

3D Graphics Visualization with Citrix and NVIDIA

Understand the performance of Citrix XenDesktop on Citrix XenServer with NVIDIA Tesla P4, P6, and P40 cards on Cisco UCS C240 M5 and B200 M5 servers with SPECviewperf 13.



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What you will learn

Using the increased processing power of today's Cisco UCS® B-Series Blade Servers and C-Series Rack Servers, applications with demanding graphics requirements are now being virtualized. To enhance the capability to deliver these high-performance and graphics-intensive applications in virtual client computing (VCC), Cisco offers support for the NVIDIA Tesla P4, P6, and P40 graphics cards in the Cisco Unified Computing System™ (Cisco UCS) portfolio of mezzanine form-factor and PCI Express (PCIe) cards for the Cisco UCS B-Series Blade Servers and C-Series Rack Servers, respectively.

With the availability of these new graphics processing capabilities, the engineering, design, imaging, and marketing departments of organizations can now experience the benefits that desktop virtualization brings to the applications they use. These new graphics capabilities help enable organizations to centralize their graphics workloads and data in the data center, facilitating collaboration across geographical boundaries.

A major focus of this document is the Cisco data center infrastructure and Citrix support for the NVIDIA virtual graphics processing unit (vGPU), including the capability of Citrix XenServer, through Citrix XenMotion, to move vGPU-enabled virtual machines from one host to another, reducing user downtime.

The purpose of this document is to help our partners and customers integrate NVIDIA GRID 6.2 software and NVIDIA Tesla graphics cards and Cisco UCS B200 M5 Blade Servers and C240 M5 Rack Servers with the Citrix XenServer 7.5 hypervisor and Citrix XenDesktop 7.15 desktop virtualization software using Microsoft Windows 10 virtual machines in vGPU mode.

Please contact our partners NVIDIA and Citrix for lists of applications that are supported by the cards, the hypervisor, and the desktop broker in each mode.

This document describes in detail how to integrate Cisco data center architecture using NVIDIA Tesla P4, P6, and P40 graphics cards with Citrix products so that the servers, hypervisor, and virtual desktops are ready for installation of high-performance graphics applications.

For the first time, we are using [SPECviewperf 13](#) to provide relative performance information in benchmark mode for NVIDIA Tesla graphics cards for the nine high-performance applications included in the tool. We also measured the impact of various frame buffer sizes (profiles) on the same card set. In all cases except one, the testing was performed in benchmark mode. The goal is to give readers a starting point to help them select the right card for their application environments.

vGPU profiles

In any given enterprise, the needs of individual users vary widely. One of the main benefits of the NVIDIA GRID software is the flexibility to use various vGPU profiles designed to serve the needs of different classes of end users.

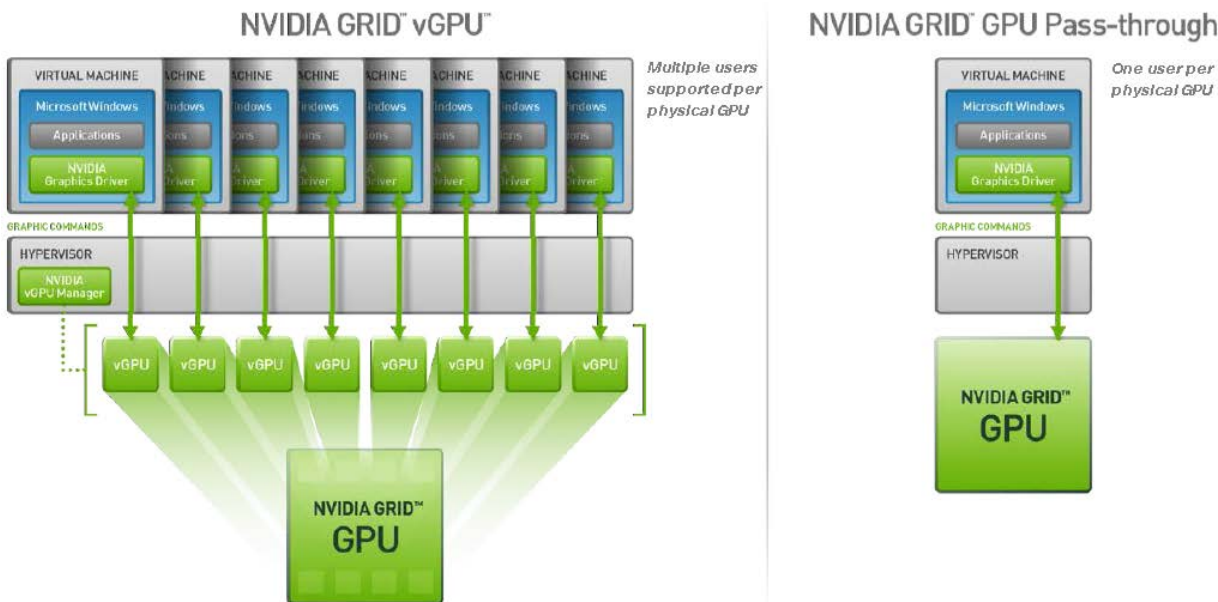
Although the needs of end users can be diverse, for simplicity users can be grouped into the following categories: knowledge workers, designers, and power users.

- For knowledge workers, the main areas of importance include 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 are users who need to run more demanding office applications, such as office productivity software, image editing software such as Adobe Photoshop, mainstream computer-aided design (CAD) software such as Autodesk AutoCAD, and product lifecycle management (PLM) applications. These applications are more demanding and require additional graphics resources with full support for APIs such as OpenGL and Direct3D.

- Designers are users in an organization who 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.

NVIDIA GRID vGPU profiles allow the GPU hardware to be time-sliced to deliver exceptional shared virtualized graphics performance (Figure 1).

Figure 1. NVIDIA GRID vGPU GPU system architecture



Cisco Unified Computing System

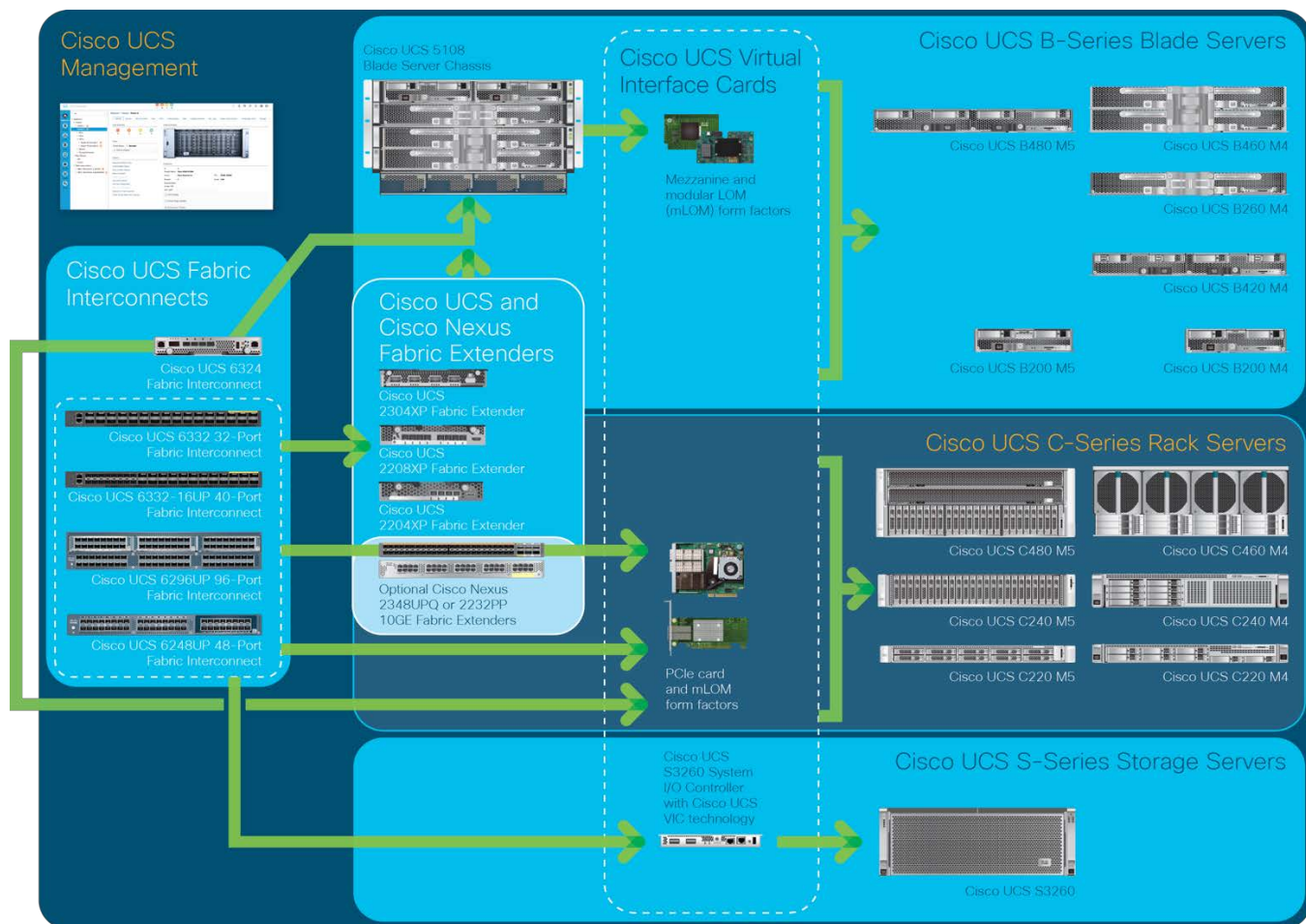
The main components of Cisco UCS are:

- **Computing:** The system is based on an entirely new class of computing system that incorporates blade servers based on Intel® Xeon® Scalable family processors.
- **Network:** The system is integrated on a low-latency, lossless, 40-Gbps unified network fabric. This network foundation consolidates LANs, SANs, and high-performance computing (HPC) networks, which are separate networks today. The unified fabric lowers costs by reducing the number of network adapters, switches, and cables needed and by decreasing the power and cooling requirements.
- **Virtualization:** The system unleashes the full potential of virtualization by enhancing the scalability, performance, and operational control of virtual environments. Cisco security, policy enforcement, and diagnostic features are now extended into virtualized environments to better support changing business and IT requirements.
- **Storage access:** The system provides consolidated access to local storage, SAN storage, and network-attached storage (NAS) over the unified fabric. With storage access unified, Cisco UCS can access storage over Ethernet, Fibre Channel, Fibre

Channel over Ethernet (FCoE), and Small Computer System Interface over IP (iSCSI) protocols. This capability provides customers with a choice for storage access and investment protection. In addition, server administrators can preassign storage-access policies for system connectivity to storage resources, simplifying storage connectivity and management and helping increase productivity.

- Management:** Cisco UCS uniquely integrates all system components, enabling the entire solution to be managed as a single entity by Cisco UCS Manager. The manager has an intuitive GUI, a command-line interface (CLI), and a robust API for managing all system configuration processes and operations. Figure 2 provides an overview of the Cisco® data center with Cisco UCS

Figure 2. Cisco data center overview



Cisco UCS is designed to deliver:

- Reduced total cost of ownership (TCO) and increased business agility
- Increased IT staff productivity through just-in-time provisioning and mobility support
- A cohesive, integrated system that unifies the technology in the data center; the system is managed, serviced, and tested as a whole

- Scalability through a design for hundreds of discrete servers and thousands of virtual machines and the capability to scale I/O bandwidth to match demand
- Industry standards supported by a partner ecosystem of industry leaders

Cisco UCS Manager provides unified, embedded management of all software and hardware components of the Cisco Unified Computing System across multiple chassis, rack servers, and thousands of virtual machines. Cisco UCS Manager manages Cisco UCS as a single entity through an intuitive GUI, a CLI, or an XML API for comprehensive access to all Cisco UCS Manager functions

Cisco UCS Manager

Cisco UCS Manager provides unified, embedded management of all software and hardware components of Cisco UCS through an intuitive GUI, a CLI, and an XML API. The manager provides a unified management domain with centralized management capabilities and can control multiple chassis and thousands of virtual machines. Tightly integrated Cisco UCS manager and NVIDIA GPU cards provides better management of firmware and graphics card configuration.

Cisco UCS 6332 Fabric Interconnect

The Cisco UCS 6332 Fabric Interconnect (Figure 3) is the management and communication backbone for Cisco UCS B-Series Blade Servers, C-Series Rack Servers, and 5100 Series Blade Server Chassis. All servers attached to 6332 Fabric Interconnects become part of one highly available management domain.

Because they support unified fabric, Cisco UCS 6300 Series Fabric Interconnects provide both LAN and SAN connectivity for all servers within their domains. For more details, see <https://www.cisco.com/c/dam/en/us/products/collateral/servers-unified-computing/ucs-b-series-blade-servers/6332-specsheet.pdf>.

Features and capabilities include:

- Bandwidth of up to 2.56-Tbps full-duplex throughput
- Thirty-two 40-Gbps QSFP+ ports in one 1 rack unit (RU)
- Support for four 10-Gbps breakout cables
- Ports capable of line-rate, low-latency, lossless 40 Gigabit Ethernet and FCoE
- Centralized unified management with Cisco UCS Manager
- Efficient cooling and serviceability

Figure 3. Cisco UCS 6332 Fabric Interconnect

Front View



Rear View



Cisco UCS C-Series Rack Servers

Cisco UCS C-Series Rack Servers keep pace with Intel Xeon processor innovation by offering the latest processors with an increase in processor frequency and improved security and availability features. With the increased performance provided by the [Intel Xeon Scalable processors](#), C-Series servers offer an improved price-to-performance ratio. They also extend Cisco UCS innovations to an industry-standard rack-mount form factor, including a standards-based unified network fabric, Cisco VN-Link virtualization support, and Cisco Extended Memory Technology.

Designed to operate both in standalone environments and as part of a Cisco UCS managed configuration, these servers enable organizations to deploy systems incrementally—using as many or as few servers as needed—on a schedule that best meets the organization’s timing and budget. C-Series servers offer investment protection through the capability to deploy them either as standalone servers or as part of Cisco UCS.

One compelling reason that many organizations prefer rack-mount servers is the wide range of I/O options available in the form of PCIe adapters. C-Series servers support a broad range of I/O options, including interfaces supported by Cisco as well as adapters from third parties.

Cisco UCS C240 M5 Rack Server

The Cisco UCS C240 M5 Rack Server (Figure 4, Figure 5, and Table 1) is designed for both performance and expandability over a wide range of storage-intensive infrastructure workloads, from big data to collaboration.

The Cisco UCS C240 M5 small-form-factor (SFF) server extends the capabilities of the Cisco UCS portfolio in a 2RU form factor with the addition of the Intel Xeon Scalable family processors, 24 DIMM slots for 2666-MHz DDR4 DIMMs and up to 128-GB capacity points, up to 6 PCIe 3.0 slots, and up to 26 internal SFF drives. The C240 M5 SFF server also includes one dedicated internal slot for a 12-Gbps SAS storage controller card. The C240 M5 server includes a dedicated internal modular LAN on motherboard (mLOM) slot for installation of a Cisco virtual interface card (VIC) or third-party network interface card (NIC), without consuming a PCI slot, in addition to 2 x 10GBASE-T Intel x550 LOM ports (embedded on the motherboard).

In addition, the C240 M5 offers outstanding levels of internal memory and storage expandability with exceptional performance. It delivers:

- Up to 24 DDR4 DIMMs at speeds of up to 2666 MHz for improved performance and lower power consumption
- One or two Intel Xeon processor scalable family CPUs
- Up to 6 PCIe 3.0 slots (4 full-height, full-length for GPU)
- Six hot-swappable fans for front-to-rear cooling
- 24 SFF front-facing SAS/SATA hard disk drives (HDDs) or SAS/SATA solid state disks (SSDs)
- Optionally, up to two front-facing SFF Non-Volatile Memory Express (NVMe) PCIe SSDs (replacing SAS/SATA drives); these drives must be placed in front drive bays 1 and 2 only and are controlled from Riser 2 option C
- Optionally, up to two SFF, rear-facing SAS/SATA HDDs or SSDs, or up to two rear-facing SFF NVMe PCIe SSDs, with rear-facing SFF NVMe drives connected from Riser 2, Option B or C; 12-Gbps SAS drives are also supported
- The dedicated mLOM slot on the motherboard can flexibly accommodate the following cards:
 - Cisco VICs
 - Quad-port Intel i350 1GbE RJ45 mLOM NIC
 - Two 1 Gigabit Ethernet embedded LOM ports
- Support for up to 2 double-wide NVIDIA GPUs, providing a graphics-rich experience to more virtual users
- Excellent reliability, availability, and serviceability (RAS) features with tool-free CPU insertion, easy-to-use latching lid, hot-swappable and hot-pluggable components
- One slot for a micro-SD card on PCIe Riser 1 (Option 1 and 1B); the micro-SD card serves as a dedicated local resource for utilities such as the Cisco Host Upgrade Utility (HUU), and images can be pulled from a file share (Network File System [NFS] or Common Internet File System [CIFS]) and uploaded to the cards for future use

A mini-storage module connector on the motherboard that supports either:

- An SD card module with two SD card slots; mixing of different capacity SD cards is not supported
- An M.2 module with two SATA M.2 SSD slots; mixing of different capacity M.2 modules is not supported

Note: SD cards and M.2 modules cannot be mixed. M.2 does not support RAID 1 with VMware. Only Microsoft Windows and Linux operating systems are supported.

The C240 M5 also increases performance and customer choice over many types of storage-intensive applications, such as:

- Collaboration
- Small and medium-sized business (SMB) databases
- Big data infrastructure
- Virtualization and consolidation
- Storage servers
- High-performance appliances

The C240 M5 can be deployed as a standalone server or as part of Cisco UCS. Cisco UCS unifies computing, networking, management, virtualization, and storage access into a single integrated architecture that enables end-to-end server visibility, management, and control in both bare-metal and virtualized environments. Within a Cisco UCS deployment, the C240 M5 takes

advantage of Cisco’s standards-based unified computing innovations, which significantly reduce customers’ TCO and increase business agility.

For more information about the Cisco UCS C240 M5 Rack Server, see

<https://www.cisco.com/c/dam/en/us/products/collateral/servers-unified-computing/ucs-c-series-rack-servers/c240m5-sff-specsheet.pdf>.

Figure 4. Cisco UCS C240 M5 Rack Server



Figure 5. Cisco UCS C240 M4 Rack Server rear view



Table 1. Cisco UCS C240 M4 PCIe slots

PCIe slot	Length	Lane
1	Half	x8
2	Full	x16
3	Half	x8
4	Half	x8
5	Full	x16
6	Full	x8

Cisco UCS VIC 1387

The Cisco UCS VIC 1387 (Figure 6) is a dual-port Enhanced Small Form-Factor Pluggable (SFP+) 40-Gbps Ethernet and FCoE-capable PCIe mLOM adapter installed in the Cisco UCS C-Series Rack Servers. The mLOM slot can be used to install a Cisco VIC without consuming a PCIe slot, which provides greater I/O expandability. It incorporates next-generation converged network adapter (CNA) technology from Cisco, providing investment protection for future feature releases. The card enables a policy-based, stateless, agile server infrastructure that can present more than 256 PCIe standards-compliant interfaces to the host that can be dynamically configured as either NICs or host bus adapters (HBAs). The personality of the card is determined dynamically at boot time using the service profile associated with the server. The number, type (NIC or HBA), identity (MAC address and World Wide

Name [WWN]), failover policy, bandwidth, and quality-of-service (QoS) policies of the PCIe interfaces are all determined using the service profile.

For more information about the VIC, see <https://www.cisco.com/c/en/us/products/interfaces-modules/ucs-virtual-interface-card-1387/index.html>.

Figure 6. Cisco UCS VIC 1387 CAN



Cisco UCS B200 M5 Blade Server

Delivering performance, versatility and density without compromise, the Cisco UCS B200 M5 Blade Server (Figure 7) addresses the broadest set of workloads, from IT and web infrastructure to distributed database workloads. The enterprise-class Cisco UCS B200 M5 blade server extends the capabilities of the Cisco UCS portfolio in a half-width blade form factor. The B200 M5 harnesses the power of the latest Intel Xeon Scalable processor family CPUs, with up to 3072 GB of RAM (using 128-GB DIMMs), two SSDs or HDDs, and connectivity with throughput of up to 80 Gbps.

The B200 M5 server mounts in a Cisco UCS 5100 Series Blade Server Chassis or Cisco UCS Mini blade server chassis. It has 24 slots for error-correcting code (ECC) registered DIMMs (RDIMMs) or load-reduced DIMMs (LR DIMMs). It supports one connector for the Cisco UCS VIC 1340 adapter, which provides Ethernet and FCoE.

The B200 M5 has one rear mezzanine adapter slot, which can be configured with a Cisco UCS port expander card for the VIC. This hardware option enables an additional four ports of the VIC 1340, bringing the total capability of the VIC 1340 to a dual native 40-Gbps interface or a dual 4 x 10 Gigabit Ethernet port-channel interface, respectively. Alternatively the same rear mezzanine adapter slot can be configured with an NVIDIA P6 GPU.

The B200 M5 has one front mezzanine slot. The B200 M5 can be ordered with or without the front mezzanine card. The front mezzanine card can accommodate a storage controller or an NVIDIA P6 GPU.

For more information, see <https://www.cisco.com/c/dam/en/us/products/collateral/servers-unified-computing/ucs-b-series-blade-servers/b200m5-specsheet.pdf>.

Figure 7. Cisco UCS B200 M5 Blade Server front view



Cisco UCS VIC 1340

The Cisco UCS VIC 1340 (Figure 8) is a 2-port 40-Gbps Ethernet or dual 4 x 10-Gbps Ethernet and FCoE-capable mLOM designed exclusively for the M4 generation of Cisco UCS B-Series Blade Servers. When used in combination with an optional port expander, the VIC 1340 is enabled for two ports of 40-Gbps Ethernet. The VIC 1340 enables a policy-based, stateless, agile server infrastructure that can present more than 256 PCIe standards-compliant interfaces to the host that can be dynamically configured as either NICs or HBAs. In addition, the VIC 1340 supports Cisco Virtual Machine Fabric Extender (VM-FEX) technology, which extends the Cisco UCS fabric interconnect ports to virtual machines, simplifying server virtualization deployment and management.

For more information, see <https://www.cisco.com/c/en/us/products/collateral/interfaces-modules/ucs-virtual-interface-card-1340/datasheet-c78-732517.html>.

Figure 8. Cisco UCS VIC 1340



NVIDIA Tesla graphics cards

For desktop virtualization applications, the NVIDIA Tesla P4, P6, and P40 cards are optimal choices for most high-performance graphics applications. Table 2 lists the technical specifications.

Table 2. Technical specifications for NVIDIA GRID cards



	P6	P4	P40
Number of GPUs	Single NVIDIA Pascal	Single NVIDIA Pascal	Single NVIDIA Pascal
NVIDIA Compute Unified Device Architecture (CUDA) cores	2048	2560	3840
Memory size	16 (1-GB profile)	8 (1-GB profile)	24 (1-GB profile)
Maximum number of vGPU instances	90 W	50 to 75W	250W
Power	75W	225W	250W
Form factor	Mobile PCIe Module (MXM), for blade servers, with x16 lanes	PCIe 3.0 single slot (low profile), for rack servers, with x16 lanes	PCIe 3.0 dual slot, for rack servers, with x16 lanes
Cooling solution	Bare board	Passive	Passive
H.264 1080p30 streams	24	24	24
Maximum number of users per board	16 (1-GB profile)	8 (1-GB profile)	24 (1-GB profile)
Virtualization use case	Blade optimized	Performance optimized	Performance optimized

NVIDIA GRID

NVIDIA GRID is the industry's most advanced technology for sharing GPUs across multiple virtual desktop and application instances. You can now use the full power of NVIDIA data center GPUs to deliver a superior virtual graphics experience to any device anywhere. The NVIDIA GRID platform offers the highest levels of performance, flexibility, manageability, and security—offering the right level of user experience for any virtual workflow.

For more information about NVIDIA GRID technology, see <http://www.nvidia.com/object/nvidia-grid.html>.

NVIDIA GRID 6.2 GPU

The NVIDIA GRID solution runs on Tesla GPUs based on NVIDIA Volta, NVIDIA Pascal, and NVIDIA Maxwell architectures. These GPUs come in two server form factors: the NVIDIA Tesla [P6](#) for blade servers and converged infrastructure, and the NVIDIA Tesla [P4](#) and [P40](#) for rack servers.

NVIDIA GRID 6.2 license requirements

NVIDIA GRID 6.2 requires concurrent user licenses and an on-premises NVIDIA license server to manage the licenses. When the guest OS boots, it contacts the NVIDIA license server and consumes one concurrent license. When the guest OS shuts down, the license is returned to the pool.

GRID 6.2 also requires the purchase of a 1:1 ratio of concurrent licenses to NVIDIA Support, Update, and Maintenance Subscription (SUMS) instances.

The following NVIDIA GRID products are available as licensed products on NVIDIA Tesla GPUs:

- Virtual workstation
- Virtual PC
- Virtual applications

For complete details about GRID 6.2 license requirements, see the [NVIDIA documentation](#).

Citrix XenServer 7.5

Citrix XenServer is a complete server virtualization platform from Citrix. The XenServer package contains all you need to create and manage a deployment of virtual x86 computers running on Citrix Xen, the open-source paravirtualizing hypervisor with near-native performance. XenServer is optimized for both Windows and Linux virtual servers.

XenServer 7 extends its leadership as the most mature hypervisor for virtual graphics capabilities, the hypervisor most integrated with Citrix XenApp and XenDesktop, and revolutionary security capabilities available only with XenServer.

The XenServer 7.5 platform offers mature graphics capabilities. XenServer is the only hypervisor to support live migration of GPU-enabled virtual machines with vGPU XenMotion at the time this document was written. vGPU XenMotion improves the user experience and administrative flexibility by enabling administrators to rebalance GPU-enabled virtual machines across pool hosts to improve virtual machine performance. vGPU XenMotion also enhances user productivity, enabling users to remain productive during unexpected maintenance operations.

Another feature of XenServer 7 is increased administrative flexibility. XenServer 7 offers new features that simplify snapshot lifecycle management, accelerate VMware vSphere migration, and greatly improve the administrative experience.

- Simplify administration with snapshot lifecycle management. Now you can easily schedule hourly, daily, weekly, or monthly snapshots for a group of virtual machines. The platform also aids in the management of your snapshot lifecycles. XenServer allows you to set the maximum number of snapshots to keep, deleting the oldest snapshot in a rolling fashion.
- Live-patch hosts without downtime, available only with XenServer. Live patching is an industry-first hypervisor capability brought to you with XenServer 7.1. It greatly reduces operational overhead by enabling IT administrators to hot-patch (update) their active XenServers without rebooting. This capability is not found on any other commercial hypervisor and has been used in production by a large cloud computing provider for months.
- Simplify administration and reduce overhead with new automated updates. Simplify patching at scale with new automated updates. XenServer now supports the automated application of fixes to multiple hosts. This new automated update technology batch-patches multiple hosts by automatically downloading the necessary fixes from Citrix, installing these patches in the correct order, and rebooting the hosts in sequence while redistributing virtual machines to prevent outages.
- Get greater migration flexibility with Linux virtual machine conversion. XenServer Conversion Manager now offers the capability to migrate Linux virtual machines from other hypervisors to XenServer. This feature offers greater migration flexibility for customers wanting to migrate from VMware solutions. Customers wanting to deliver secure Linux virtual desktops and applications from XenDesktop can avoid the vTax by using XenServer.
- Increase scalability and simplify administration with increased pool sizes. XenServer 7.5 quadruples the maximum pool size to 64 hosts. The benefits of deploying larger pools include fewer pools to manage, more flexible in-pool migration with shared

storage, more flexibility with high availability, and the need for fewer machine catalogs for large XenApp and XenDesktop deployments. This feature saves you time and administrative effort during your image update processes and ongoing maintenance.

- Extend XenApp and XenDesktop integration. XenServer 7 extends alignment with XenApp and XenDesktop release cycles, and the expanded XenServer Enterprise entitlement helps ensure that you can use unique application and desktop performance integrations available only with XenServer.
- Support the Microsoft Windows Continuum experience. With patent-pending technology from XenServer, XenDesktop is the only virtual desktop infrastructure (VDI) platform that enables the Windows Continuum experience with Windows 10 virtual desktops. XenDesktop allows Windows 10 virtual desktops to automatically toggle between tablet and desktop mode, in real-time, as the state of the hardware changes, to provide the most native Windows 10 experience.
- Accelerate Citrix Provisioning Services performance with XenServer. The new Provisioning Services (PVS) Accelerator technology results in up to 25 percent faster desktop boot times, up to 98 percent less network bandwidth use, and up to 93 percent less PVS CPU use. These capabilities are available only with XenServer.
- Enhance support with the first-ever long-term service release (LTSR), for XenServer 7.1. The XenServer LTSR enables up to 10 years of support (5 years of mainstream support and 5 years of extended support), making it the only hypervisor to have product lifecycle dates fully aligned with Citrix XenApp and XenDesktop, which can radically simplify infrastructure maintenance for customers choosing to deploy a full Citrix solution.
- Extend the benefits of XenServer Enterprise to all XenApp and XenDesktop deployments. XenApp and XenDesktop customers are now entitled to all the features of XenServer Enterprise edition, regardless of their XenApp and XenDesktop license type. Additionally, all editions of XenApp and XenDesktop are now entitled to features like such as Machine Creation Services (MCS) Accelerator technology, previously a platinum-only feature.

Graphics acceleration in Citrix XenDesktop and XenApp

Citrix HDX 3D Pro enables you to deliver the desktops and applications that perform best with a GPU for hardware acceleration, including 3D professional graphics applications based on OpenGL and DirectX. (The standard virtual delivery agent [VDA] supports GPU acceleration of DirectX only.)

Examples of 3D professional applications include:

- Computer-aided design (CAD), manufacturing (CAM), and engineering (CAE) applications
- Geographical information system (GIS) software
- Picture archiving and communication system (PACS) for medical imaging
- Applications using the latest OpenGL, DirectX, NVIDIA CUDA, and OpenCL versions
- Computationally intensive nongraphical applications that use CUDA GPUs for parallel computing

HDX 3D Pro provides an outstanding user experience over any bandwidth:

- On WAN connections: Delivers an interactive user experience over WAN connections with bandwidth as low as 1.5 Mbps
- On LAN connections: Delivers a user experience equivalent to that of a local desktop on LAN connections with bandwidth of 100 Mbps

You can replace complex and expensive workstations with simpler user devices by moving graphics processing into the data center for centralized management.

Citrix HDX 3D Pro provides GPU acceleration for Microsoft Windows desktops and Microsoft Windows Server. When used with VMware vSphere 6 and NVIDIA GRID GPUs, Citrix HDX 3D Pro provides vGPU acceleration for Windows desktops. For more information, see [Citrix Virtual GPU Solution](#).

GPU acceleration for Microsoft Windows desktops

With Citrix HDX 3D Pro, you can deliver graphics-intensive applications as part of hosted desktops or applications on desktop OS machines. HDX 3D Pro supports physical host computers (including desktop, blade, and rack workstations) and GPU pass-through and GPU virtualization technologies offered by VMware vSphere Hypervisor.

Using GPU pass-through, you can create virtual machines with exclusive access to dedicated graphics processing hardware. You can install multiple GPUs on the hypervisor and assign virtual machines to each of these GPUs on a one-to-one basis.

Using GPU virtualization, multiple virtual machines can directly access the graphics processing power of a single physical GPU. The true hardware GPU sharing provides desktops suitable for users with complex and demanding design requirements. GPU virtualization for NVIDIA Tesla cards use the same NVIDIA graphics drivers that are deployed on bare-metal operating systems with NVIDIA Quadro desktop and workstation cards.

