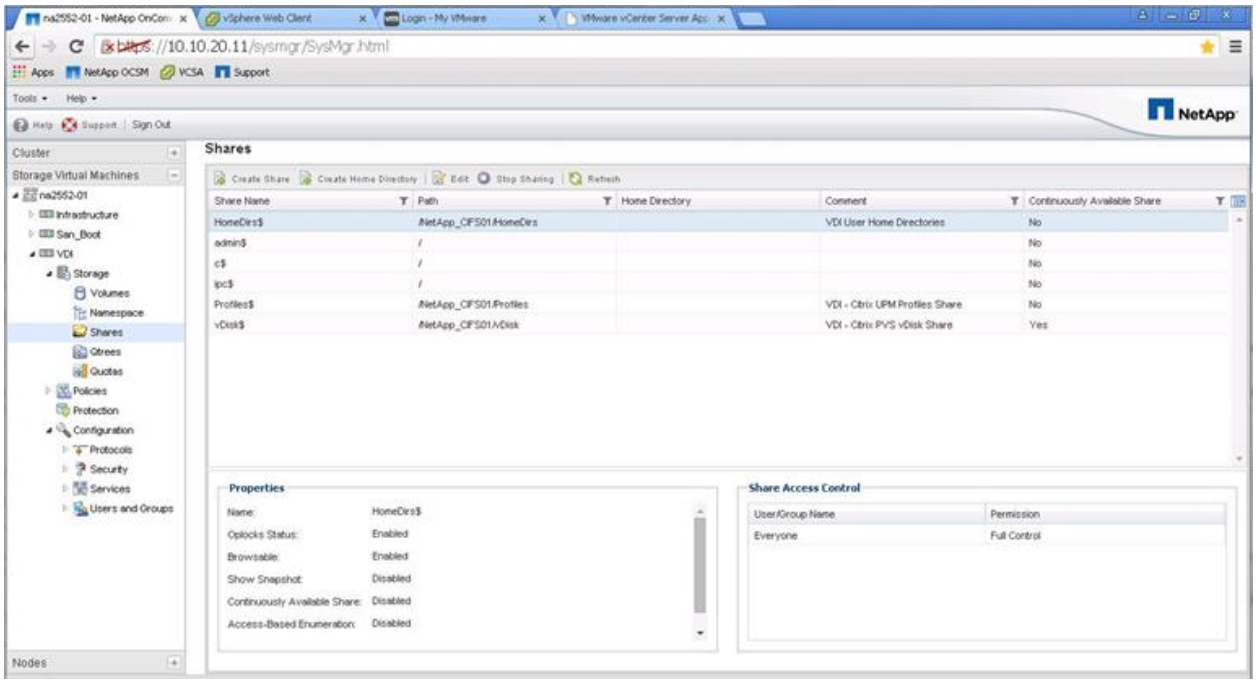
2. Enter the folder to share (the qtree path). The CIFS share name is the advertised SMB share name to which the VDI clients map. Enter an informational comment. If this share is for the Provisioning Services (PVS) vDisk, select Enable Continuous Availability for Hyper-V and SQL and click Create. Do not select Enable Continuous Availability for Hyper-V and SQL if the share is for home directories or profiles. Click Create.



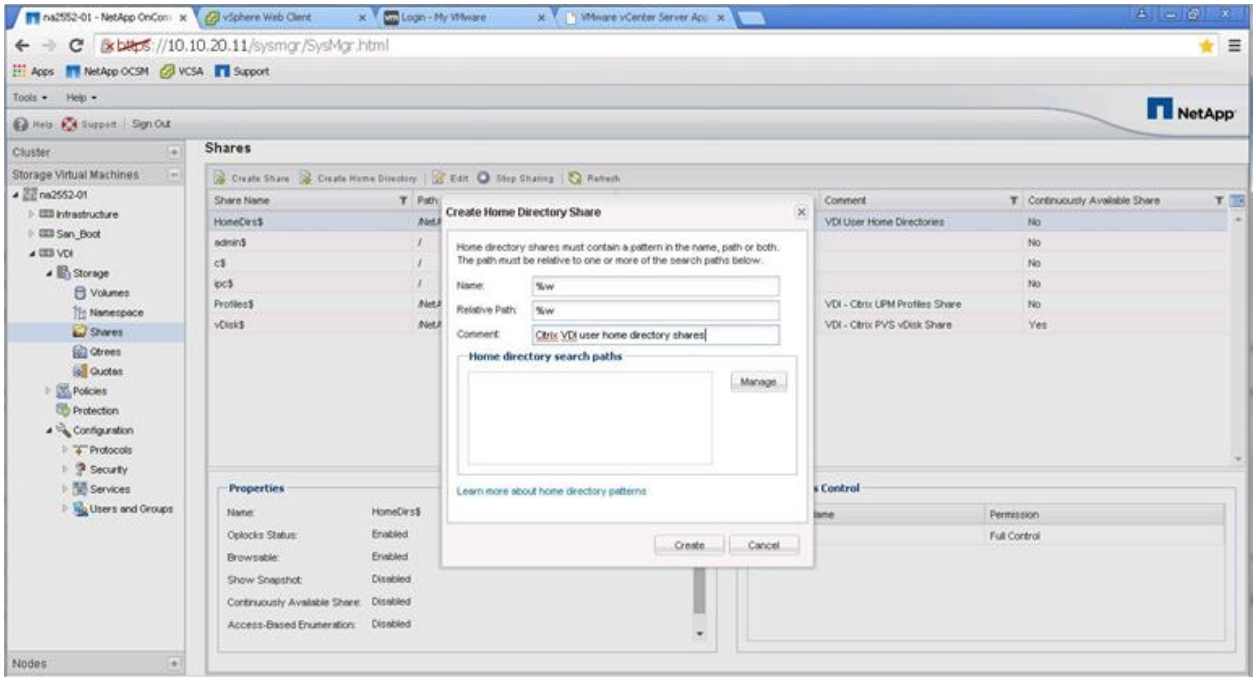
Best Practices
• Enable persistent handles for PVS vDisk CIFS shares by selecting Enable Continuous Availability for Hyper-V and SQL when using System Manager CIFS shares to create the PVS vDisk share. • Do not select Enable Continuous Availability for Hyper-V and SQL in System Manager CIFS share creation for home directory shares and for profile shares.

Create User Home Directory Shares in ONTAP

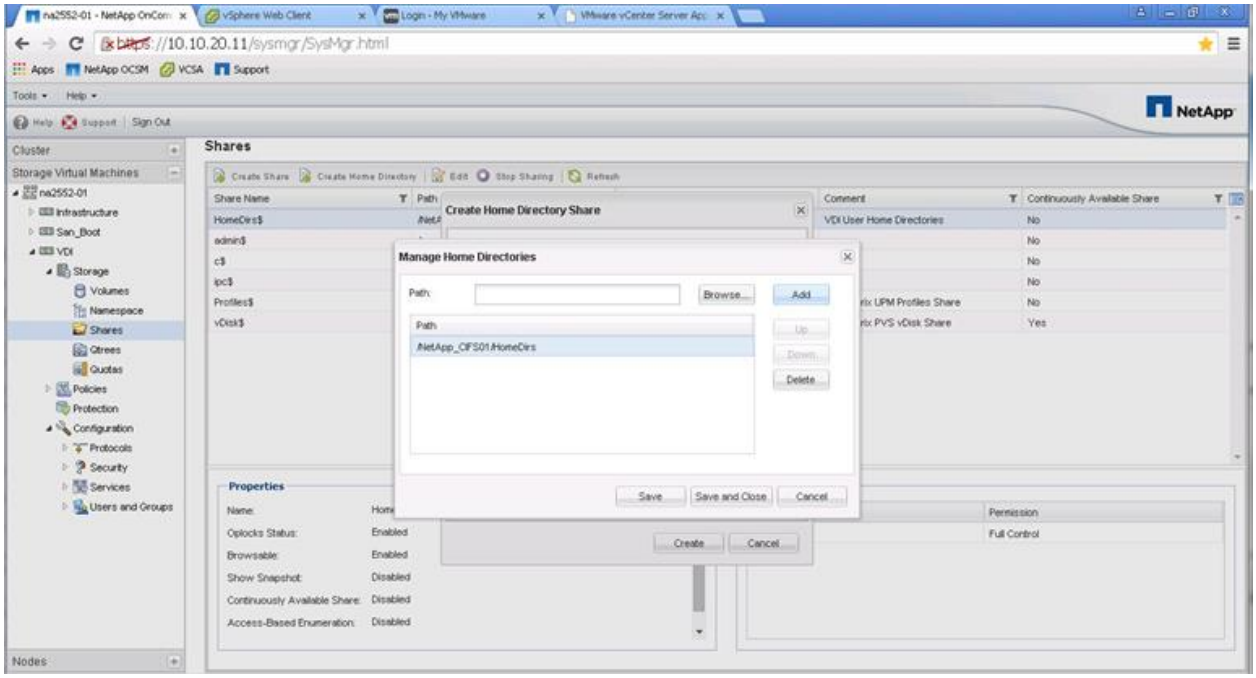
1. In System Manager, expand the SVM menu and select Storage > Shares. Then click Create Home Directory in the Shares window pane.



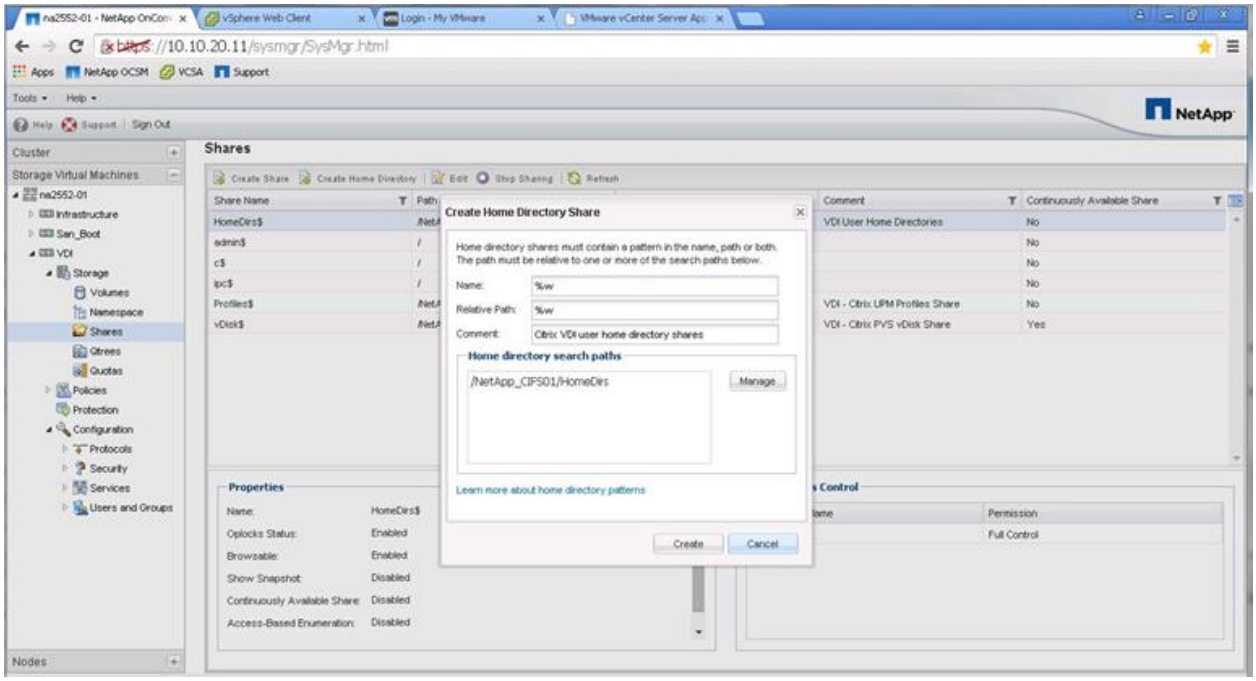
2. Enter `%w` in the Name field, enter `%w` in the Relative Path field, and include an informational comment. Under Home Directory Search Paths, click Manage to add a home directory search path.



3. Click Browse for the Path field and choose the qtree path where the home directories reside. If you have multiple locations spanning multiple volumes, enter the other volume and qtree paths here. Click Add to add each path and then click Save and Close.



4. Click Create to create the user home directory share.



5. Now test the share by using a Windows client or 2012 server and map the user home directory share to a drive letter (for example, H:\). Keep in mind that the user home directory folder must be created first. We created a Powershell script that creates 3,000 home directory folders.

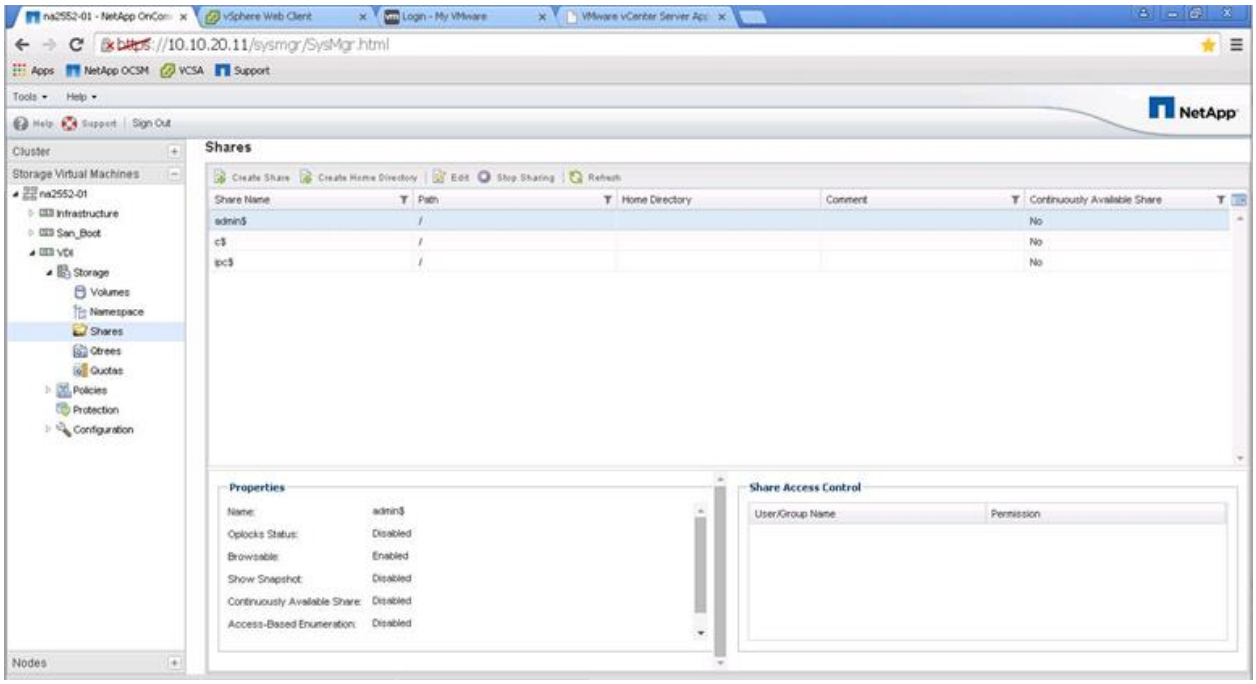
Note: Using NetApp user home directory shares reduces I/O and mount points and streamlines maintenance because you do not need to create an individual share for each user. Therefore, it is a best practice to use NetApp user home directory shares.

Best Practice
• Implement NetApp user home directory shares for VDI home directories.

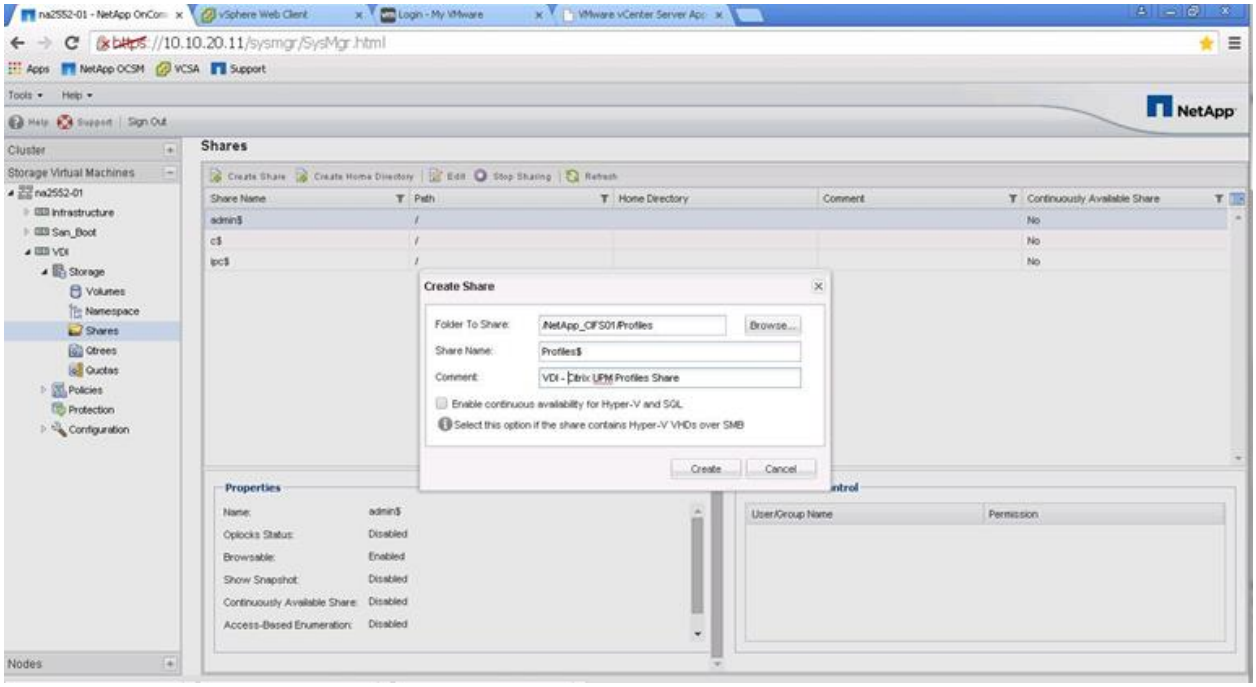
Create CIFS Share for User Profile Management

For this reference architecture, we use NetApp System Manager to create the profile share.