HDX 3D Pro offers the following features:

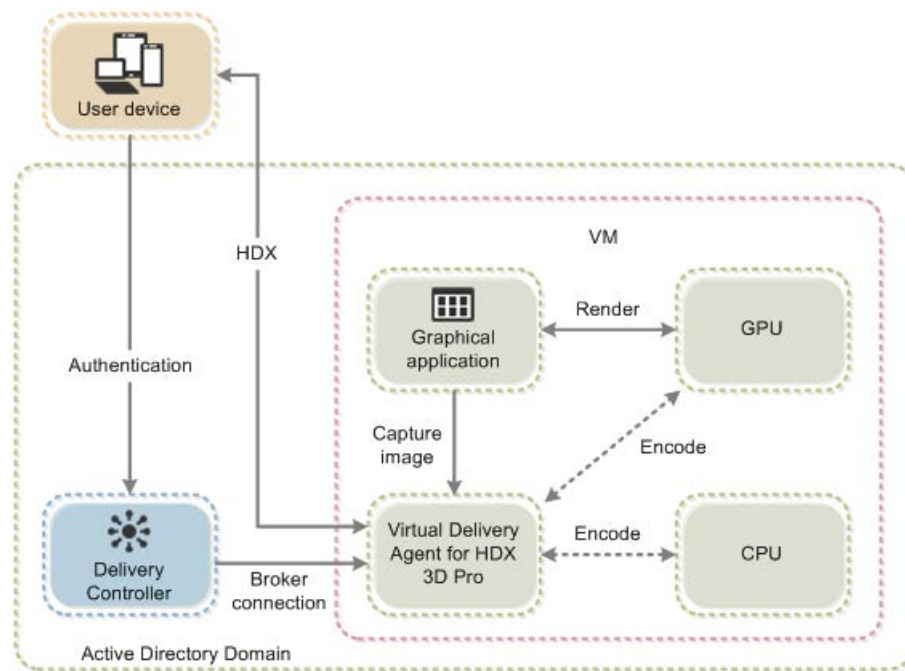
- Adaptive H.264-based deep compression for optimal WAN and wireless performance: Citrix HDX 3D Pro uses CPU-based full-screen H.264 compression as the default compression technique for encoding. Hardware encoding is used with NVIDIA cards that support NVIDIA NVENC.
- Lossless compression option for specialized use cases: Citrix HDX 3D Pro offers a CPU-based lossless codec to support applications that require pixel-perfect graphics, such as medical imaging. True lossless compression is recommended only for specialized use cases because it consumes significantly more network and processing resources.
 - When you use lossless compression, the lossless indicator, a system tray icon, shows the user whether the screen displayed is a lossy frame or a lossless frame. This information is helpful when the Visual Quality policy setting specifies a lossless build. The lossless indicator turns green when the frames sent are lossless.
 - The lossless switch enables the user to change to Always Lossless mode at any time in the session. To select or deselect Always Lossless at any time in a session, right-click the icon or use the shortcut Alt+Shift+1.
 - For lossless compression, Citrix HDX 3D Pro uses the lossless codec for compression regardless of the codec selected through policy.
 - For lossy compression, Citrix HDX 3D Pro uses the original codec: either the default or the one selected through policy.
 - Lossless switch settings are not retained for subsequent sessions. To use the lossless codec for every connection, select Always Lossless for the Visual Quality policy setting.
- Multiple and high-resolution monitor support: For Microsoft Windows 7 and 8 desktops, Citrix HDX 3D Pro supports user devices with up to four monitors. Users can arrange their monitors in any configuration and can mix monitors with different resolutions and orientations. The number of monitors is limited by the capabilities of the host computer GPU, the user device, and the available bandwidth. HDX 3D Pro supports all monitor resolutions and is limited only by the capabilities of the GPU on the host computer.
- Dynamic resolution: You can resize the virtual desktop or application window to any resolution.
- Support for VMware vSphere and ESX using virtual direct graphics acceleration (vDGA): You can use Citrix HDX 3D Pro with vDGA for both remote desktop service (RDS) and VDI workloads. When you use Citrix HDX 3D Pro with virtual shared graphics acceleration (vSGA), support is limited to one monitor. Use of vSGA with large 3D models can result in performance

problems because of its use of API-intercept technology. For more information, see VMware vSphere 5.1: Citrix Known Issues.

As shown in Figure 9,

- The host computer must reside in the same Microsoft Active Directory domain as the delivery controller.
- When a user logs on to Citrix Receiver and accesses the virtual application or desktop, the controller authenticates the user and contacts the VDA for Citrix HDX 3D Pro to broker a connection to the computer hosting the graphical application.
- The VDA for Citrix HDX 3D Pro uses the appropriate hardware on the host to compress views of the complete desktop or of just the graphical application.
- The desktop or application views and the user interactions with them are transmitted between the host computer and the user device through a direct HDX connection between Citrix Receiver and the VDA for HDX 3D Pro.

Figure 9. Citrix HDX 3D Pro process flow



GPU acceleration for Microsoft Windows Server

Citrix HDX 3D Pro allows graphics-intensive applications running in Microsoft Windows Server sessions to render on the server's GPU. With OpenGL, DirectX, Direct3D, and Windows Presentation Foundation (WPF) rendering moved to the server's GPU, the server's CPU is not slowed by graphics rendering. Additionally, the server can process more graphics because the workload is split between the CPU and the GPU.

GPU sharing for Citrix XenApp RDS workloads

RDS GPU sharing enables GPU hardware rendering of OpenGL and Microsoft DirectX applications in remote desktop sessions.

- Sharing can be used on bare-metal devices or virtual machines to increase application scalability and performance.
- Sharing enables multiple concurrent sessions to share GPU resources (most users do not require the rendering performance of a dedicated GPU).
- Sharing requires no special settings.

For DirectX applications, only one GPU is used by default. That GPU is shared by multiple users. The allocation of sessions across multiple GPUs with DirectX is experimental and requires registry changes. Contact Citrix Support for more information.

You can install multiple GPUs on a hypervisor and assign virtual machines to each of these GPUs on a one-to-one basis: either install a graphics card with more than one GPU, or install multiple graphics cards with one or more GPUs each. Mixing heterogeneous graphics cards on a server is not recommended.

Virtual machines require direct pass-through access to a GPU, which is available with Citrix XenServer, VMware vSphere vDGA, and Intel GVT-d. When Citrix HDX 3D Pro is used with GPU pass-through, each GPU in the server supports one multiuser virtual machine.

Scalability using RDS GPU sharing depends on several factors:

- The applications being run
- The amount of video RAM that the applications consume
- The graphics card's processing power

Some applications handle video RAM shortages better than others. If the hardware becomes extremely overloaded, the system may become unstable, or the graphics card driver may fail. Limit the number of concurrent users to avoid such problems.

To confirm that GPU acceleration is occurring, use a third-party tool such as GPU-Z. GPU-Z is available at <http://www.techpowerup.com/gpuz/>.

Citrix HDX 3D Pro requirements

The physical or virtual machine hosting the application can use GPU pass-through or vGPU:

- GPU pass-through is available with Citrix XenServer; VMware vSphere and ESX, where it is referred to as virtual direct graphics acceleration (vDGA); and Microsoft Hyper-V in Microsoft Windows Server 2016, where it is referred to as discrete device assignment (DDA).
- vGPU is available with Citrix XenServer and VMware vSphere; see <https://www.citrix.com/products/xenapp-xendesktop/hdx-3d-pro.html>.
- Citrix recommends that the host computer have at least 4 GB of RAM and four virtual CPUs with a clock speed of 2.3 GHz or higher.

The requirements for the GPU are as follows:

- For CPU-based compression (including lossless compression), Citrix HDX 3D Pro supports any display adapter on the host computer that is compatible with the application being delivered.
- For virtualized graphics acceleration using the NVIDIA GRID API, Citrix HDX 3D Pro can be used with supported GRID cards (see [NVIDIA GRID](#)). GRID delivers a high frame rate, resulting in a highly interactive user experience.
- Virtualized graphics acceleration is supported on the Intel Xeon processor E3 family data center graphics platform. For more information, see <http://www.citrix.com/intel> and <http://www.intel.com/content/www/us/en/servers/data-center-graphics.html>.

The requirements for the user device are as follows:

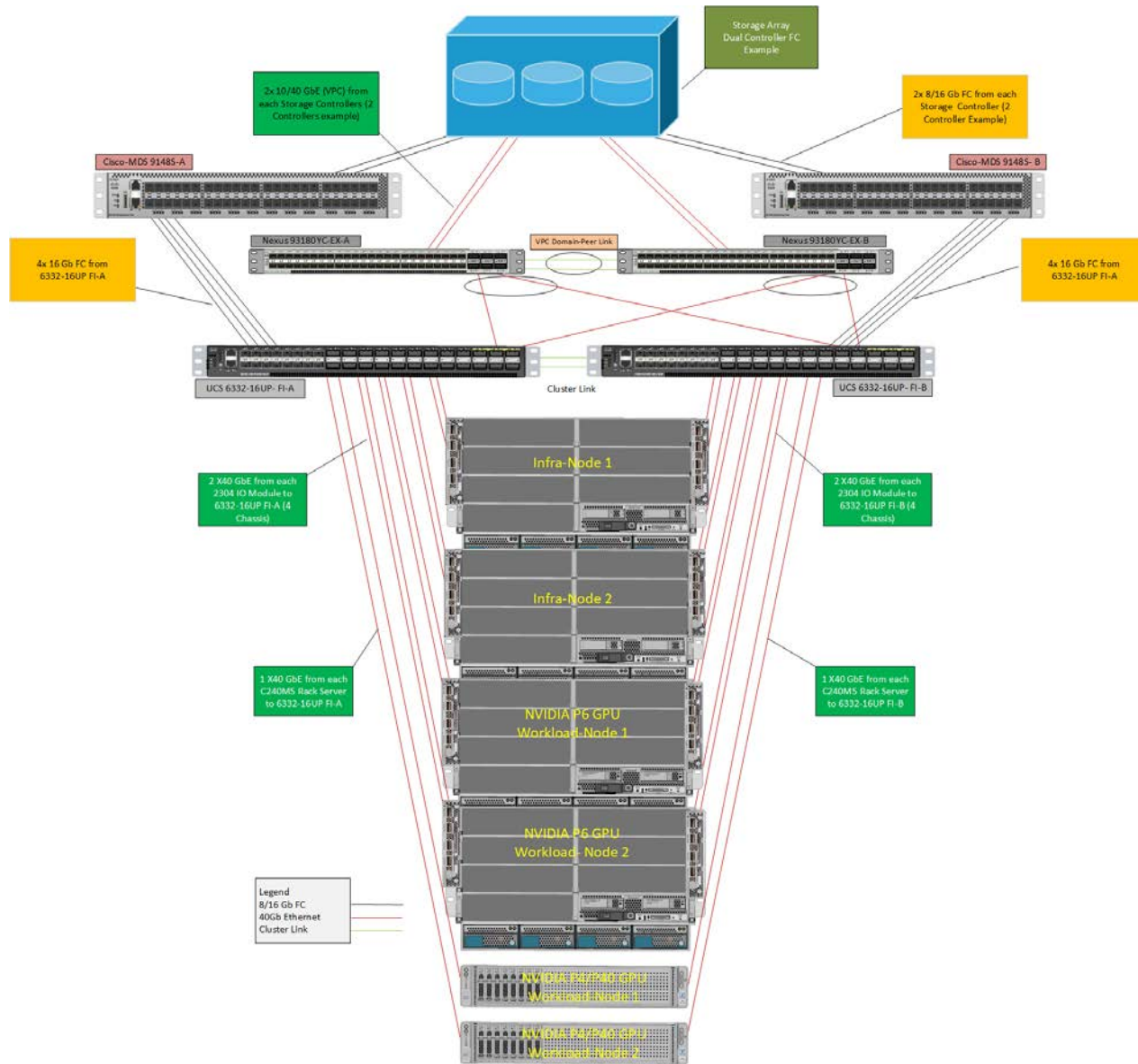
- Citrix HDX 3D Pro supports all monitor resolutions that are supported by the GPU on the host computer. However, for optimal performance with the minimum recommended user device and GPU specifications, Citrix recommends a maximum monitor resolution for user devices of 1920 x 1200 pixels for LAN connections, and 1280 x 1024 pixels for WAN connections.
- Citrix recommends that user devices have at least 1 GB of RAM and a CPU with a clock speed of 1.6 GHz or higher. Use of the default deep compression codec, which is required on low-bandwidth connections, requires a more powerful CPU unless the decoding is performed in hardware. For optimum performance, Citrix recommends that user devices have at least 2 GB of RAM and a dual-core CPU with a clock speed of 3 GHz or higher.
- For multiple-monitor access, Citrix recommends user devices with quad-core CPUs.
- User devices do not need a GPU to access desktops or applications delivered with HDX 3D Pro.
- Citrix Receiver must be installed.

For more information, see the Citrix HDX 3D Pro articles at Citrix HDX 3D Pro articles at <http://docs.citrix.com/en-us/xenapp-and-xendesktop/7-12/hdx/hdx-3d-pro.html> and <http://www.citrix.com/xenapp/3>.

Solution configuration

Figure 10 provides an overview of the physical connectivity configuration of the Cisco data center solution. This architecture was used to conduct NVIDIA Tesla graphic cards validation using SPECviewperf 13, Citrix XenDesktop HDX 3D Pro, and the XenServer hypervisor, and to create this document.

Figure 10. Cabling diagram for a Cisco data center with Cisco UCS



The hardware components in the solution are as follows:

- Cisco UCS B200 M5 Blade Servers with Intel Xeon Silver 4114 2.20-GHz 10-core processors and 768-GB 2666-MHz RAM for infrastructure
- Cisco UCS B200 M5 Blade Servers with Intel Xeon Gold 6140 2.30-GHz 18-core processors, 768-GB 2666-MHz RAM, and two NVIDIA Tesla P6 GPUs for graphics accelerated virtual client computing workloads
- Cisco UCS C240 M5 Rack Servers with Intel Xeon Gold 6140 2.30-GHz 18-core processors, 768-GB 2666-MHz RAM, and six NVIDIA Tesla P4 or P40 GPUs for graphics accelerated virtual client computing workloads
- Cisco UCS VIC 1387 mLOM (Cisco UCS C240 M5)
- Cisco UCS VIC 1340 mLOM (Cisco UCS B200 M5)
- Cisco Nexus® 93180YC-FX Switches in Cisco NX-OS mode for Layer 2 communications
- Cisco MDS 9148S 16G Multilayer Fabric Switch for Fibre Channel connectivity
- Customer choice of storage array capable of supporting the customer's intended workload

The software components of the solution are:

- Cisco UCS Firmware Release 3.2(3d)
- Citrix XenServer 7.5 for VDI hosts
- Citrix XenDesktop 7.15
- Microsoft Windows 10 64-bit
- Microsoft Server 2016
- SPECviewperf 13 graphics benchmark software and commercial license
- NVIDIA GRID 6.2 software and licenses:
 - NVIDIA-vGPU-xenserver-7.5-390.72.x86_64.rpm
 - 391.81_grid_win10_server2016_64bit_international

Configure Cisco UCS

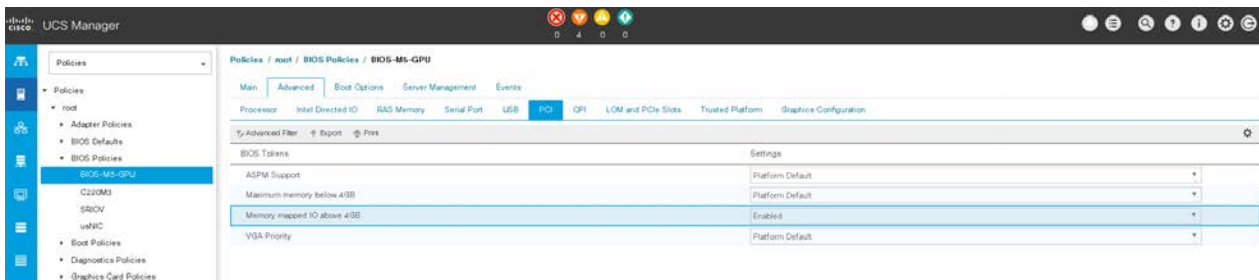
This section describes the Cisco UCS configuration.

Create BIOS policy

Create a new BIOS policy.

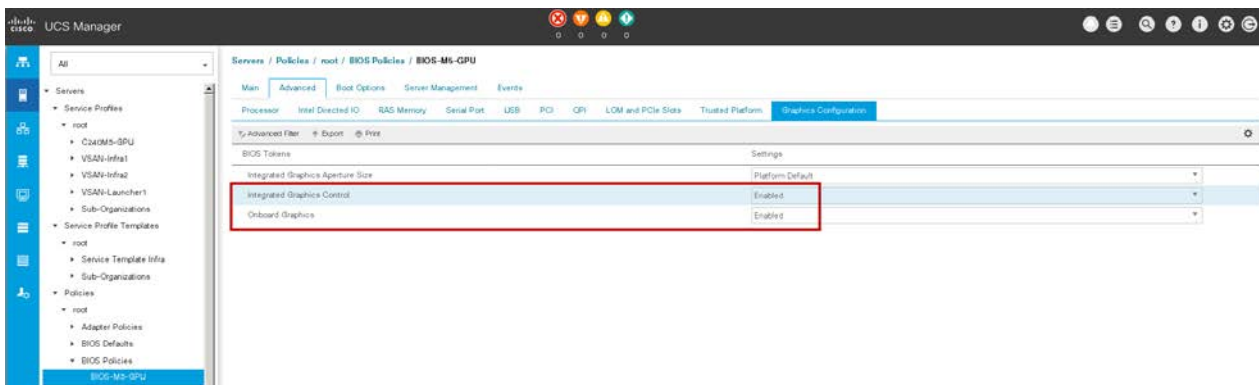
1. Right-click BIOS Policy. On the Advanced tab for the new BIOS policy
2. Click PCI. For Memory mapped IO above 4GB, choose Enabled (Figure 11).

Figure 11. PCI setting for BIOS Policy, Enable MMIO above 4GB



3. Click Graphics Configuration (Figure 12):
 - For Integrated Graphics Control, choose Enabled.
 - For Onboard Graphics, choose Enabled.

Figure 12. PCI BIOS policy configuration

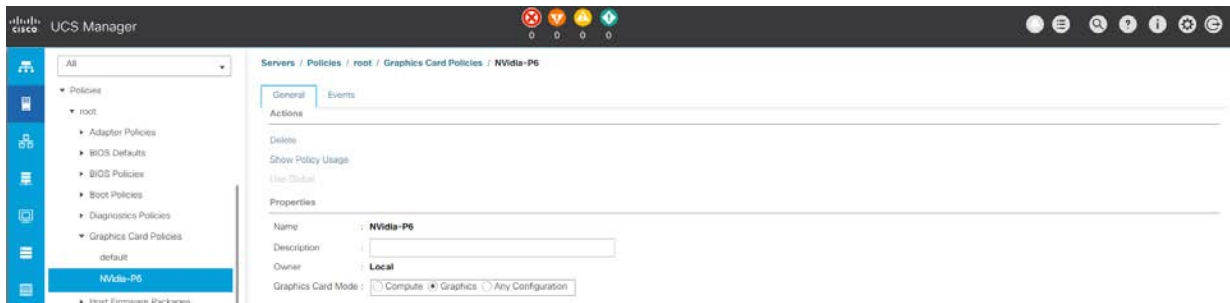


Create graphics card policy

Create a new graphics card policy with the preferred mode of graphics card.

For the VDI deployment described here, select Graphics mode (Figure 13).

Figure 13. Graphics card policy.



Install NVIDIA Tesla GPU card on Cisco UCS B200 M5

Install the NVIDIA Tesla GPU card on the Cisco UCS B200 M5 server using one of the methods described here.

Physically installing a P6 card in the Cisco UCS B200 M5 server

The NVIDIA P6 GPU card provides graphics and computing capabilities to the server. There are two supported versions of the NVIDIA P6 GPU card:

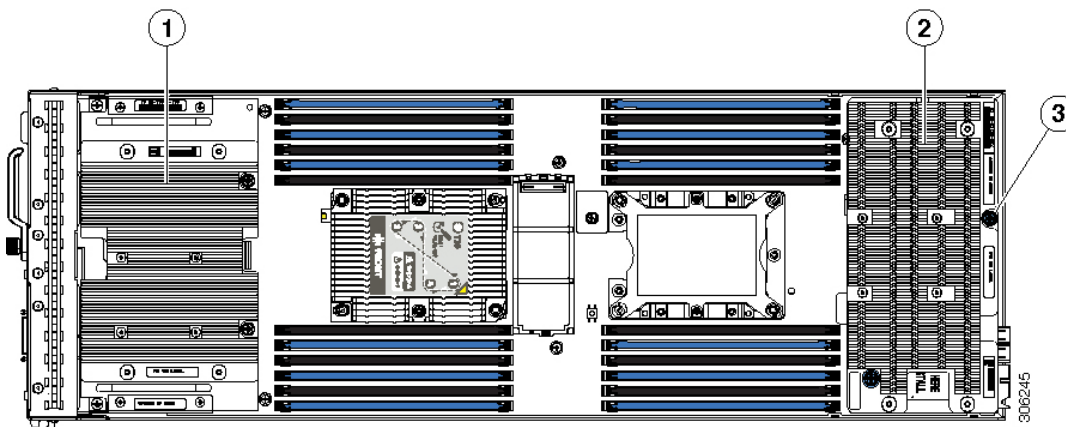
- The UCSB-GPU-P6-F card can be installed only in the front mezzanine slot of the server.

Note: No front mezzanine cards can be installed when the server has CPUs using greater than 165W.

- The UCSB-GPU-P6-R can be installed only in the rear mezzanine slot (slot 2) of the server.

Figure 14 shows the installed NVIDIA P6 GPU in the front and rear mezzanine slots.

Figure 14. NVIDIA GPU installed in the front and rear mezzanine slots

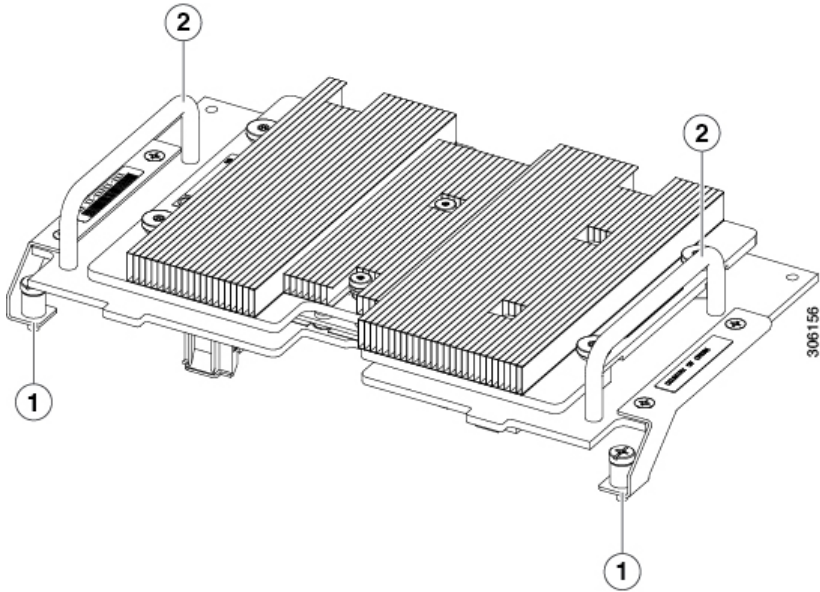


1	Front GPU	2	Rear GPU
3	Custom standoff screw	–	

Installing an NVIDIA GPU card in the front of the server

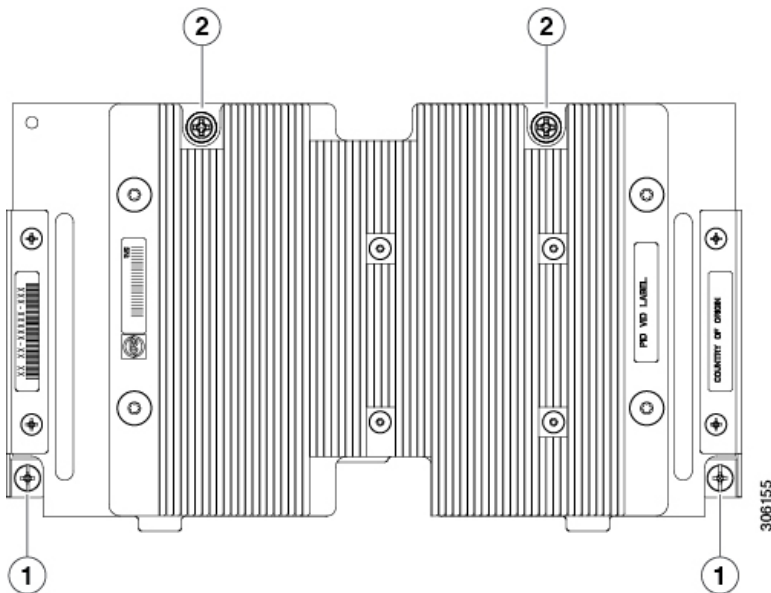
Figure 15 shows the front NVIDIA P6 GPU (UCSB-GPU-P6-F), and Figure 16 shows the top view.

Figure 15. NVIDIA P6 GPU that installs in the front of the server



1	Leg with thumb screw that attaches to the server motherboard at the front	2	Handle to press down on when installing the GPU
---	---	---	---

Figure 16. Top view of the NVIDIA P6 GPU for the front of the server



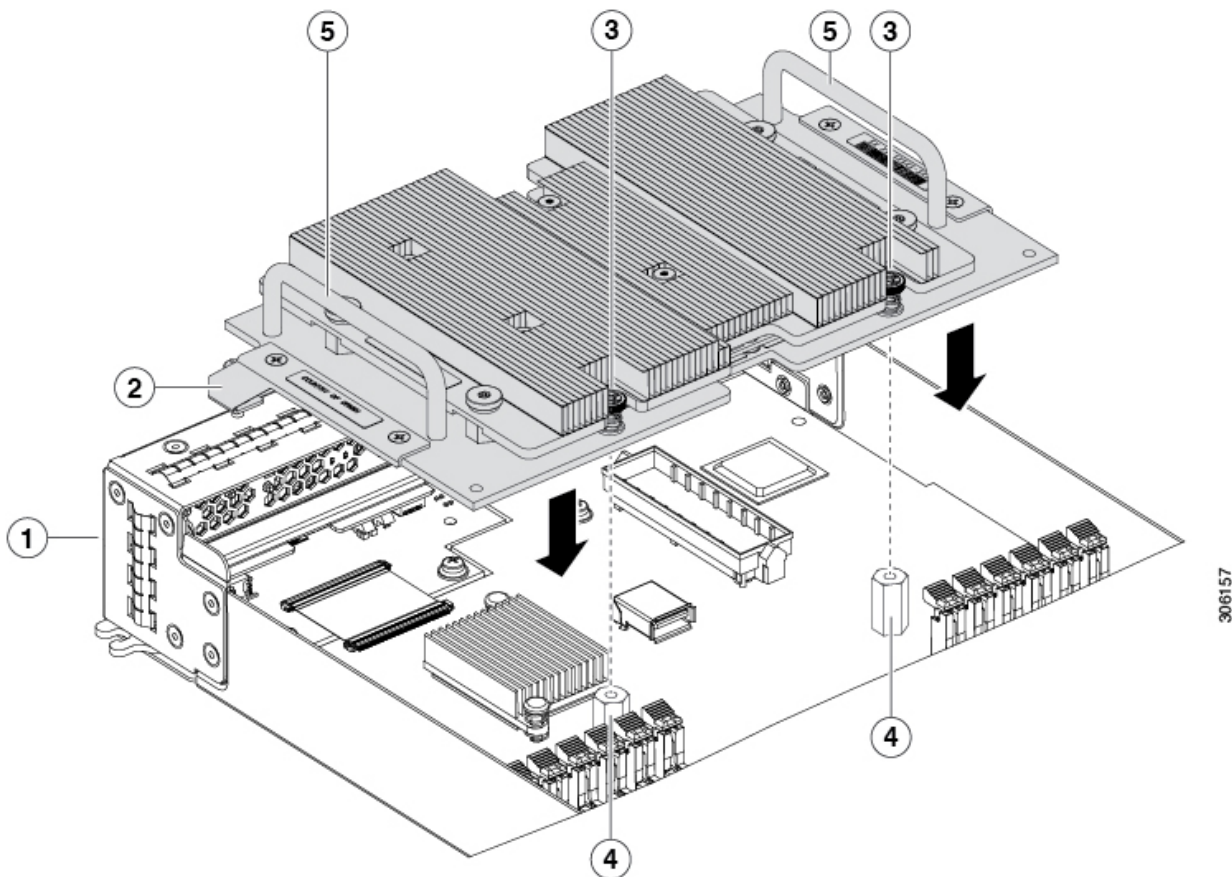
1	Leg with thumb screw that attaches to the server motherboard	2	Thumb screw that attaches to a standoff below
---	--	---	---

To install the NVIDIA P6 GPU, follow the steps presented here.

Note: Before installing the NVIDIA P6 GPU (UCSB-GPU-P6-F) in the front mezzanine slot, do the following:
 Upgrade the Cisco UCS domain that the GPU will be installed into to a version of Cisco UCS Manager that supports this card.
 Refer to the latest version of the release notes for Cisco UCS software for information about supported hardware:
<http://www.cisco.com/c/en/us/support/servers-unified-computing/ucs-manager/products-release-notes-list.html>.
 Remove the front mezzanine storage module if it is present. You cannot use the storage module in the front mezzanine slot when the NVIDIA P6 GPU is installed in the front of the server.

1. Position the GPU in the correct orientation relative to the front of the server (number 1) as shown in Figure 17.
2. Install the GPU in the server. Press down on the handles (number 5) to firmly secure the GPU.
3. Tighten the thumb screws (number 3) at the back of the GPU with the standoffs (number 4) on the motherboard.
4. Tighten the thumb screws on the legs (number 2) of the motherboard.
5. Install the drive blanking panels.

Figure 17. Installing the NVIDIA GPU in the front of the server

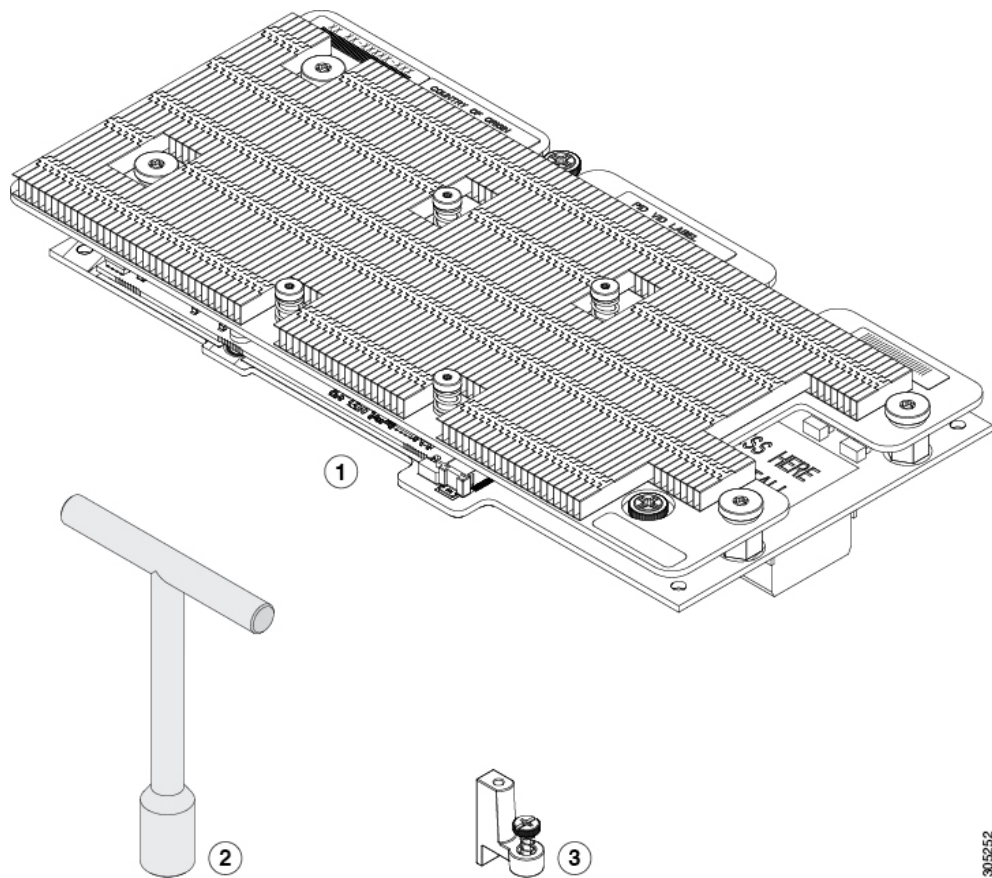


1	Front of the server	2	Leg with thumb screw that attaches to the motherboard
3	Thumbscrew to attach to standoff below	4	Standoff on the motherboard
5	Handle to press down on to firmly install the GPU	–	

Installing an NVIDIA GPU card in the rear of the server

If you are installing the UCSB-GPU-P6-R on a server in the field, the option kit comes with the GPU itself (CPU and heat sink), a T-shaped installation wrench, and a custom standoff to support and attach the GPU to the motherboard. Figure 18 shows the three components of the option kit.

Figure 18. NVIDIA P6 GPU (UCSB-GPU-P6-R) option kit



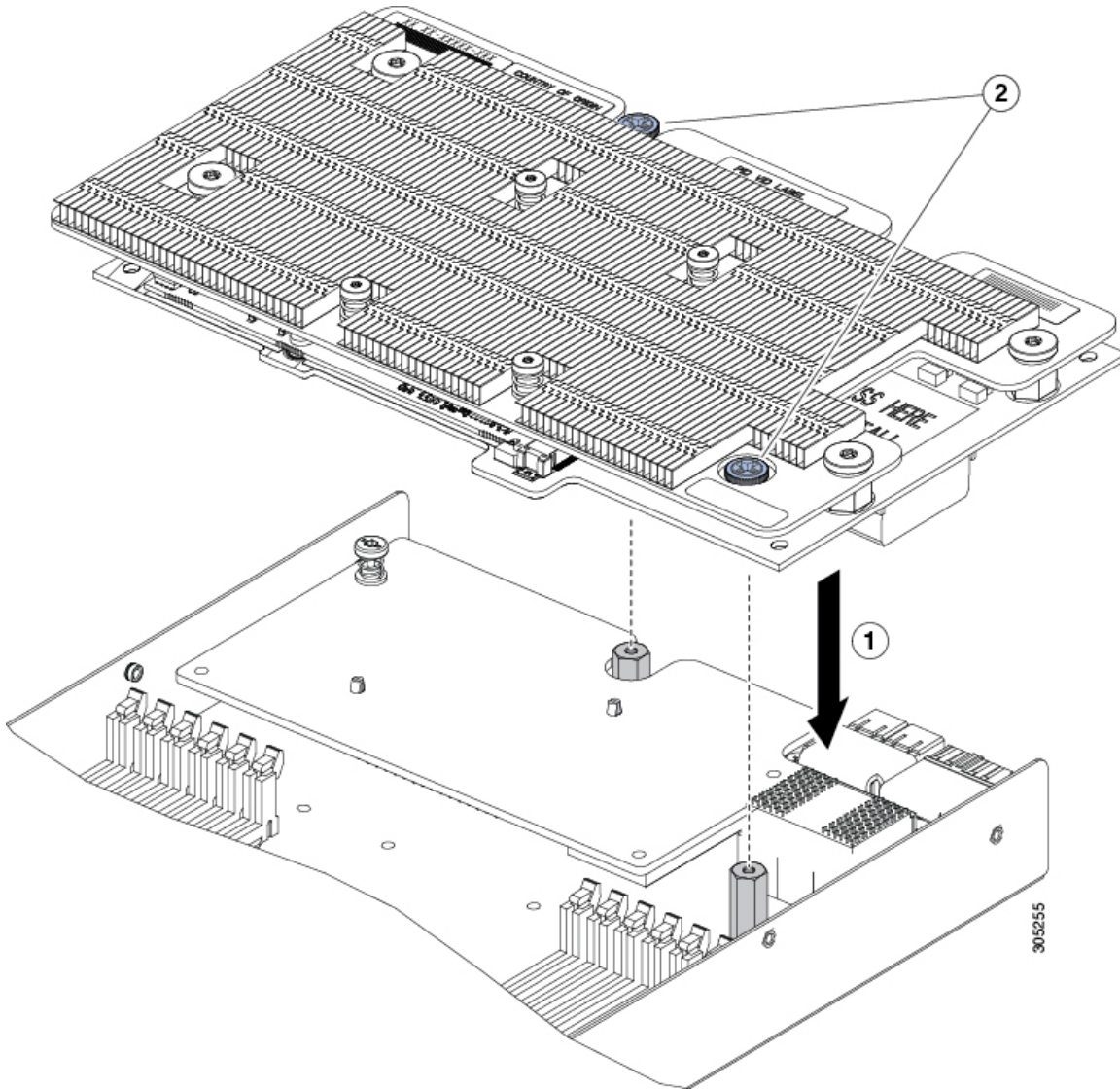
1	NVIDIA P6 GPU (CPU and heat sink)	2	T-shaped wrench
3	Custom standoff	-	

Note: Before installing the NVIDIA P6 GPU (UCSB-GPU-P6-R) in the rear mezzanine slot, do the following:
 Upgrade the Cisco UCS domain that the GPU will be installed into to a version of Cisco UCS Manager that supports this card. Refer to the latest version of the release notes for Cisco UCS software for information about supported hardware: <http://www.cisco.com/c/en/us/support/servers-unified-computing/ucs-manager/products-release-notes-list.html>.
 Remove any other card, such as a VIC 1480, VIC 1380, or VIC port expander card, from the rear mezzanine slot. You cannot use any other card in the rear mezzanine slot when the NVIDIA P6 GPU is installed.

1. Use the T-shaped wrench that comes with the GPU to remove the existing standoff at the back end of the motherboard.
2. Install the custom standoff in the same location at the back end of the motherboard (Figure 19).

3. Position the GPU over the connector on the motherboard and align all the captive screws with the standoff posts (number 1).
4. Tighten the captive screws (number 2).

Figure 19. Installing the NVIDIA P6 GPU in the rear mezzanine slot



Install the NVIDIA Tesla GPU card on the Cisco UCS C240 M5

Install the NVIDIA Tesla GPU card on the Cisco UCS C240 M5 server as described here.

Physically installing an NVIDIA Tesla P4 card

Use the following procedure to install NVIDIA Tesla P4:

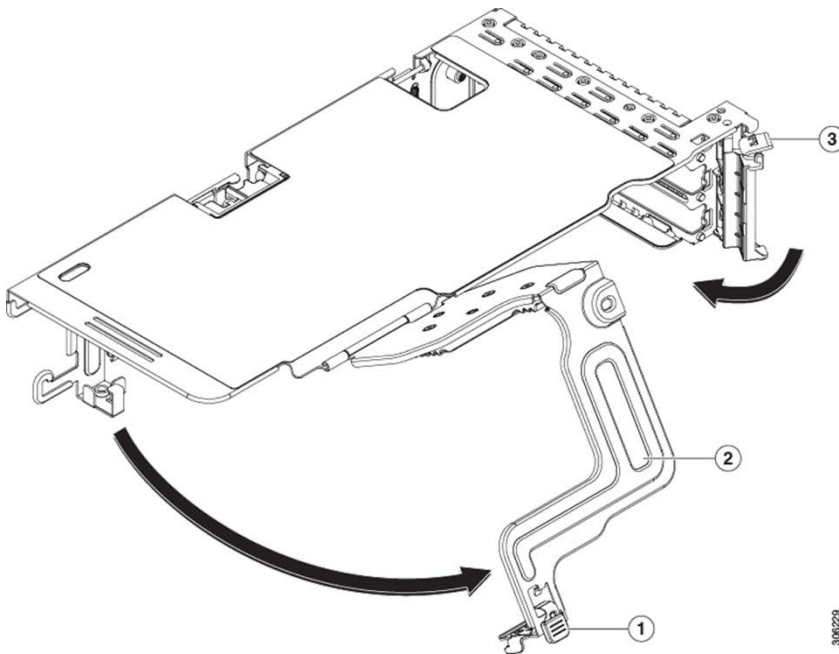
Note: This server can support up to six single-wide NVIDIA Tesla P4 GPU cards. These half-height, half-length (HHHL) GPU cards are supported in all PCIe slots.

1. Shut down and remove power from the server.
2. Slide the server out the front of the rack far enough so that you can remove the top cover. You may have to detach cables from the rear panel to provide clearance.
3. Remove the top cover from the server.
4. Install a new single-wide GPU card (Figure 20):

Note: Up to six single-wide GPU cards are supported in the PCIe slots.

- a. With the hinged card-tab retainer open, align the new single-wide GPU card with the empty socket on the PCIe riser.
 - b. Push down evenly on both ends of the card until it is fully seated in the socket.
 - c. Verify that the card's rear panel tab sits flat against the riser rear-panel opening and then close the hinged card-tab retainer over the card's rear-panel tab.
 - d. Swing the hinged securing plate closed on the bottom of the riser. Verify that the clip on the plate clicks into the locked position.
 - e. Position the PCIe riser over its socket on the motherboard and over the chassis alignment channels.
 - f. Carefully push down on both ends of the PCIe riser to fully engage its connector with the sockets on the motherboard.
5. Replace the top cover to the server.
 6. Replace the server in the rack, replace cables, and then fully power on the server by pressing the Power button.

Figure 20. PCIe riser card securing mechanism



1	Release latch on hinged securing plate	2	Hinged card-tab retainer
3	Hinged securing plate	–	

Installing a double-wide GPU card

Use the following procedure to install NVIDIA Tesla P40 card:

1. Shut down and remove power from the server.
2. Slide the server out the front of the rack far enough so that you can remove the top cover. You may have to detach cables from the rear panel to provide clearance.

Note: If you cannot safely view and access the component, remove the server from the rack.

3. Remove the top cover from the server.
4. Install a new GPU card:

Note: Observe the configuration rules for this server, as described in [GPU Card Configuration Rules](#).

- a. Align the GPU card with the socket on the riser, and then gently push the card’s edge connector into the socket. Press evenly on both corners of the card to avoid damaging the connector.
- b. Connect the GPU power cable. The straight power cable connectors are color-coded. Connect the cable's black connector into the black connector on the GPU card and the cable's white connector into the white GPU POWER connector on the PCIe riser.

Note: Do not reverse the straight power cable. Connect the black connector on the cable to the black connector on the GPU card. Connect the white connector on the cable to the white connector on the PCIe riser.

- c. Close the card-tab retainer over the end of the card.

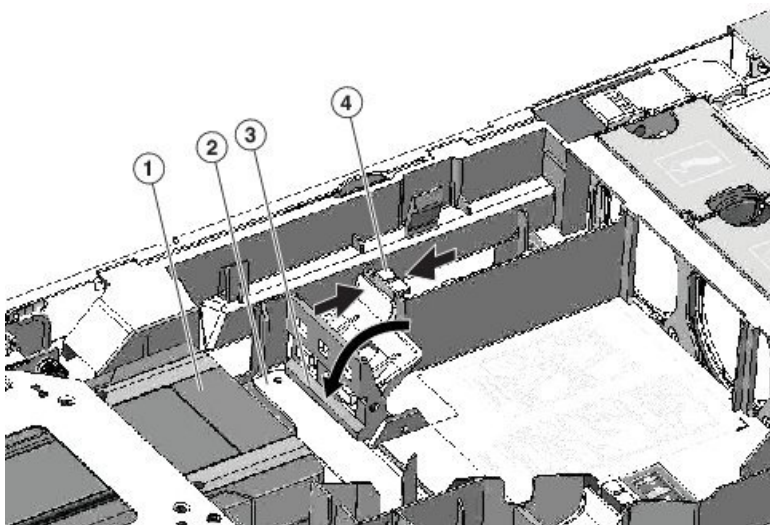
- d. Swing the hinged securing plate closed on the bottom of the riser. Verify that the clip on the plate clicks into the locked position.
- e. Position the PCIe riser over its socket on the motherboard and over the chassis alignment channels.
- f. Carefully push down on both ends of the PCIe riser to fully engage its connector with the sockets on the motherboard.
- g. At the same time, align the GPU front support bracket (on the front end of the GPU card) with the securing latch that is on the server's air baffle.
- h. Insert the GPU front support bracket into the latch that is on the air baffle (Figure 21):

Pinch the latch release tab and hinge the latch toward the front of the server.

Hinge the latch back down so that its lip closes over the edge of the GPU front support bracket.

Verify that the latch release tab clicks and locks the latch in place.

Figure 21. GPU front support bracket inserted into securing latch on air baffle



1	Front end of GPU card	2	GPU front support bracket
3	Lip on securing latch	4	Securing latch release tab

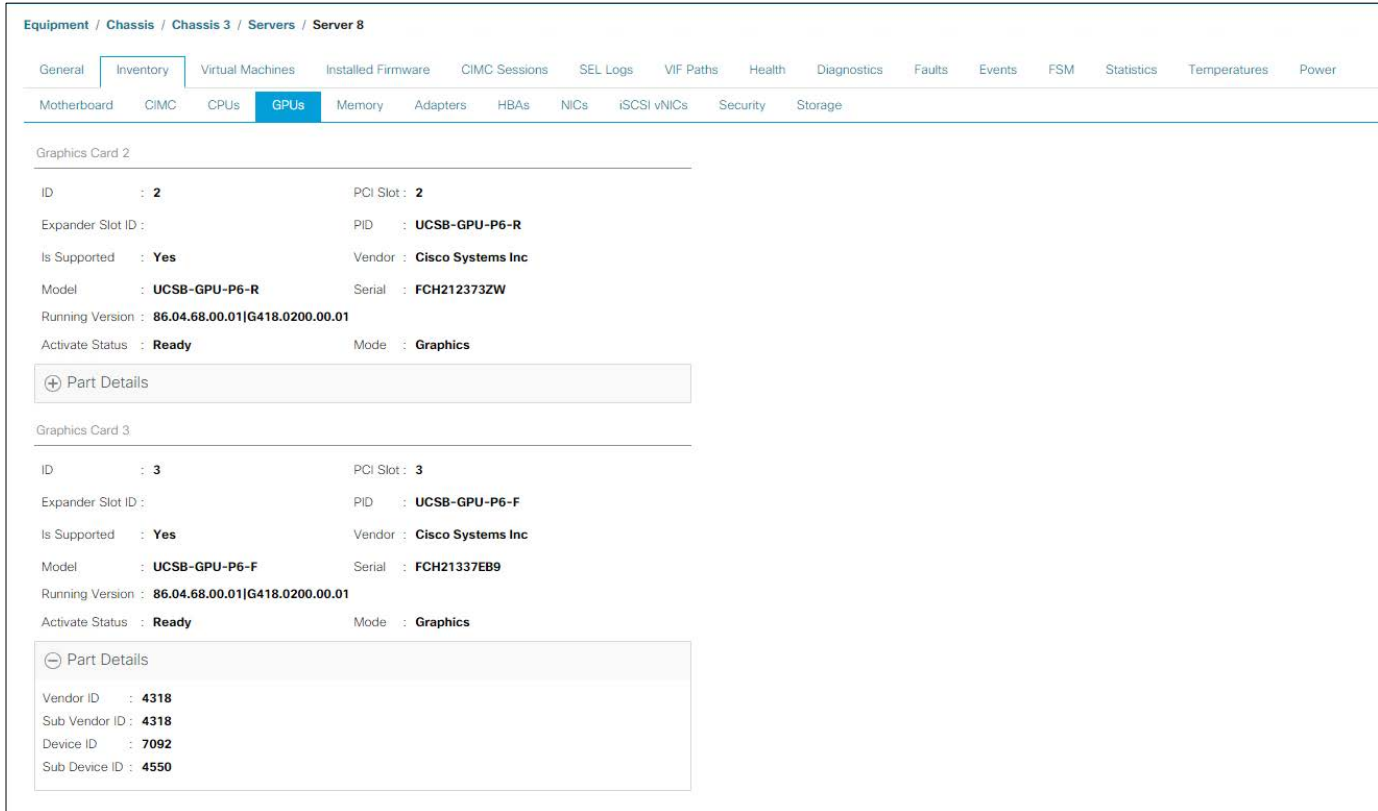
- 5. Replace the top cover to the server.
- 6. Replace the server in the rack, replace cables, and then fully power on the server by pressing the Power button.

Configure the GPU card

Follow these steps to configure the GPU card:

1. After the NVIDIA P6 GPU cards are physically installed and the Cisco UCS B200 M5 Blade Server is discovered in Cisco UCS Manager, select the server and choose Inventory > GPUs. As shown in Figure 22, PCIe slots 2 and 3 are used with two GRID P6 cards.

Figure 22. NVIDIA GRID P6 card inventory displayed in Cisco UCS Manager



The screenshot shows the Cisco UCS Manager interface for a server. The breadcrumb path is **Equipment / Chassis / Chassis 3 / Servers / Server 8**. The **Inventory** tab is selected, and the **GPUs** sub-tab is active. Two GPU cards are listed:

- Graphics Card 2:**
 - ID: 2, PCI Slot: 2
 - Expander Slot ID: (blank), PID: UCSB-GPU-P6-R
 - Is Supported: Yes, Vendor: Cisco Systems Inc
 - Model: UCSB-GPU-P6-R, Serial: FCH212373ZW
 - Running Version: 86.04.68.00.01|G418.0200.00.01
 - Activate Status: Ready, Mode: Graphics
- Graphics Card 3:**
 - ID: 3, PCI Slot: 3
 - Expander Slot ID: (blank), PID: UCSB-GPU-P6-F
 - Is Supported: Yes, Vendor: Cisco Systems Inc
 - Model: UCSB-GPU-P6-F, Serial: FCH21337EB9
 - Running Version: 86.04.68.00.01|G418.0200.00.01
 - Activate Status: Ready, Mode: Graphics

Below the details for Graphics Card 3, a **Part Details** section is expanded, showing:

- Vendor ID: 4318
- Sub Vendor ID: 4318
- Device ID: 7092
- Sub Device ID: 4550

2. After the NVIDIA P4 GPU cards are physically installed and the Cisco UCS C240 M5 Rack Server is discovered in Cisco UCS Manager, select the server and choose Inventory > GPUs. As shown in Figure 23, PCIe slots 1 through 6 are used with six GRID P4 cards.

Figure 23. NVIDIA GRID P4 card inventory displayed in Cisco UCS Manager

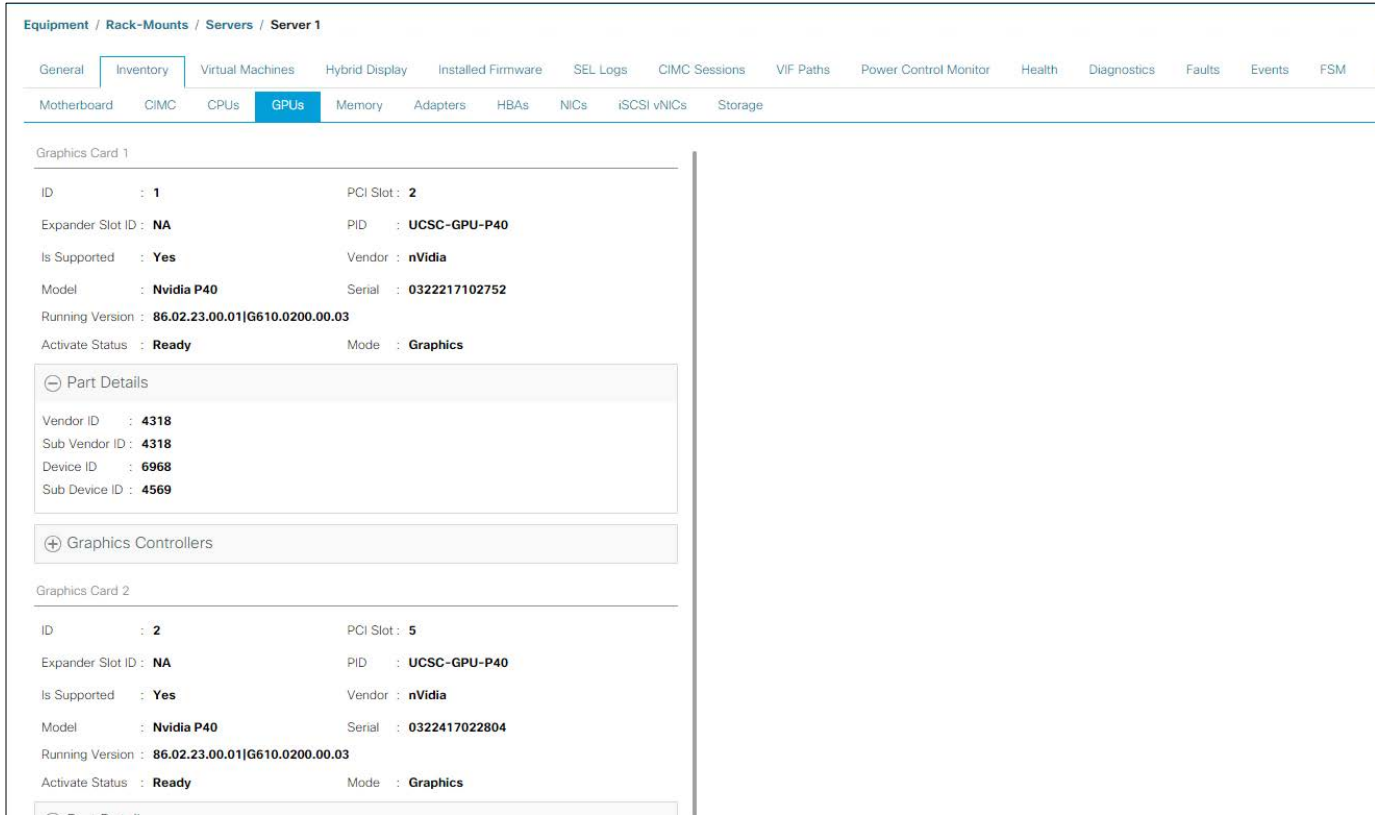
The screenshot shows the Cisco UCS Manager interface for a server. The breadcrumb trail is 'Equipment / Rack-Mounts / Servers / Server 2'. The 'Inventory' tab is active, and the 'GPUs' sub-tab is selected. The interface displays two graphics cards:

- Graphics Card 1:**
 - ID: 1, PCI Slot: 1
 - Expander Slot ID: NA, PID: UCSC-GPU-P4
 - Is Supported: Yes, Vendor: nVidia
 - Model: Nvidia P4, Serial: 0322717109959
 - Running Version: 86.04.55.00.01|G414.0200.00.03
 - Activate Status: Ready, Mode: Graphics
- Graphics Card 2:**
 - ID: 2, PCI Slot: 2
 - Expander Slot ID: NA, PID: UCSC-GPU-P4
 - Is Supported: Yes, Vendor: nVidia
 - Model: Nvidia P4, Serial: 0322717109949
 - Running Version: 86.04.55.00.01|G414.0200.00.03
 - Activate Status: Ready, Mode: Graphics

Below the card details, there are sections for 'Part Details' (Vendor ID: 4318, Sub Vendor ID: 4318, Device ID: 7091, Sub Device ID: 4568) and 'Graphics Controllers'.

- After the NVIDIA P40 GPU card is physically installed and the Cisco UCS C240 M5 Rack Server is discovered in Cisco UCS Manager, select the server and choose Inventory > GPUs. As shown in Figure 24, PCIe slot 2 and slot 5 is used with the two GRID P40 card.

Figure 24. NVIDIA GRID P40 card inventory displayed in Cisco UCS Manager



You can use Cisco UCS Manager to perform firmware upgrades to the NVIDIA GPU cards in managed Cisco UCS C240 M5 servers.

Install Citrix XenServer and XenCenter 7.5

XenServer installation media is available for download from the [XenServer Downloads](#) page.

Installers for both the XenServer host and XenCenter are located on the installation media. The installation media also includes the Readme First file, which provides descriptions of and links to helpful resources, including product documentation for XenServer and XenServer components.

You should install:

- XenServer 7.5 Base Installation ISO
- XenCenter 7.5 Windows Management Console

Note: Refer to the XenServer Installation Guide on the [Citrix Product Documentation](#) website for comprehensive details about XenServer and XenCenter installation and licensing.

Install Citrix XenServer

To install XenServer on a remote disk on a NetApp with multipathing enabled, follow these steps:

1. Boot the computer from the installation CD.
2. On the Welcome to XenServer screen, press F2.
3. At the boot prompt, enter multipath (Figure 25). This procedure configures the XenServer host, which boots from a logical unit number (LUN) with multipathing enabled.

Figure 25. XenServer installation welcome screen



4. Follow the prompts to advance through the installation process, create a management interface on the storage management VLAN, VLAN 60 (Figure 26), and choose a LUN as the primary disk for the installation (Figure 27). Then click Ok.

Figure 26. XenServer installation: Networking

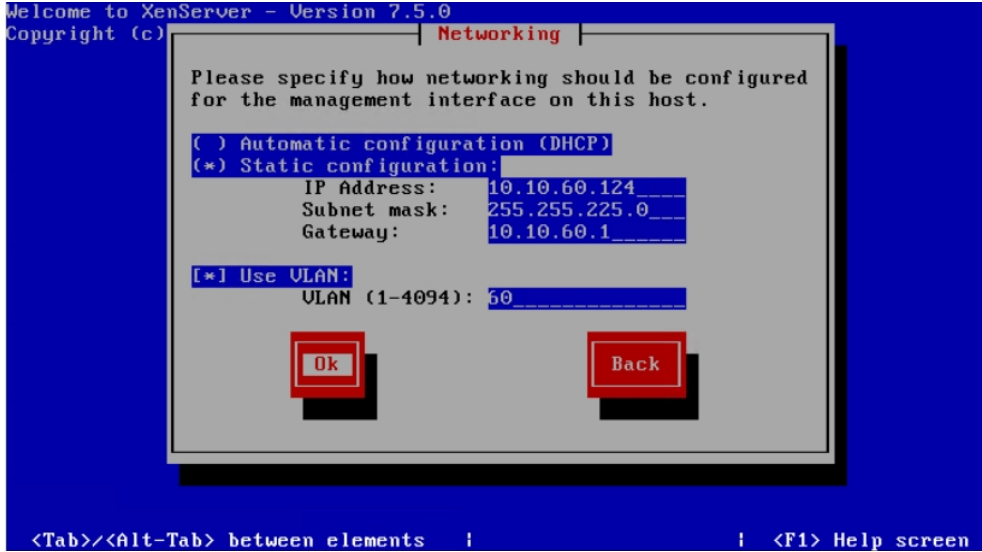
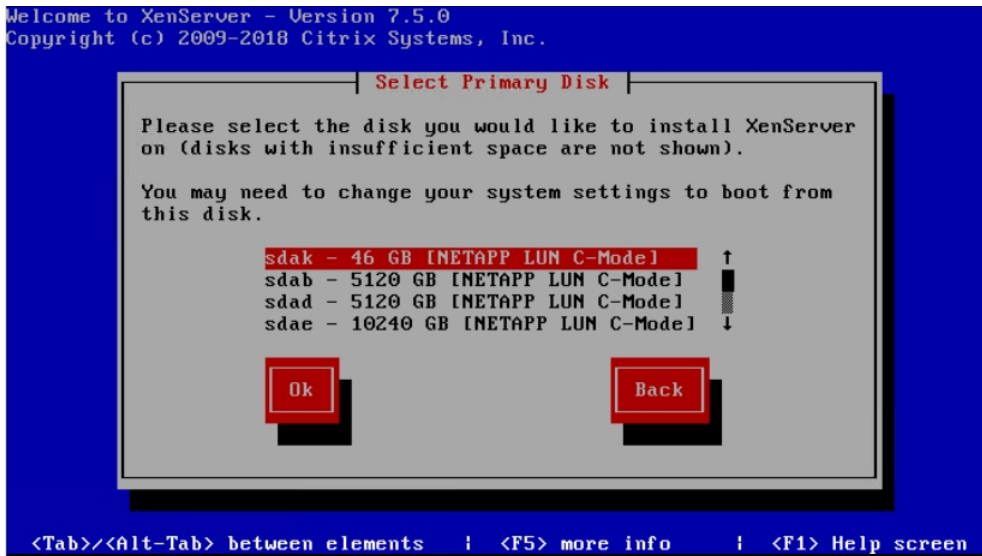
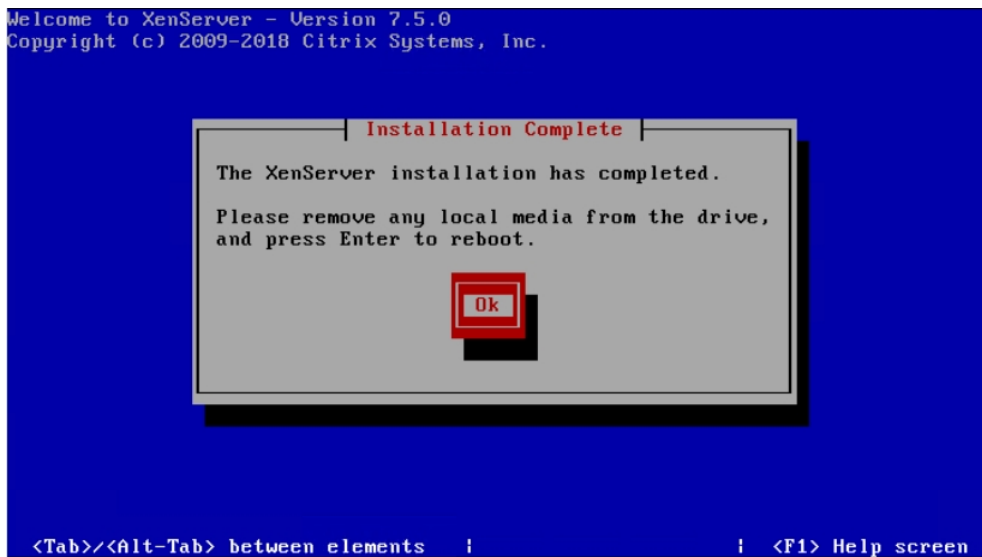


Figure 27. XenServer installation: Select Primary Disk



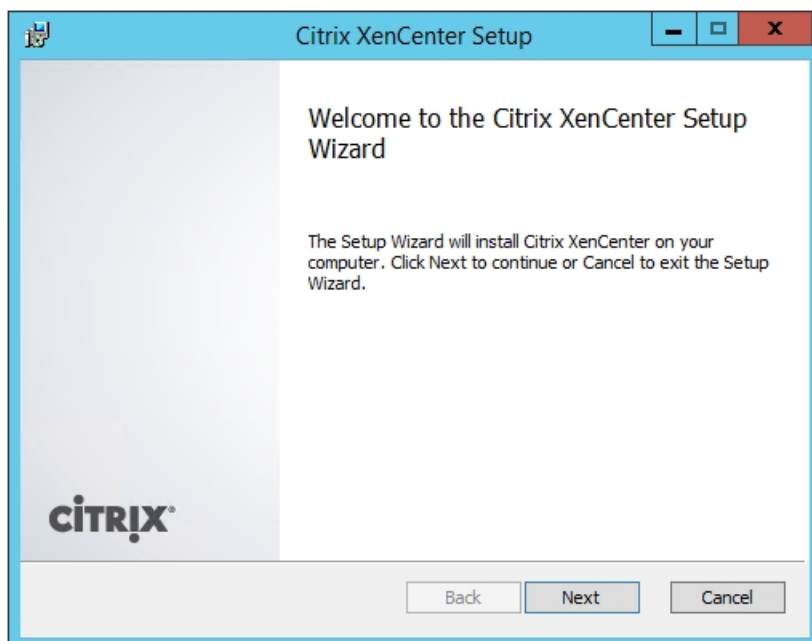
5. On the Installation Complete screen, click Ok to reboot the server (Figure 28).

Figure 28. XenServer installation: Installation Complete



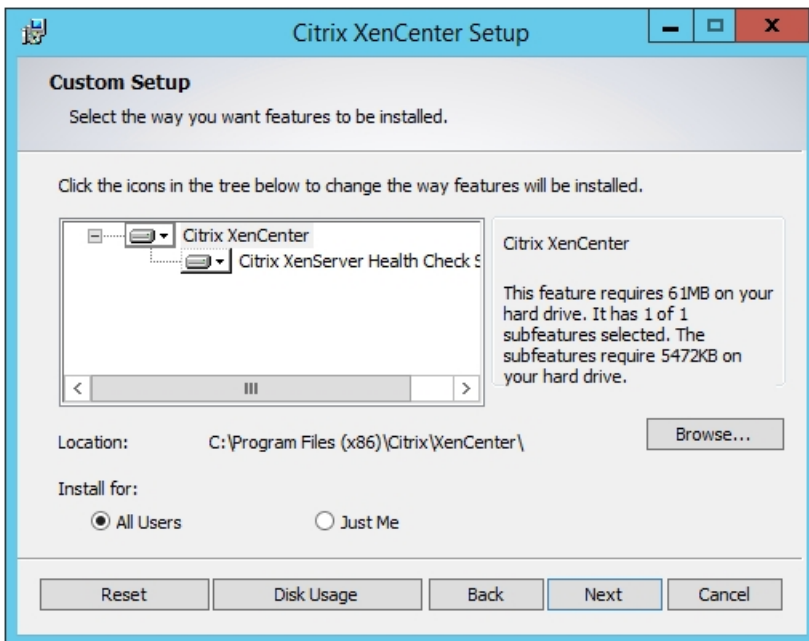
6. The XenCenter installation media is bundled with the XenServer installation media. Launch the installer and follow the setup wizard (Figure 29).

Figure 29. Launch the setup wizard



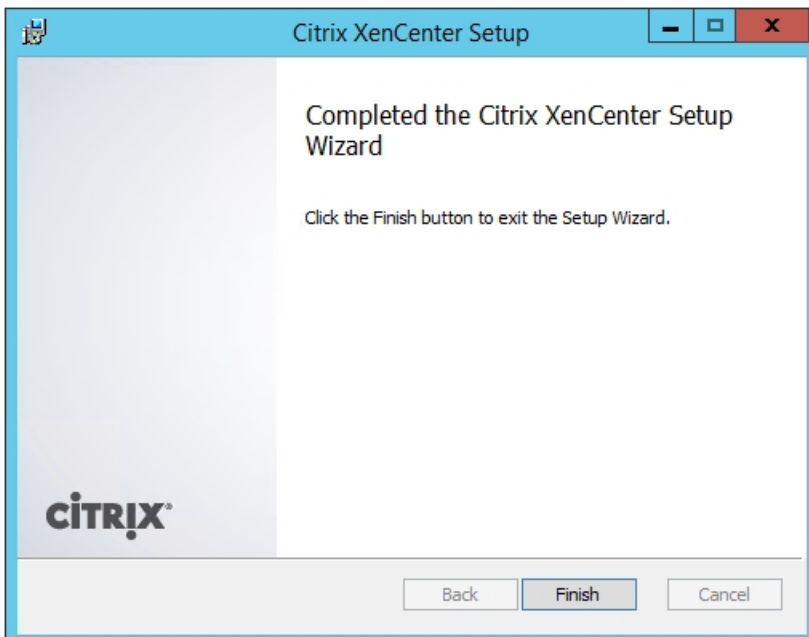
7. You can modify the default destination folder. Otherwise, choose defaults and proceed with the installation (Figure 30).

Figure 30. Choosing the setup



8. Click Finish to complete the installation (Figure 31).

Figure 31. Completing the installation

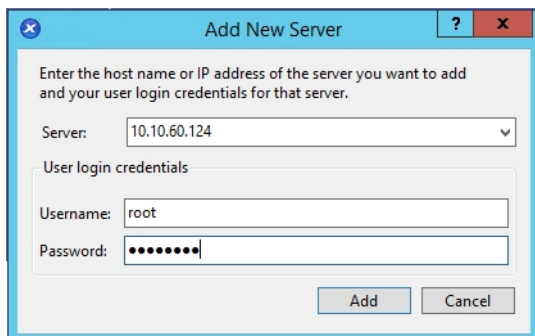


Perform initial Citrix XenServer pool configuration

Launch XenCenter, add XenServer hosts, and configure the resource pool.

1. Click Server > Add. Provide connection details and select Add (Figure 32).

Figure 32. Adding a new server



Enter the host name or IP address of the server you want to add and your user login credentials for that server.