1. Within System Manager, click the SVM menu, expand the SVM, and then select Storage > Shares in the left window pane. Click Create in the right window pane to create the profile share.



2. Enter the folder to share (the qtree path). The CIFS share name is the advertised SMB share name to which the VDI clients map. It is a best practice to use a Microsoft hidden share by adding a dollar sign ($) at the end of the share name. This prevents normal users from seeing the share when browsing the network.



3. Deselect Enable Continuous Availability for Hyper-V and SQL. This check box enables Microsoft persistent handle support on the NetApp SMB3 CIFS share, but it is not utilized on normal CIFS shares. However, it is utilized with PVS vDisks.

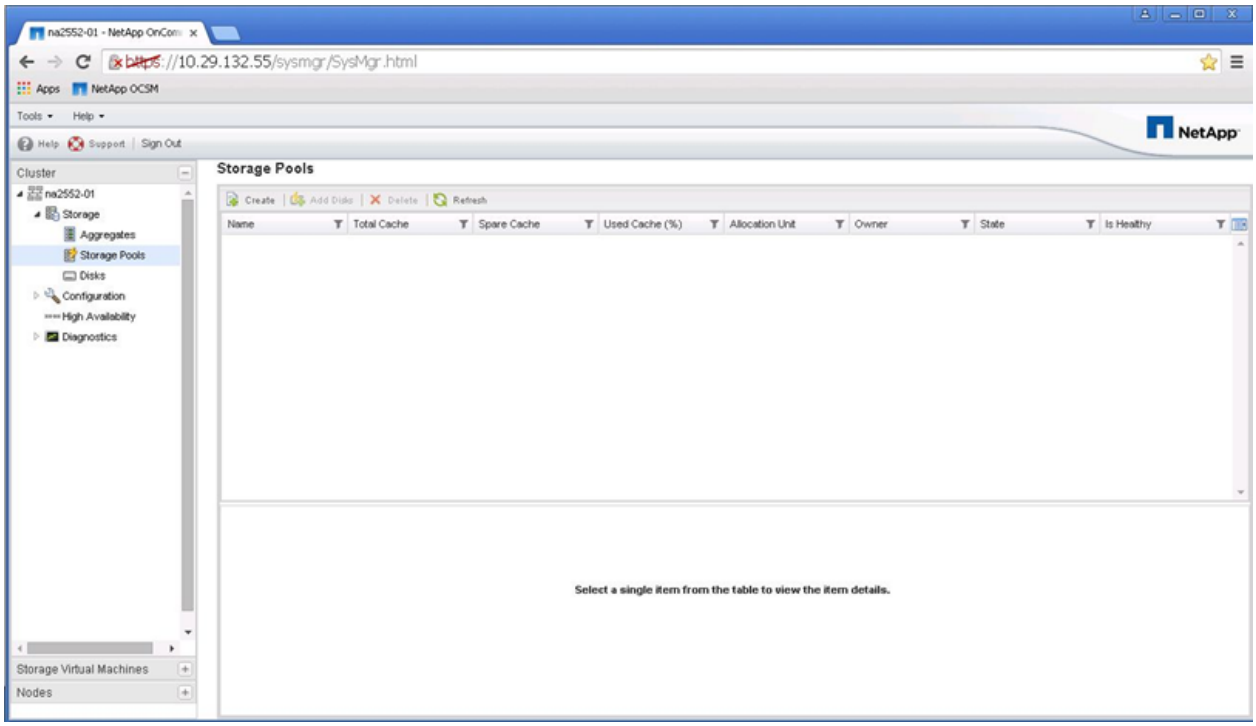
Best Practice
• Use Microsoft hidden shares by adding a dollar sign ($) at the end of the profile share name.

NetApp FAS2552 Hybrid Performance

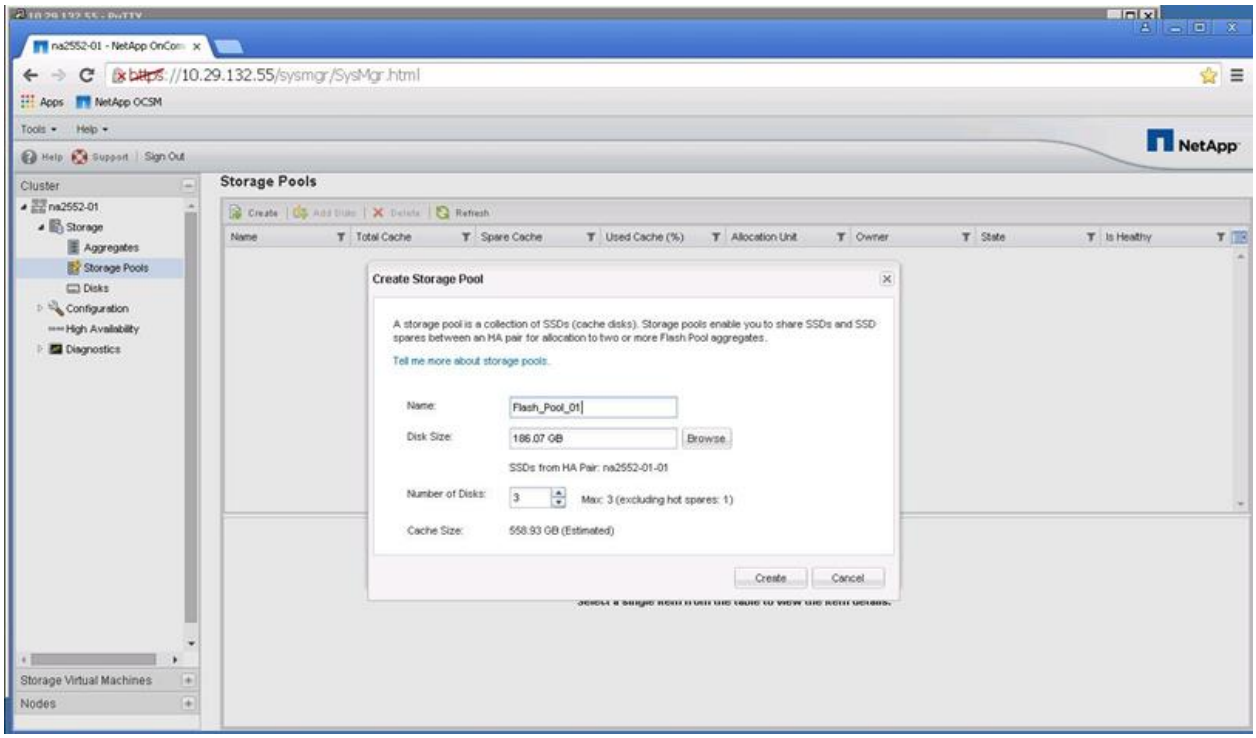
Creating Storage Pools in ONTAP

Best Practice
• In an active and passive controller configuration, assign all of the storage pool allocation units to aggregates on the active controller.

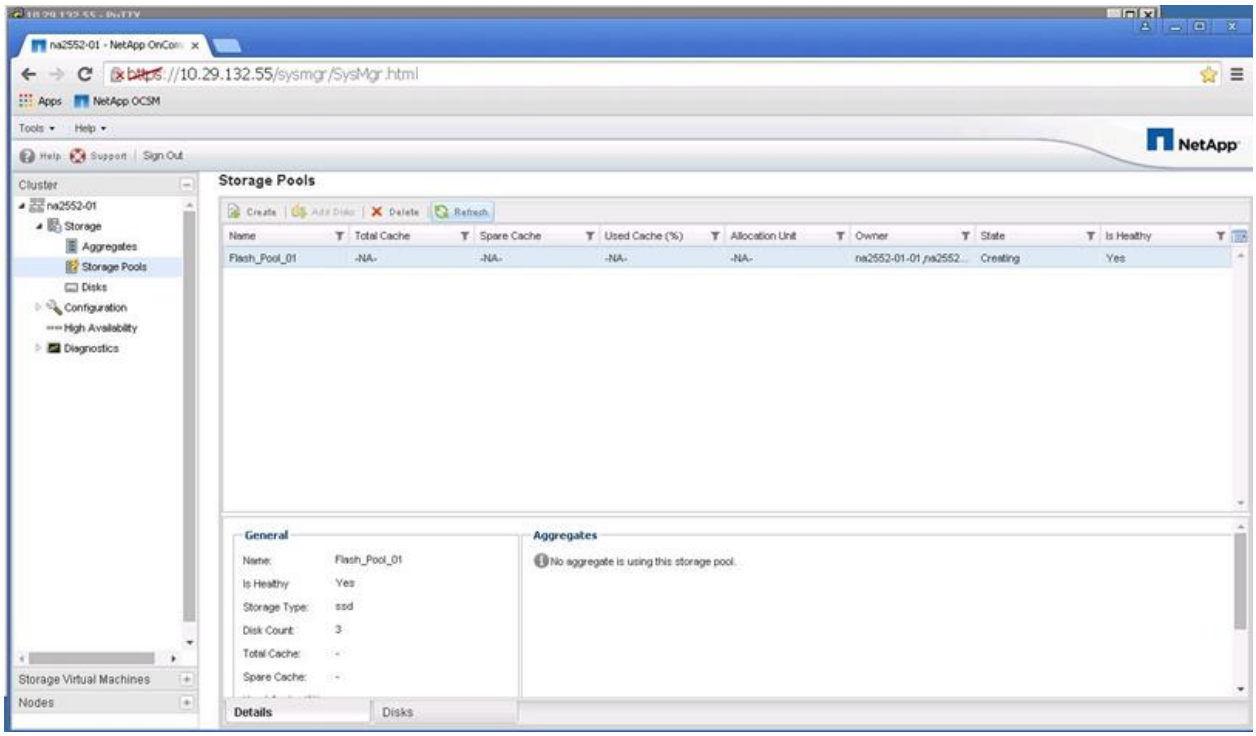
1. To create a storage pool used for a Flash Pool cache with four SSDs, log in to System Manager, click the Cluster menu, and then select Storage > Storage Pools in the left window pane. Click Create to create a storage pool.



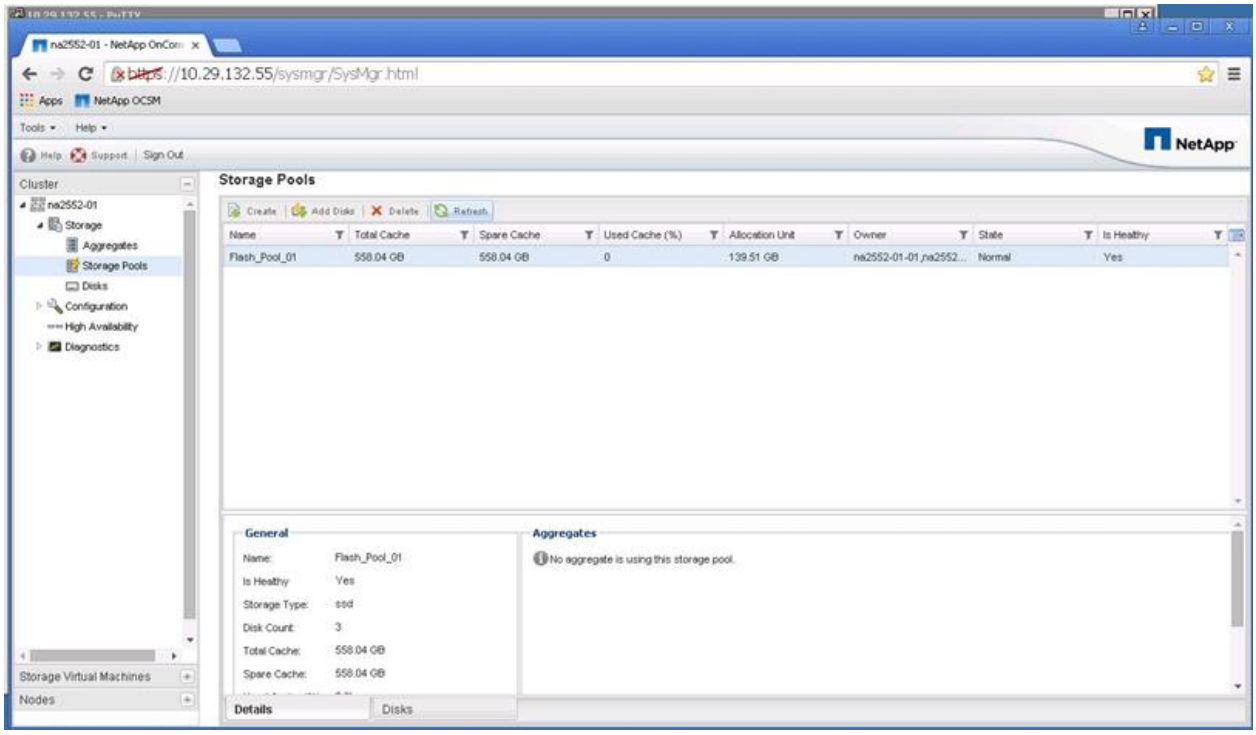
2. Enter the storage pool name, click Browse, choose the disk size, and enter the number of disks. In this reference architecture, we used four SSDs for a Flash Pool cache, three SSDs for the storage pool, and one SSD for a spare. Click Create.



3. Notice that a storage pool is listed in the right window pane with the status indicated as Creating. Because these are SSDs, the initialization process time is minimal when compared to SAS or SATA disks.



4. When the initialization process is complete, the status changes from Creating to Normal. At this point, ONTAP starts using the SSDs.



3.5 Configure Cisco Unified Computing System

This section describes the configuration of the Cisco UCS.

Install a NVIDIA GRID or a Tesla GPU card on the Cisco UCS C240 M4. Then install the GPU card on the Cisco UCS C240 M4 server. Table 2 lists the minimum firmware required for the GPU cards.

Table 2) Minimum server firmware versions required for GPU cards.

Cisco Integrated Management Controller	BIOS Minimum Version
NVIDIA GRID K1	2.0(3a)
NVIDIA GRID K2	2.0(3a)
NVIDIA Tesla K10	2.0(3e)
NVIDIA Tesla K20	2.0(3e)
NVIDIA Tesla K20X	2.0(3e)
NVIDIA Tesla K40	2.0(3a)

Note the following NVIDIA GPU card configuration rules:

- You can mix GRID K1 and K2 GPU cards in the same server.
- Do not mix GRID GPU cards with Tesla GPU cards in the same server.
- Do not mix different models of Tesla GPU cards in the same server.
- All GPU cards require two CPUs and at least two 1400W power supplies in the server.

For more information, see the Cisco UCS C240 M4 Server Installation and Service Guide.

The configuration requirements for servers with GPUs can differ, depending on the server version and other factors. Table 3 lists rules for populating the C240 M4 with NVIDIA GPUs. Figure 2 shows a one-GPU installation, and Figure 3 shows a two-GPU installation.

Table 3) NVIDIA GPU population rules for Cisco UCS C240 M4 rack server.

Single GPU	Dual GPU
Riser 1A, slot 2 or Riser 2, slot 5	Riser 1A, slot 2 and Riser 2, slot 5

Note: When you install a GPU card in slot 2, Network Communications Services Interface (NCSI) support in riser 1 automatically moves to slot 1. When you install a GPU card in slot 5, NCSI support in riser 2 automatically moves to slot 4. Therefore, you can install a GPU card and a Cisco UCS VIC in the same riser.

Figure 2) One-GPU card scenario.