Server: 10.10.60.124

User login credentials

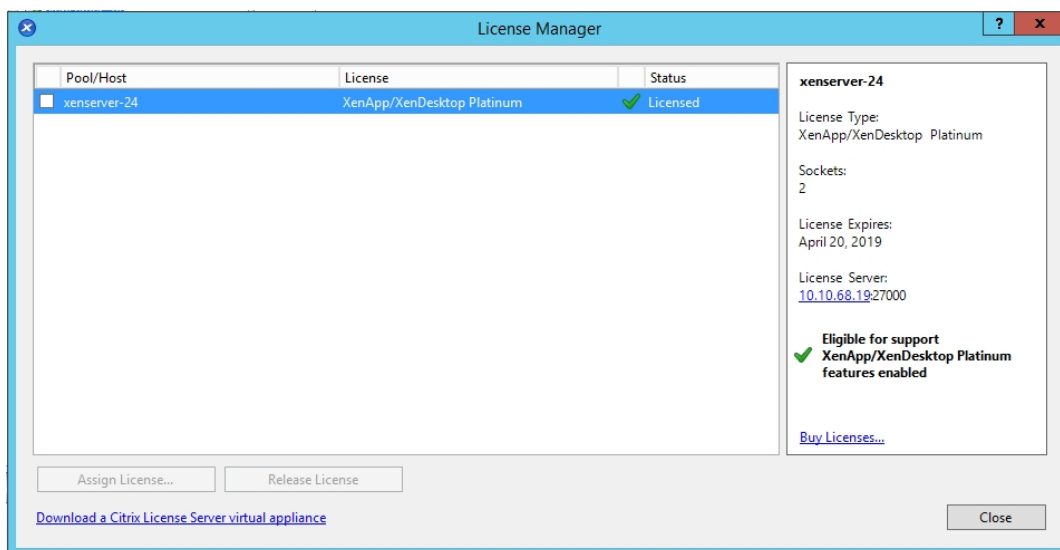
Username: root

Password: ●●●●●●

Add Cancel

2. Click Tools > License Manager and provide licensing details (Figure 33). Click Close to close the License Manager.

Figure 33. Providing license details



Pool/Host	License	Status
xenserver-24	XenApp/XenDesktop Platinum	Licensed

xenserver-24

License Type:
XenApp/XenDesktop Platinum

Sockets:
2

License Expires:
April 20, 2019

License Server:
[10.10.68.19:27000](#)

Eligible for support
 XenApp/XenDesktop Platinum features enabled

[Buy Licenses...](#)

Assign License... Release License

[Download a Citrix License Server virtual appliance](#)

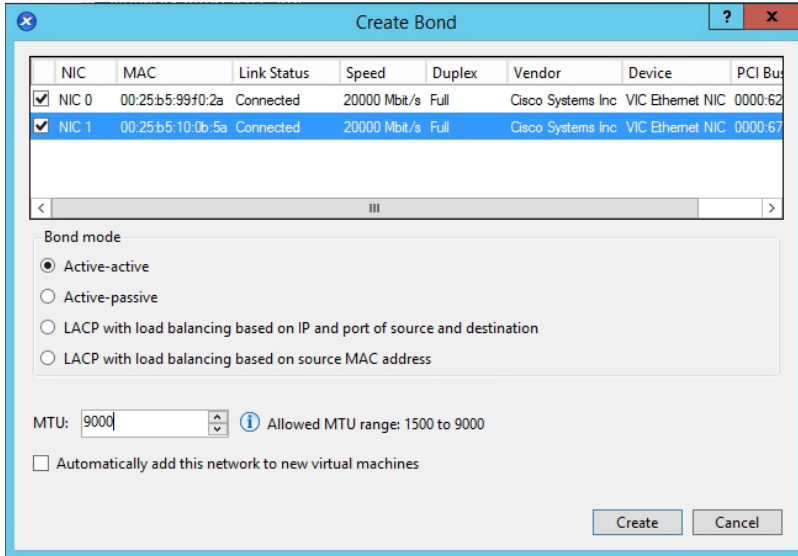
Close

3. Repeat the same procedure for the additional XenServer hosts.
4. Create a NIC bond on XenServer (Figure 34):
 - a. Select Active-active bond mode.
 - b. Set the maximum transmission unit (MTU) to 9000.

Note: For simplicity and to prevent misconfiguration, Citrix recommends using XenCenter to create NIC bonds. Whenever possible, create NIC bonds as part of initial resource pool creation prior to joining additional hosts to the pool or creating virtual

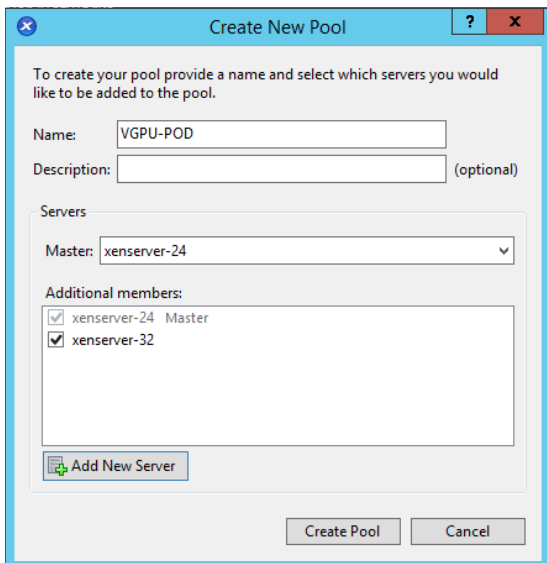
machines. Doing so allows the bond configuration to be automatically replicated to hosts as they join the pool and reduces the number of steps required.

Figure 34. Creating a NIC bond



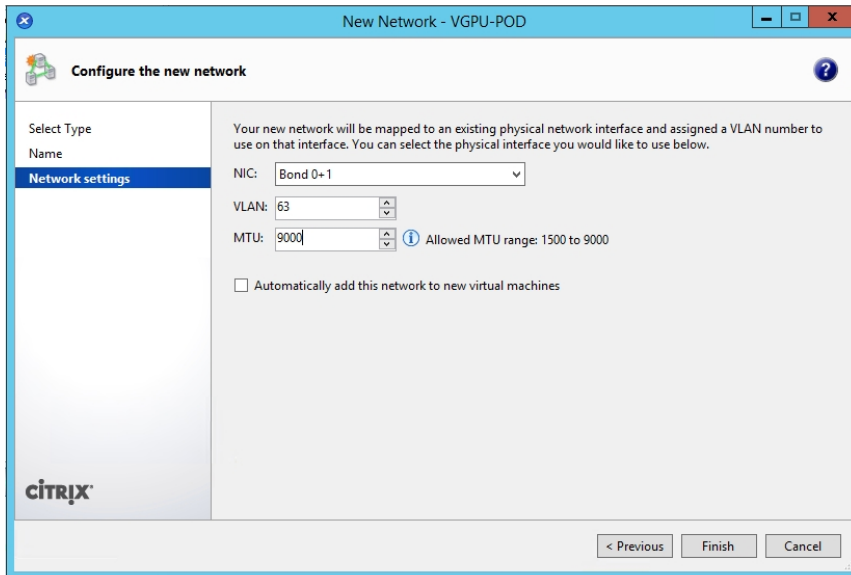
- To create a resource pool, choose Pool > New Pool. Provide the name of your pool and assign additional servers. Select Create Pool to finish creation process (Figure 35).

Figure 35. Creating a new resource pool



6. Configure pool networking by creating two external networks to be used for storage and virtual machine connectivity:
 - a. Create the storage network (Figure 36).

Figure 36. Creating a storage network



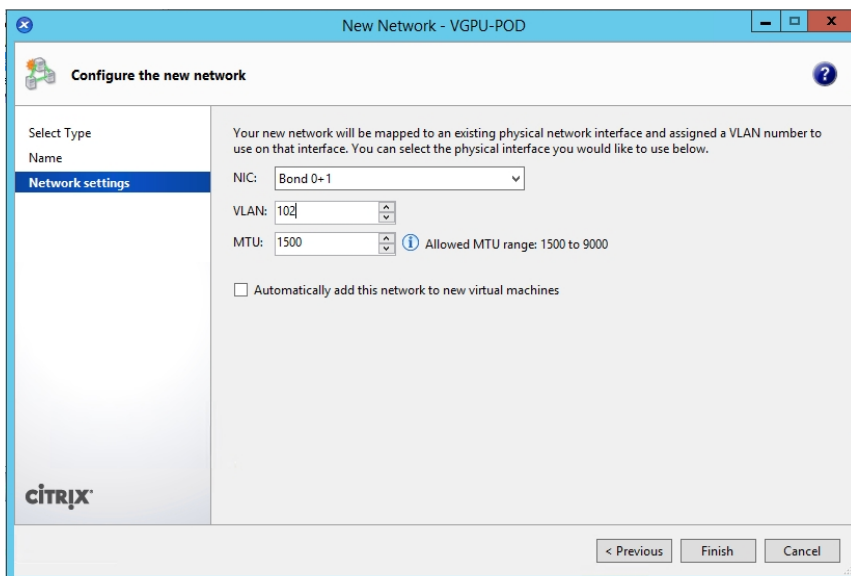
The screenshot shows a Citrix configuration window titled "New Network - VGPU-POD". The window is divided into two main sections. On the left, there is a sidebar with "Select Type" and "Name" options, and a "Network settings" section. The main area on the right contains the following configuration options:

- NIC:** Bond 0+1 (selected in a dropdown menu)
- VLAN:** 63 (selected in a dropdown menu)
- MTU:** 9000 (selected in a dropdown menu). A note below indicates "Allowed MTU range: 1500 to 9000".
- Automatically add this network to new virtual machines

At the bottom of the window, there are three buttons: "< Previous", "Finish", and "Cancel". The Citrix logo is visible in the bottom left corner.

- b. Create the virtual machine network (Figure 37).

Figure 37. Creating a virtual machine network



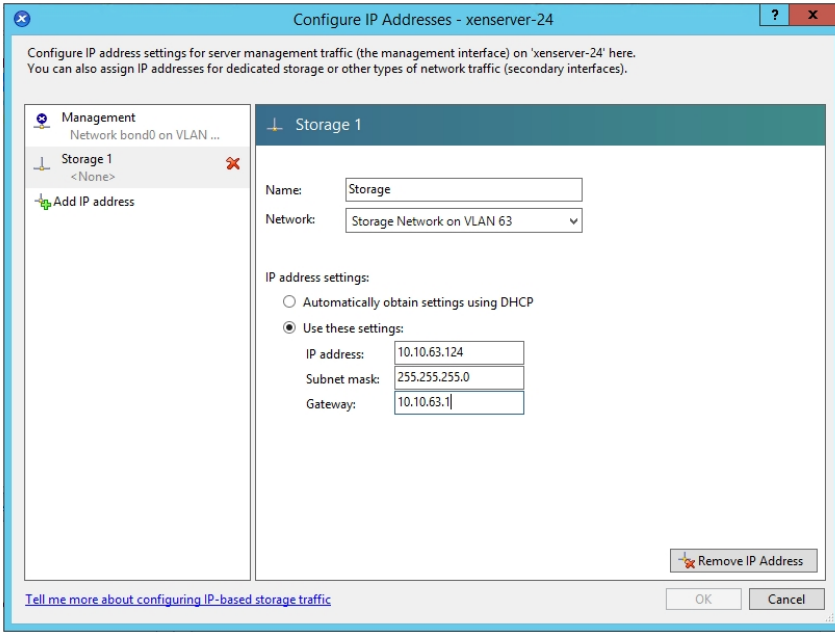
The screenshot shows a Citrix configuration window titled "New Network - VGPU-POD". The window is divided into two main sections. On the left, there is a sidebar with "Select Type" and "Name" options, and a "Network settings" section. The main area on the right contains the following configuration options:

- NIC:** Bond 0+1 (selected in a dropdown menu)
- VLAN:** 102 (selected in a dropdown menu)
- MTU:** 1500 (selected in a dropdown menu). A note below indicates "Allowed MTU range: 1500 to 9000".
- Automatically add this network to new virtual machines

At the bottom of the window, there are three buttons: "< Previous", "Finish", and "Cancel". The Citrix logo is visible in the bottom left corner.

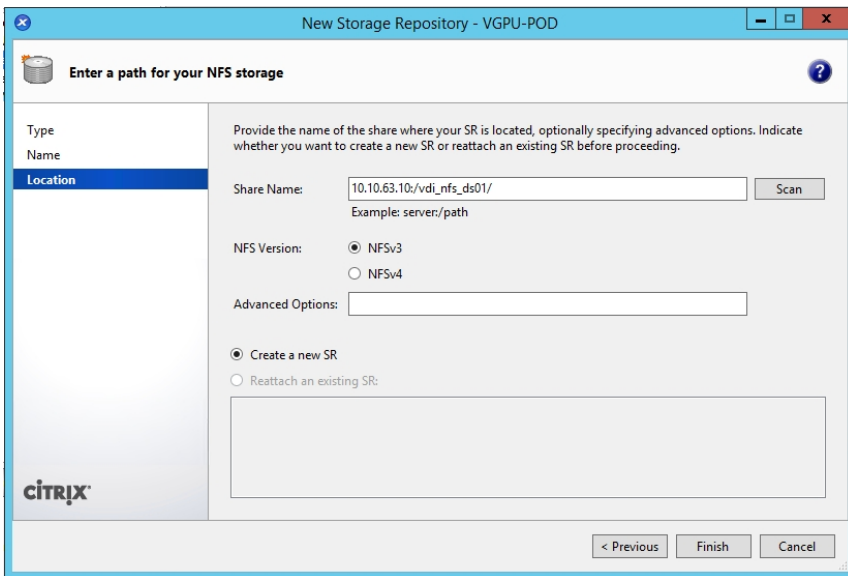
7. Configure dedicated storage NICs on each host in the resource pool (Figure 38).

Figure 38. Configuring dedicated NICs



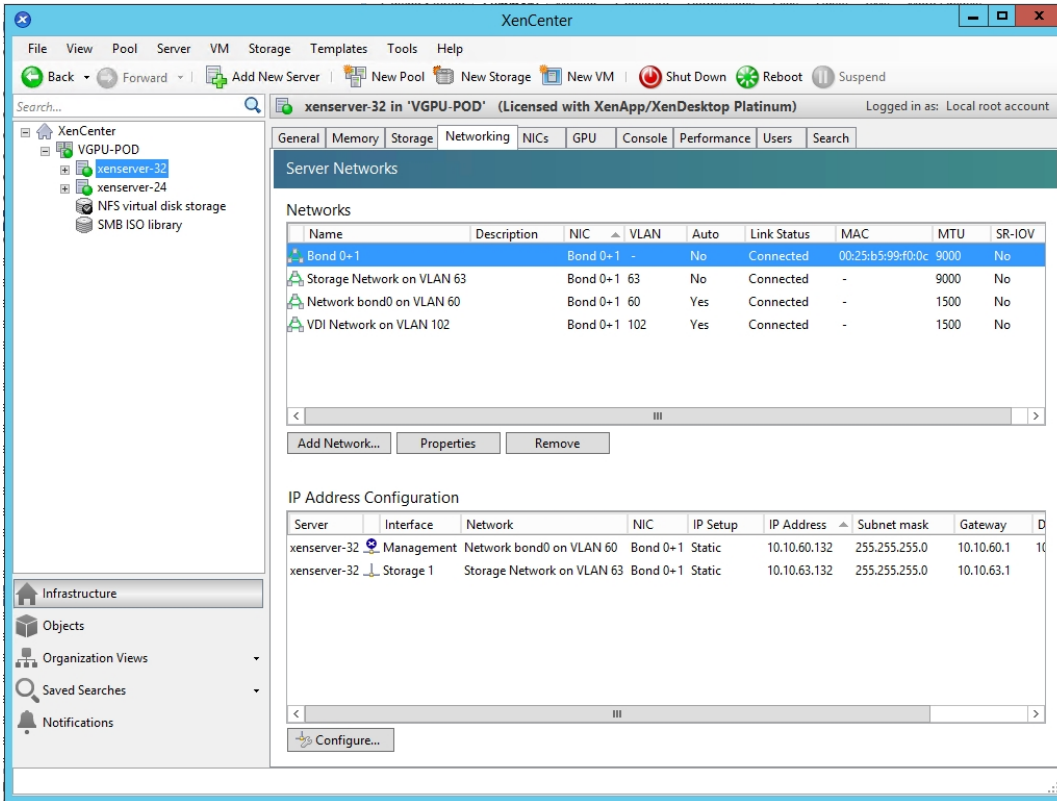
8. Create an NFS storage repository for virtual machines by connecting to the appropriate NFS share on NetApp (Figure 39).

Figure 39. Connecting to an NFS share



The resulting resource pool configuration should look similar to Figure 40.

Figure 40. Resource pool configuration example



Install the NVIDIA GRID vGPU Manager for Citrix XenServer

NVIDIA GRID allows virtual machines using the same NVIDIA graphics drivers as nonvirtualized operating systems to directly access the physical GPU on the hypervisor host. The NVIDIA GRID vGPU Manager manages multiple vGPU devices, which can be assigned directly to virtual machines.

You should install the latest NVIDIA GRID vGPU software. Instructions for obtaining the software are available from [NVIDIA](https://www.nvidia.com/en-us/grid/).

The GRID vGPU Manager runs in the XenServer Control Domain (dom0). It is provided as either a supplemental pack or a Red Hat Package Manager (RPM) file.

To install the GRID vGPU Manager in dom0 from an RPM package, follow the steps presented here.

Note: When installing the GRID vGPU Manager using an RPM file, you must ensure that the RPM file is accessible from within dom0 prior to the installation.

When using NVIDIA vGPU with XenServer hosts with more than 768 GB of RAM, add the parameter **iommu=dom0-passthrough** to the Xen command line and restart the host.

1. Use the `rpm -ivh` command to install the package (Figure 41):

```
[root@xenserver ~]# rpm -ivh NVIDIA-vGPU-xenserver-7.5-390.72.x86_64.rpm
```

Figure 41. Installing the RPM package

```
[root@xenserver-24 NVIDIA-GRID-XenServer-7.5-390.72-390.75-391.81]# rpm -ivh NVIDIA-vGPU-xenserver-7.5-390.72.x86_64.rpm
Preparing... ##### [100%]
Updating / installing...
 1:NVIDIA-vGPU-xenserver-7.5-390.72 ##### [100%]
[root@xenserver-24 NVIDIA-GRID-XenServer-7.5-390.72-390.75-391.81]#
```

2. Reboot the XenServer host.
3. After rebooting the XenServer host, verify that the GRID package is installed and loaded correctly by checking for the NVIDIA kernel driver in the list of kernel loaded modules (Figure 42):

```
[root@xenserver ~]# lsmod |grep nvidia
```

Figure 42. Verifying that the package is installed and loaded correctly

```
[root@xenserver-24 ~]# lsmod | grep nvidia
nvidia          14360576  27
ipmi_msghandler  49152  3 ipmi_devintf,nvidia,ipmi_si
[root@xenserver-24 ~]#
```

- Verify that the NVIDIA kernel driver can successfully communicate with the GRID physical GPUs in your host by running the `nvidia-smi` command, which produces a list of the GPUs on your platform similar to Figure 43.

Figure 43. List of GPUs

```
root@xenserver-24 ~]# nvidia-smi
Tue Sep  4 15:14:55 2018

+-----+
| NVIDIA-SMI 390.72                Driver Version: 390.72      |
+-----+-----+
| GPU   Name           Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf    Pwr:Usage/Cap|  Memory-Usage | GPU-Util  Compute M. |
+-----+-----+-----+-----+-----+-----+
|    0   Tesla P6             On      | 00000000:18:00.0 Off  |    0%      Default  |
| N/A   27C    P8             9W / 90W |  42MiB / 16383MiB |           |
+-----+-----+-----+-----+-----+
|    1   Tesla P6             On      | 00000000:D8:00.0 Off  |    0%      Default  |
| N/A   38C    P8             9W / 90W |  42MiB / 16383MiB |           |
+-----+-----+-----+-----+-----+

Processes:
+-----+-----+-----+-----+-----+
| GPU   PID  Type  Process name      GPU Memory |
|                               Usage          |
+-----+-----+-----+-----+-----+
| No running processes found |
+-----+-----+-----+-----+-----+

root@xenserver-24 ~]#
```

- Repeat the same process for all hosts in the pool.
- After the GRID vGPU Manager has been installed on all hosts in the resource pool, verify that the GPUs and vGPUs are visible on the XenCenter Host GPU tab as shown in Figure 44, Figure 45, and Figure 46.

Figure 44. Example of dual P6 availability on the Cisco UCS B200 M5 host for XenServer

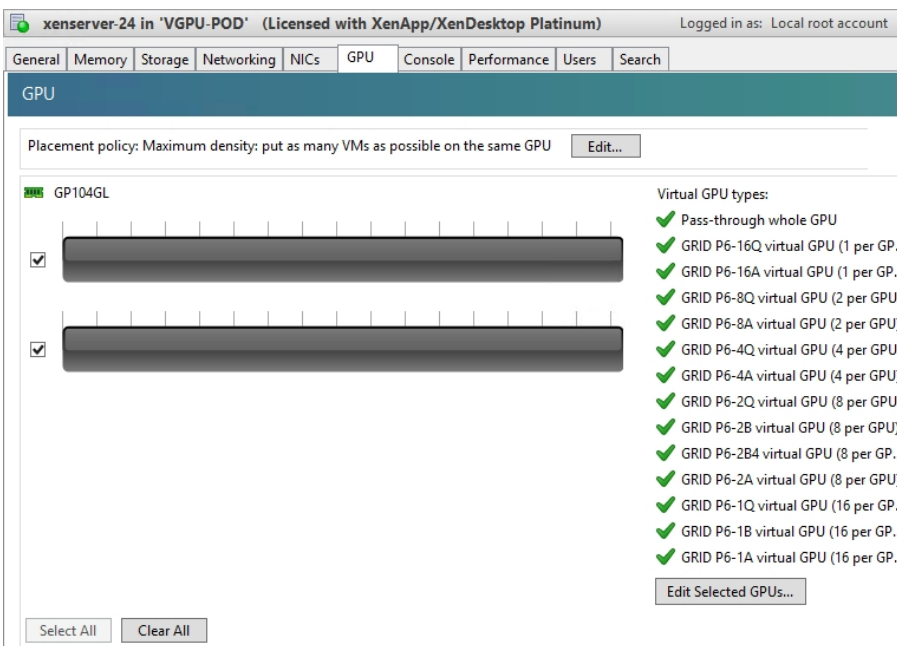


Figure 45. Example of dual P40 availability on the Cisco UCS C240 M5 host for XenServer

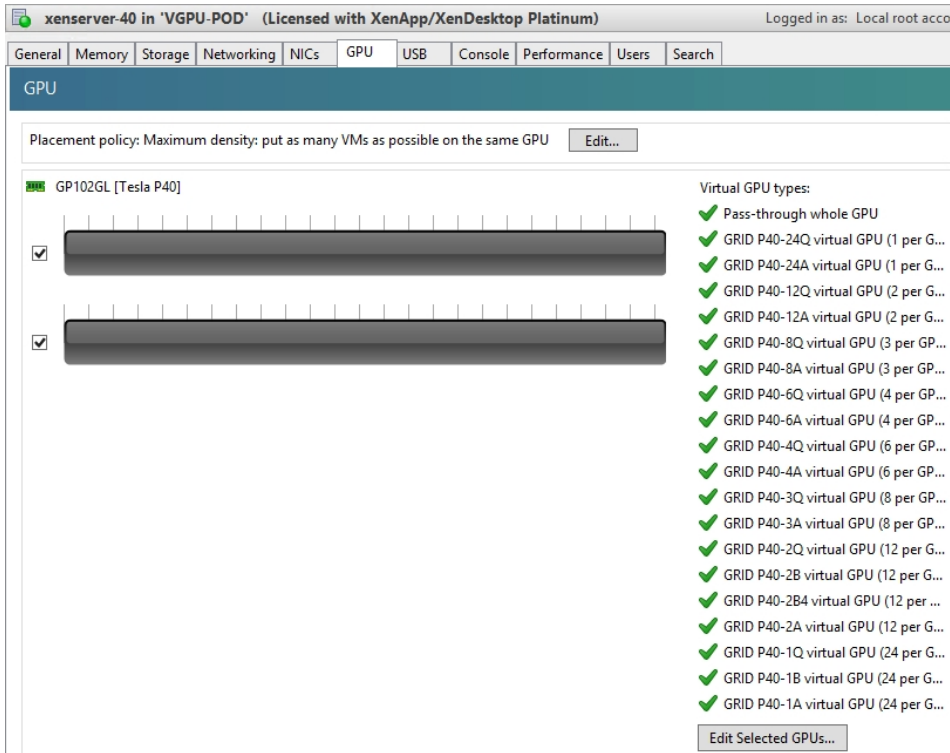
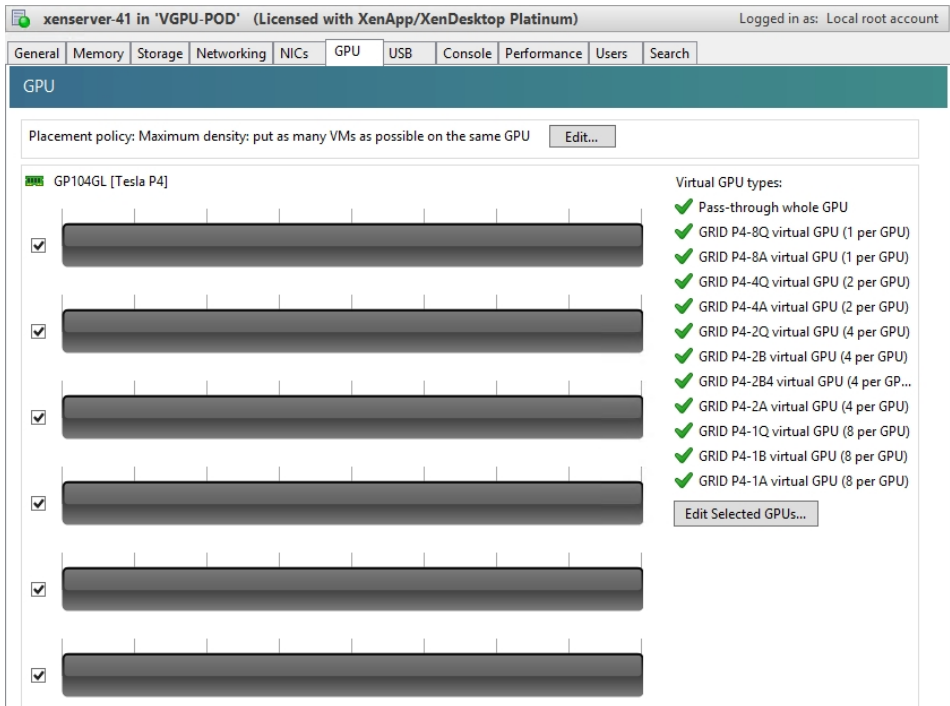


Figure 46. Example of sextuple P4 availability on the Cisco UCS C240 M5 host for XenServer



7. Additionally, the GPU tab allows you to set a hostwide policy to assign virtual machines to available GPUs to achieve either maximum density or maximum performance. Select an option based on your requirements. Figure 47 and Figure 48 shows examples of GPU utilization with these policies.

Figure 47. Virtual machine distribution policy for maximum density

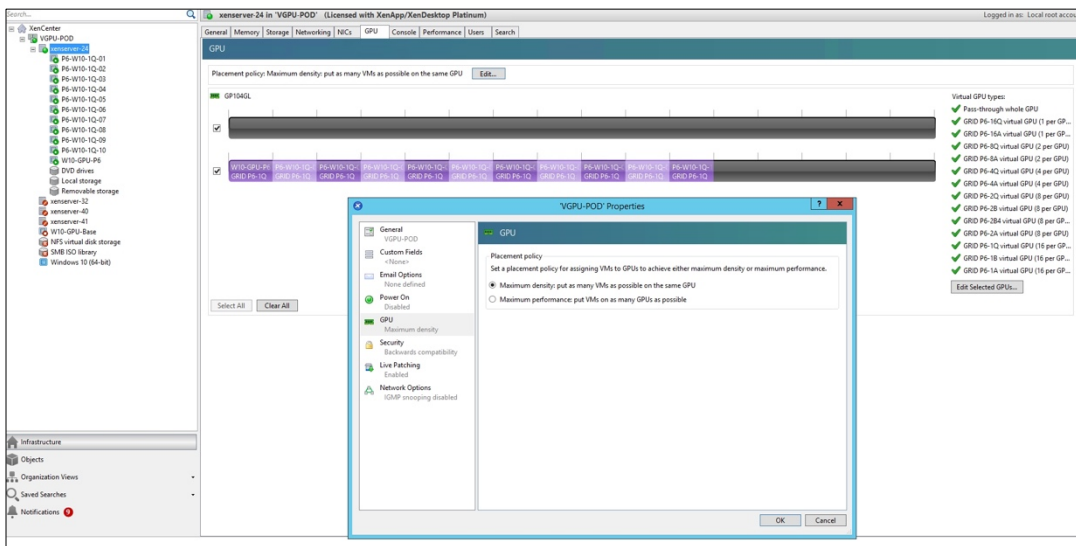
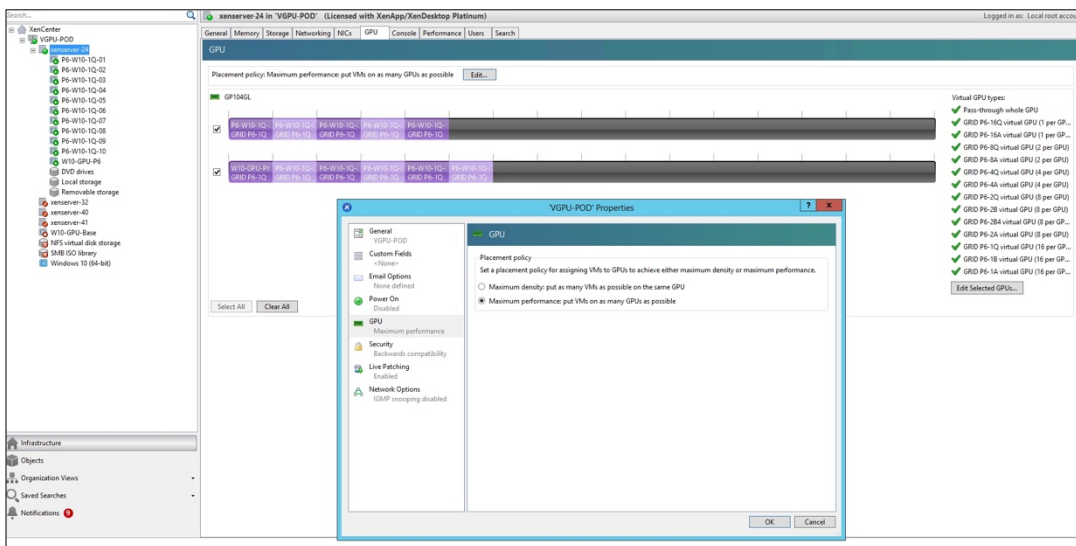


Figure 48. Virtual machine distribution policy for maximum performance



Note: GPU virtualization is available for XenServer Enterprise Edition customers and for those who have access to XenServer through their XenApp or XenDesktop entitlement. The GPU tab is displayed when the pool meets the license requirements and also has GPUs that support various vGPU types.

Install and configure the NVIDIA GRID license server

This section summarizes the installation and configuration process for the GRID 6.2 license server.





The NVIDIA GRID vGPU is a licensed feature on Tesla P6, P40, and P4. A software license is required to use the full vGPU features on a guest virtual machine. An NVIDIA license server with the appropriate licenses is required.

To get an evaluation license code and download the software, register at [http://www.nvidia.com/object/grid-evaluation.html - utm_source=shorturl&utm_medium=referrer&utm_campaign=grideval](http://www.nvidia.com/object/grid-evaluation.html?utm_source=shorturl&utm_medium=referrer&utm_campaign=grideval).

The following packages are required to set up the Citrix environment (Figure 49):

- NVIDIA GRID license server installer
- NVIDIA GRID Manager software, which is installed on XenServer dom0
- NVIDIA drivers and software that are installed in Microsoft Windows

Figure 49. Software required for NVIDIA GRID 6.2 setup on the VMware ESXi host

Name	Date modified	Type	Size
 NVIDIA-ls-windows-2018.06.0.24304595.zip	7/17/2018 12:50 PM	Compressed (zipp...	248,221 KB
 NVIDIA-GRID-XenServer-7.5-390.72-390.75-391.81.zip	7/17/2018 12:51 PM	Compressed (zipp...	1,103,099 KB
 NVIDIA-GRID-Windows-390.75-391.81.zip	7/17/2018 12:51 PM	Compressed (zipp...	1,079,622 KB
 jre-8u181-windows-x64.exe	7/17/2018 1:27 PM	Application	70,110 KB






Install the NVIDIA GRID 6.2 license server

The steps shown here use the Microsoft Windows version of the license server installed on Windows Server 2012 R2. A Linux version of the license server is also available.

The GRID 6.2 license server requires Java Version 7 or later. Go to Java.com and install the latest version.

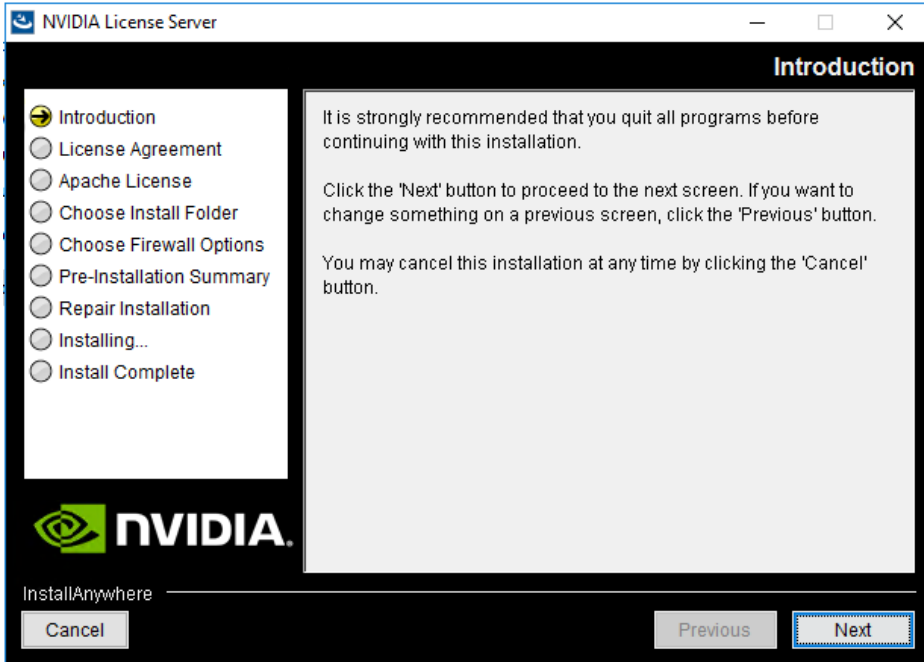
1. Extract and open the NVIDIA-ls-windows-\$version folder. Run setup.exe (Figure 50).

Figure 50. Run setup.exe

Name	Date modified	Type	Size
 grid-license-server-release-notes.pdf	6/15/2018 6:59 PM	PDF File	1,626 KB
 grid-license-server-user-guide.pdf	6/15/2018 7:00 PM	PDF File	3,587 KB
 grid-licensing-user-guide.pdf	6/15/2018 7:01 PM	PDF File	2,046 KB
 grid-software-quick-start-guide.pdf	6/15/2018 6:51 PM	PDF File	3,526 KB
 setup	6/8/2018 7:29 AM	Application	238,574 KB

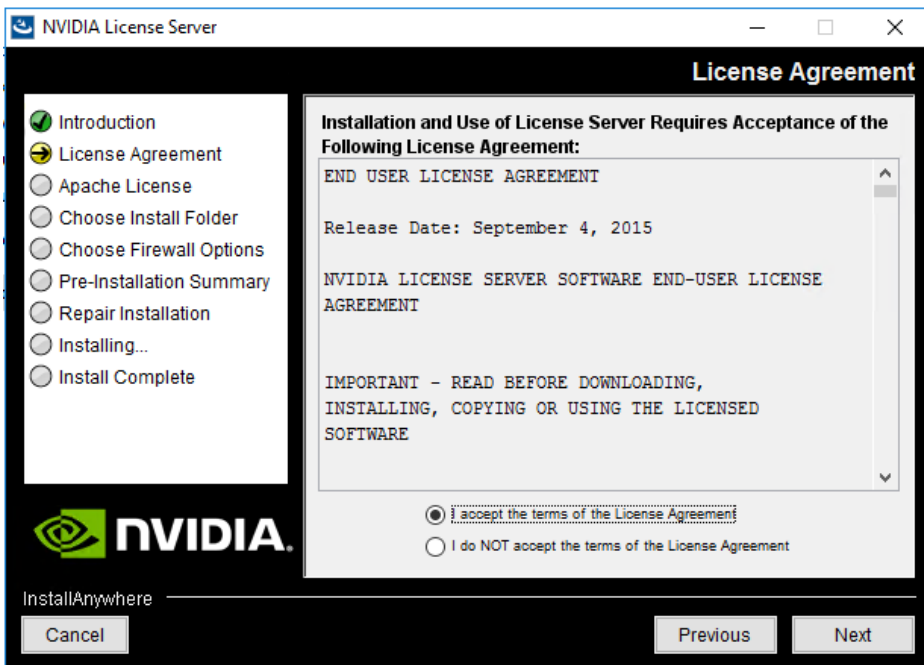
2. Click Next (Figure 51).

Figure 51. NVIDIA License Server page



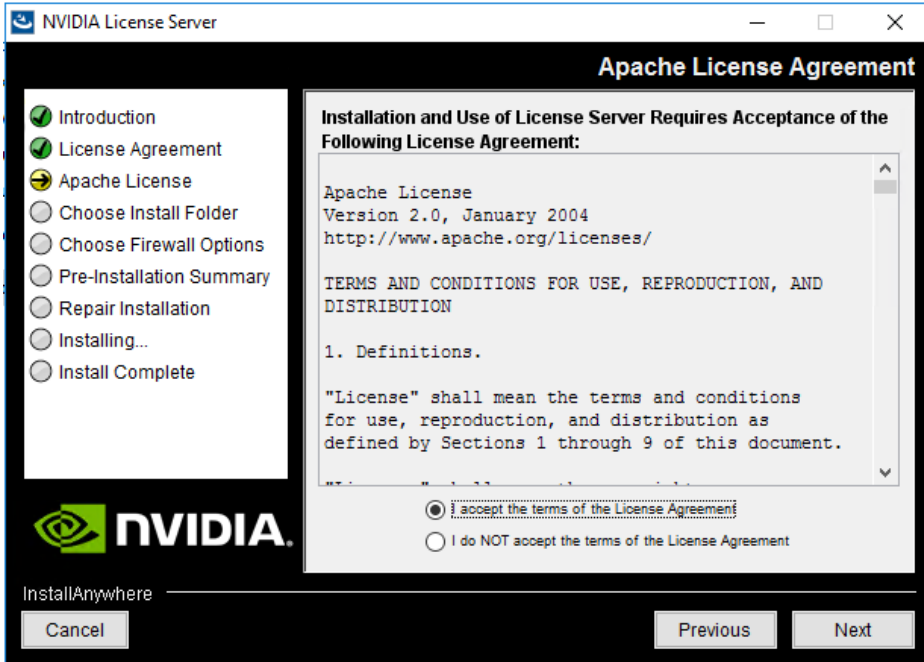
3. Accept the license agreement and click Next (Figure 52).

Figure 52. NVIDIA License Agreement page



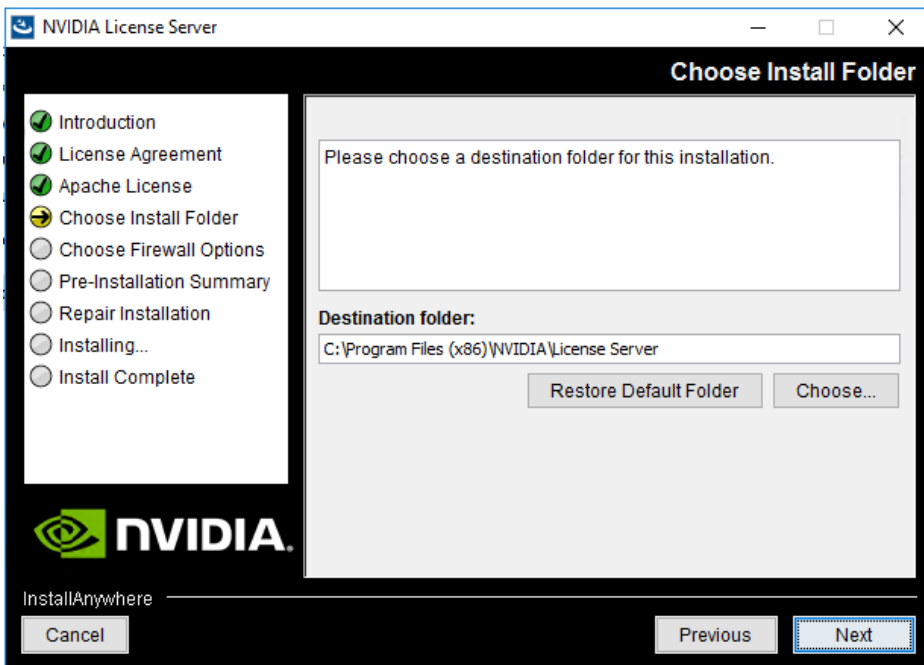
4. Accept the Apache license agreement and click Next (Figure 53).

Figure 53. Apache License Agreement page



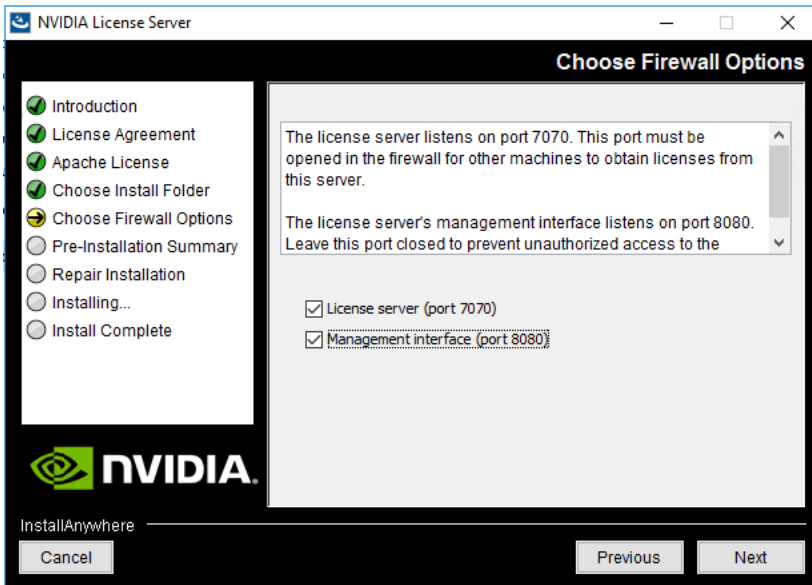
5. Choose the desired installation folder and click Next (Figure 54).

Figure 54. Choosing a destination folder



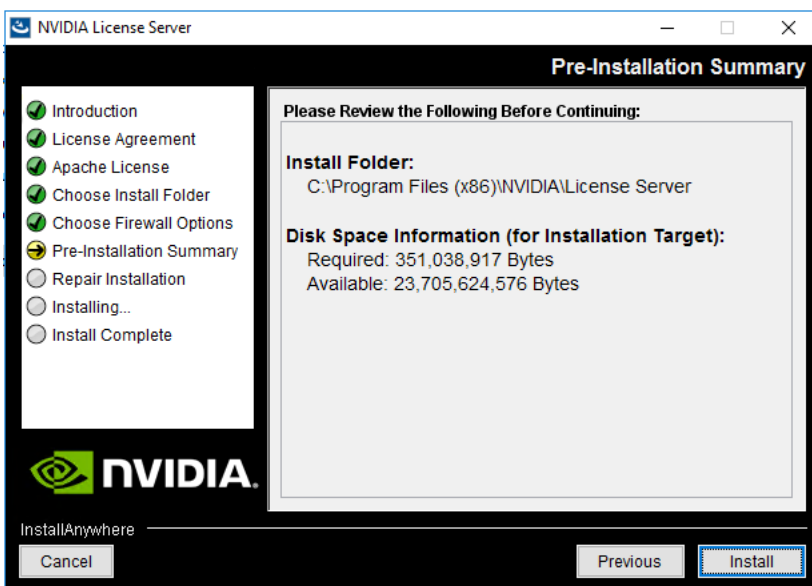
6. The license server listens on port 7070. This port must be opened in the firewall for other machines to obtain licenses from this server. Select the “License server (port 7070)” option.
7. The license server’s management interface listens on port 8080. If you want the administration page accessible from other machines, you need to open port 8080. Select the “Management interface (port 8080)” option.
8. Click Next (Figure 55).

Figure 55. Setting firewall options



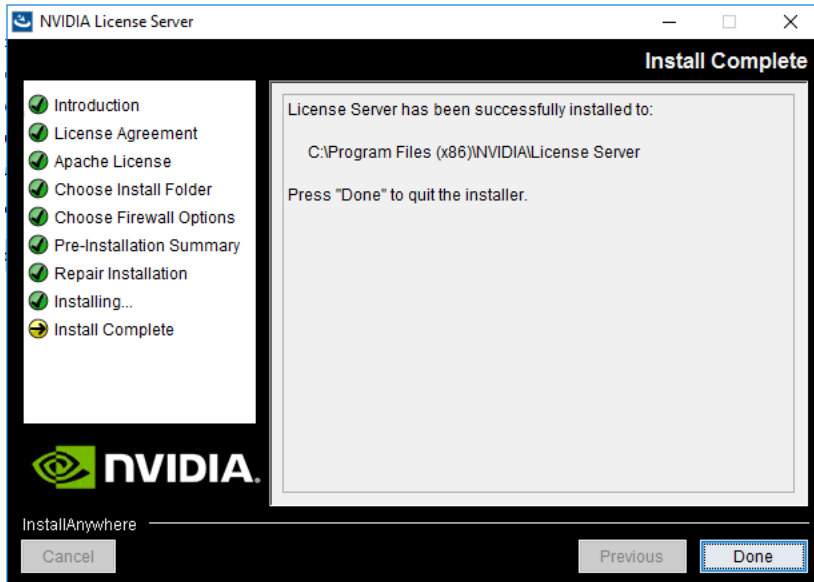
9. The Pre-installation Summary and Repair Installation options automatically progress without user input (Figure 56).

Figure 56. Installing the license server



10. When the installation process is complete, click Done (Figure 57).

Figure 57. Installation complete

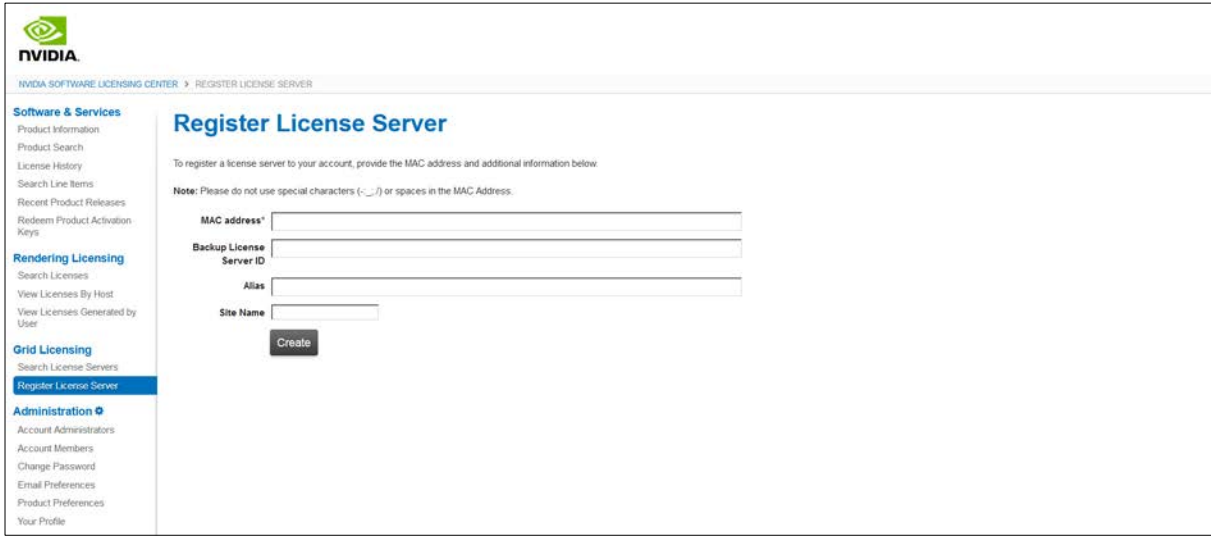


Configure the NVIDIA GRID 6.2 license server

Now configure the NVIDIA GRID license server.

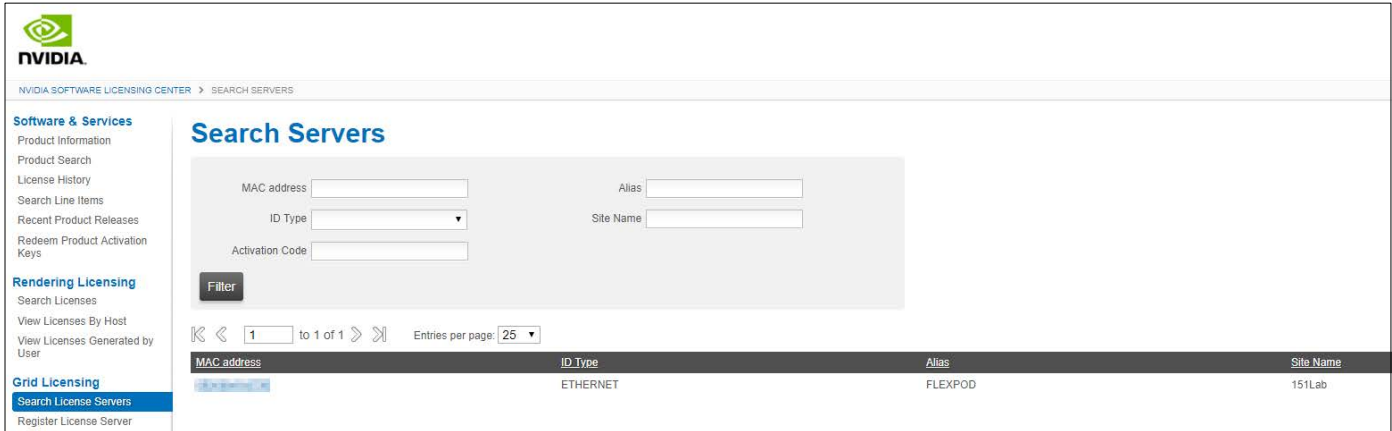
1. Log in to the license server site with the credentials set up during the registration process at nvidia.com/grideval. A license file is generated from <https://nvidia.flexnetoperations.com/>.
2. After you are logged in, click Register License Server.
3. Specify the fields as shown in Figure 58. In the License Server ID field, enter the MAC address of your local license server's NIC. Leave ID Type set to Ethernet. For Alias and Site Name, choose user-friendly names. Then click Create.

Figure 58. Registering the license server



4. Click the Search License Servers node.
5. Click your license server ID (Figure 59).

Figure 59. Selecting the license server ID



6. Click Map Add-Ons, choose the number of license units from your total pool to allocate to this license server, and click Map Add-Ons (Figure 60 and Figure 61).

Figure 60. Choosing the number of license units

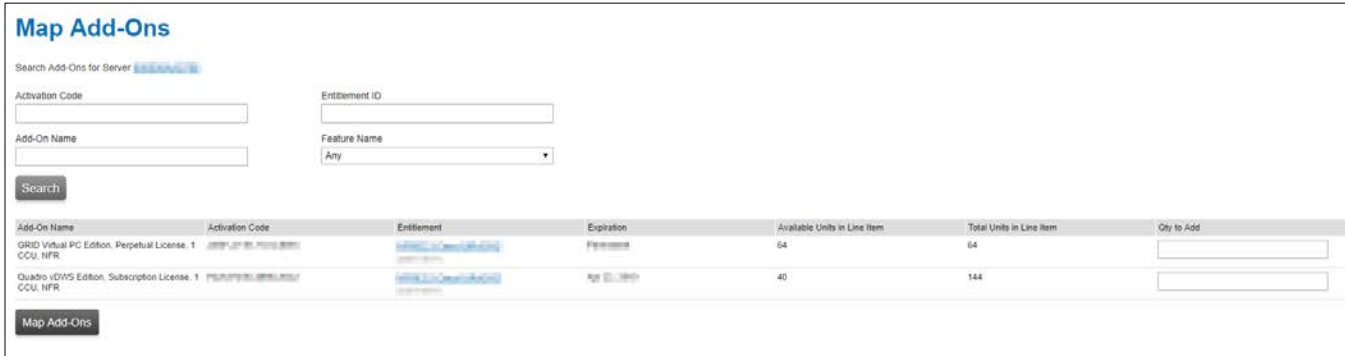
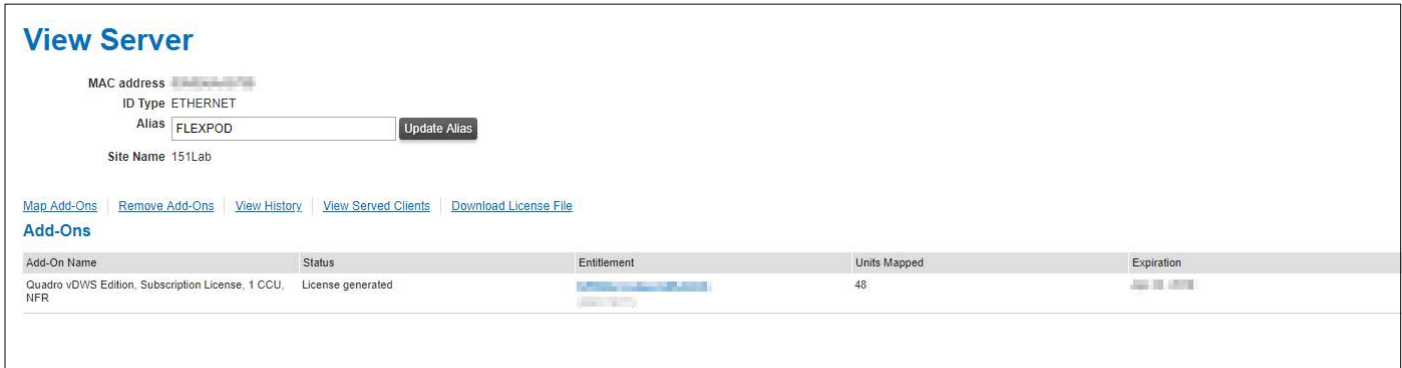


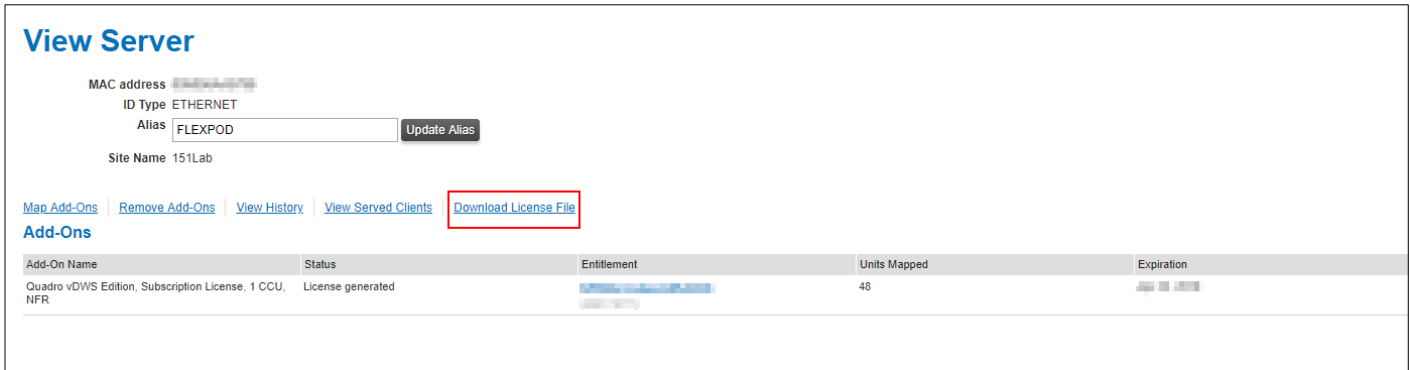
Figure 61. Mapped add-ons after successful mapping



7. Click Download License File and save the .bin file to your license server (Figure 62).

Note: The .bin file must be uploaded to your local license server within 24 hours of its generation. Otherwise, you will need to regenerate .bin file.

Figure 62. Saving the .bin file



8. On the local license server, browse to `http://<FQDN>:8080/licserver` to display the License Server Configuration page.
9. Click License Management in the left pane.
10. Click Browse to locate your recently download .bin license file. Select the .bin file and click OK.
11. Click Upload. The message “Successfully applied license file to license server” should appear on the screen (Figure 63). The features are now available (Figure 64).

Figure 63. License file successfully applied

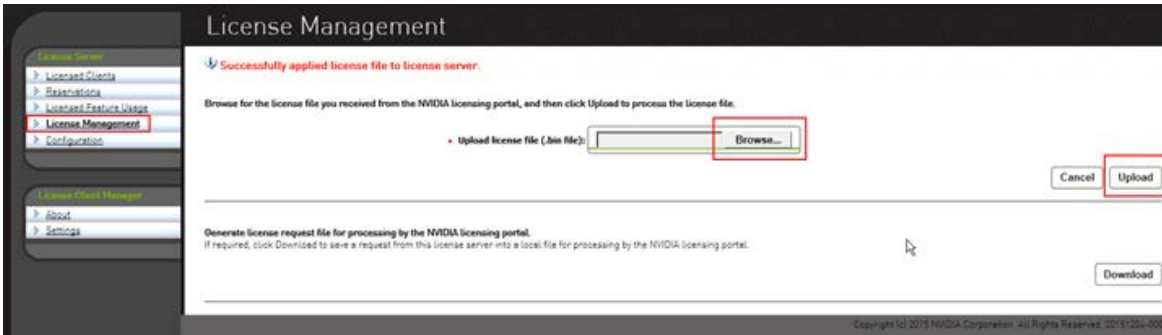
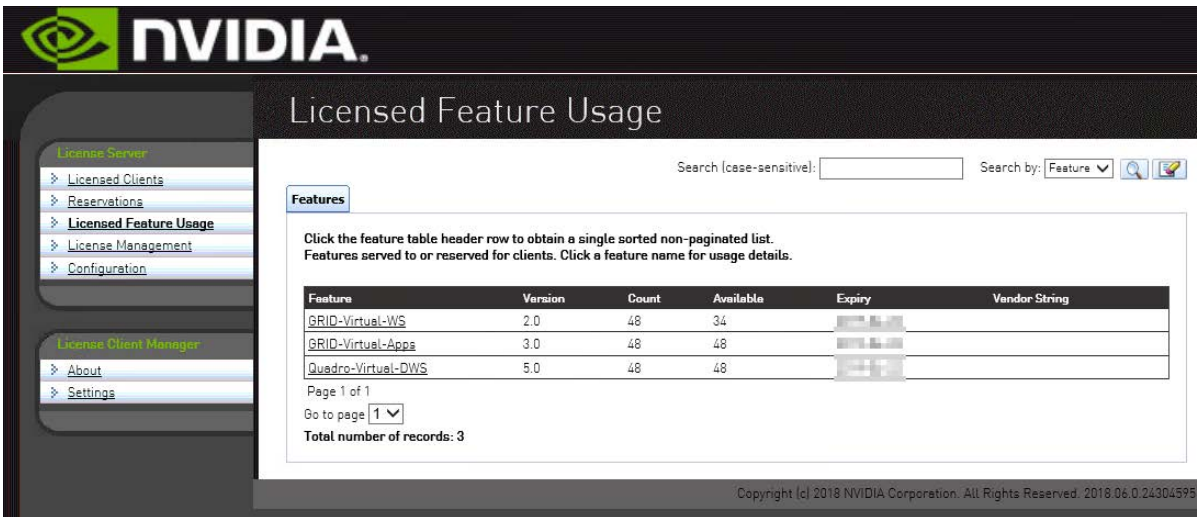


Figure 64. NVIDIA Licensed Feature Usage page



NVIDIA Tesla P6, P4, and P40 profile specifications

The Tesla P6, P4, and P40 cards have a single physical GPU. Each physical GPU can support several different types of vGPU. Each type of vGPU has a fixed amount of frame buffer space, a fixed number of supported display heads, and a fixed maximum resolution, and each is targeted at a different class of workload. Table 3 lists the vGPU types supported by GRID GPUs.

For more information, see <http://www.nvidia.com/object/grid-enterprise-resources.html>.

Table 3. User profile specifications for NVIDIA Tesla cards

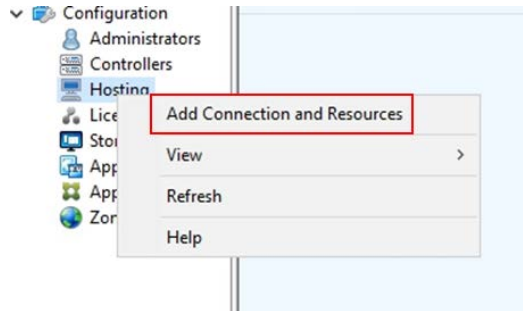
End-user GRID options			
End-user profile	GRID virtual application profiles	GRID virtual PC profiles	NVIDIA Quadro Virtual Data Center Workstation (Quadro vDWS) profiles
1 GB	P6-1A P4-1A P40-1A	P6-1B P4-1B P40-1B	P6-1Q P4-1Q P40-1Q
2 GB	P6-2A P4-2A P40-2A	P6-2B P4-2B P40-2B	P6-2Q P4-2Q P40-2Q
3 GB	P40-3A	-	P40-3Q
4 GB	P6-4A P4-4A P40-4A	-	P6-4Q P4-4Q P40-4Q
6 GB	P40-6A	-	P40-6Q
8 GB	P6-8A P4-8A P40-8A	-	P6-8Q P4-8Q P40-8Q
12 GB	P40-12A	-	P40-12Q
16 GB	P6-16A	-	P6-16Q
24 GB	P40-24A	-	P40-24Q

Prepare Citrix delivery controllers for MCS provisioning with vGPU support

Follow these steps to prepare Citrix delivery controllers for MCS provisioning with vGPU support.

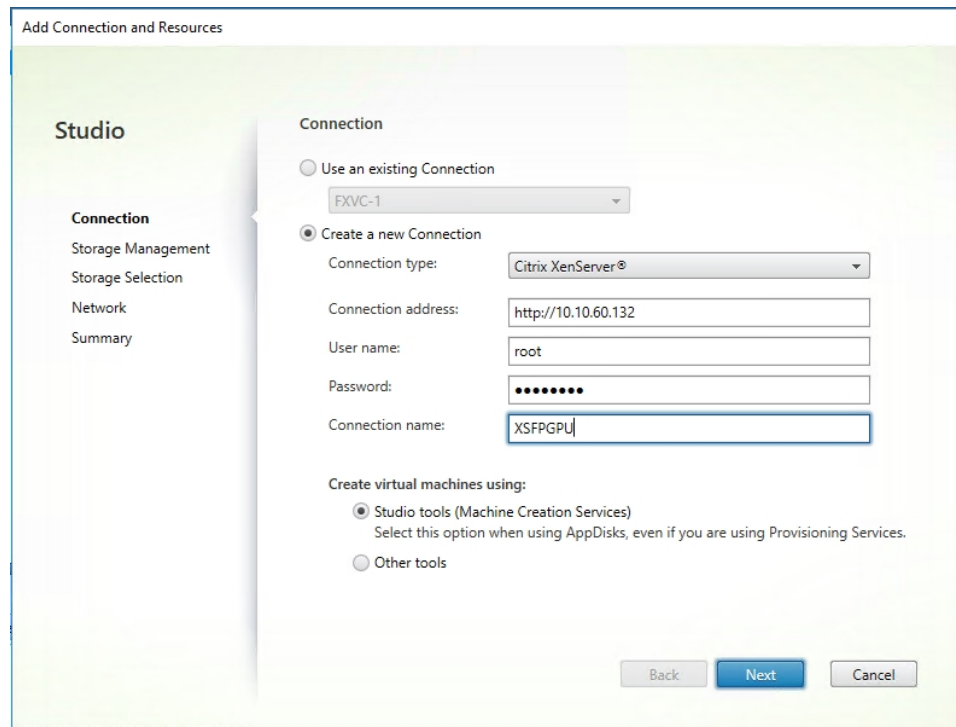
1. In the Studio navigation pane, select Configuration > Hosting > Add Connection and Resources (Figure 65).

Figure 65. Adding a connection and resources



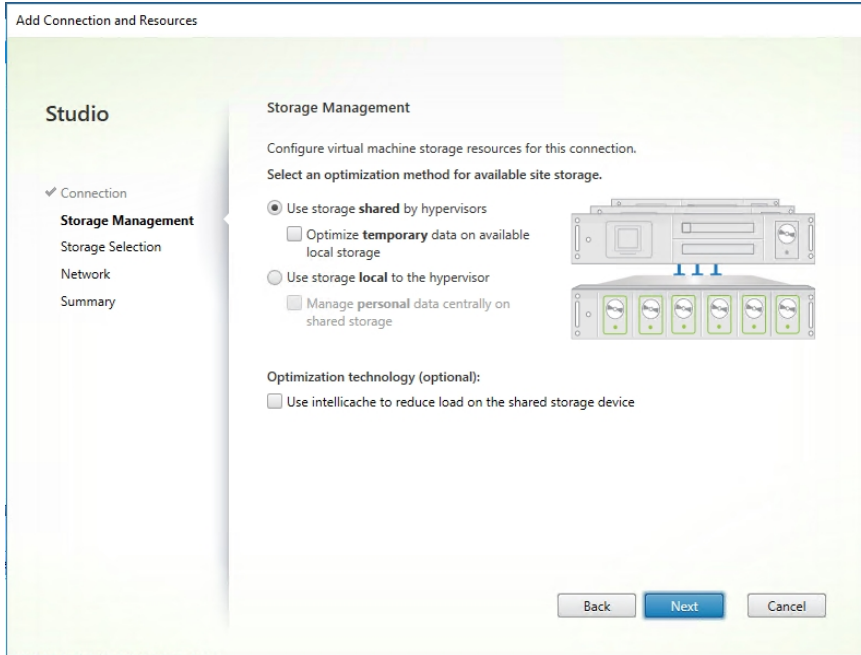
2. On the Connection page, select Create a new Connection and provide the necessary credentials (Figure 66).