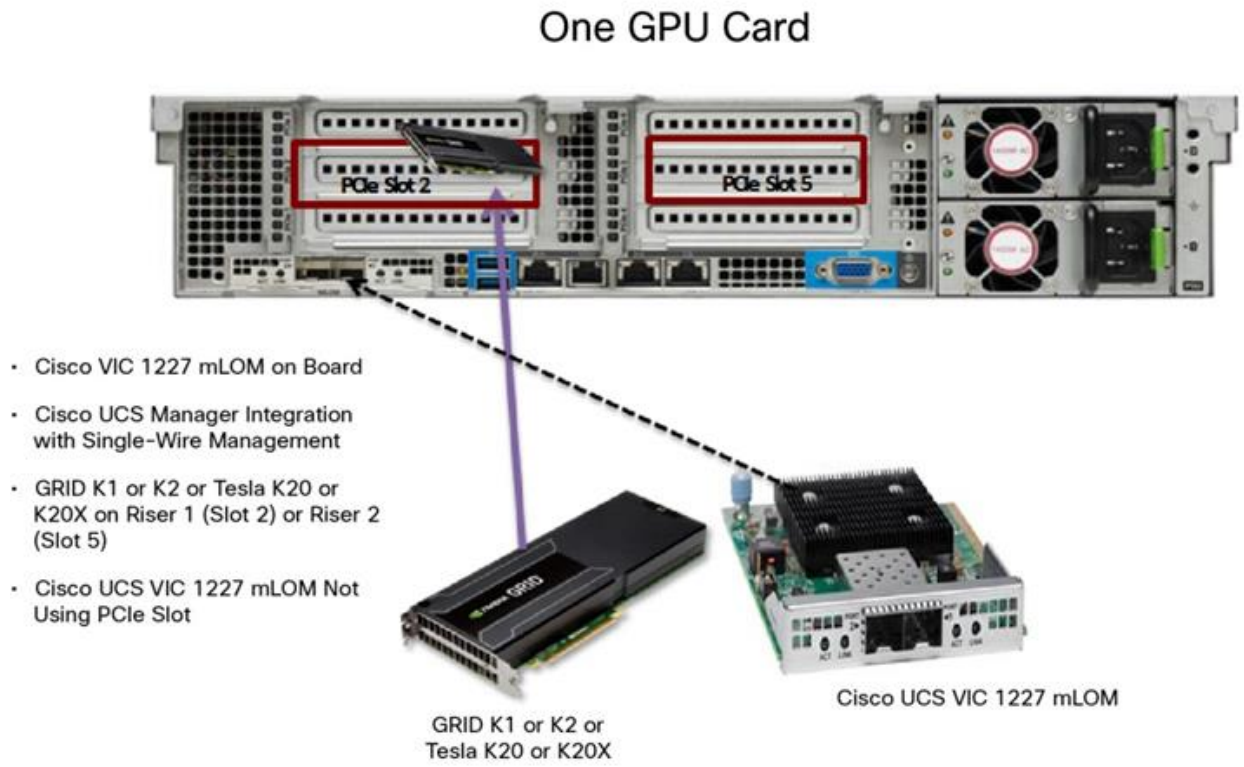
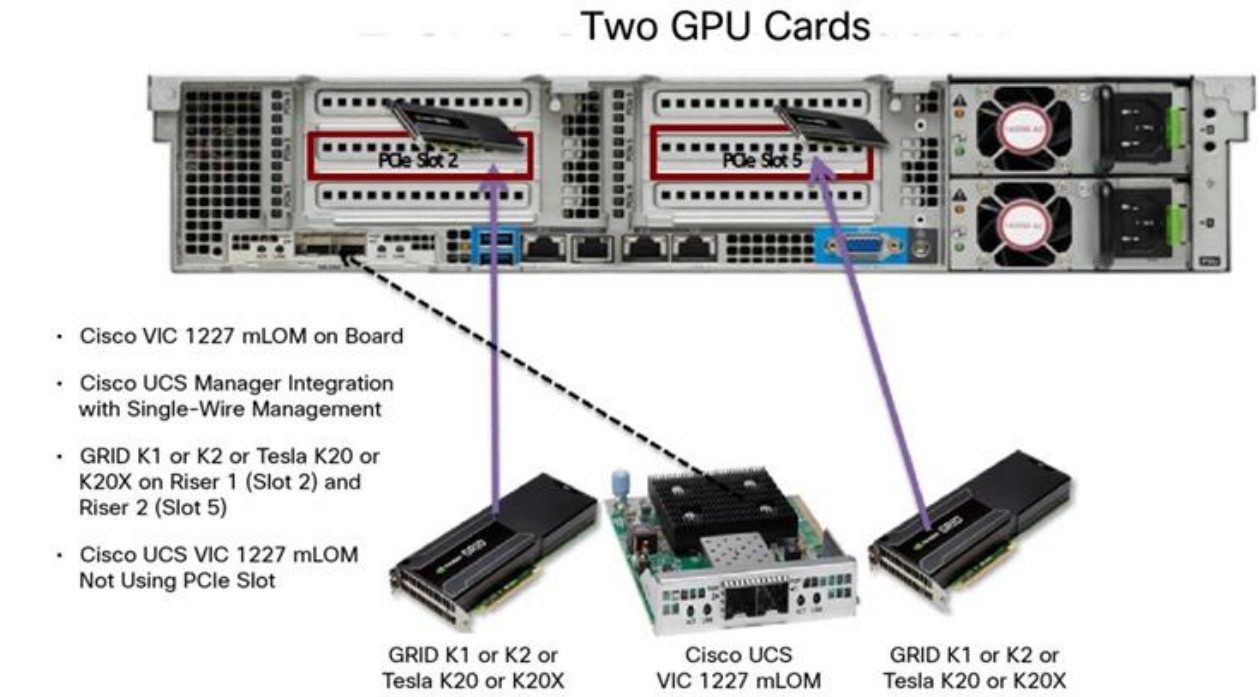


Figure 3) Two-GPU card scenario.



Specify the Base Cisco UCS Configuration

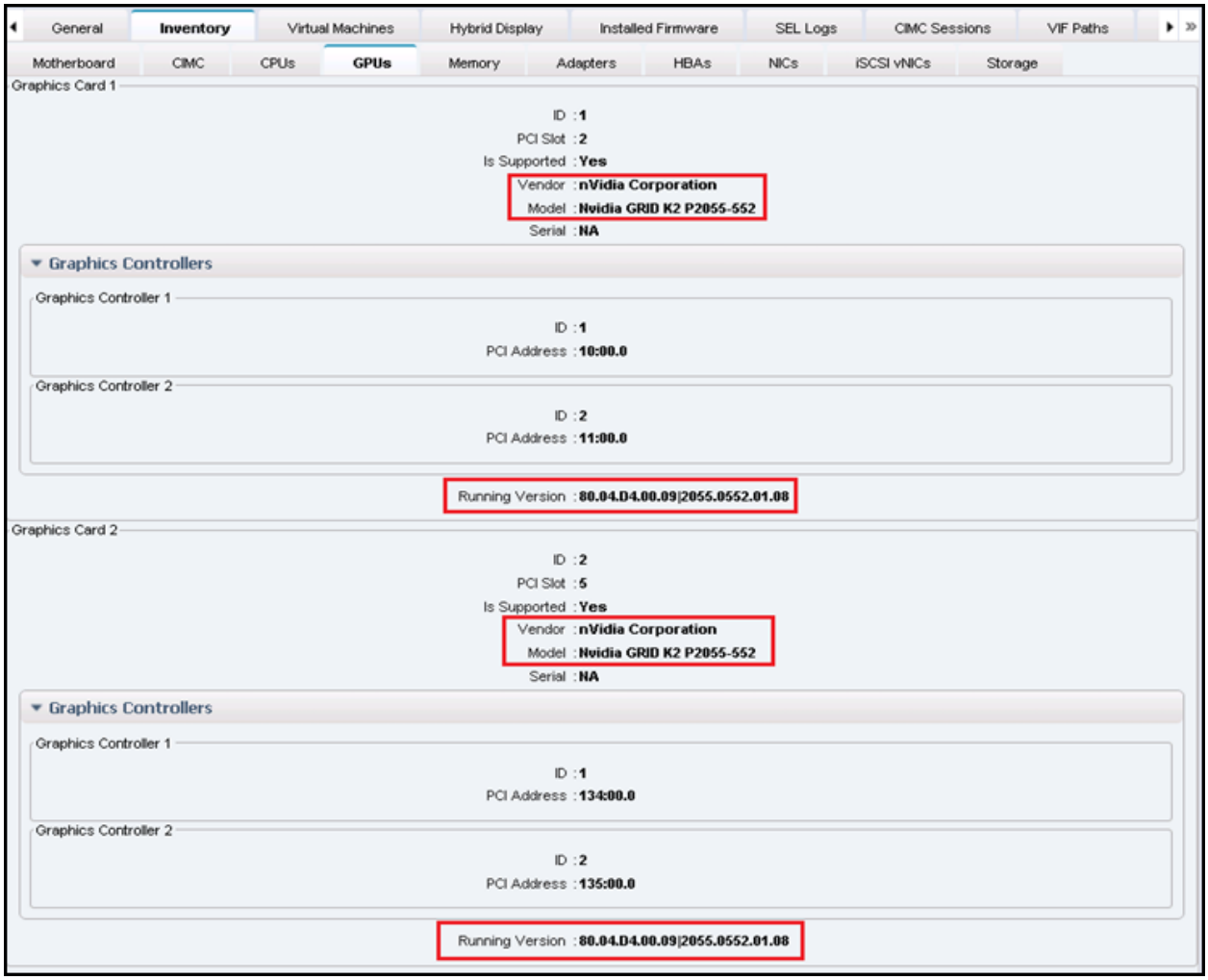
To configure physical connectivity and implement best practices for Cisco UCS C-Series server integration with Cisco UCS Manager, see the Release Notes for Cisco UCS Software, Release 2.2.

Configure the GPU Card

To configure the GPU card, complete the following steps:

1. After the NVIDIA GPU cards are physically installed and the C240 M4 rack server is discovered in Cisco UCS Manager, select the server and then select Inventory > GPUs.

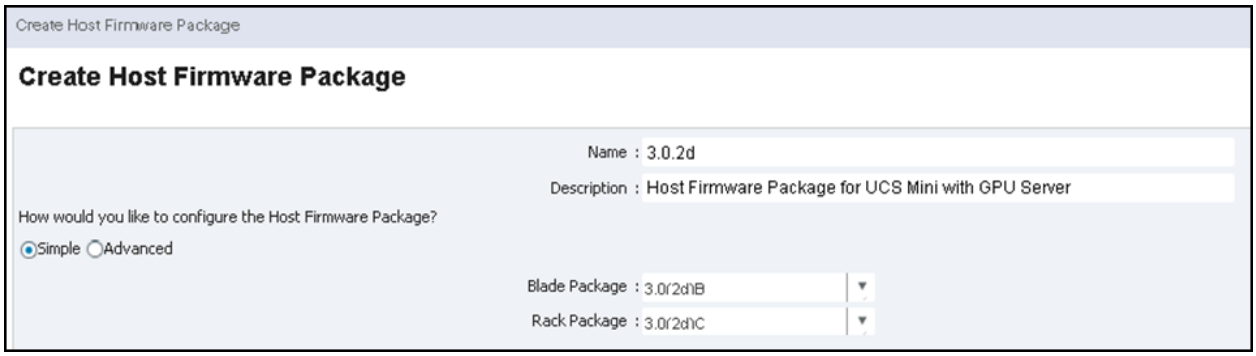
   PCIe slot 2 and PCIe slot 5 are used with two GRID K2 cards running firmware version 80.04.D4.00.09 | 2055.0552.01.08.



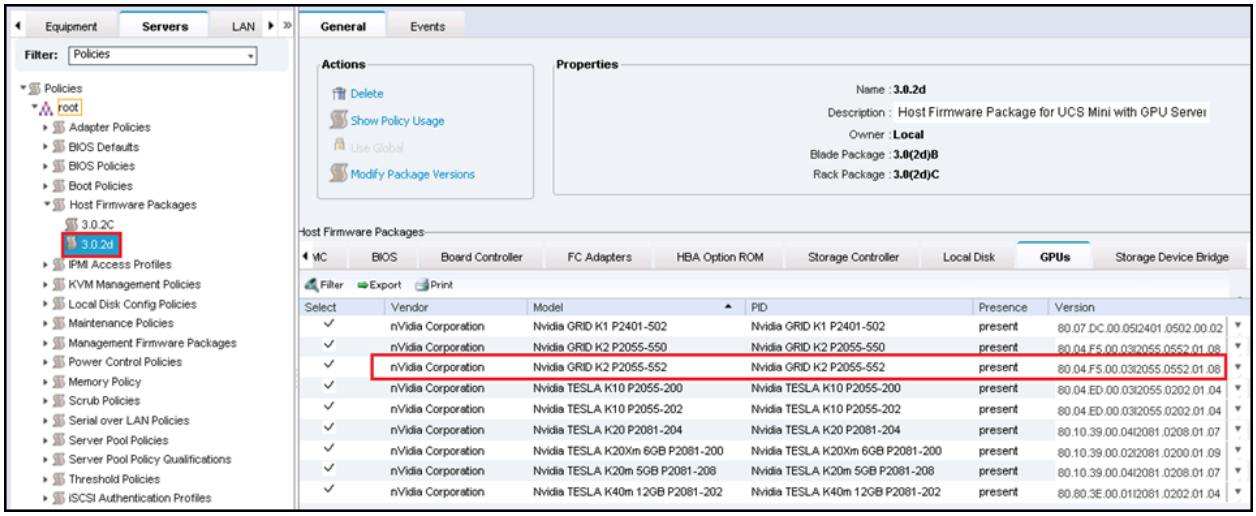
   Note: You also can use Cisco UCS Manager to perform firmware updates to the NVIDIA GPU cards.

2. Create the host firmware policy by selecting the Servers tab in Cisco UCS Manager. Then select Policies > Host Firmware Packages. Right-click and select Create Host Firmware Package.

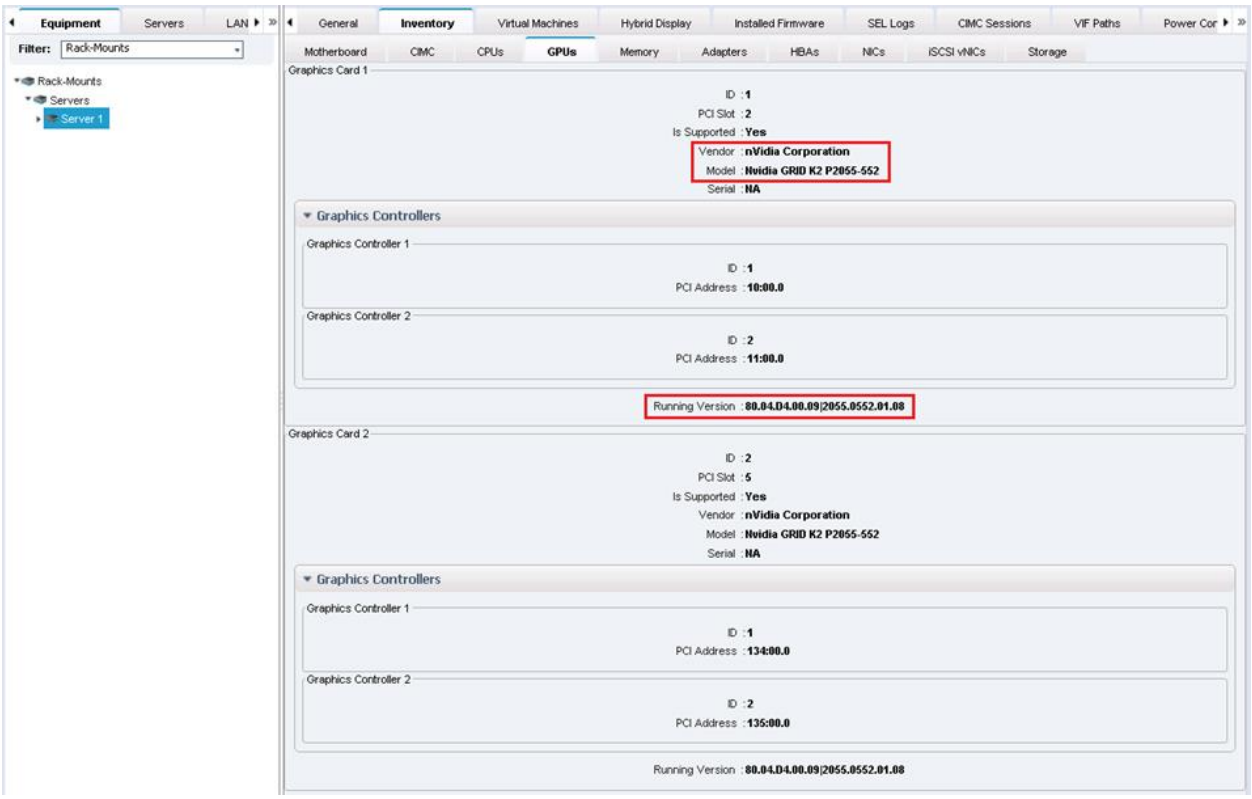
3. Select the Simple configuration of the host firmware package and select 3.0(2d)C for the rack package.



4. Click OK to display the list of firmware packages.



5. Apply the host firmware package in the service profile template service profiles firmware policy. After the firmware upgrades have completed, the running firmware version for the GPUs is selected.

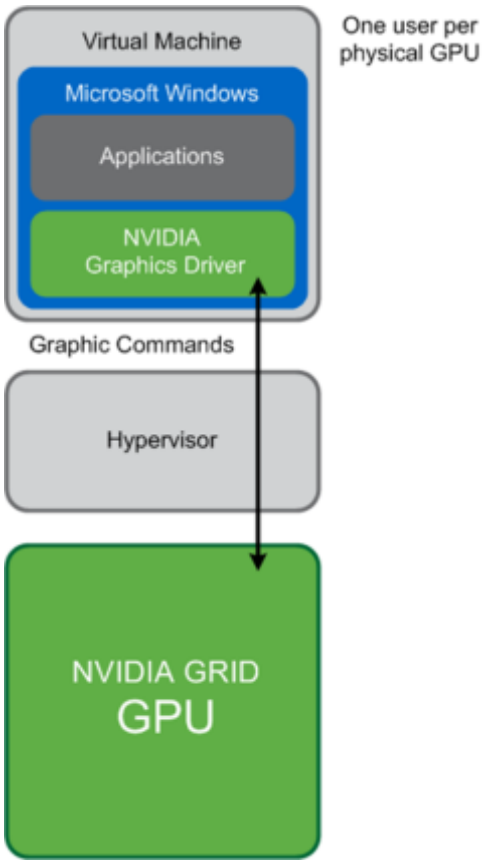


Note: VM hardware version 9 or later is required for virtual GPU (vGPU) and vDGA configuration. Manage settings for VMs with hardware version 9 or later through the vSphere web client.

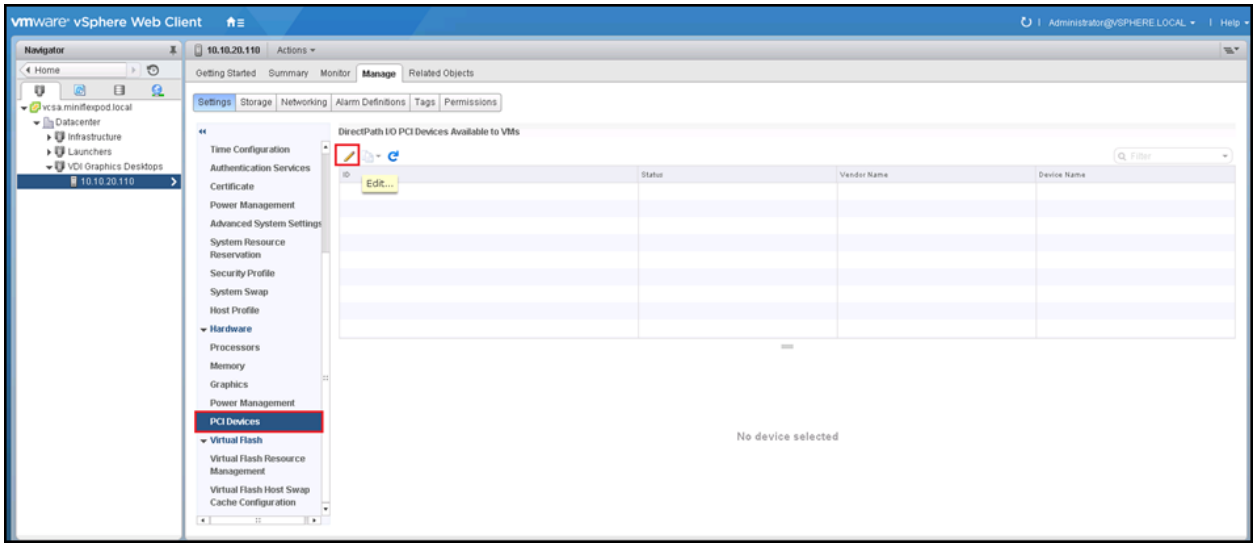
Configure Virtual Direct Graphics Acceleration Pass-Through GPU Deployment

This section outlines the installation process for configuring an ESXi host and VM for Virtual Direct Graphics Acceleration (vDGA) support. Figure 4 shows the GRID GPU components used for pass-through support.

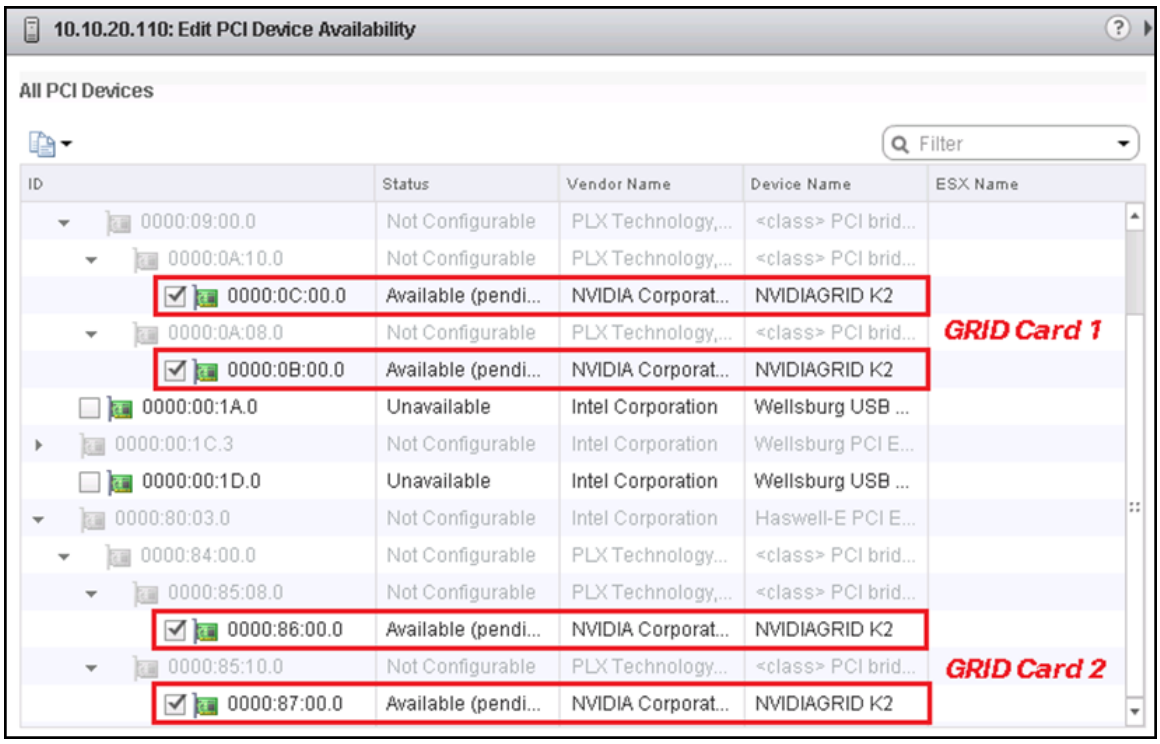
Figure 4) NVIDIA GRID GPU pass-through components.



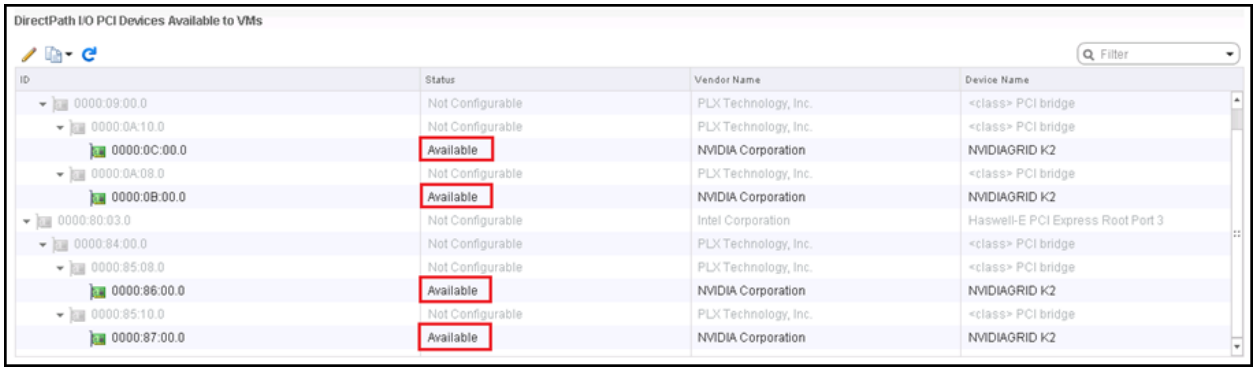
1. You must install the GRID cards in the C240 M4 rack server. With the vSphere web client, select the ESXi host server, select the Manage tab, select Settings, and then select Hardware > PCI Devices > Edit.



2. A dialog box appears showing all PCI devices along with the GRID cards. Select the GRID card types installed on the server from the available adapters.



3. After making the changes for pass-through configuration, reboot the ESXi host.
4. Verify that the GPU devices used for pass-through configuration are marked as available. If a device isn't marked as available, refer to the VMware documentation to perform troubleshooting.

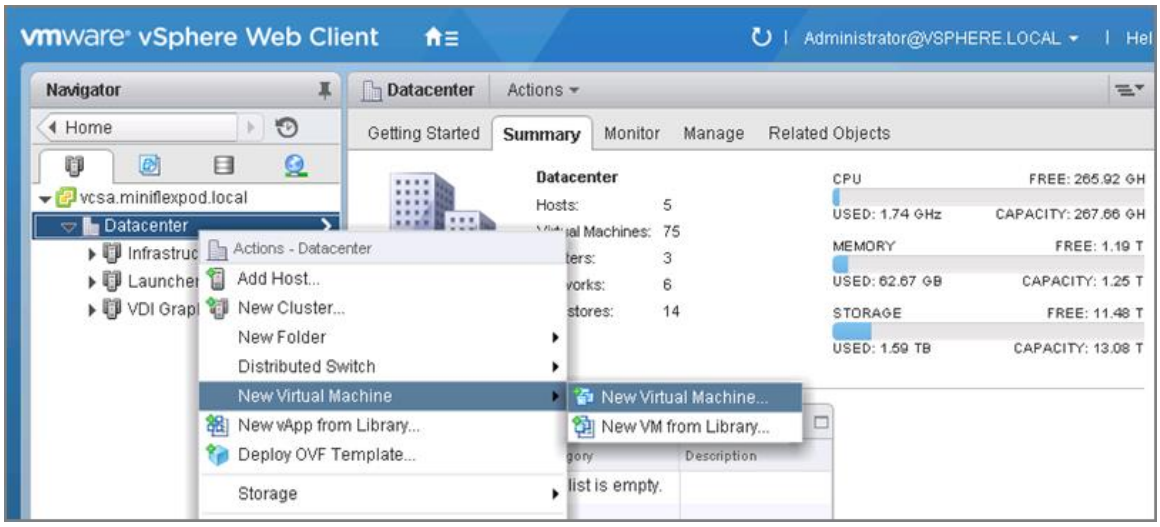


Note: vDGA does not support live vSphere vMotion capabilities. Bypassing the virtualization layer, vDGA uses vSphere DirectPath I/O to allow direct access to the GPU card. By enabling direct pass-through from the VM to the PCI device installed on the host, you effectively lock the VM to that specific host. If you need to move a vDGA-enabled VM to a different host, power off the VM, use vMotion to migrate it to another host that has a GPU card installed, and reenable pass-through to the specific PCI device on that host. Then power on the VM.

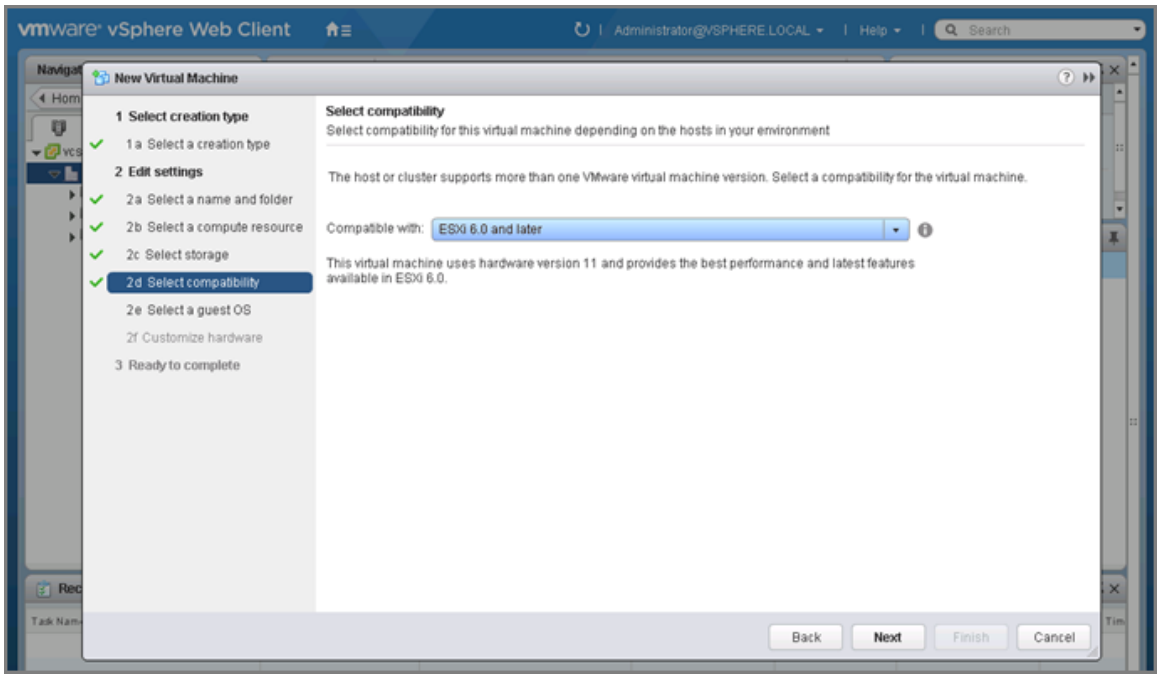
Prepare a Virtual Machine for vDGA Configuration

Use the following procedure to create the VM to use as the VDI base image:

1. With the vSphere web client, create a new VM. To do this, right-click a host or cluster, select New Virtual Machine, and complete the New Virtual Machine wizard. Unless another configuration is specified, select the configuration settings appropriate for your environment.

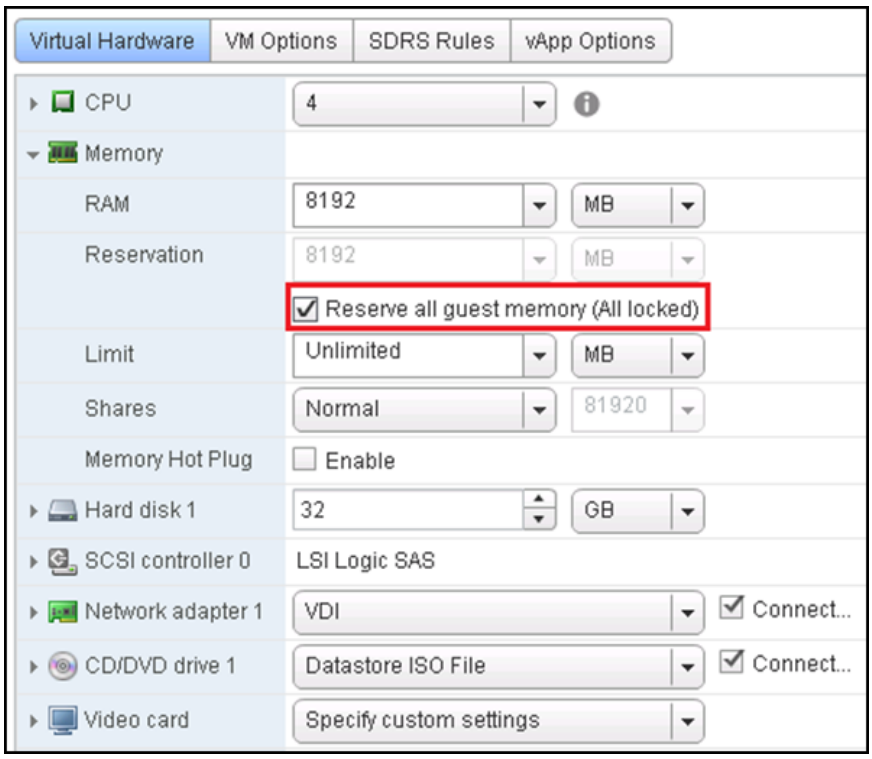


2. Select ESXi 6.0 and Later from the Compatible With menu. This selection enables you to use the latest features, including the mapping of shared PCI devices, which is required for the vGPU.



Note: If you are using existing VMs for 3D enablement, be sure that the VM is configured with version 9 or later for compatibility. VM version 11 is recommended.

3. Reserve all guest memory. In the VM Edit Settings options, select the Resources tab. Select Reserve All Guest Memory (All Locked).



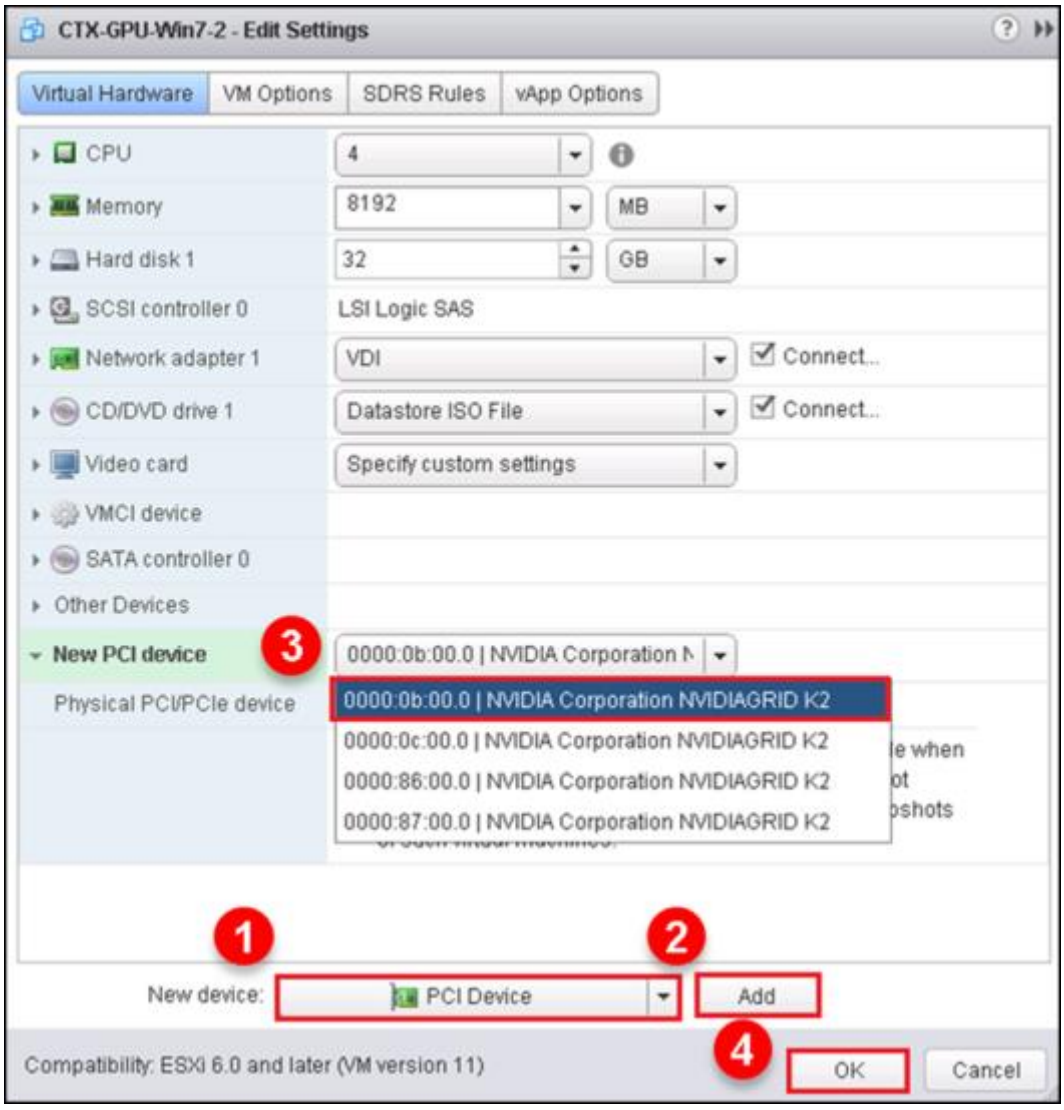
4. If the VM has more than 2GB of configured memory, adjust `pciHole.start`. Add the following parameter to the .vmx file of the VM. You can add this parameter at the end of the file:

```
pciHole.start = "2048"
```

Note: This step is required only if the VM has more than 2GB of configured memory.