Figure 66. Creating a new connection



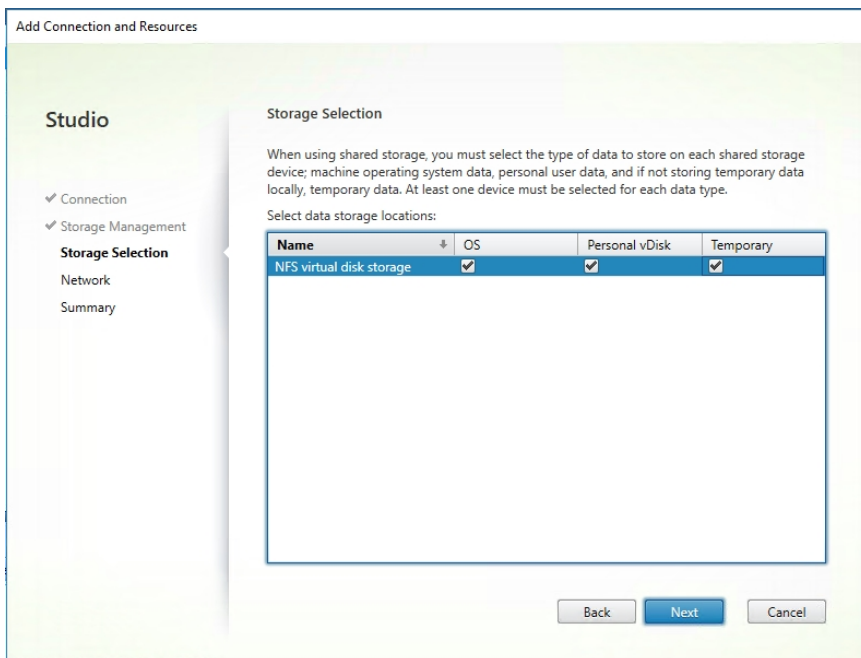
- On the Storage Management page, select a storage management method. Select “Use storage shared by hypervisors” (Figure 67).

Figure 67. Selecting a storage management method



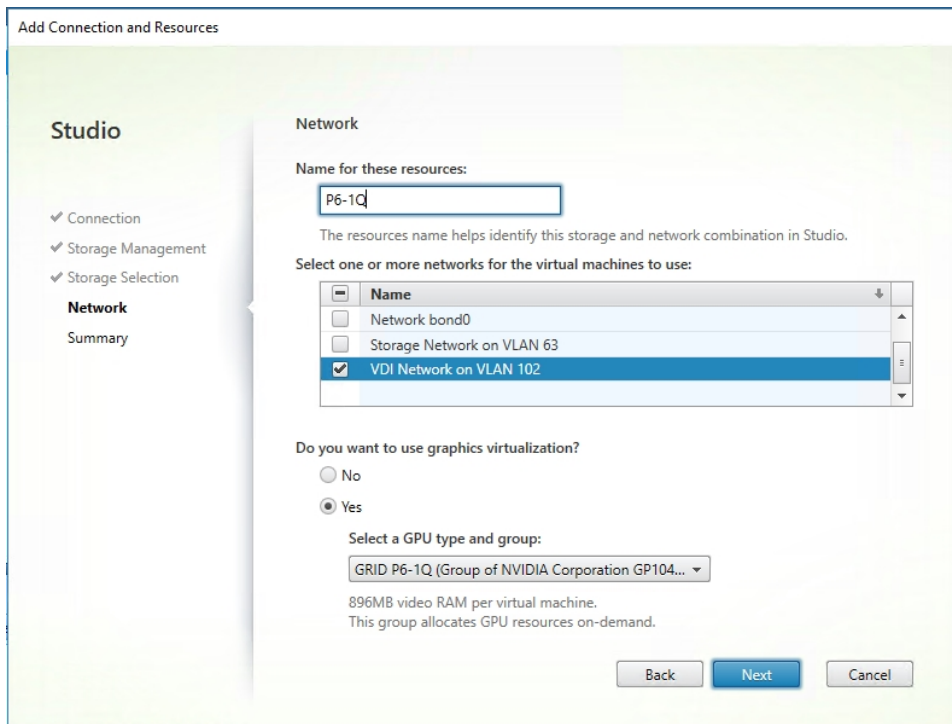
- Perform storage selection (Figure 68).

Figure 68. Storage Selection page



5. On the Network page, specify the following settings (Figure 69):
 - a. Enter a name for the resources; this name appears in Studio to identify the storage and network combination associated with the connection.
 - b. Select the networks to be used by your virtual machines.
 - c. Enable the use of graphics virtualization, and from the drop-down list choose the appropriate profile type.

Figure 69. Specifying network settings



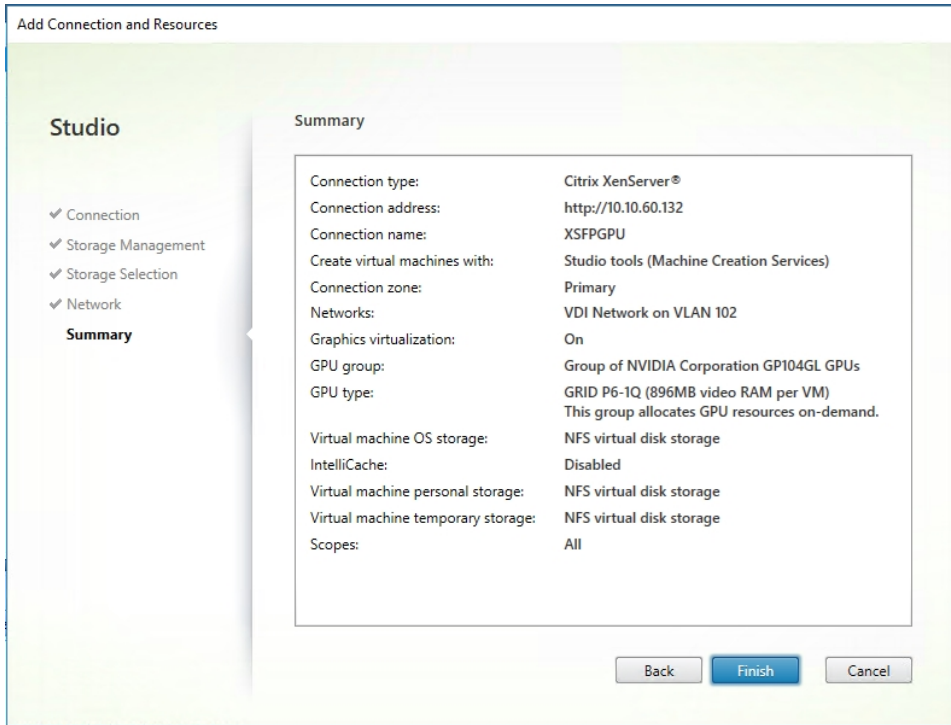
The screenshot shows the 'Add Connection and Resources' dialog box in Studio. The 'Network' tab is selected in the left sidebar. The main content area is titled 'Network' and contains the following elements:

- Name for these resources:** A text input field containing 'P6-1Q'. Below it, a note states: 'The resources name helps identify this storage and network combination in Studio.'
- Select one or more networks for the virtual machines to use:** A list box with three items:

<input type="checkbox"/>	Name
<input type="checkbox"/>	Network bond0
<input type="checkbox"/>	Storage Network on VLAN 63
<input checked="" type="checkbox"/>	VDI Network on VLAN 102
- Do you want to use graphics virtualization?** Radio buttons for 'No' and 'Yes'. The 'Yes' option is selected.
- Select a GPU type and group:** A dropdown menu showing 'GRID P6-1Q (Group of NVIDIA Corporation GP104...'. Below it, a note states: '896MB video RAM per virtual machine. This group allocates GPU resources on-demand.'
- At the bottom, there are three buttons: 'Back', 'Next', and 'Cancel'.

6. Review the Summary page and click Finish to create the connection (Figure 70).

Figure 70. Connection Summary page



After the connection has been created, you can modify it by working through the Add Connection and Resources wizard to configure additional resources to deploy a variety of the vGPUs, as shown in Figure 71.

Figure 71. Connection with multiple vGPU resources

XSFPGPU	Citrix XenServer®	http://10.10.60.132	Enabled
P4-1Q			
P6-1Q			
P6-4Q			
P6-8Q			

Create virtual desktops with vGPU support

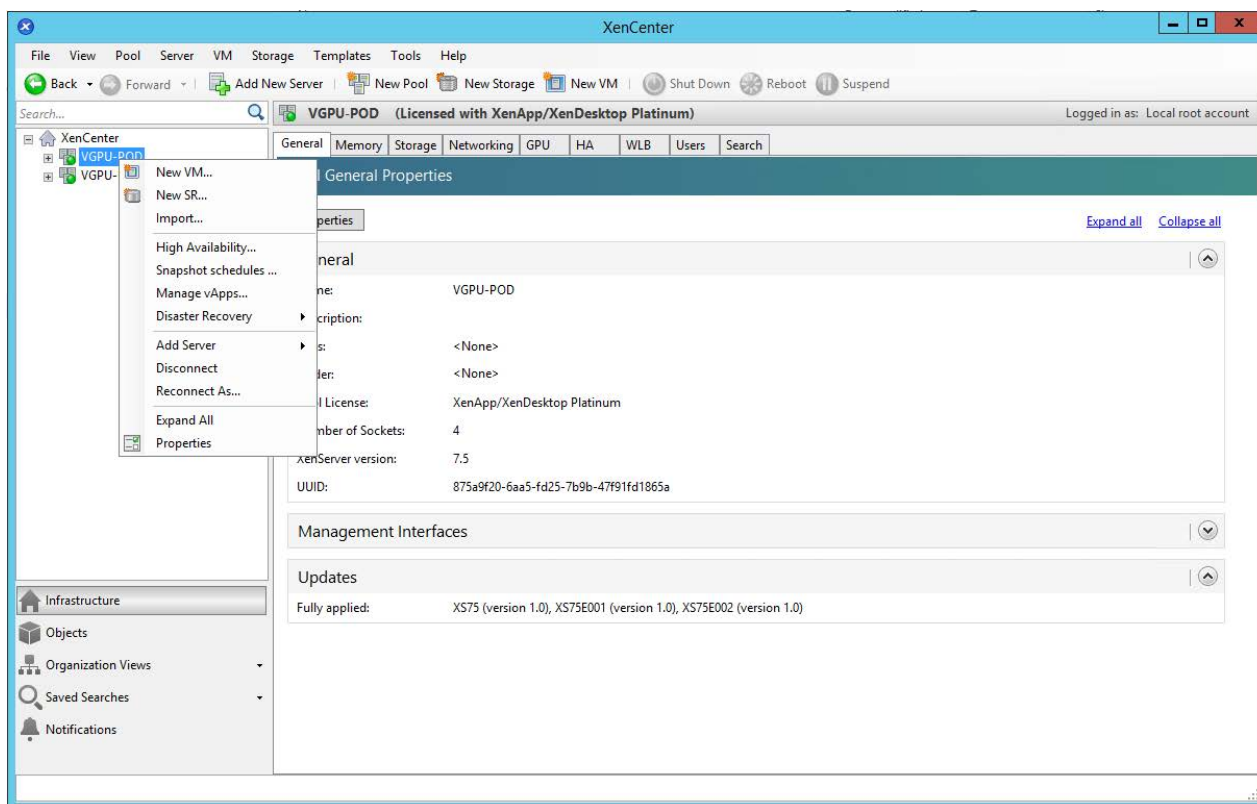
Now create virtual desktops with vGPU support.

Create the Citrix XenDesktop base image

Use the following procedure to create the virtual machine that will later be used as the virtual desktop base image.

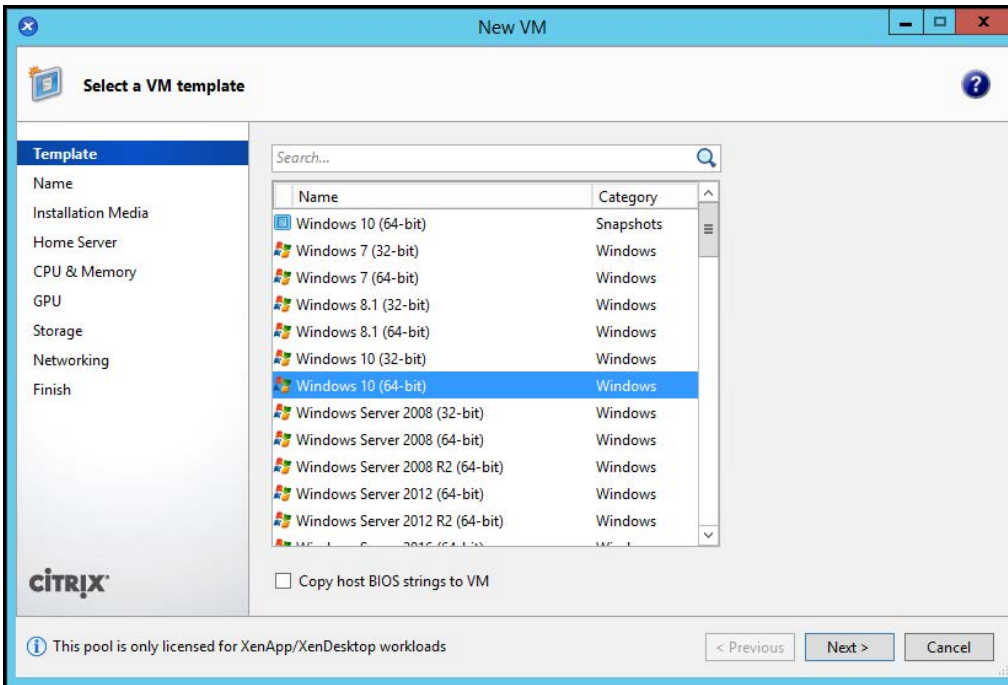
1. Using XenCenter, create a new virtual machine. To do this, right-click a host or resource pool and choose New VM. Work through the New VM wizard. Unless another configuration is specified, select the configuration settings appropriate for your environment (Figure 72).

Figure 72. Creating a new virtual machine in Citrix XenCenter



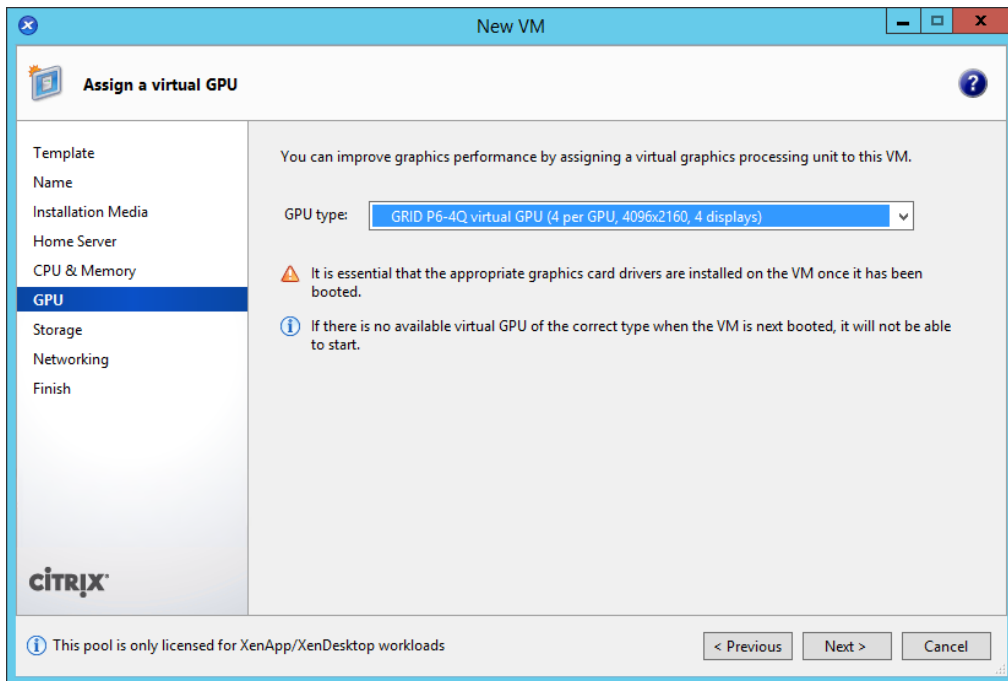
2. Choose a virtual machine template appropriate for your environment. Figure 73 shows the Windows 10 (64-bit) template required by SPECviewer13.

Figure 73. Selecting a virtual machine template



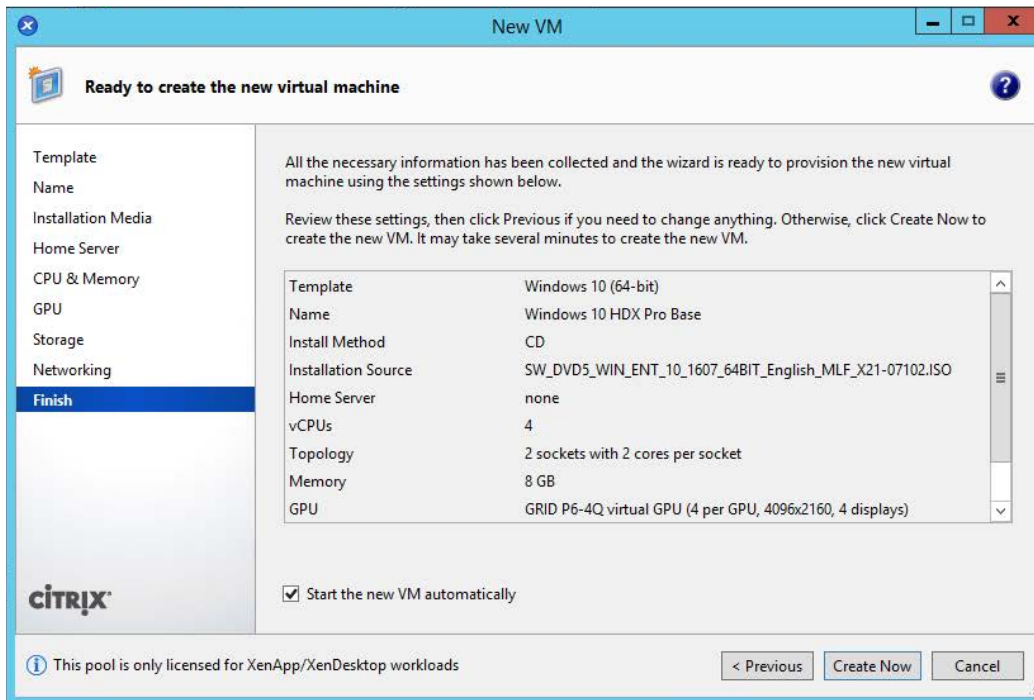
3. Follow New VM wizard to customize the hardware of the new virtual machine and assign the appropriate GPU type to be used by the virtual machine template (Figure 74).

Figure 74. Selecting a new virtual machine GPU



4. Continue to follow the New VM wizard. On the Finish screen, select Create Now to create a virtual machine that will be used for the base desktop image (Figure 75).

Figure 75. New VM summary page



Note: A virtual machine with a vGPU assigned will not start if ECC is enabled. As a workaround, disable ECC by entering the following commands:

```
#nvidia-smi -i 0 -e 0
```

```
#nvidia-smi -i 1 -e 0
```

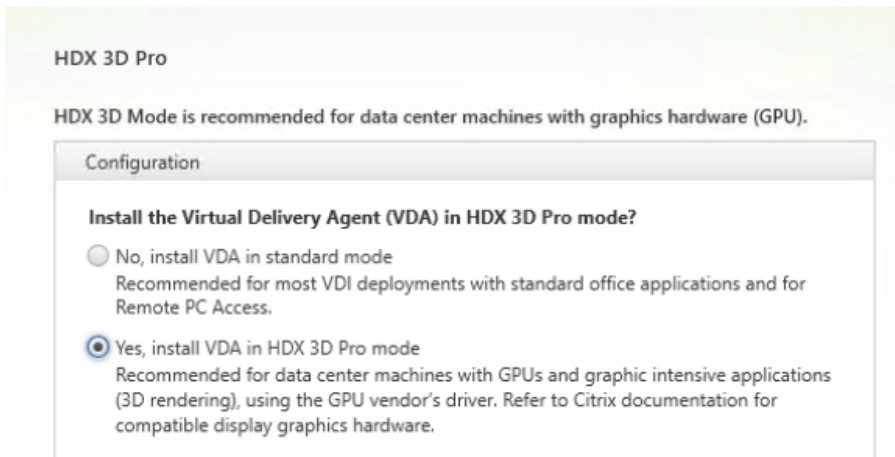
Use option `-i` to target a specific GPU. If two cards are installed in a server, run the command twice as shown here, where 0 and 1 each indicate a GPU card.

5. Install and configure Microsoft Windows on the virtual machine:
 - a. Install XenServer Tools.
 - b. Install SPECviewperf13.
 - c. Join the virtual machine to the Microsoft Active Directory domain.
 - d. Install or upgrade Citrix HDX 3D Pro Virtual Desktop Agent using the CLI (Figure 76).

When you use the installer's GUI to install a VDA for a Windows desktop, simply 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.

Figure 76. Installing the VDA in HDX 3D Pro



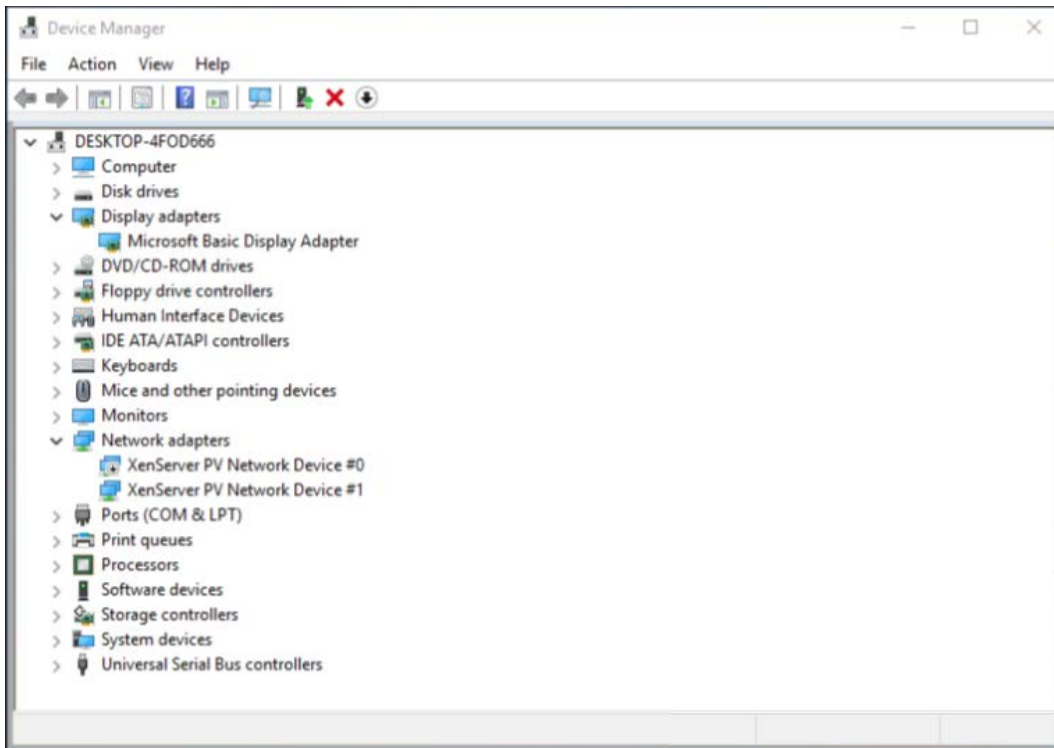
- e. Optimize the Windows OS. [CitrixOptimizer](#), the optimization tool, includes customizable templates to enable or disable Windows system services. Most Windows system services are enabled by default, but you can use the optimization tool to easily disable unnecessary services and features to improve performance.

Install the NVIDIA vGPU software driver

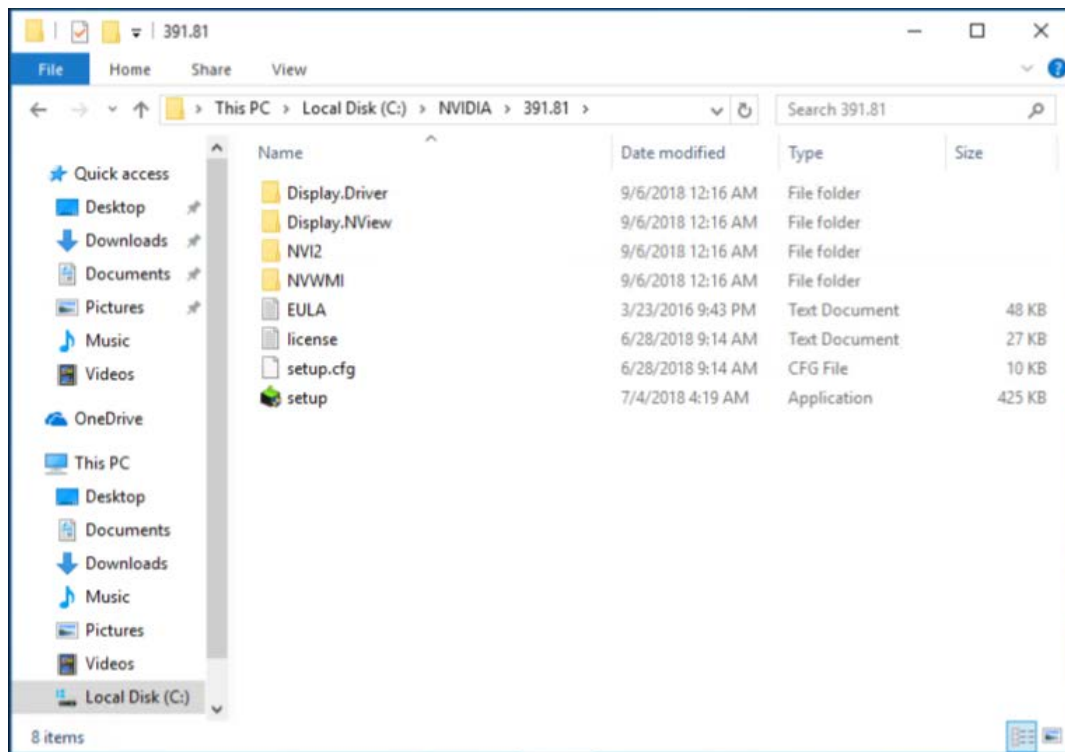
To fully enable vGPU operation, the NVIDIA driver must be installed. Use the following procedure to install the NVIDIA GRID vGPU drivers on the desktop virtual machine.

Before the NVIDIA driver is installed on the guest virtual machine, the Device Manager shows the Microsoft Basic Display adapter installed (Figure 77).

Figure 77. Device Manager before the NVIDIA driver is installed



1. Copy the Windows drivers from the NVIDIA GRID vGPU driver pack downloaded earlier to the master virtual machine.
2. Copy the 32- or 64-bit NVIDIA Windows driver from the vGPU driver pack to the desktop virtual machine and run setup.exe (Figure 78).

Figure 78. NVIDIA driver pack

Note: The vGPU host driver and guest driver versions need to 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.

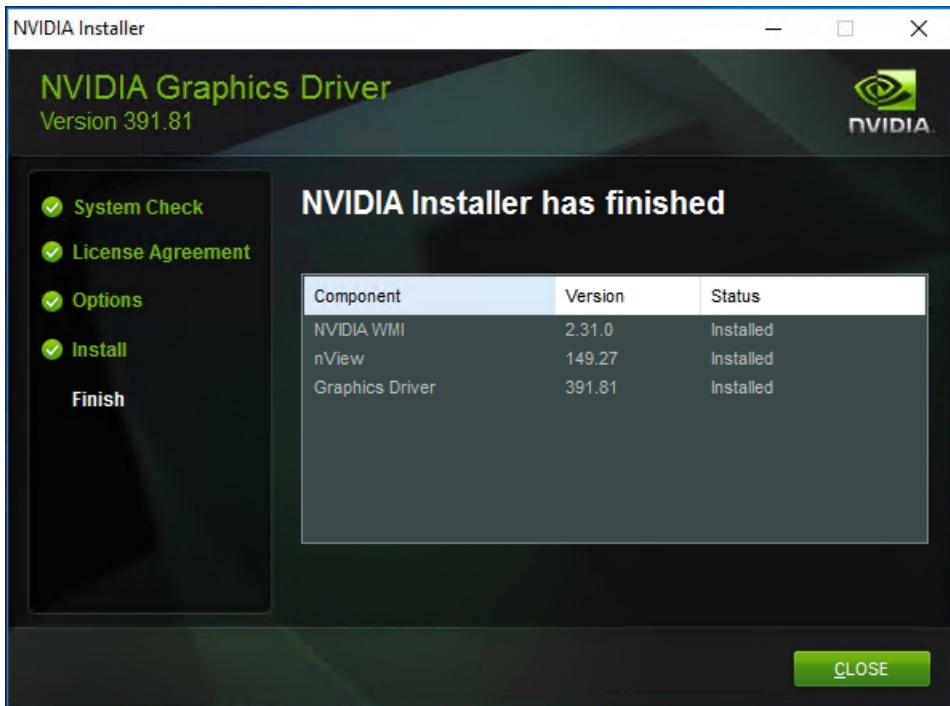
3. Install the graphics drivers using the Express Option (Figure 79). After the installation is completed successfully, click Close (Figure 80) and restart the virtual machine.

Note: Be sure that remote desktop connections have been enabled. After this step, console access may to the virtual machine may not be available when you connect from a vSphere client.

Figure 79. Select the Express or Custom installation option



Figure 80. Components installed during the NVIDIA graphics driver installation process

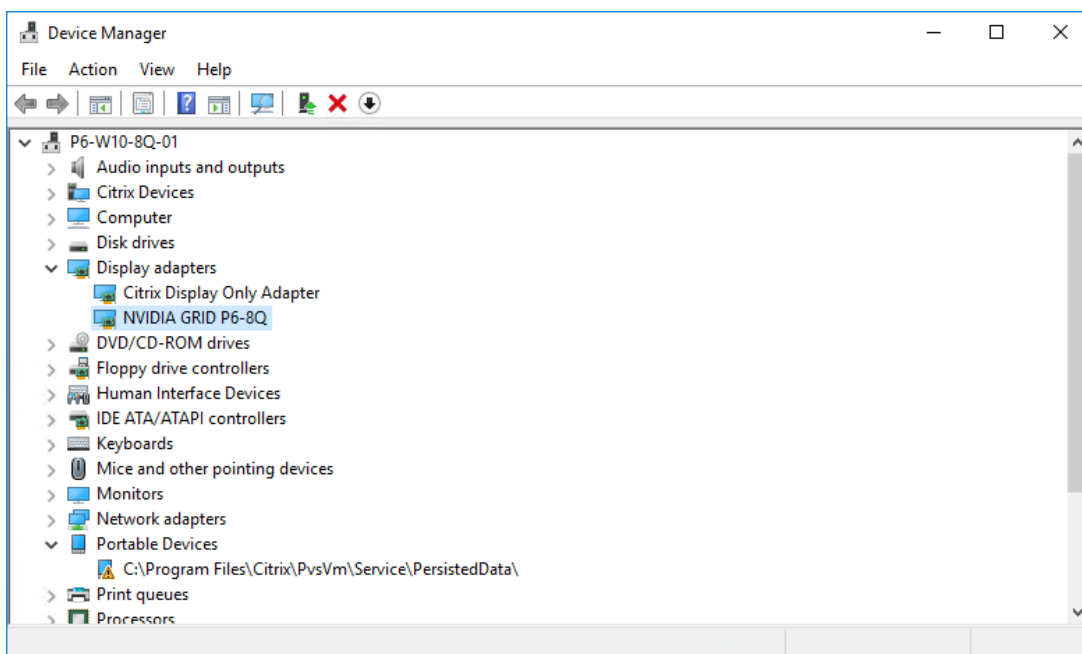


Verify that the virtual machine is ready to support the vGPU

Verify the successful installation of the graphics drivers and the vGPU device.

1. Open Windows Device Manager and expand the Display Adapter section. The device will reflect the chosen profile (Figure 81).

Figure 81. Verifying the driver installation: Device Manager



2. Verify that NVIDIA GRID is enabled by using the NVFBCEnable tool provided by NVIDIA (Figure 82).

Figure 82. Validating the driver installation: NVFBCEnable tool

```
Administrator: Windows PowerShell
PS C:\Users\administrator> NvFBCEnable.exe -checkstatus
NVFBC is enabled
-> NOT capturing in display: vidPnSrcId = 0, displayName = \\.\DISPLAY1
PS C:\Users\administrator> _
```

3. If NVBC is disabled as shown in Figure 83, enable it with the NVFBCEnable tool as shown in Figure 84 and then reboot the virtual machine.