5. Add a PCI device:
   a. In the VM Edit settings, choose New Device > PCI Device. Click Add to add the new PCI device (step 1 and step 2).
   b. Select the PCI device and choose NVIDIA GPU from the drop-down list (step 3).
   c. Click OK (step 4).

Note: Only one VM can be powered on if the same PCI device is added to multiple VMs.

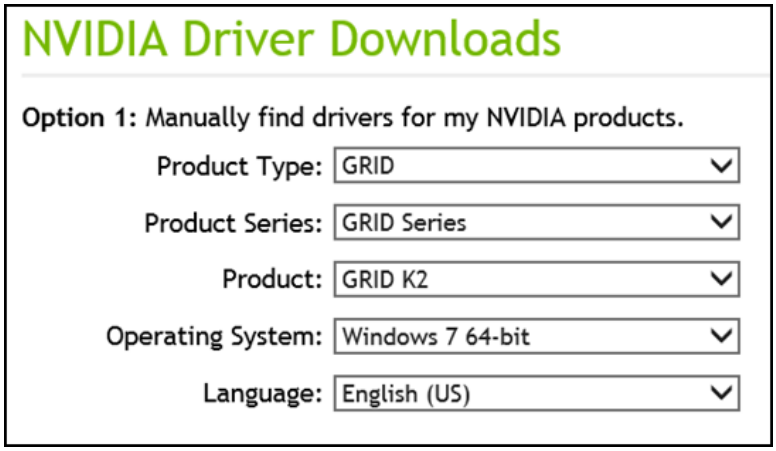


6. Install and configure Windows on the VM:
   a. Configure the VM with four virtual CPUs (vCPUs) and 8GB of RAM (as an example configuration).
   b. Install VMware Tools.
   c. Join the VM to the Active Directory domain.
   d. Select Allow Remote Connections to This Computer in the Windows System Properties menu.

Download and Install Virtual Machine GPU Drivers

1. Download the VM drivers from the NVIDIA website.

   Note: Select 32-bit or 64-bit graphics drivers based on the guest OS type.

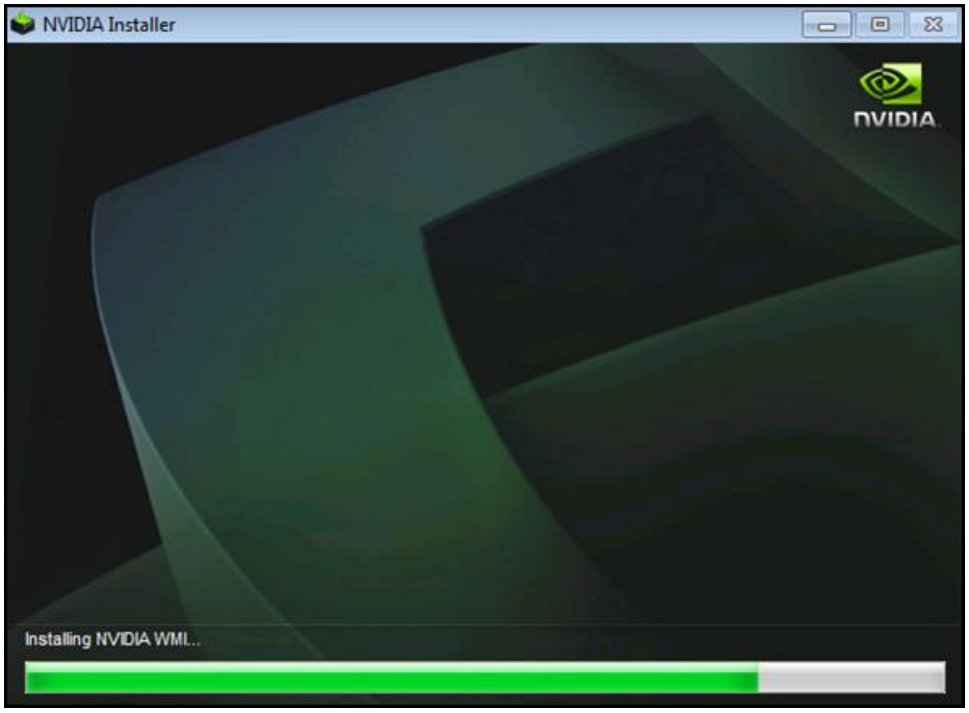


2. Install the drivers.
   a. Accept the license terms and agreement and click Next.

   b. Select Custom (Advanced) installation and click Next.

c. Select the check box for each option, select Perform a Clean Installation, and click Next.

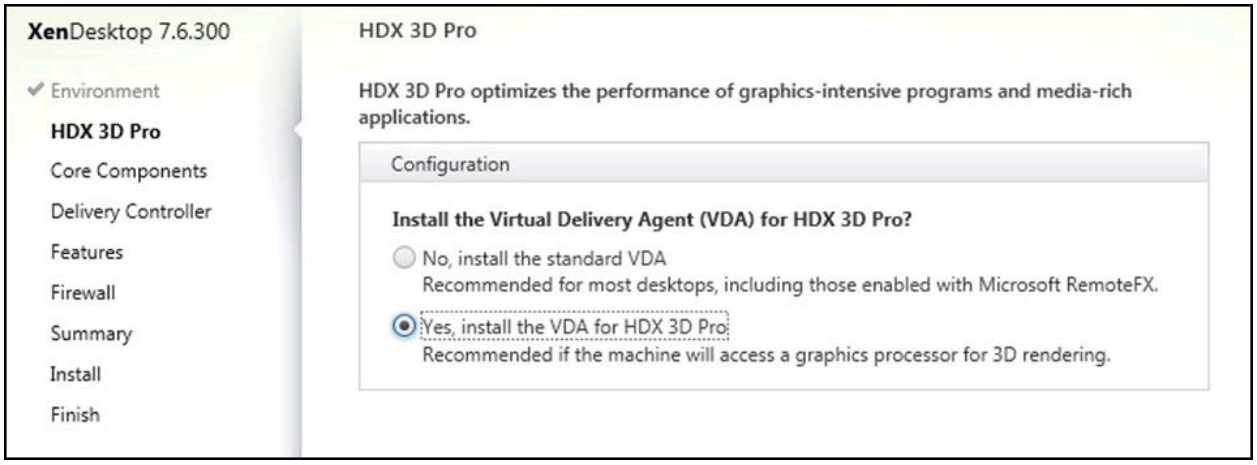
The installation begins, and a progress bar appears.



d. Click Restart Now. Reboot the VM.

Note: After you restart the VM, the mouse cursor might not track properly with the Virtual Network Computing (VNC) or vSphere console. If so, use Remote Desktop.

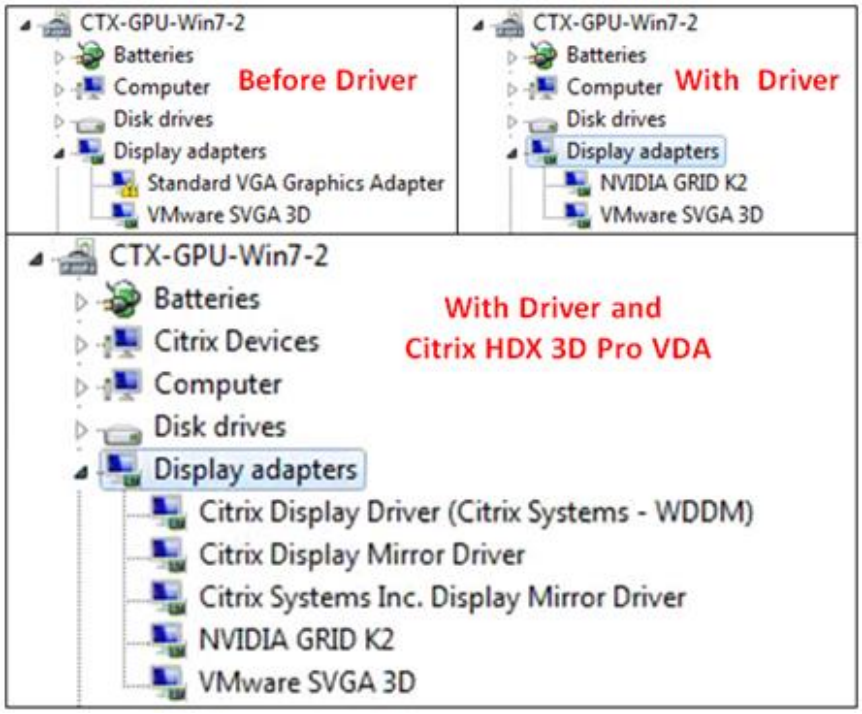
3. Install the Citrix XenDesktop HDX 3D Pro Virtual Desktop Agent. Reboot when prompted to do so.



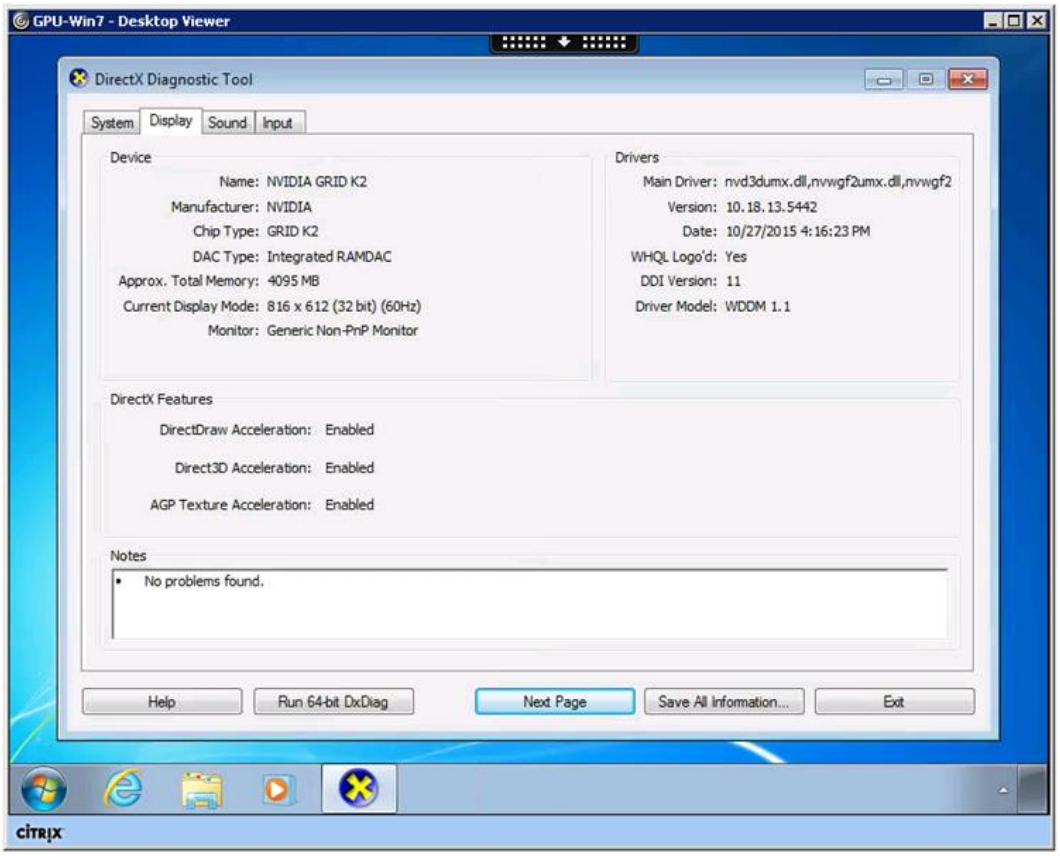
Verify That Applications Are Ready to Support the vGPU

To verify that the VM is using the NVIDIA GPU and driver, complete the following steps:

1. Verify that the correct display adapters were installed with Windows Device Manager.



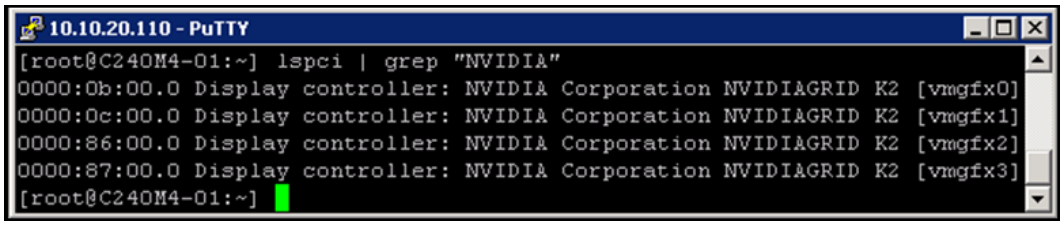
2. Connect through the Citrix HDX protocol to the virtual desktop machine and verify that the GPU is active by viewing the displayed information in the DirectX Diagnostic Tool:
   a. Click the Start menu from the VM to which the GRID card pass-through device is attached.
   b. Type `dxdiag` and click Enter when DxDiag appears in the list.
   c. After DxDiag launches, click the Display tab to verify that the VM is using the NVIDIA GPU and driver.



3. Verify that all the GRID card controllers are present on the host with the following command:

```
lspci | grep NVIDIA
```

This command returns the following output if you are using two GRID K2 cards.

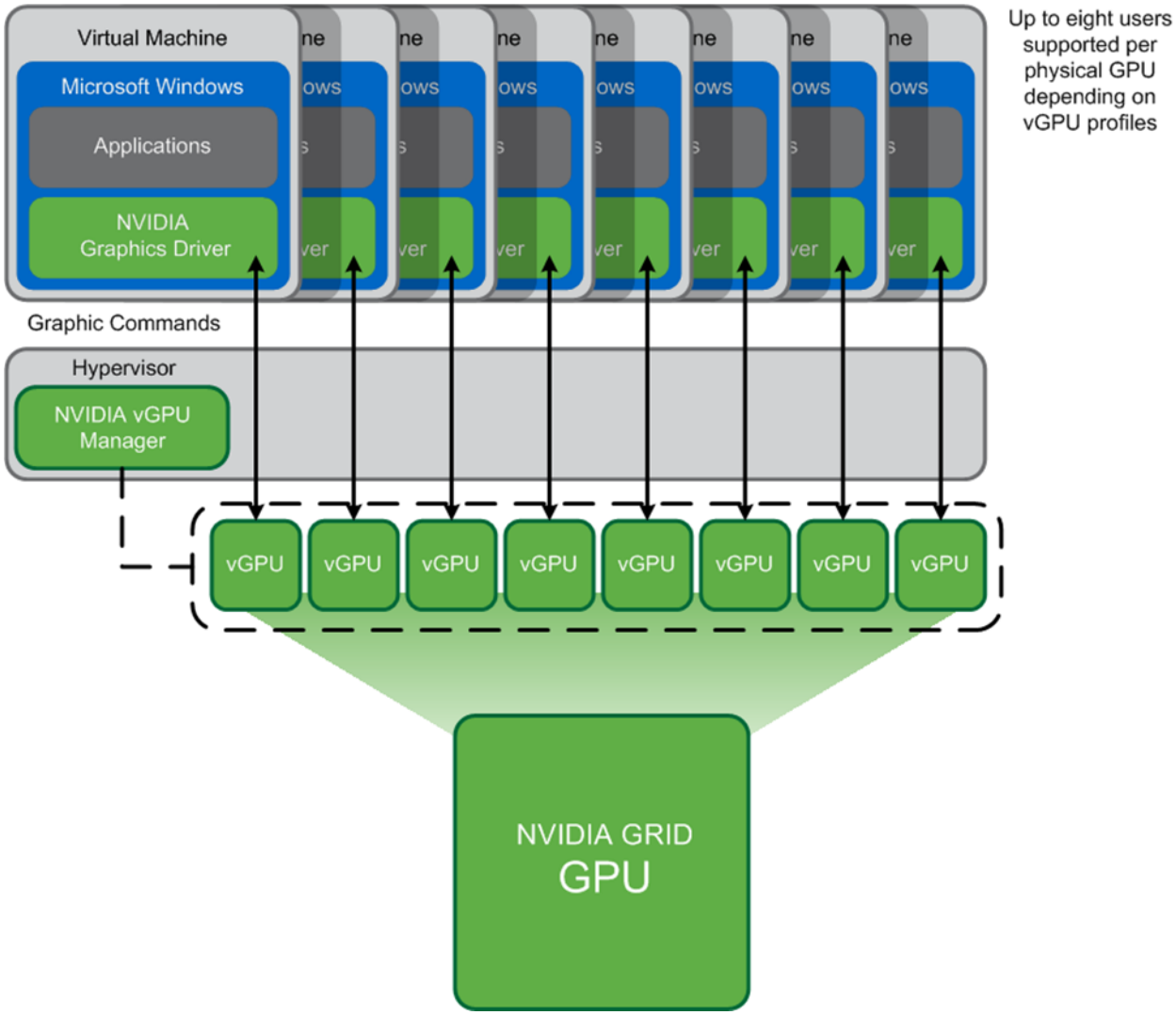


Note: When you deploy vDGA, it uses the graphics driver from the GPU vendor rather than the VM's vGPU 3D driver. To provide frame-buffer access, vDGA uses an interface between the remote protocol and the graphics driver.

Configure Virtual GPU Deployment

This section outlines the installation process for configuring an ESXi host and VM for vGPU support. Figure 5 shows the components used for vGPU support.

Figure 5) NVIDIA GRID vGPU components.

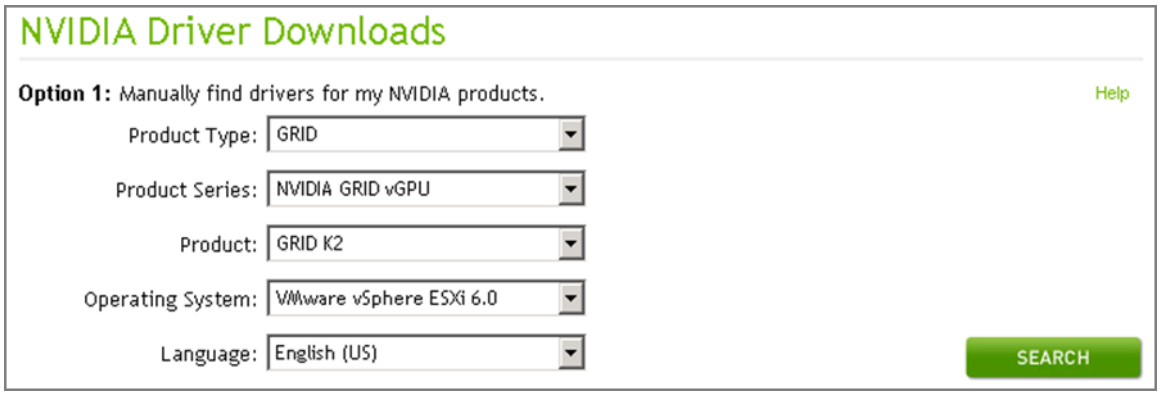


3.6 Configure VMware ESXi Host Server for vGPU Configuration

This section outlines the installation process for configuring an ESXi host for vGPU support.

1. First, download the NVIDIA GRID GPU driver pack for vSphere ESXi 6.0 from the VMware vSphere ESXi 6.0 Driver download site.

   Note: Do not select the GRID series drivers.



2. Enable the ESXi Shell and the Secure Shell (SSH) protocol on the vSphere host from the Troubleshooting menu of the vSphere Configuration Console.

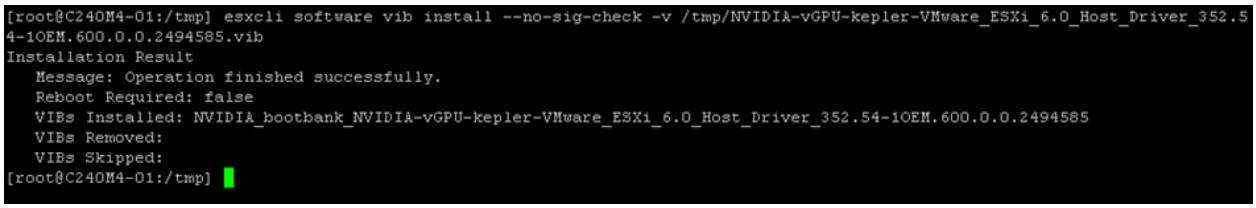
3. Upload the NVIDIA driver (vSphere Installation Bundle [VIB] file) to the `/tmp` directory on the ESXi host by using a tool such as WinSCP. Shared storage is preferred if you are installing drivers on multiple servers. You can also use the VMware update manager.
4. Log in as the root to the vSphere console through SSH with a tool such as Putty.

   Note: The ESXi host must be in maintenance mode to install the VIB module.

5. To install the NVIDIA vGPU drivers, enter the following command:

```
esxcli software vib install --no-sig-check -v /<path>/<filename>.VIB
```

   This command returns an output similar to the following screenshot:



Note: Although the display states `Reboot Required: false`, a reboot is necessary for the VIB file to load and for xorg to start.

6. Exit the ESXi host from maintenance mode and reboot the host by using the vSphere web client or by entering the following commands:

```
esxcli system maintenanceMode set -e false
reboot
```

7. After the host reboots successfully, determine whether the kernel module has loaded successfully with the following command:

```
esxcli software vib list | grep -i nvidia
```

   This command returns an output similar to the following screenshot:

```
[root@C240M4-01:~] esxcli software vib list | grep -i nvidia
NVIDIA-vGPU-kepler-VMware_ESXi_6.0_Host_Driver  352.54-1OEM.600.0.0.2494585
   NVIDIA  VMwareAccepted    2015-11-06
[root@C240M4-01:~]
```

Note: See the VMware knowledge base article entitled Installing and configuring the NVIDIA VIB on ESXi for information about removing any existing NVIDIA drivers before installing new drivers for any vGPU or vDGA test.

8. Confirm GRID GPU detection on the ESXi host. To determine the status of the GPU card's CPU, the status of the card's memory, and the amount of disk space left on the card, run the following command:

```
nvidia-smi
```

This command returns an output similar to the following screenshot if you are using two GRID K2 cards:

```
[root@C240M4-01:~] nvidia-smi
Wed Nov 11 15:27:22 2015
+------------------------------------------------------+
| NVIDIA-SMI 352.54     Driver Version: 352.54         |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  GRID K2             On   | 0000:0B:00.0     Off |                  Off |
| N/A   48C    P8    28W / 117W |      8MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   1  GRID K2             On   | 0000:0C:00.0     Off |                  Off |
| N/A   43C    P8    27W / 117W |      8MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   2  GRID K2             On   | 0000:86:00.0     Off |                  Off |
| N/A   49C    P8    27W / 117W |      8MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   3  GRID K2             On   | 0000:87:00.0     Off |                  Off |
| N/A   44C    P8    27W / 117W |      8MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID  Type  Process name                               Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
[root@C240M4-01:~]
```

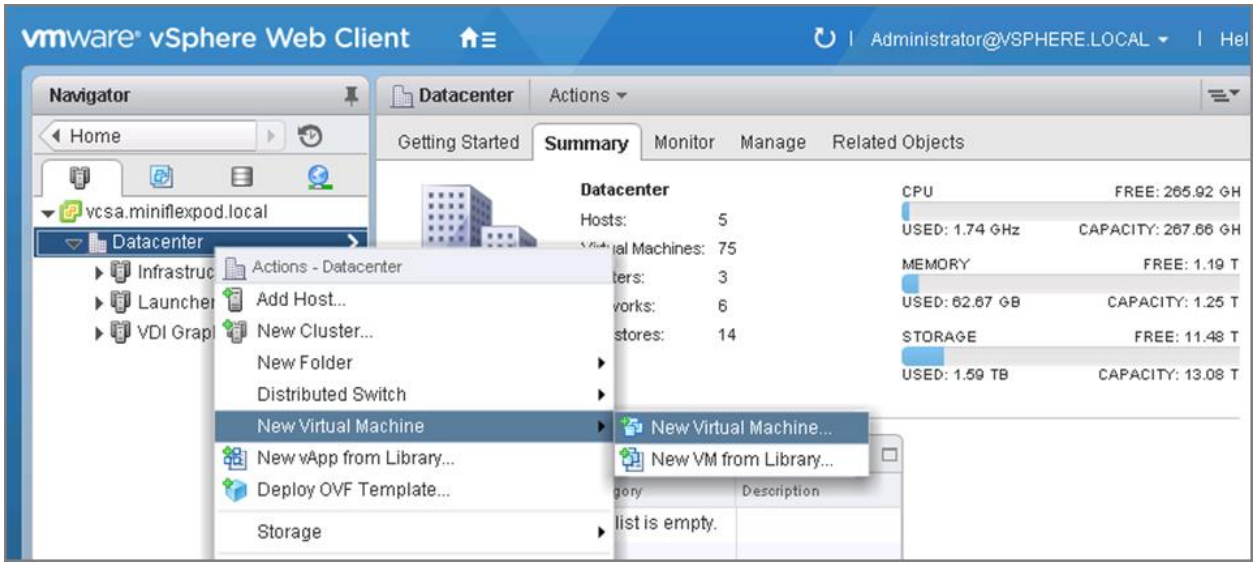
The NVIDIA system management interface (SMI) also allows GPU monitoring by using the following command to automatically refresh the display:

```
nvidia-smi -l
```

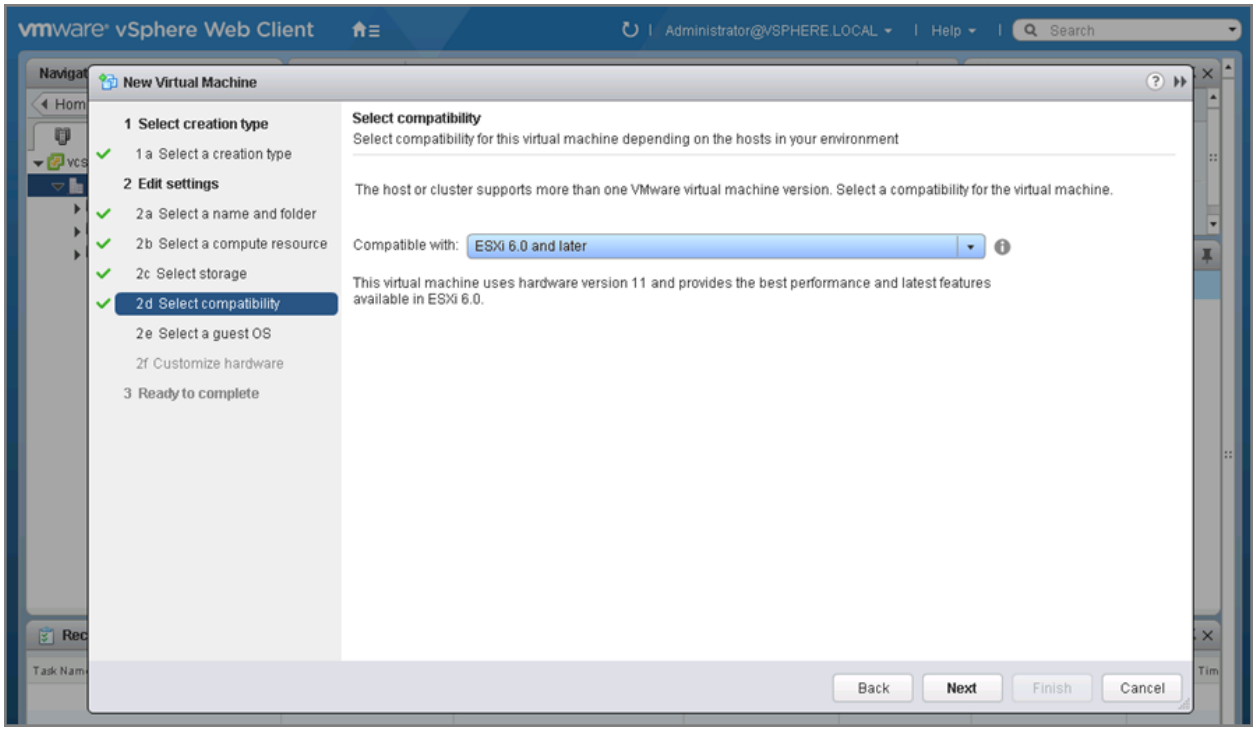
Prepare a Virtual Machine for vGPU Configuration

Use the following procedure to create the VM used later as the VDI base image:

1. Using the vSphere web client, create a new VM. First, right-click a host or cluster, choose New Virtual Machine, and complete the New Virtual Machine wizard. Unless another configuration is specified, select the configuration settings appropriate for your environment.

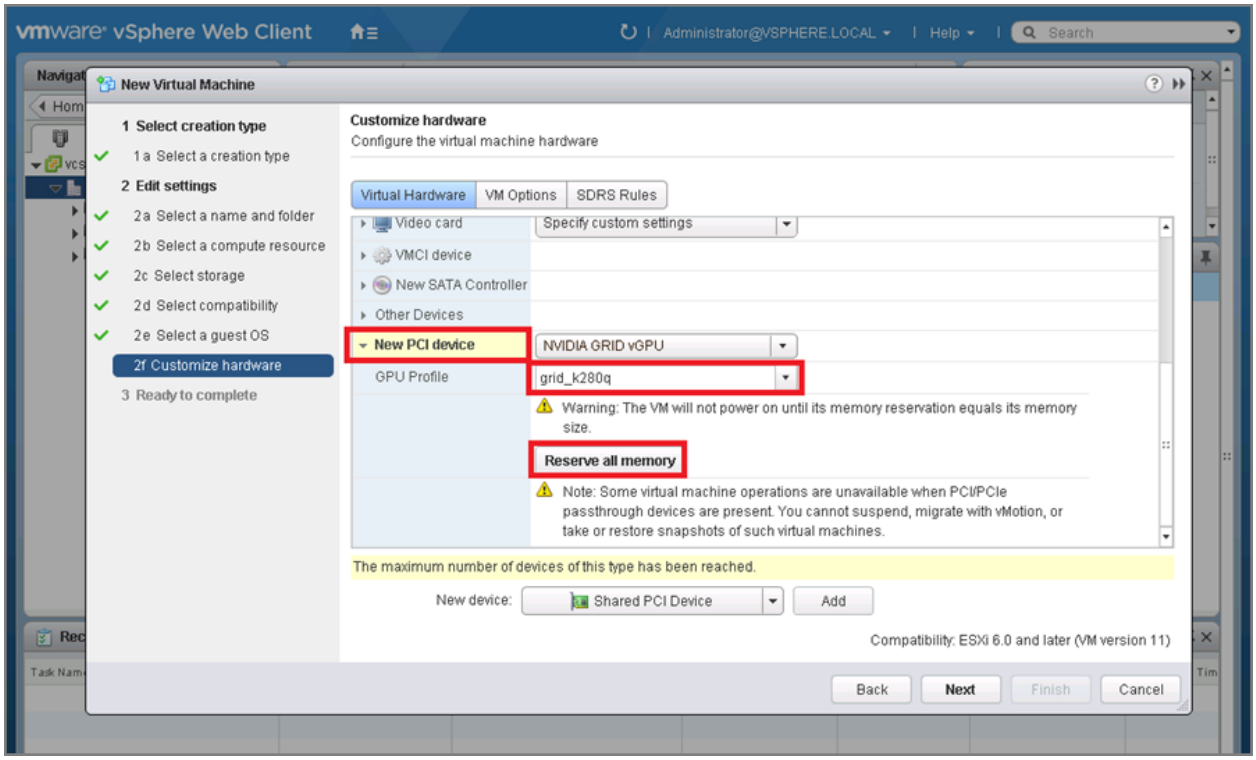


2. Select ESXi 6.0 and Later from the Compatible With menu. This configuration enables the latest features, including the mapping of shared PCI devices, which is required for the vGPU.



3. When customizing the new VM hardware, add a new shared PCI device, select the appropriate GPU profile, and reserve all VM memory.

   Note: If you are creating a new VM and using the vSphere web client's VM console functions, then the mouse is not usable in the VM until after both the operating system and the VMware tools have been installed. If you cannot use the traditional vSphere client to connect to the VM, do not enable NVIDIA GRID vGPU at this time.



4. Install and configure Windows on the VM:
   a. Configure the VM with the appropriate amount of vCPU and RAM according to the GPU profile selected.
   b. Install the VMware tools.
   c. Join the VM to the Active Directory domain.
   d. Select Allow Remote Connections to This Computer in the Windows System Properties menu.

GRID K1 and K2 Profile Specifications

The GRID vGPU allows up to eight users to share each physical GPU. vGPU assigns the graphics resources of the available GPUs to VMs using a balanced approach. Each GRID K1 card has four GPUs, allowing 32 users to share a single card. Each GRID K2 card has two GPUs, allowing 16 users to share a single card. Table 4 summarizes the user profile specifications.

For more information, see the NVIDIA GRID Resources page.

Table 4) User profile specifications for GRID K1 and K2 cards.