Figure 83. Verifying the driver installation: NVFBCEnable tool (NVFBC disabled)

```
Administrator: Windows PowerShell
Windows PowerShell
Copyright (C) 2016 Microsoft Corporation. All rights reserved.

PS C:\Users\administrator> NvFBCEnable.exe -checkstatus
NVFBC is disabled
PS C:\Users\administrator> _
```

Figure 84. Verifying the driver installation: NVFBCEnable tool (enable NVFBC)

```
PS C:\Users\administrator> NvFBCEnable.exe -enable
NvFBC is enabled
PS C:\Users\administrator> _
```

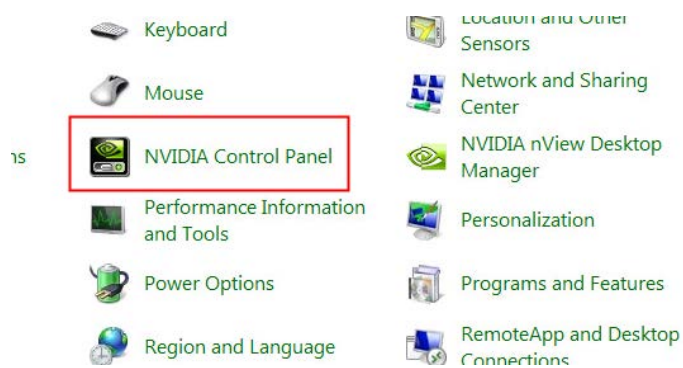
Configure the virtual machine for an NVIDIA GRID vGPU license

You need to point the master image to the license server so the virtual machines with vGPUs can obtain the license.

Note: The license settings persist across reboots. These settings can also be preloaded through register keys.

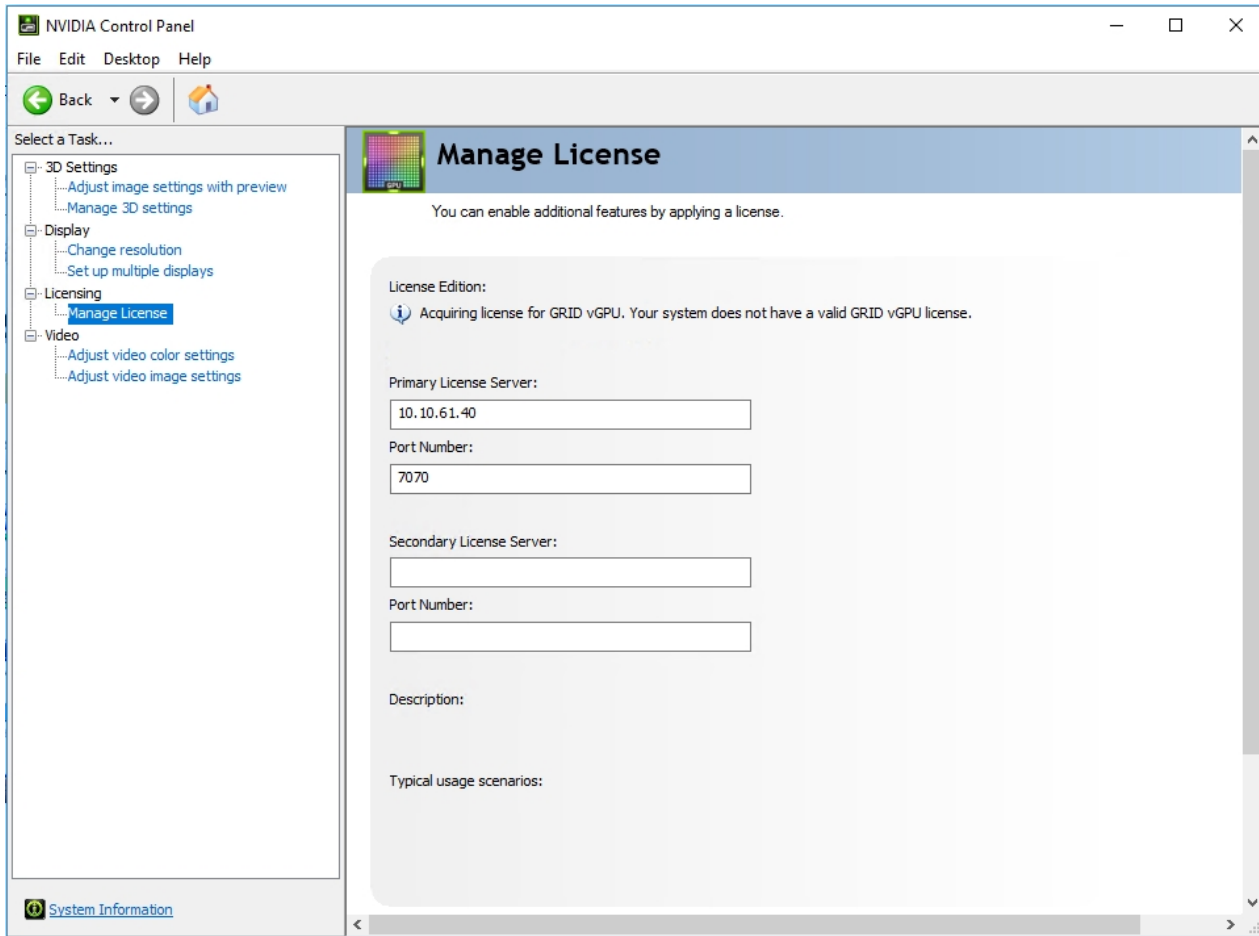
1. In the Microsoft Windows Control Panel, double-click NVIDIA Control Panel (Figure 85).

Figure 85. Choosing the NVIDIA control panel



2. Select Manage License from the left pane and enter your license server address and port (Figure 86).

Figure 86. Managing your license



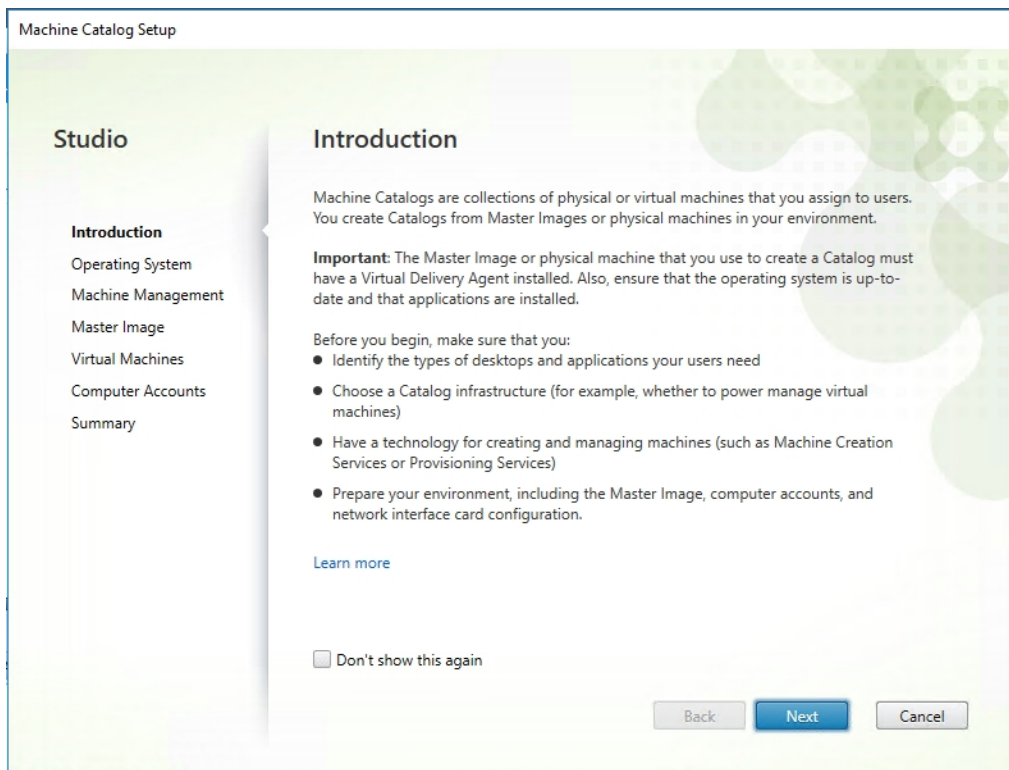
3. Click Apply.

Deploy virtual machines with Citrix Machine Creation Services

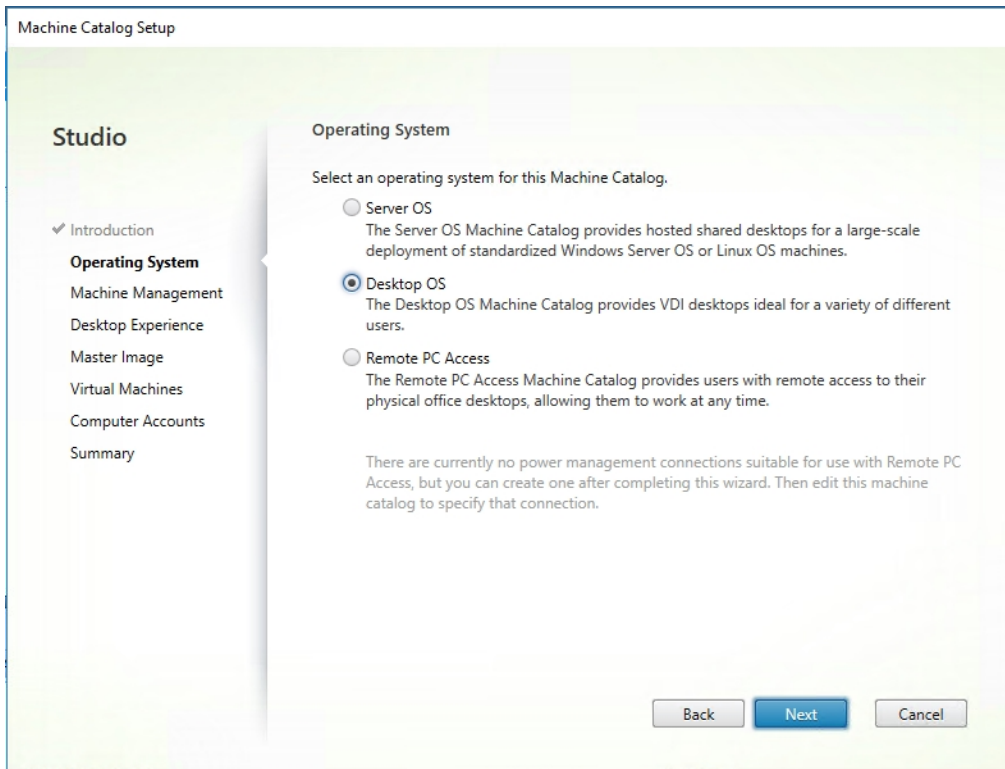
A collection of virtual machines managed as a single entity is called a machine catalog. To create virtual machines in a catalog that have the same type of GPU using Citrix MCS, follow these steps:

1. Connect to a XenDesktop server and launch Citrix Studio.
2. Choose Create Machine Catalog from the Actions pane. Then click Next (Figure 87).

Figure 87. Creating a machine catalog

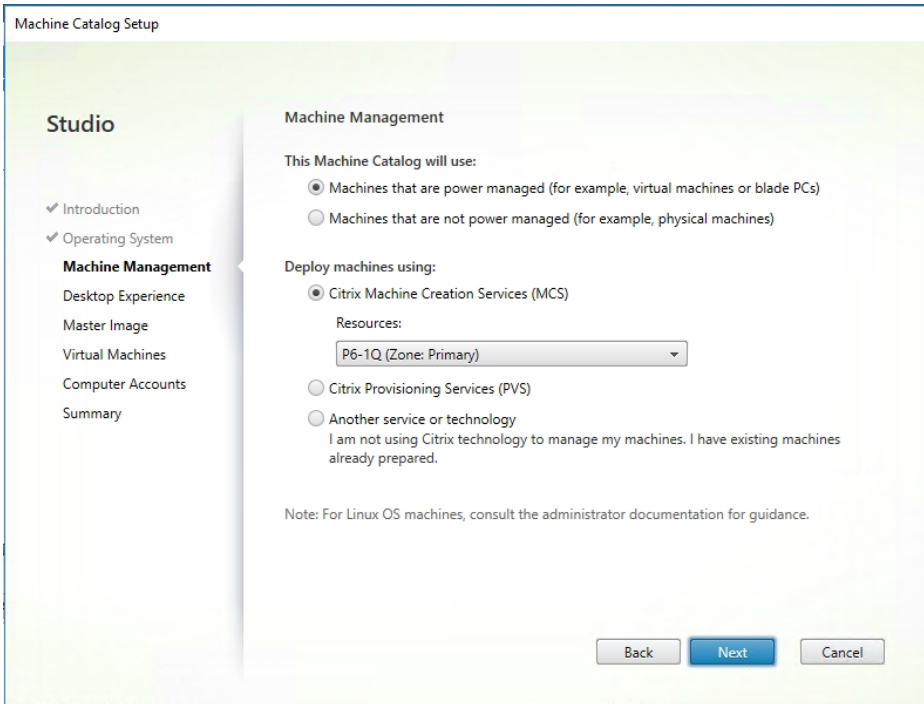


3. Select Desktop OS. Then click Next (Figure 88).

Figure 88. Selecting the OS

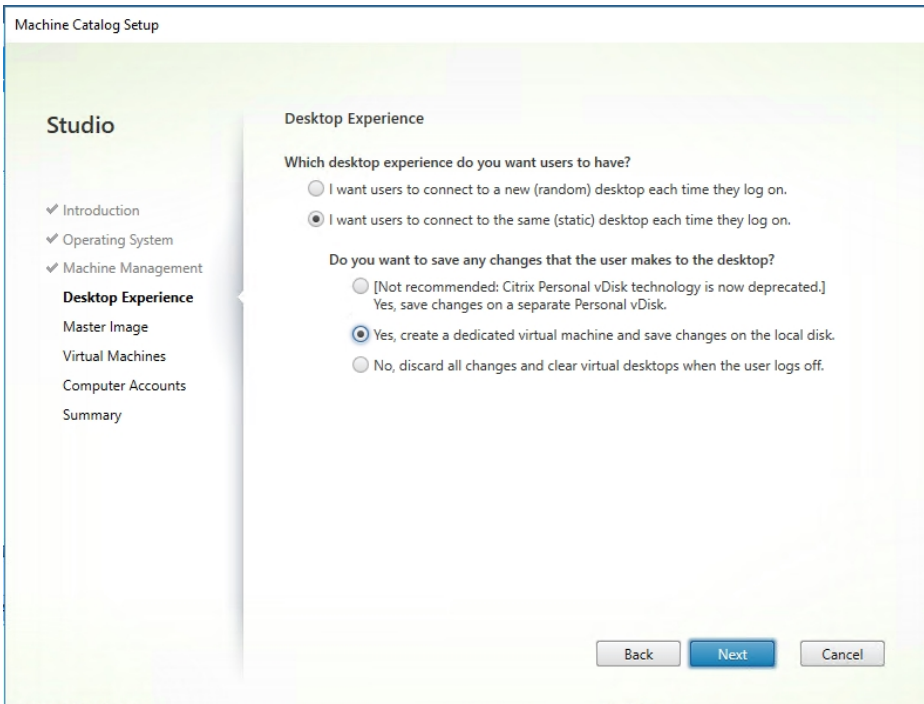
4. Select the appropriate machine management. Select the resource that will provision the virtual machine with the required GPU profile. Then click Next (Figure 89).

Figure 89. Selecting machine management



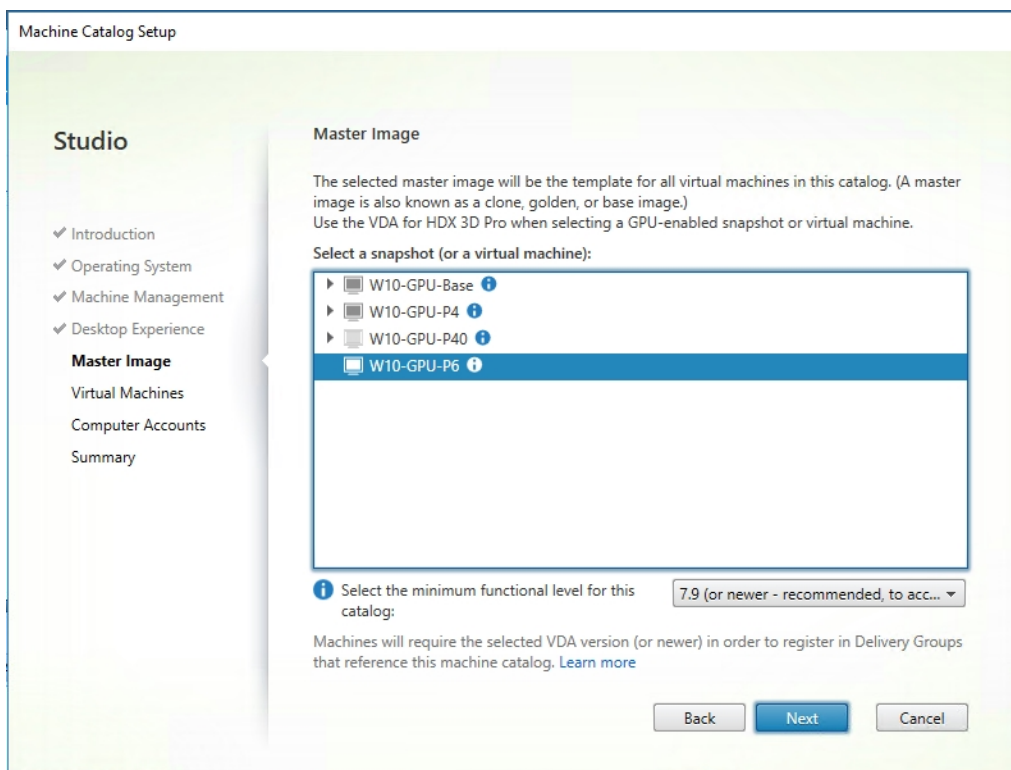
5. For Desktop Experience, select Static, Dedicated Virtual Machine. Then click Next (Figure 90).

Figure 90. Selecting the desktop experience



6. Select a virtual machine to be used as the catalog master image. Then click Next (Figure 91).

Figure 91. Selecting a virtual machine for the catalog master image

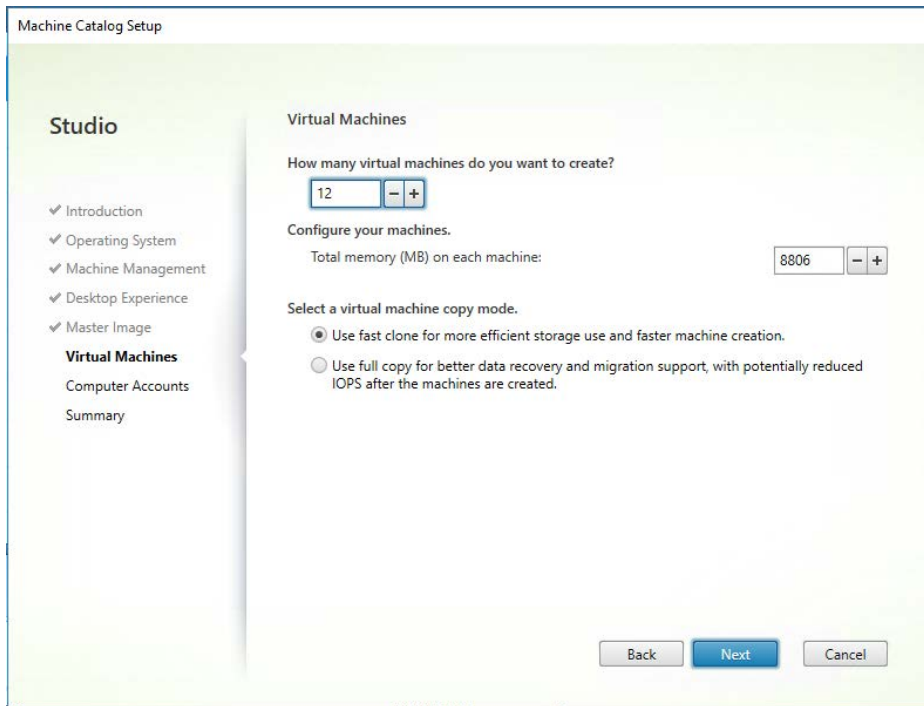


7. Specify the number of desktops to create and the machine configuration.

8. Set the amount of memory (in megabytes) to be used by virtual desktops.

9. Select Fast Clone as the machine copy mode.

10. Click Next (Figure 92).

Figure 92. Configuring the virtual machines

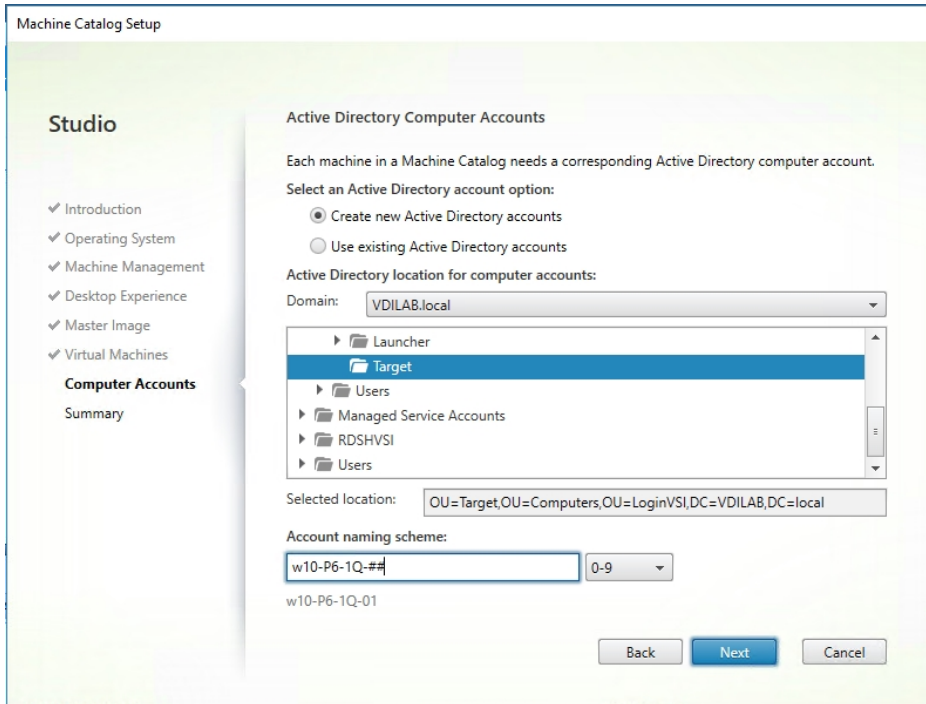
The screenshot shows the 'Machine Catalog Setup' interface. On the left is a 'Studio' sidebar with a list of steps: Introduction, Operating System, Machine Management, Desktop Experience, Master Image, **Virtual Machines** (highlighted), Computer Accounts, and Summary. The main area is titled 'Virtual Machines' and contains the following configuration options:

- How many virtual machines do you want to create?** A numeric input field with the value '12' and minus/plus buttons.
- Configure your machines.** A sub-section with the label 'Total memory (MB) on each machine:' and a numeric input field with the value '8806' and minus/plus buttons.
- Select a virtual machine copy mode.** Two radio button options:
 - Use fast clone for more efficient storage use and faster machine creation.
 - Use full copy for better data recovery and migration support, with potentially reduced IOPS after the machines are created.

At the bottom right of the main area are three buttons: 'Back', 'Next' (highlighted in blue), and 'Cancel'.

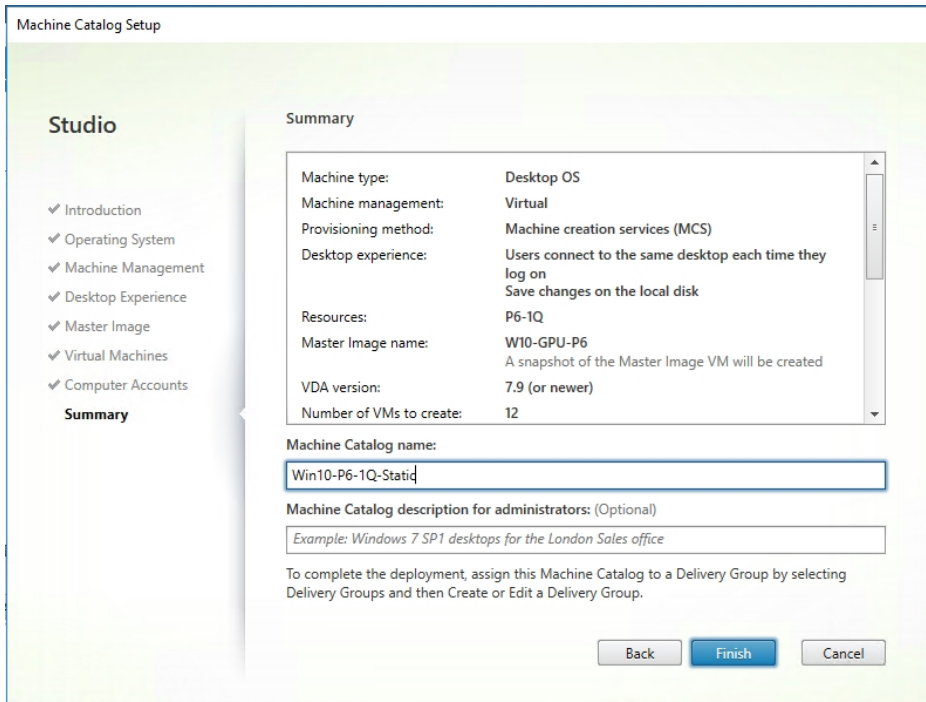
11. Specify the Active Directory account naming scheme and organizational unit in which accounts will be created. Then click Next (Figure 93).

Figure 93. Configuring Microsoft Active Directory accounts



12. On the Summary page specify the catalog name and click Finish to start deployment (Figure 94).

Figure 94. Machine catalog Summary page



Verify vGPU deployment

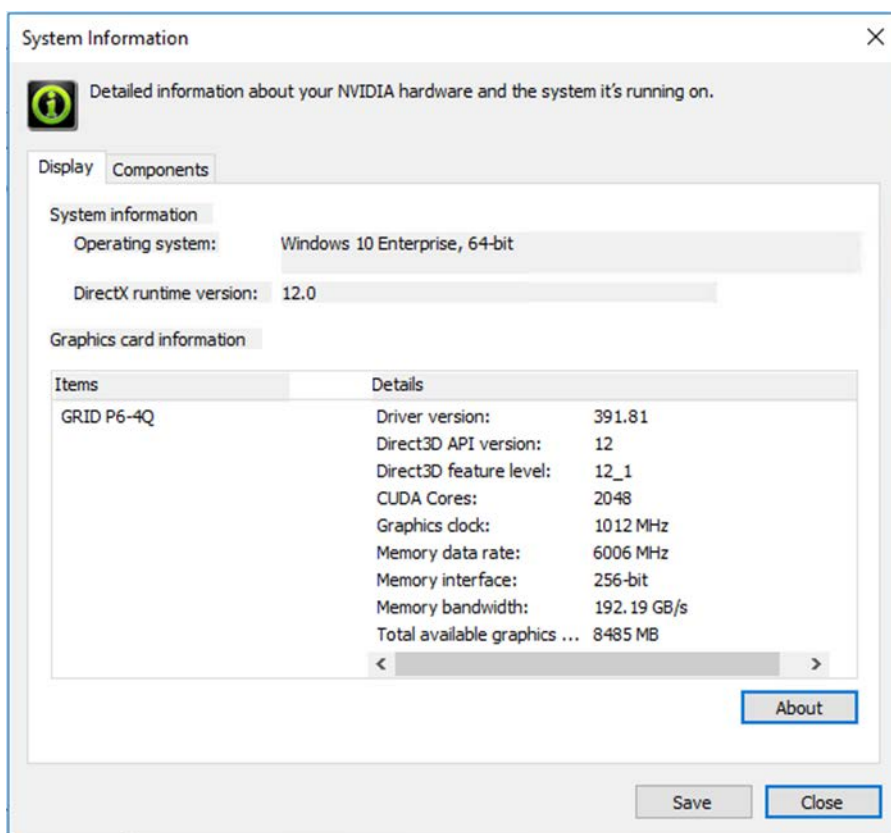
After the desktops are provisioned, use the following steps to verify vGPU deployment in the Citrix XenDesktop environment.

Verify that the NVIDIA driver is running on the desktop

Follow these steps to verify that the NVIDIA driver is running on the desktop:

1. Right-click the desktop. In the menu, choose NVIDIA Control Panel to open the control panel.
2. In the control panel, select System Information to see the vGPU that the virtual machine is using, the vGPU's capabilities, and the NVIDIA driver version that is loaded (Figure 95).

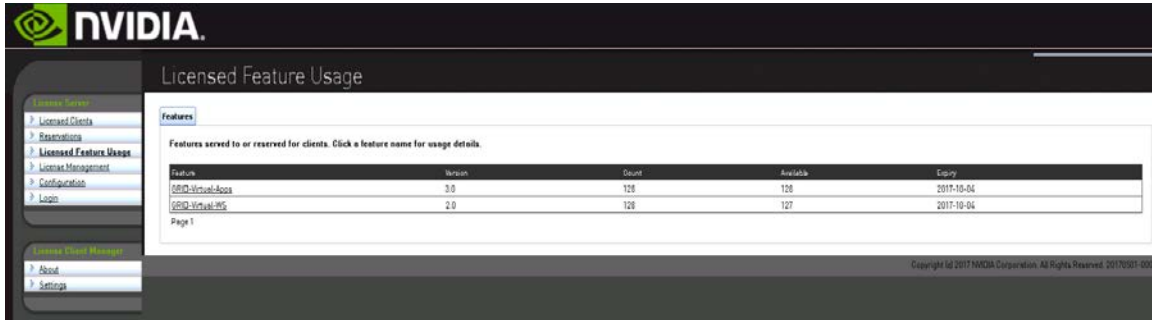
Figure 95. NVIDIA control panel: System Information page



Verify NVIDIA license acquisition by desktops

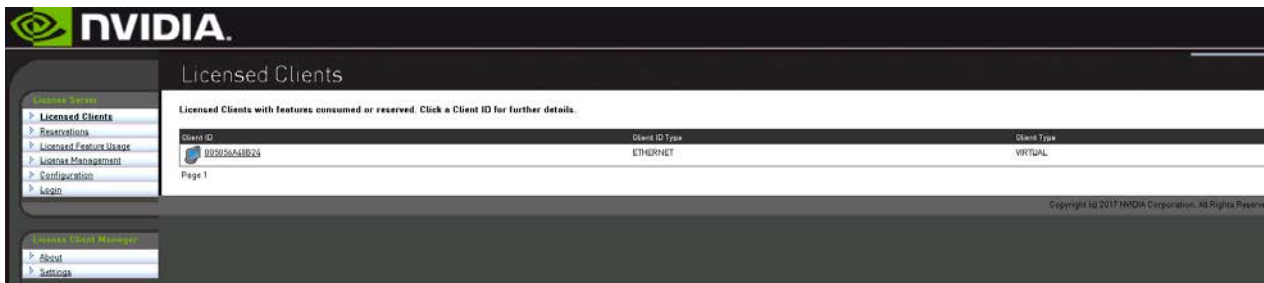
A license is obtained after the virtual machine is fully booted and before the user logs on to the virtual machine (Figure 96).

Figure 96. NVIDIA license server: Licensed Feature Usage page



To view the details, select Licensed Clients in the left pane (Figure 97).

Figure 97. NVIDIA license server: Licensed Clients page



Citrix XenDesktop policies

Policies and profiles allow the Citrix XenDesktop environment to be easily and efficiently customized.

Citrix XenDesktop policies control user access and session environments and provide the most efficient means for controlling connection, security, and bandwidth settings. You can create policies for specific groups of users, devices, or connection types with each policy. Policies can contain multiple settings and typically are defined through Citrix Studio. (You can also use the Windows Group Policy Management Console if the network environment includes Microsoft Active Directory and permissions are set for managing group policy objects.) Figure 98 shows the policies for GPU testing used in this document.

Figure 98. GPU testing policies (very high-definition user experience)

GPU Testing

Overview	Settings	Assigned to
	<ul style="list-style-type: none"> ▶ Extra color compression User setting - ICA\Visual Display\Still Images Disabled (Default: Disabled) ▶ Legacy graphics mode Computer setting - ICA\Graphics Disabled (Default: Disabled) ▶ Preferred color depth for simple graphics User setting - ICA\Visual Display 24 bits per pixel (Default: 24 bits per pixel) ▶ Target frame rate User setting - ICA\Visual Display (Default: 30 fps) ▶ Target minimum frame rate User setting - ICA\Visual Display\Moving Images 10 fps (Default: 10 fps) ▶ Use hardware encoding for video codec User setting - ICA\Graphics Enabled (Default: Enabled) ▶ Use video codec for compression User setting - ICA\Graphics For the entire screen (Default: Use when preferred) ▶ Visual quality User setting - ICA\Visual Display High (Default: Medium) 	

SPECviewperf 13 benchmark results

[SPECviewperf 13](#) is the latest version of the benchmark that measures the 3D graphics performance of systems running under the OpenGL and Direct X APIs. The benchmark’s workloads, called viewsets, represent graphics content and behavior from actual applications.