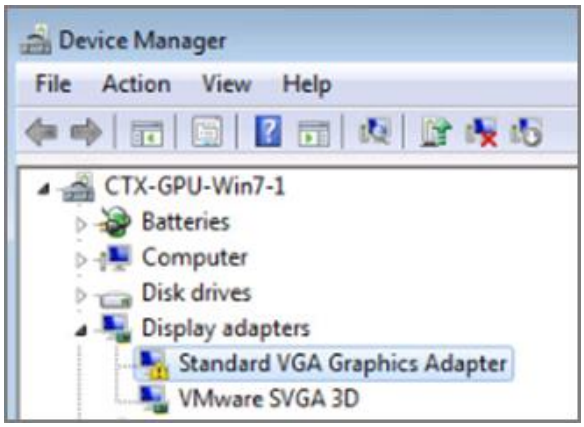
NVIDIA GRID Card	Virtual GPU Profile	Application Certification	Graphics Memory in MB	Max Display per User	Maximum Resolution per Display	Maximum Users per Board	Use Case
3	K280Q	Yes	4,096	4	2,560 x 1,600	2	Designer
	K260Q	Yes	2,048	4	2,560 x 1,600	4	Designer and power user

NVIDIA GRID Card	Virtual GPU Profile	Application Certification	Graphics Memory in MB	Max Display per User	Maximum Resolution per Display	Maximum Users per Board	Use Case
	K240Q	Yes	1,024	2	2,560 x 1,600	8	Designer and power user
	K220Q	Yes	512	2	2,560 x 1,600	16	Power user
GRID K1	K180Q	Yes	4,096	4	2,560 x 1,600	4	Power user
	K160Q	Yes	2,048	4	2,560 x 1,600	8	Power user
	K140Q	Yes	1,024	2	2,560 x 1,600	16	Knowledge worker
	K120Q	Yes	512	2	2,560 x 1,600	32	Knowledge worker

NVIDIA vGPU Software (Driver) and Citrix HDX 3D Pro Agent Installation

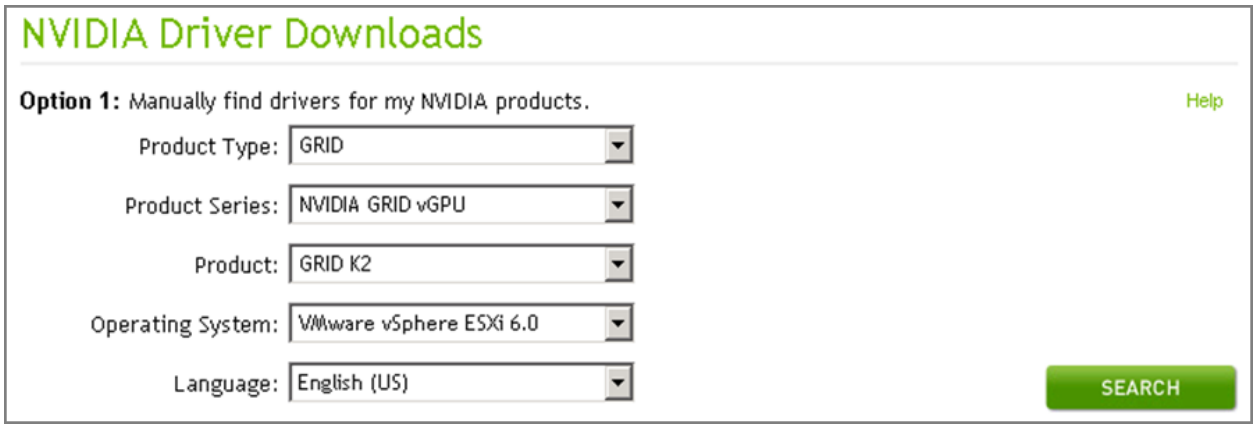
Use the following procedure to install the GRID vGPU drivers on the desktop VM and to install the HDX 3D Pro VDA to prepare this VM for management by the XenDesktop controller. To fully enable vGPU operation, the NVIDIA driver must be installed.

Before the NVIDIA driver is installed on the guest VM, Device Manager shows the standard VGA graphics adapter.

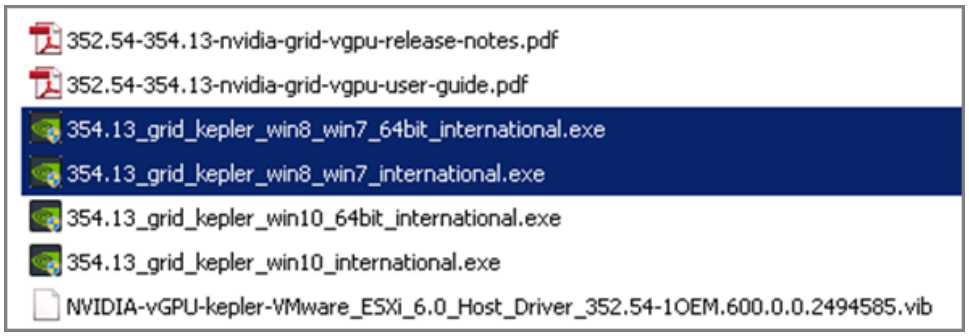


1. Copy the Windows drivers from the NVIDIA GRID vGPU driver pack downloaded earlier to the master VM. Alternatively, download the drivers from the NVIDIA drivers download page and extract the contents.

   Note: Do not select the GRID Series drivers.



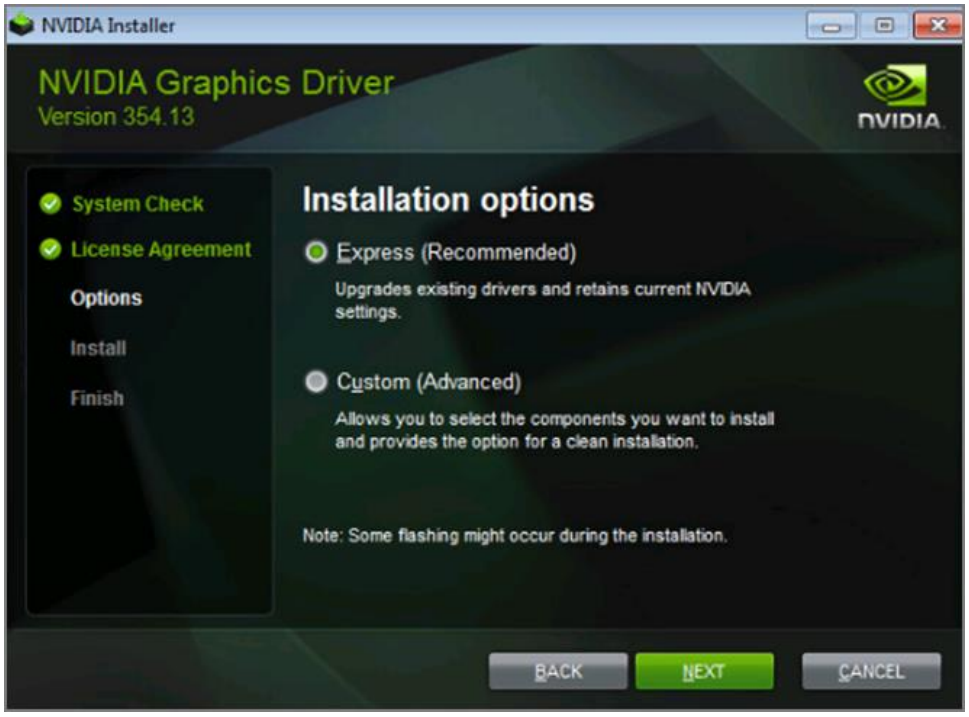
2. Copy the 32-bit or 64-bit NVIDIA Windows driver from the vGPU driver pack to the desktop VM and run `setup.exe`.



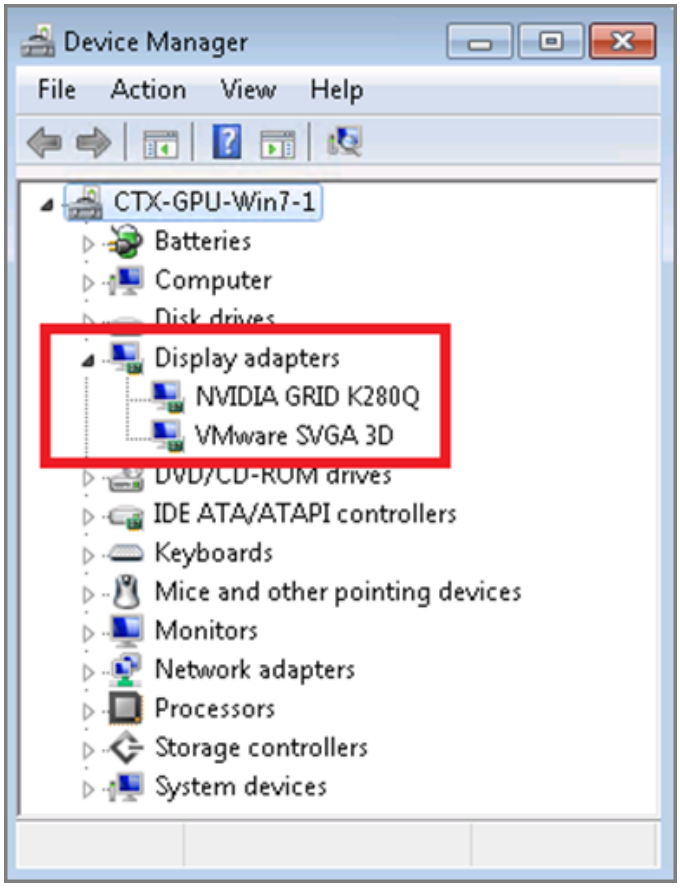
Note: The vGPU host driver and guest driver versions must match. Do not attempt to use a newer guest driver with an older vGPU host driver or an older guest driver with a newer vGPU host driver. In addition, the vGPU driver from NVIDIA is a different driver than the GPU pass-through driver.

3. Install the graphics drivers with the Express option. After the installation has been completed successfully, restart the VM.

Note: Make sure that remote desktop connections have been enabled. After this step, console access might not be available to the VM when connecting from a vSphere client.



4. To validate the successful installation of the graphics drivers and the vGPU device, open Windows Device Manager and expand the Display Adapter section.

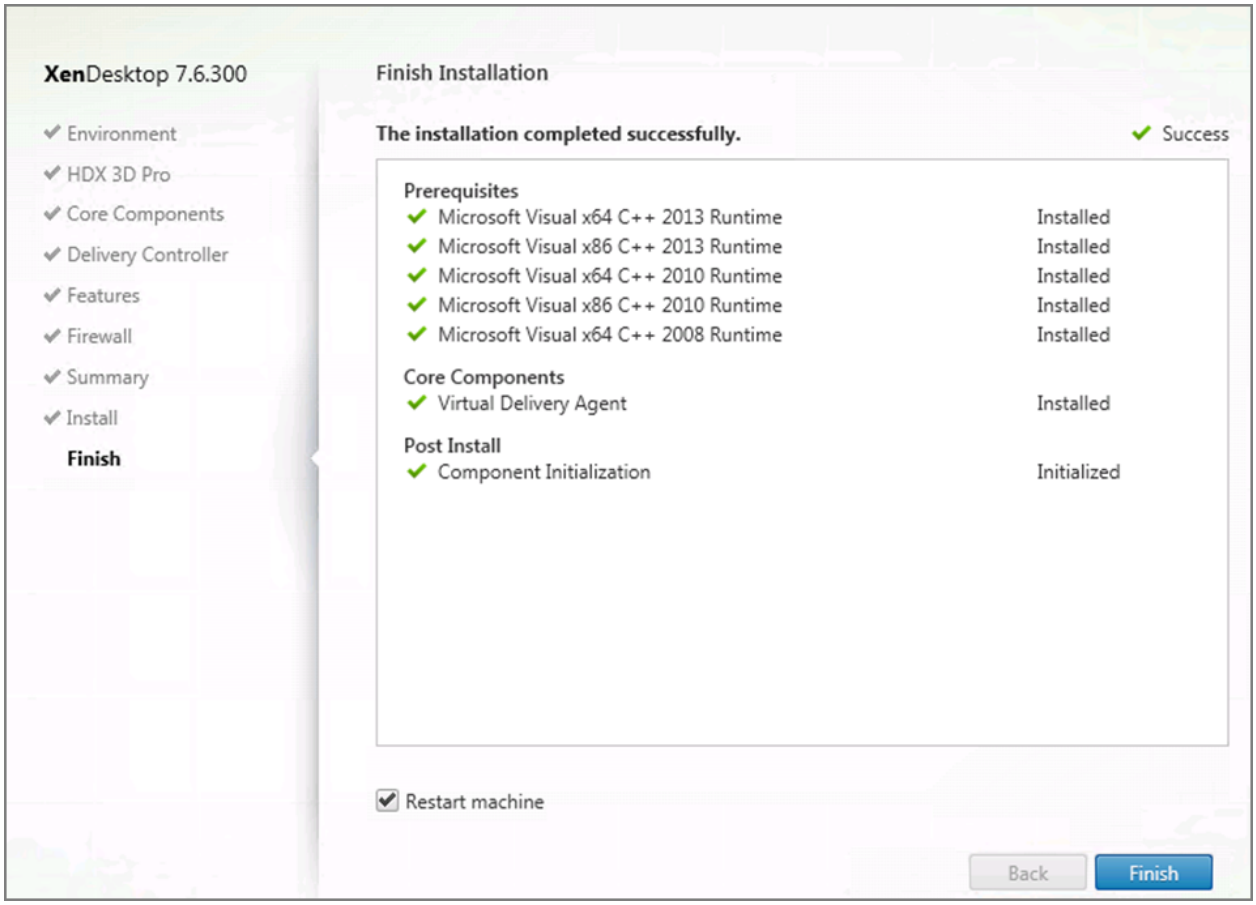


Note: If you continue to see an exclamation mark, the following issues are the most likely cause:

- The GPU driver service is not running.
- The GPU driver is incompatible.

5. To start the HDX 3D Pro VDA installation, mount the XenApp and XenDesktop 7.6 (or later) ISO image on the VM or copy the Feature Pack VDA installation media to the virtual desktop VM.
6. Install Citrix XenDesktop HDX 3D Pro Virtual Desktop Agent. Reboot when prompted to do so.

7. Reboot the VM after VDA for HDX 3D Pro has been installed successfully.

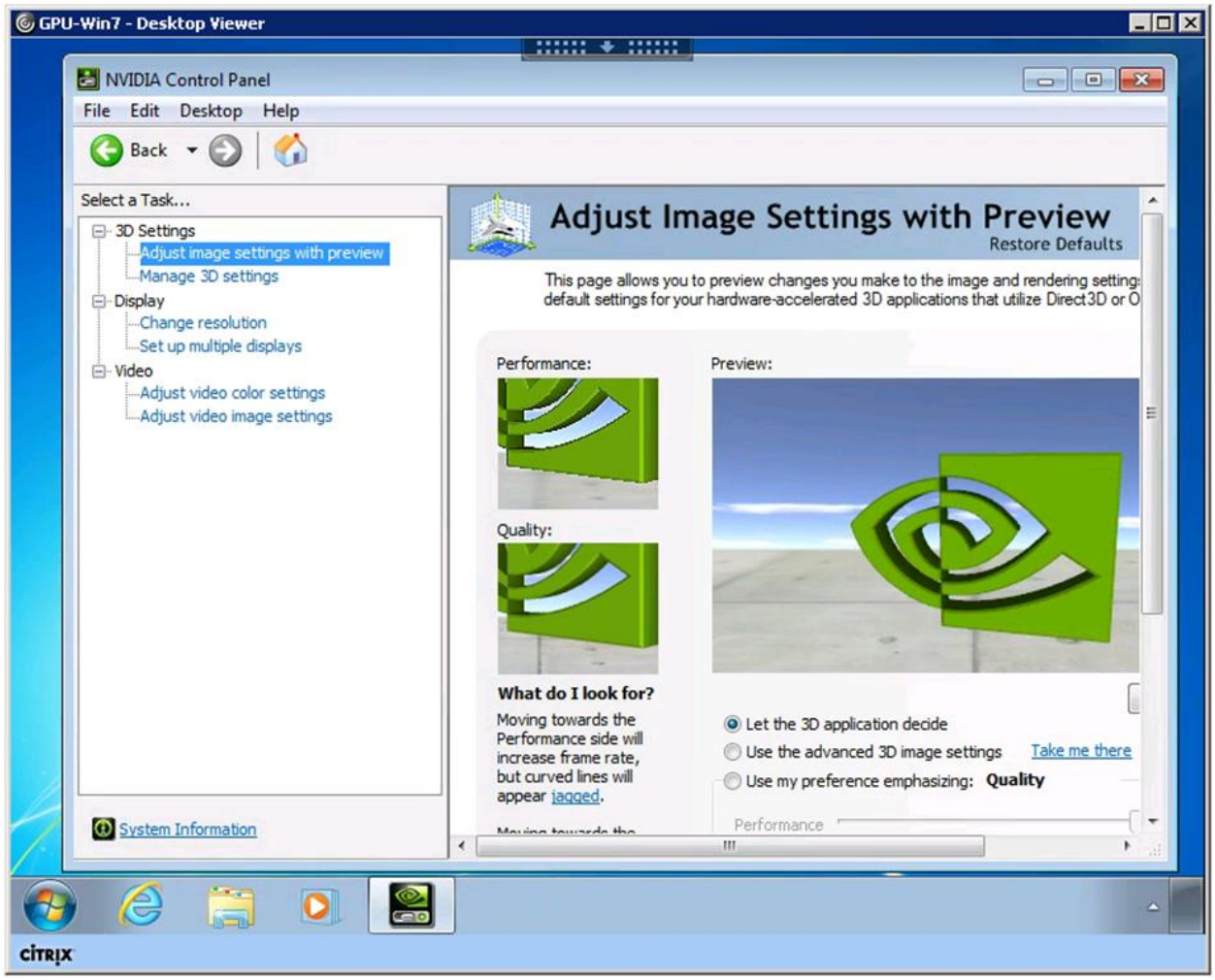


After the HDX 3D Pro Virtual Desktop Agent has been installed and the VM has been rebooted successfully, install the graphics applications, benchmark tools, and sample models that you want to deliver to all users. Refer to this Citrix blog for a list of graphics tools that you can use for evaluation and testing purposes.

Verify That Applications Are Ready to Use vGPU Support

Verify that the NVIDIA driver is running by completing the following steps:

1. Right-click the desktop. The NVIDIA control panel is listed in the menu; select it to open the control panel.
2. Select System Information in the NVIDIA control panel to see the vGPU that the VM is using, the capabilities of the vGPU, and the NVIDIA driver version that is loaded.



Why Use NVIDIA GRID vGPU for Graphic Deployments?

GRID vGPU allows multiple virtual desktops to share a single physical GPU, and it allows multiple GPUs to reside on a single physical PCI card. All virtual desktops that use GRID vGPUs provide the 100% application compatibility characteristic of vDGA pass-through graphics, but with lower cost because multiple desktops share a single graphics card. With XenDesktop, you can centralize, pool, and more easily manage traditionally complex and expensive distributed workstations and desktops. Now all of your user groups can take advantage of the benefits of virtualization.

The GRID vGPU brings the full benefits of NVIDIA hardware-accelerated graphics to virtualized solutions. This technology provides exceptional graphics performance for virtual desktops equivalent to local PCs that share a GPU among multiple users.

GRID vGPU is the industry's most advanced technology for sharing true GPU hardware acceleration among multiple virtual desktops without compromising the graphics experience. Application features and compatibility are exactly the same as they would be at the user's desk.

With GRID vGPU technology, the graphics commands of each VM are passed directly to the GPU, without translation by the hypervisor. By allowing multiple VMs to access the power of a single GPU in the virtualization server, enterprises can increase the number of users with access to true GPU-based graphics acceleration on VMs.

The physical GPU in the server can be configured with a specific vGPU profile. Organizations have a great deal of flexibility in how to best configure their servers to meet the needs of the various types of end users. vGPU support allows businesses to use the power of the NVIDIA GRID technology to create a whole new class of VMs designed to provide end users with a rich, interactive graphics experience.

In any given enterprise, the needs of individual users vary widely. One of the main benefits of GRID vGPU is the flexibility to use various vGPU profiles designed to serve the needs of different classes of end users. Although the needs of end users can be diverse, for simplicity, users can be grouped into the following categories: knowledge workers, designers, and power users.

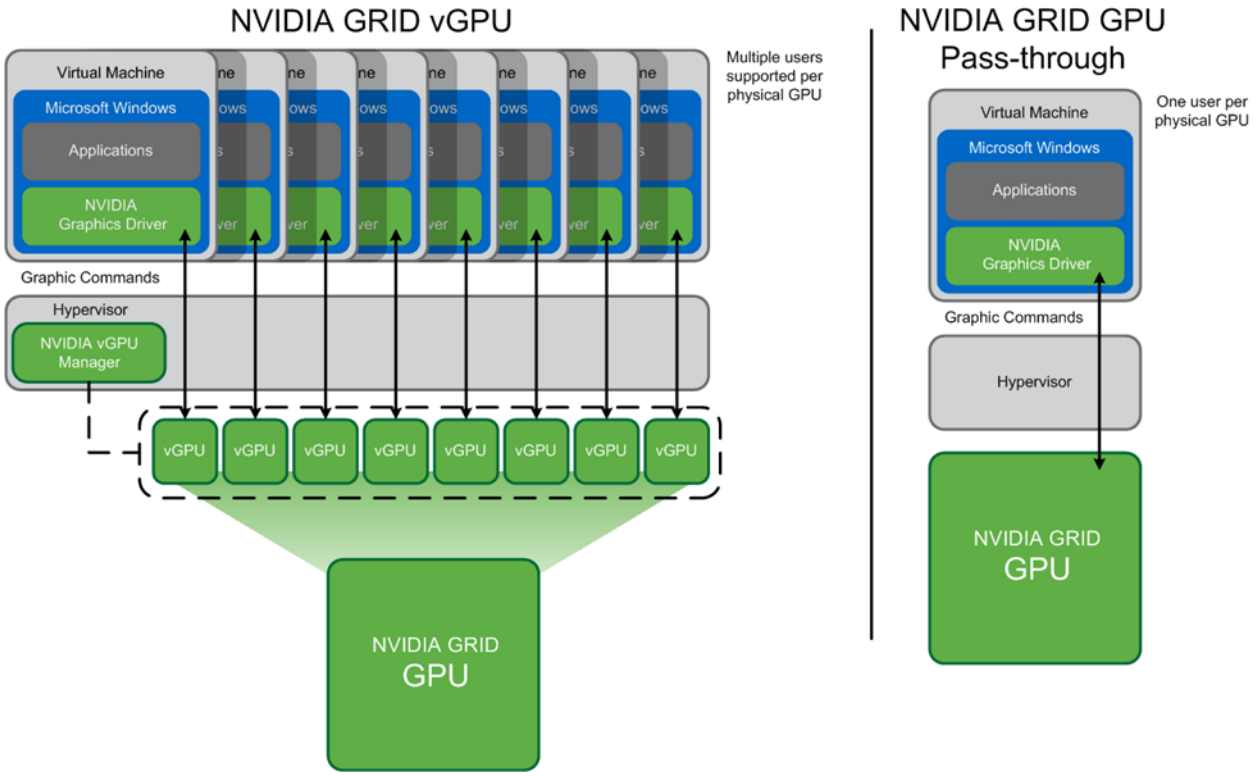
Knowledge workers typically require office productivity applications, a robust web experience, and fluid video playback. Knowledge workers have the least-intensive graphics demands, but they expect the same smooth, fluid experience that exists natively on today’s graphics-accelerated devices such as desktop PCs, notebooks, tablets, and smartphones.

Power users typically run more demanding office applications, such as office productivity software, image-editing software such as Adobe Photoshop, mainstream CAD software such as Autodesk AutoCAD, and product lifecycle management applications. These applications are more demanding and require additional graphics resources with full support for APIs such as OpenGL and Direct3D.

Designers typically run demanding professional applications such as high-end CAD software and professional digital content creation (DCC) tools. Examples include Autodesk Inventor, PTC Creo, Autodesk Revit, and Adobe Premiere. Historically, designers have used desktop workstations and have been a difficult group to incorporate into virtual deployments because of their need for high-end graphics and the certification requirements of professional CAD and DCC software.

vGPU profiles allow the GPU hardware to be time-sliced to deliver exceptional shared virtualized graphics performance.

Figure 6) GRID vGPU GPU system architecture.



3.7 Additional Configurations

Install HDX 3D Pro Virtual Desktop Agent with CLI

When you use the installer's GUI to install a VDA for a Windows desktop, select Yes on the HDX 3D Pro page. When you use the CLI, include the `/enable_hdx_3d_pro` option with the XenDesktop `VdaSetup.exe` command.

To upgrade HDX 3D Pro, uninstall both the separate HDX 3D for Professional Graphics component and the VDA before installing the VDA for HDX 3D Pro. Similarly, to switch from the standard VDA for a Windows desktop to the HDX 3D Pro VDA, uninstall the standard VDA and then install the VDA for HDX 3D Pro.

Install and Upgrade NVIDIA Drivers

The NVIDIA GRID API provides direct access to the frame buffer of the GPU, providing the fastest possible frame rate for a smooth and interactive user experience. If you install NVIDIA drivers before you install a VDA with HDX 3D Pro, NVIDIA GRID is enabled by default.

1. To enable GRID on a VM, disable Microsoft Basic Display Adapter from the Device Manager. To do so, run the following command:

```
Montereyenable.exe -enable -noreset
```

2. Restart the VDA.
3. If you install NVIDIA drivers after you install a VDA with HDX 3D Pro, GRID is disabled. Enable GRID by using the MontereyEnable tool provided by NVIDIA.

   To disable GRID, run the following command:

```
Montereyenable.exe -disable -noreset
```

4. Restart the VDA.

HDX Monitor

Use the HDX Monitor tool (which replaces the Health Check tool) to validate the operation and configuration of HDX visualization technology and to diagnose and troubleshoot HDX problems. To download the tool and learn more about it, see the Citrix HDX Monitor download page.

Optimize the HDX 3D Pro User Experience

To use HDX 3D Pro with multiple monitors, be sure that the host computer is configured with at least as many monitors as there are monitors attached to user devices. The monitors attached to the host computer can be either physical or virtual.

Do not attach a monitor (either physical or virtual) to a host computer while a user is connected to the virtual desktop or any application providing the graphical application. Doing so can cause instability for the duration of a user's session.

Let your users know that changes to the desktop resolution (by them or an application) are not supported when a graphical application session is running. After closing the application session, a user can change the resolution of the desktop viewer window in the Citrix Receiver Desktop Viewer preferences.

When multiple users share a connection with limited bandwidth (for example, at a branch office), Citrix recommends that you use the overall session bandwidth limit policy setting to limit the bandwidth available to each user. This setting helps make sure that the available bandwidth does not fluctuate widely as users log on and off. Because HDX 3D Pro automatically adjusts to make use of all the available bandwidth, large variations in the available bandwidth over the course of user sessions can negatively affect performance.

For example, if 20 users share a 60Mbps connection, the bandwidth available to each user can vary between 3Mbps and 60Mbps, depending on the number of concurrent users. To optimize the user experience in this scenario, determine the bandwidth required per user at peak periods and limit users to this amount at all times.

For users of a 3D mouse, Citrix recommends that you increase the priority of the generic USB redirection virtual channel to 0. For information about changing the virtual channel priority, see Change Virtual Channel Priority in XenDesktop (CTX128190).

GPU Acceleration for Windows Server OS: DirectX, Direct3D, and WPF Rendering

DirectX, Direct3D, and WPF rendering is available only on servers with a GPU that supports display driver interface version 9ex, 10, or 11:

- Windows Server 2008 R2, DirectX, and Direct3D require no special settings to use a single GPU.
- For Windows Server 2012, Remote Desktop Services (RDS) sessions on the remote desktop session host server use the Microsoft Basic Render driver as the default adapter. To use the GPU in RDS sessions on Windows Server 2012, select Use the Hardware Default Graphics Adapter for All Remote Desktop Services Sessions in the group policy by selecting Local Computer Policy > Computer Configuration > Administrative Templates > Windows Components > Remote Desktop Services > Remote Desktop Session Host > Remote Session Environment.
- On Windows Server 2008 R2 and Windows Server 2012, all DirectX and Direct3D applications running in all sessions use the same single GPU by default. To enable experimental support for distributing user sessions across all eligible GPUs for DirectX and Direct3D applications, create the following settings in the registry of the server running Windows Server sessions:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Citrix\CtxHook\AppInit_Dlls\Graphics Helper]
"DirectX"=dword:00000001
```

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Citrix\CtxHook\AppInit_Dlls\Graphics Helper]
"DirectX"=dword:00000001
```

To enable rendering by WPF applications by using the server's GPU, create the following settings in the registry of the server running Windows Server sessions:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Citrix\CtxHook\AppInit_Dlls\Multiple Monitor Hook]
"EnableWPFHook"=dword:00000001
[HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Citrix\CtxHook\AppInit_Dlls\Multiple Monitor Hook]
"EnableWPFHook"=dword:00000001
```

GPU Acceleration for Windows Server OS: Experimental GPU Acceleration for CUDA or OpenCL Applications

Experimental support is provided for GPU acceleration of CUDA and OpenCL applications running in a user session. This support is disabled by default, but you can enable it for testing and evaluation purposes.

- To use the experimental CUDA acceleration features, enable the following registry settings:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Citrix\CtxHook\AppInit_Dlls\Graphics Helper] "CUDA"=dword:00000001
[HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Citrix\CtxHook\AppInit_Dlls\Graphics Helper]
"CUDA"=dword:00000001
```

- To use the experimental OpenCL acceleration features, enable the following registry settings:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Citrix\CtxHook\AppInit_Dlls\Graphics Helper] "OpenCL"=dword:00000001
[HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Citrix\CtxHook\AppInit_Dlls\Graphics Helper]
"OpenCL"=dword:00000001
```

OpenGL Software Accelerator

The OpenGL Software Accelerator is a software rasterizer for OpenGL applications such as ArcGIS, Google Earth, Nehe, Maya, Blender, Voxler, CAD, and CAM. In some cases, the OpenGL Software Accelerator can eliminate the need to use graphics cards to deliver a good user experience with OpenGL applications.

Note: The OpenGL Software Accelerator is provided as is and must be tested with all applications. It might not work with some applications and should be tried if the Windows OpenGL rasterizer does not provide adequate performance. If the OpenGL Software Accelerator works with your applications, it can be used to avoid the cost of GPU hardware.

The OpenGL Software Accelerator is provided in the support folder on the installation media and is supported on all valid VDA platforms.

Try the OpenGL Software Accelerator in the following cases:

- If the performance of OpenGL applications running in VMs is a concern, try the OpenGL accelerator. For some applications, the accelerator outperforms the Microsoft OpenGL software rasterizer that is included with Windows because the OpenGL accelerator uses SSE4.1 and AVX. The OpenGL accelerator also supports applications using OpenGL up to version 2.1.
- For applications running on a workstation, first try the default version of OpenGL support provided by the workstation's graphics adapter. If the graphics card is the latest version, it should deliver the best performance in most situations. If the graphics card is an earlier version or does not deliver satisfactory performance, try the OpenGL Software Accelerator.
- 3D OpenGL applications that are not adequately delivered using CPU-based software rasterization might benefit from OpenGL GPU hardware acceleration. This feature can be used on bare-metal devices or VMs.

4 Conclusion

The combination of Cisco UCS Manager, Cisco UCS C240 M4 rack servers, NVIDIA GRID K1 and K2 or Tesla cards using VMware vSphere ESXi 6.0, and Citrix XenDesktop 7.6 provides a high-performance platform for virtualizing graphics-intensive applications.

NetApp FAS provides high performance for the processing of graphics files on CIFS shares and the VDI environment for shared storage. The combination of both Cisco and NetApp in a FlexPod Express converged infrastructure provides excellent performance for GPU users. With the guidance in this document, our customers and partners are ready to host a growing list of graphics applications.

The following key findings were observed during the reference architecture configuration:

- Use the drivers prescribed in this document for NVIDIA configuration.
- Use NetApp storage for the VDI write cache and infrastructure environment.
- The use of Flash Pool storage caching is very beneficial.
- Use NetApp CIFS for the Citrix PVS vDisks, user profile management profiles, and home directories.
- NetApp CIFS provides very high performance for processing large video graphics data workloads.

References

This section lists the resources we used to build out the lab environment.

Cisco UCS C-Series Rack Servers

- Cisco Servers: Unified Computing
  http://www.cisco.com/en/US/products/ps10265/
- Cisco UCS C240 M4 Rack Server
  http://www.cisco.com/c/en/us/products/servers-unified-computing/ucs-c240-m4-rack-server/index.html
- Cisco UCS Virtual Interface Card 1227
  http://www.cisco.com/c/en/us/products/interfaces-modules/ucs-virtual-interface-card-1227/index.html
- Cisco UCS C-Series Rack Servers
  http://www.cisco.com/c/en/us/products/servers-unified-computing/ucs-c-series-rack-servers/index.html

NVIDIA

- GRID vGPU Deployment Guide
  http://www.nvidia.com/object/grid-citrix-deployment-guide.html
- NVIDIA GRID Resources
  http://www.nvidia.com/object/grid-enterprise-resources.html#deploymentguides
- NVIDIA GRID K1 and K2 Graphics-Accelerated Virtual Desktops and Applications
  http://www.nvidia.com/content/cloud-computing/pdf/nvidia-grid-datasheet-k1-k2.pdf
- Tesla Kepler GPU Accelerators
  http://www.cisco.com/c/dam/en/us/products/collateral/servers-unified-computing/ucs-b-series-blade-servers/tesla_kseries_overview_lr.pdf
- NVIDIA GRID K1 Graphics Board Specifications
  http://www.nvidia.com/content/grid/pdf/GRID_K1_BD-06633-001_v02.pdf
- NVIDIA GRID K1 Graphics Board Specifications
  http://www.nvidia.com/content/grid/pdf/GRID_K2_BD-06580-001_v02.pdf

Citrix XenApp/XenDesktop 7.6

- FlexCast Services: Virtualize 3D Professional Graphics | Design Guide
  https://www.citrix.com/content/dam/citrix/en_us/documents/products-solutions/virtualize-3d-professional-graphics-design-guide.pdf
- Citrix HDX System Requirements
  http://docs.citrix.com/en-us/xenapp-and-xendesktop/7/cds-deliver-landing/hdx-enhance-ux-xd/hdx-sys-reqs.html
- Citrix GPU Acceleration for Windows Desktop OS
  http://docs.citrix.com/en-us/xenapp-and-xendesktop/7-6/xad-hdx-landing/xad-hdx3dpro-gpu-accel-desktop.html
- Citrix GPU Acceleration for Windows Server OS
  http://docs.citrix.com/en-us/xenapp-and-xendesktop/7-6/xad-hdx-landing/xad-hdx3dpro-gpu-accel-server.html
- Citrix OpenGL Software Accelerator
  http://docs.citrix.com/en-us/xenapp-and-xendesktop/7-6/xad-hdx-landing/xad-hdx-opengl-sw-accel.html
- Reviewer's Guide for HDX 3D Pro
  https://www.citrix.com/content/dam/citrix/en_us/documents/products-solutions/reviewers-guide-for-hdx-3d-pro.pdf
- Reviewer's Guide for Remote 3D Graphics Apps
  https://www.citrix.com/content/dam/citrix/en_us/documents/go/reviewers-guide-remote-3d-graphics-apps-part-2-vsphere-gpu-passthrough.pdf
- Citrix HDX 3D Pro
  http://docs.citrix.com/en-us/xenapp-and-xendesktop/7-6/xad-hdx-landing/xad-hdx3dpro-intro.html
- Citrix XenApp and XenDesktop 7.6 what's new
  http://support.citrix.com/proddocs/topic/xenapp-xendesktop-76/xad-whats-new.html
- Citrix XenApp and XenDesktop 7.6 architecture
  http://support.citrix.com/proddocs/topic/xenapp-xendesktop-76/xad-architecture-article.html
- Citrix Virtual Desktop Handbook 7.x
  http://support.citrix.com/article/CTX139331
- Citrix XenDesktop 7.x Blueprint
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- Citrix HDX blog
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NetApp Storage and Storage Interconnect Switches

- NetApp FAS2500 Series Technical Specifications
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- Clustered Data ONTAP High-Availability Configuration Guide
  https://library.netapp.com/ecmdocs/ECMP1367947/html/index.html
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- TR-4182: Ethernet Storage Design Considerations and Best Practices for Clustered Data ONTAP Configurations
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- TR-4138: Design Guide for Citrix XenDesktop on NetApp Storage
  http://www.netapp.com/us/system/pdf-reader.aspx?pdfuri=tcm:10-108557-16&m=tr-4138.pdf
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Recognition

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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.