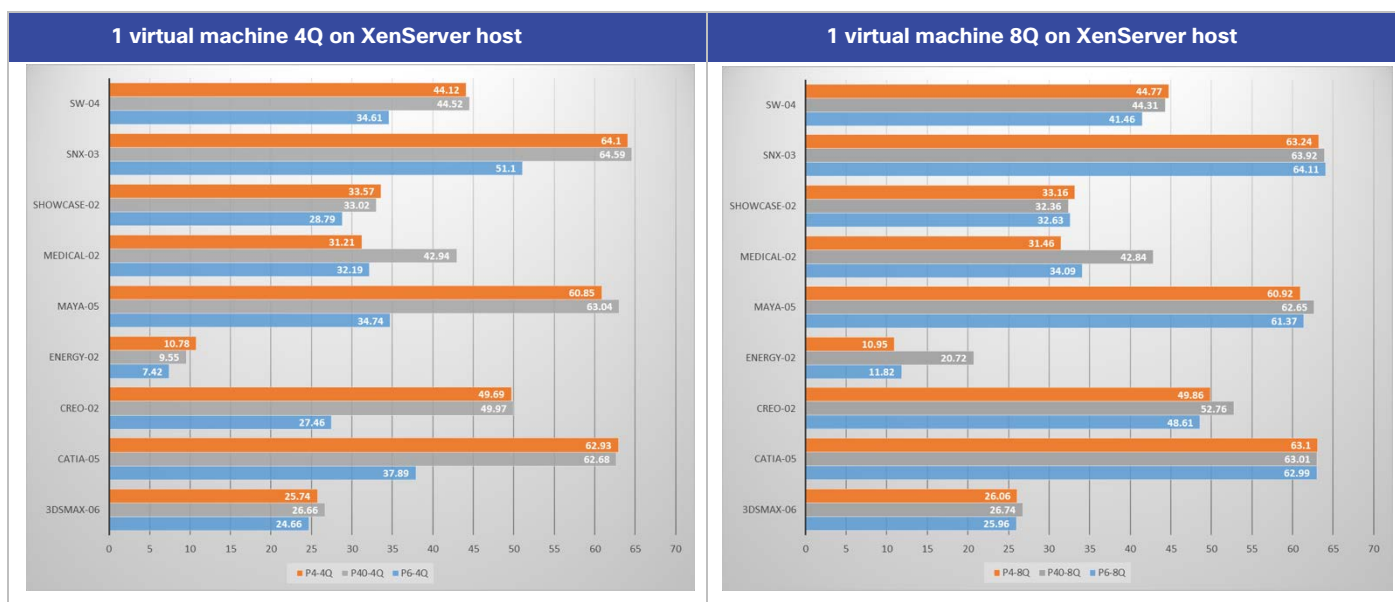
SPECviewperf 13 has the following viewsets:

- 3ds Max (3dsmax-06)
- CATIA (catia-05)
- Creo (creo-02)
- Energy (energy-02)
- Maya (maya-05)
- Medical (medical-02)
- Showcase (showcase-02)
- Siemens NX (snx-03)
- Solidworks (sw-04)

The benchmark is available for download at <https://www.spec.org/gwpg/downloadindex.html - viewperf13>.

Figure 99 compares all three graphics cards studied over the nine benchmark applications with NVIDIA GRID vDWS 4Q and 8Q profiles to show the impact of increased video frame buffer size by card and by application. The tests reported here used the default settings for the NVIDIA driver for the frame rate limiter (on), with best-effort scheduling. The intent was to get a clean benchmark comparison of the three Tesla cards with the default settings. In some situations and for some applications, these settings can be changed to enhance the end-user experience.

Figure 99. SPECviewperf results: Single virtual machine comparison: P4, P6, and P40 with vDWS 4Q (left) and 8Q (right)



For the NVIDIA Tesla P4 and P40 PCIe cards running in Cisco UCS C240 M5 servers, increasing the frame buffer size from 4 GB to 8 GB had only a small effect on the composite frame rate. However, in the case of the NVIDIA Tesla P6 cards running in Cisco UCS B200 M5 servers, the 8-GB frame buffer provided a dramatic improvement in frame rate in most of the applications.

The next set of tests compared individual cards using 4-GB and 8-GB profiles with the Tesla card host running one virtual machine or the maximum number of virtual machines possible across the cards in the host.

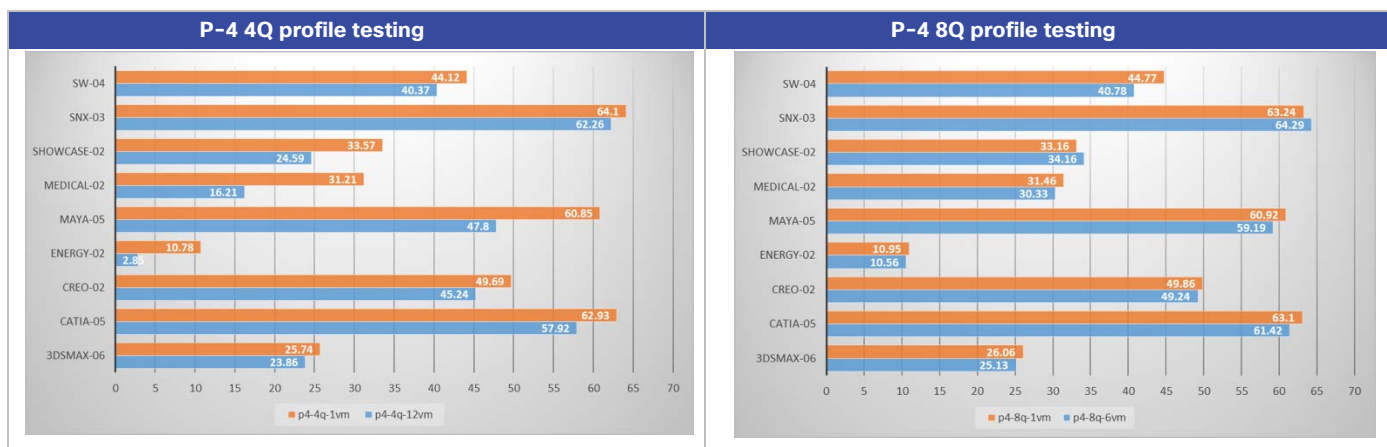
NVIDIA Tesla P4 test results

Figure 100 shows the results for the NVIDIA Tesla P4 8-GB card running each profile size. The Cisco UCS C240 host contained six P4 cards, for a total of 48 GB of frame buffer space across the server.

The left chart shows the P4 performance with one virtual machine running a 4-GB profile (orange) and 12 virtual machines running 4-GB profiles (blue) on the same host (two test cycles).

The right chart shows the P4 performance with one virtual machine running an 8-GB profile (orange) and six virtual machines running 8-GB profiles (blue) on the same host (two test cycles).

Figure 100. SPECviewperf results for P4 4Q and 8Q profile tests: Single virtual machine versus maximum host density based on profile size



This test reveals that using a P4 card with twelve 4-GB profiles across the six cards in the server has a measurable negative impact on application frame rate. The impact varies by application, with some applications, such as Siemens NX and 3DSMAX, showing a light impact, and others, such as Medical and Energy, showing a substantial impact.

The tests of the P4 card with six virtual machines with 8-GB profiles (each virtual machine getting the full power of the P4 card) shows the expected results: near parity in performance with a single virtual machine running on a single card. The differences can be explained by the traffic on the PCI bus and increased CPU utilization.

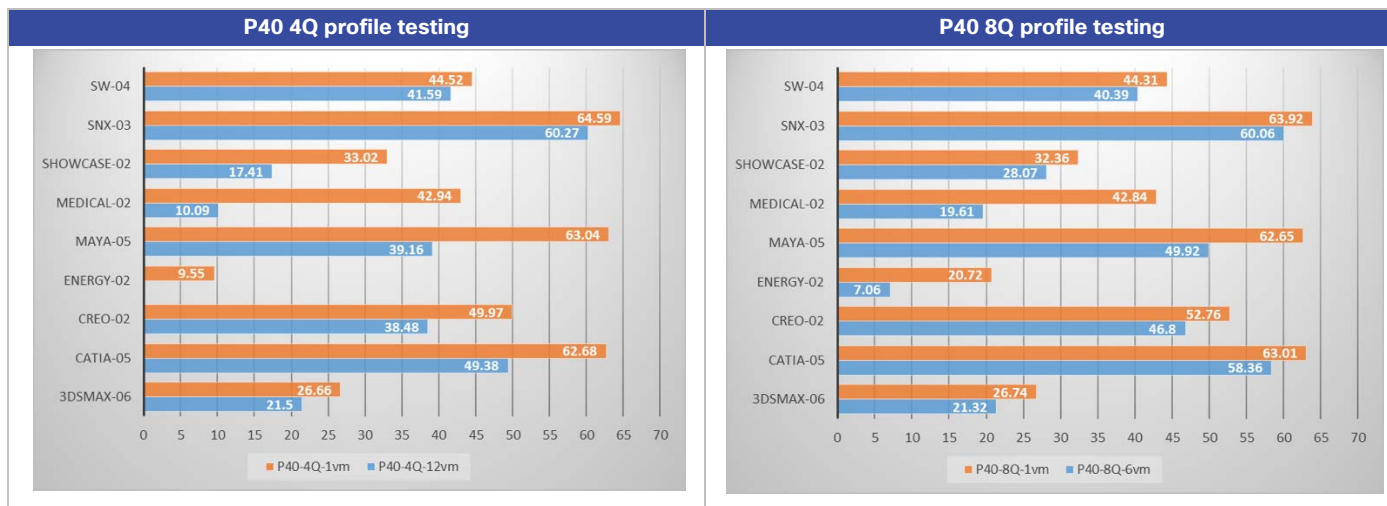
NVIDIA Tesla P40 test results

Figure 101 shows the results for the NVIDIA Tesla P40 24-GB card running the 4-GB and 8-GB profile sizes. The Cisco UCS C240 host contained two P40 cards, for a total of 48 GB of frame buffer space across the server.

The left chart shows the P40 performance with one virtual machine running a 4-GB profile (orange) and 12 virtual machines running 4-GB profiles (blue) on the same host (two test cycles).

The right chart shows the P40 performance with one virtual machine running an 8-GB profile (orange) and six virtual machines running 8-GB profiles (blue) on the same host (two test cycles).

Figure 101. SPECviewperf results for P40 4Q and 8Q profile tests: Single virtual machine versus maximum host density based on profile size



Note: For the 4-GB frame buffer tests, the impact of running six virtual machines on each Tesla P40 card versus a single virtual machine on one card is pronounced. In fact, we were unable to complete benchmark test cycles with six virtual machines on each Tesla P40 because the Energy application failed on multiple virtual machines during the test. Therefore, the chart in Figure 101 was generated by running the test without that application.

For the 8-GB frame buffer tests, the variation in frame buffer with one virtual machine and with six virtual machines was not quite as pronounced as what was seen with the 4-GB buffer. The Energy application did run with the 8-GB frame buffer with multiple virtual machines per card.

P40 4Q tests with 12 virtual machines (maximum density with two NVIDIA P40 cards installed in the Cisco UCS C240 server) were performed without the Energy viewset. The Energy viewset failed with a “[TRD Detected](#)” error on all 12 virtual machines.

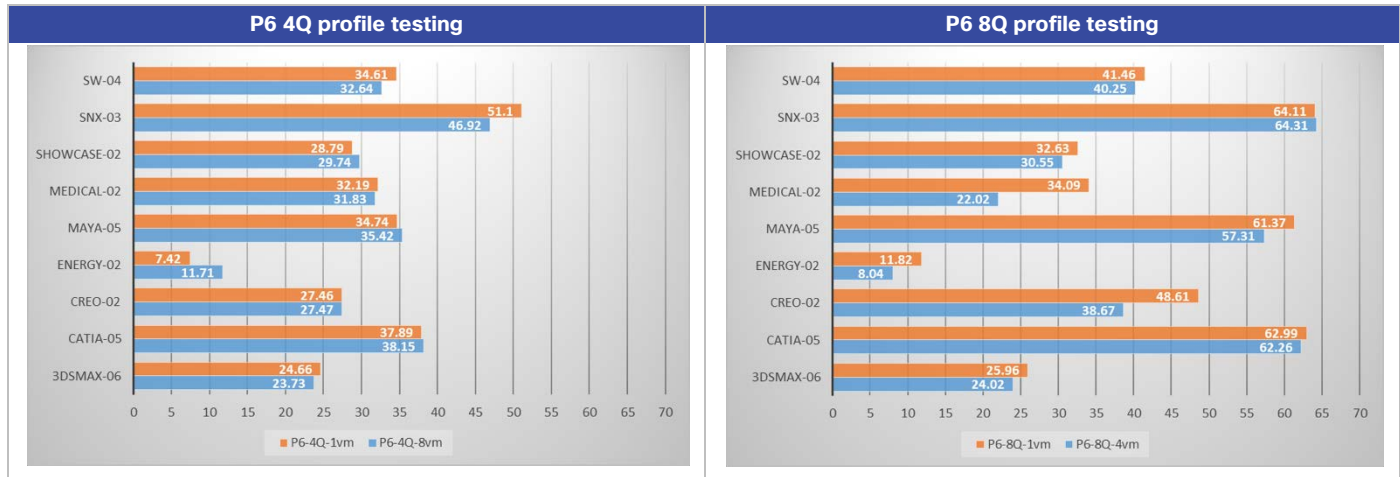
NVIDIA Tesla P6 test results

Figure 102 shows the results for the NVIDIA Tesla P6 16-GB card running the 4-GB and 8-GB profile sizes. The Cisco B200 M5 host contained two P6 cards, for a total of 32-GB of frame buffer space across the server.

The left chart shows the P6 performance with one virtual machine running a 4-GB profile (orange) and eight virtual machines running 4-GB profiles (blue) on the same host (two test cycles).

The right chart shows the P6 performance with one virtual machine running an 8-GB profile (orange) and four virtual machines running 8-GB profiles (blue) on the same host (two test cycles).

Figure 102. SPECviewperf results for P6 4Q and 8Q profile tests: Single virtual machine versus maximum host density based on profile size



The Tesla P6 running the 4-GB profile showed the best performance at scale across the application set. The Tesla P6 with the 8-GB profile showed a significant performance improvement for the tests with one virtual machine and multiple virtual machines on most of the application sets.

Host CPU utilization test results

The NVIDIA Tesla GPUs work in concert with the host’s Intel Xeon Scalable family processors. The following sections discuss CPU utilization during the same tests described in the preceding sections.

Figure 103 presents the data for the Tesla P4 4Q and 8Q profiles.

Figure 104 presents the data for the Tesla P40 4Q and 8Q profiles.

Figure 105 presents the data for the Tesla P6 4Q and 8Q profiles.

Figure 103. Cisco UCS C240 CPU utilization results for SPECviewperf P-4 4Q and 8Q profile tests: Single virtual machine versus maximum density

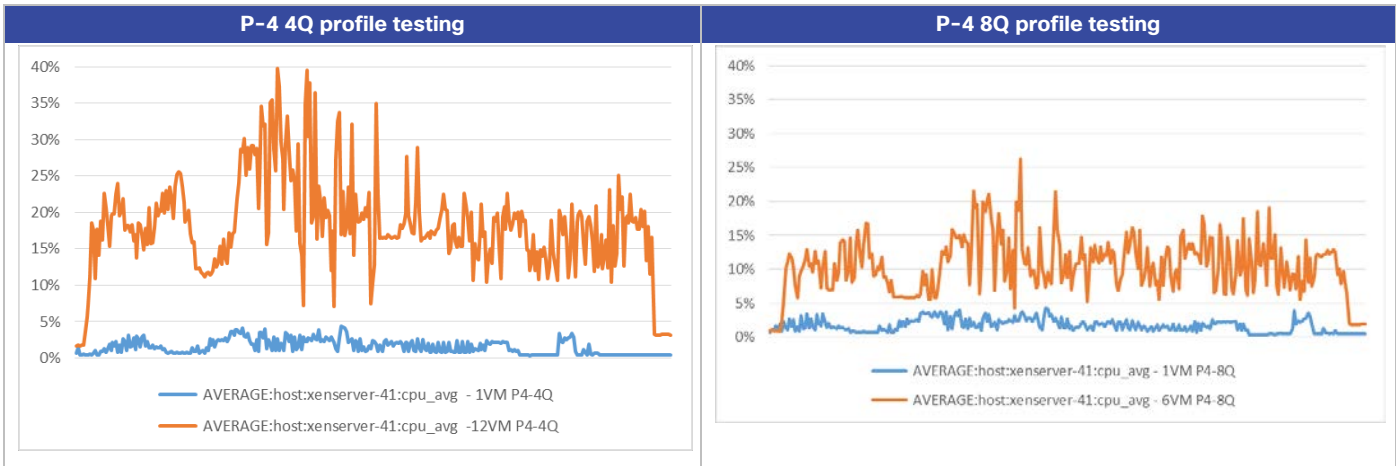


Figure 104. Cisco UCS C240 CPU utilization results for SPECviewperf P-40 4Q and 8Q profile tests: Single virtual machine versus maximum density

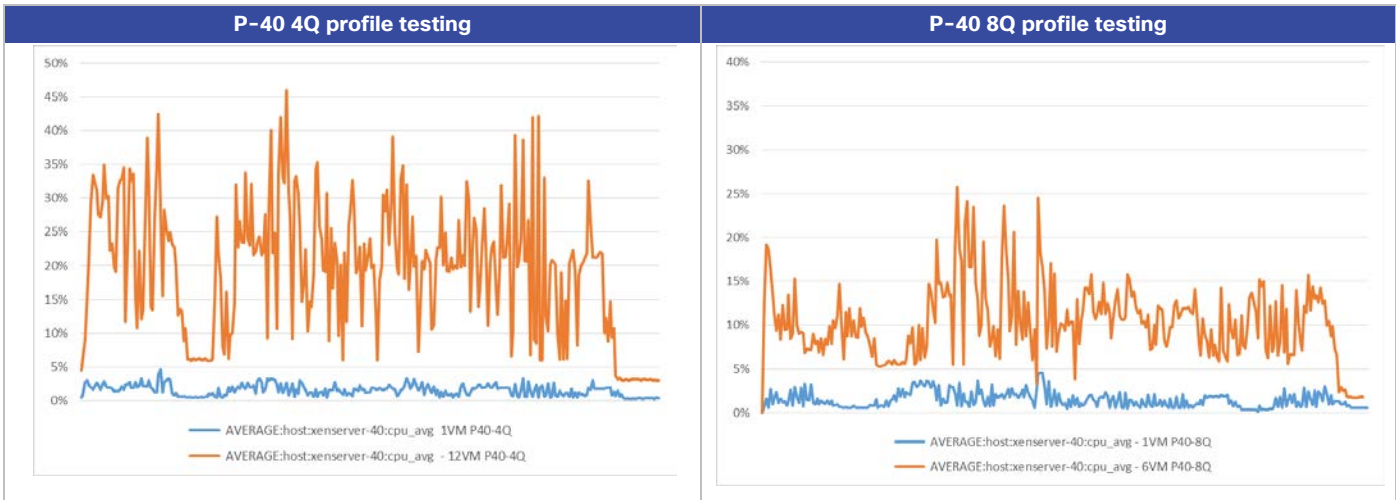
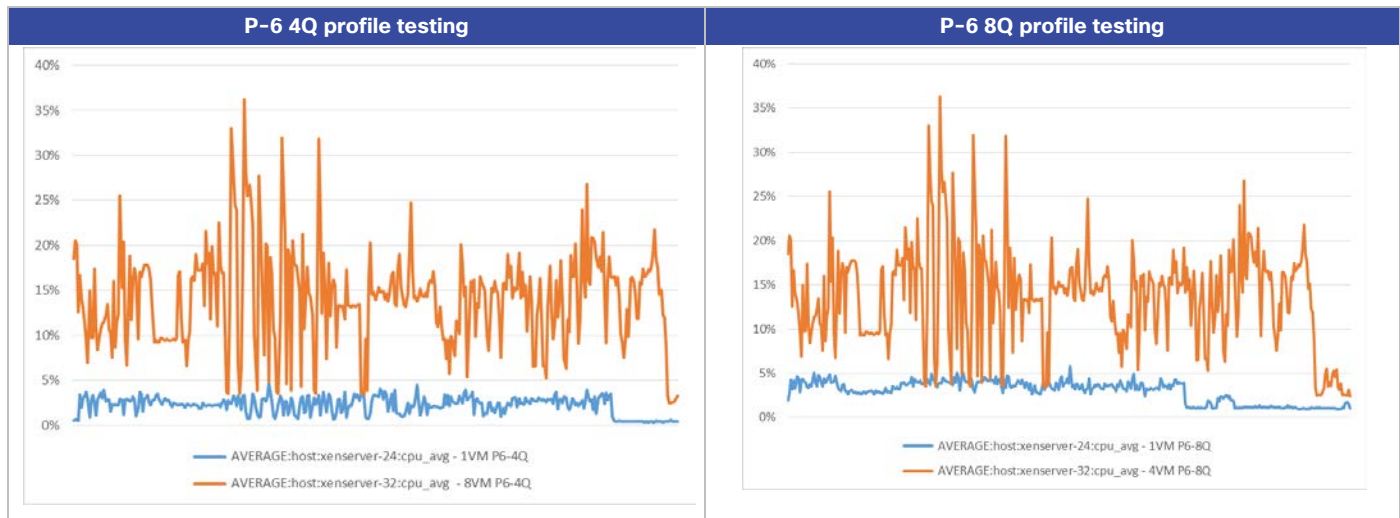


Figure 105. Cisco UCS B200 CPU utilization results for SPECviewperf P-6 4Q and 8Q profile tests: Single virtual machine versus maximum density



Host GPU utilization test results

The NVIDIA Tesla GPUs work in concert with the host’s Intel Xeon Scalable family processors. The following figures show the GPU utilization during the same tests discussed in the preceding sections.

Figure 106 presents the data for the Tesla P4 4Q and 8Q profiles.

Figure 107 presents the data for the Tesla P40 4Q and 8Q profiles.

Figure 108 presents the data for the Tesla P6 4Q and 8Q profiles.

The blue plot in each graph represents GPU utilization during the tests using a single virtual machine.

The orange plot in each graph represents GPU utilization during the tests using multiple virtual machines.

Note: Even with a single virtual machine, there are times when the full GPU is utilized.

Figure 106. NVIDIA P-4 results for SPECviewperf P-4 4Q and 8Q profile tests: Single virtual machine versus maximum density

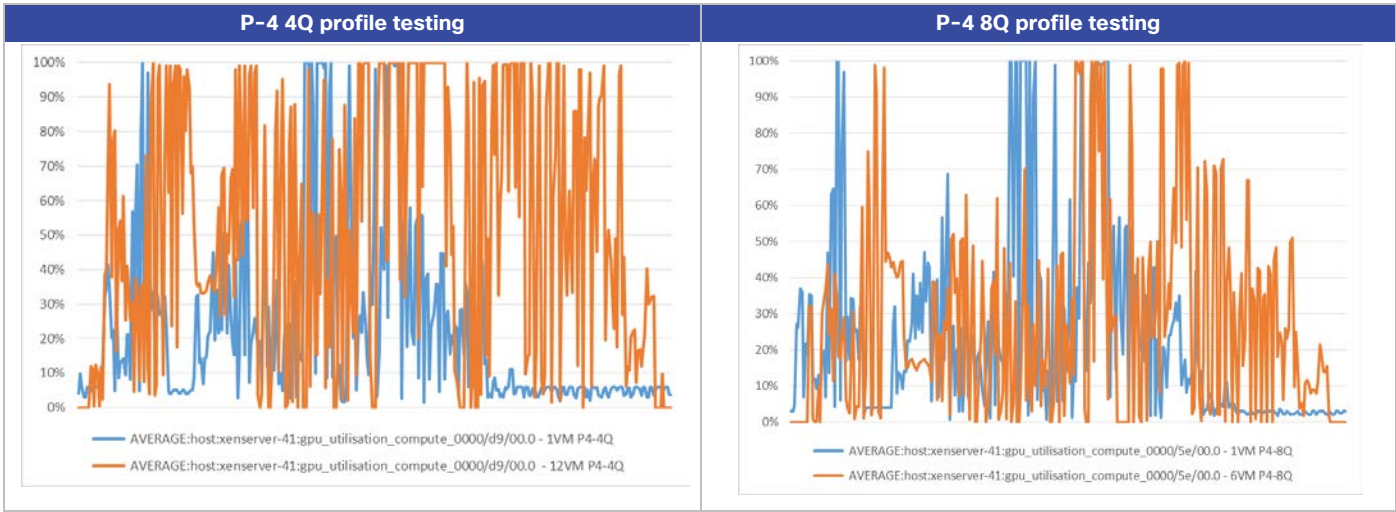


Figure 107. NVIDIA P-40 results for SPECviewperf P-40 4Q and 8Q profile tests: Single virtual machine versus maximum density

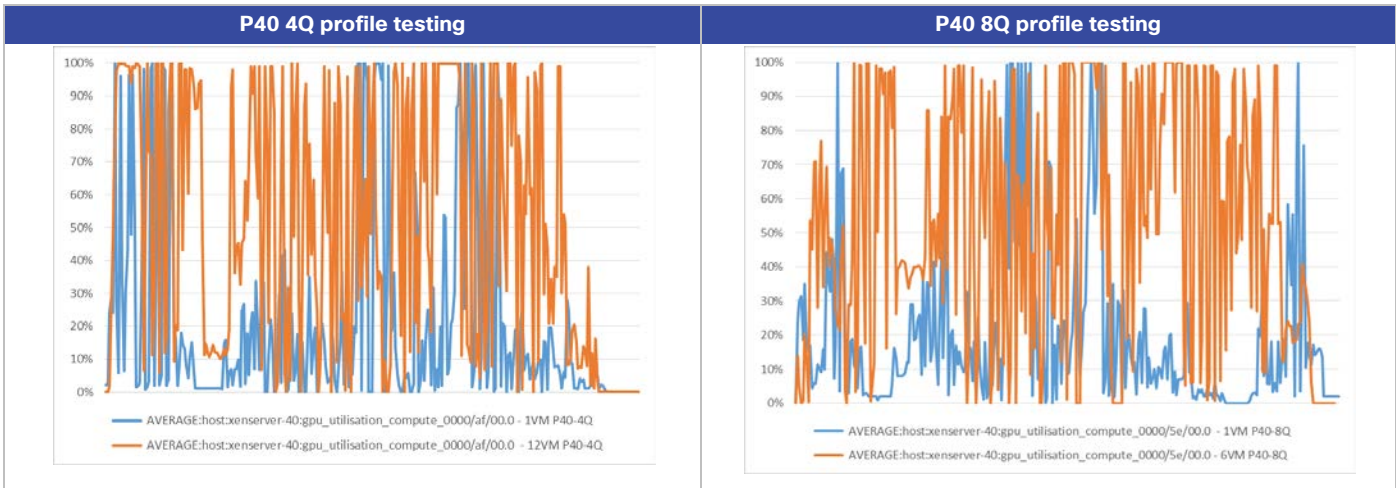
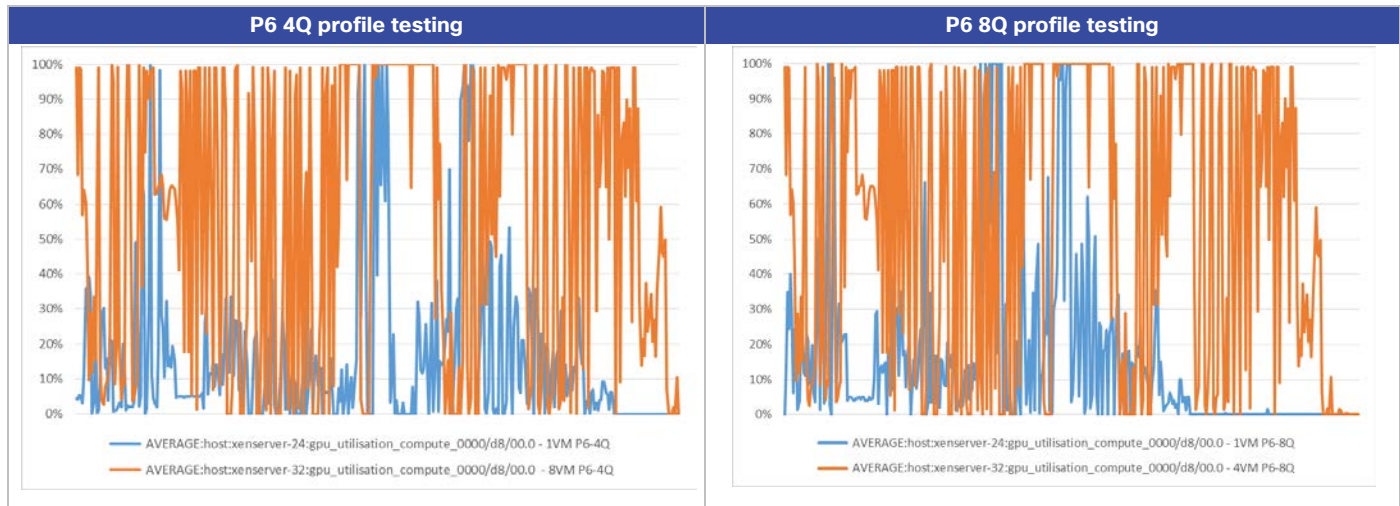


Figure 108. NVIDIA P6 results for SPECviewperf P6 4Q and 8Q profile tests: Single virtual machine versus maximum density



Live vGPU-enabled virtual machine Citrix XenMotion operations

vGPU XenMotion enables a virtual machine that uses a vGPU to perform Citrix XenMotion, Storage XenMotion, and virtual machine Suspend operations. Virtual machines with vGPU XenMotion capabilities can be migrated to avoid downtime and can be included in high-availability deployments. For more information about support and restrictions, refer to [Configuring Citrix XenServer 7.5](#).

1. To initiate XenMotion operations for vGPU-enabled virtual machines, select the virtual machines in XenCenter, right-click, and select Migrate to Server. The list will show compatible servers, as shown in Figure 109.

Figure 109. Citrix XenCenter vGPU-enabled virtual machine XenMotion operations

Name	CPU Usage	Used Memory	Disks (avg / max KBs)	Network (avg / max KBs)	Address	Uptime
VGPU-POD	-	-	-	-	-	-
xenserver-32 Default install of XenServer	2% of 72 CPUs	92 GB of 767 GB	-	4/7	10.10.60.132, 10.10...	24 days 12 hours 28 minutes
P6-W10-4Q-01	5% of 4 CPUs	1.9 GB of 8.6 GB	27/80	0/0	10.2.0.24, fe80::88cb...	1 day 2 hours 11 minutes
P6-W10-4Q-02	5% of 4 CPUs	1.8 GB of 8.6 GB	1/3	0/0	10.2.0.22, fe80::9c8c...	1 day 2 hours 11 minutes
P6-W10-4Q-03	4% of 4 CPUs	1.4 GB of 8.6 GB	0/1	0/0	10.2.0.58, fe80::25d9...	1 day 2 hours 11 minutes
P6-W10-4Q-04	4% of 4 CPUs	1.4 GB of 8.6 GB	2/7	0/0	10.2.0.59, fe80::cd51...	1 day 2 hours 11 minutes
P6-W10-4Q-05	4% of 4 CPUs	1.4 GB of 8.6 GB	3/10	0/0	10.2.0.21, fe80::c16e...	1 day 2 hours 11 minutes
P6-W10-4Q-06	4% of 4 CPUs	1.4 GB of 8.6 GB	1/4	0/0	10.2.0.23, fe80::3906...	1 day 2 hours 11 minutes
P6-W10-4Q-07	4% of 4 CPUs	1.4 GB of 8.6 GB	2/6	0/0	10.2.0.60, fe80::90c7...	1 day 2 hours 11 minutes
P6-W10-4Q-08	4% of 4 CPUs	1.4 GB of 8.6 GB	2/6	0/0	10.2.0.57, fe80::2422...	1 day 2 hours 11 minutes
xenserver-24 Default install of XenServer	-	4 GB of 767 GB	-	1/1	10.10.63.124, 10.10...	9 hours 43 minutes
P6-W10-1Q-01	-	-	-	-	10.2.0.31, fe80::154a...	-
P6-W10-1Q-02	-	-	-	-	10.2.0.32, fe80::854a...	-
P6-W10-1Q-03	-	-	-	-	10.2.0.27, fe80::f5aa...	-
P6-W10-1Q-04	-	-	-	-	10.2.0.29, fe80::d9c0...	-
P6-W10-1Q-05	-	-	-	-	10.2.0.34, fe80::8c22...	-
P6-W10-1Q-06	-	-	-	-	10.2.0.33, fe80::a16b...	-
P6-W10-1Q-07	-	-	-	-	10.2.0.31, fe80::70e5...	-
P6-W10-1Q-08	-	-	-	-	10.2.0.25, fe80::9922...	-

2. Selecting the server will start the virtual machine migration, as shown in Figure 110 and Figure 111.

Figure 110. Citrix XenCenter Events window: vGPU-enabled virtual machine XenMotion operations

Message	Server / Pool	Date	Actions
Migrating VM 'P6-W10-4Q-07' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-06' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-03' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VMs	VGPU-POD	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-08' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-05' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-04' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-02' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel
Migrating VM 'P6-W10-4Q-01' from 'xenserver-32' to 'xenserver-24'	xenserver-24	Sep 7, 2018 4:32 PM	Cancel

Figure 111. Citrix XenCenter Events window: vGPU-enabled virtual machine XenMotion operation completion

Message	Server / Pool	Date	Actions
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-07' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:02:46 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-06' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:02:49 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-03' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:02:24 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VMs Migrated Time: 00:03:03 	VGPU-POD	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-08' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:03:03 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-05' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:03:00 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-04' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:02:57 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-02' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:03:02 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss
<ul style="list-style-type: none"> ✓ Migrating VM 'P6-W10-4Q-01' from 'xenserver-32' to 'xenserver-24' Migrated Time: 00:02:45 	xenserver-24	Sep 7, 2018 4:32 PM	Dismiss

Additional configurations

This section presents additional configuration options.

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.

Use Citrix HDX Monitor

Use the Citrix 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, go to <https://taas.citrix.com/hdx/download/>.

Optimize the Citrix 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 are 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 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 while a graphical application session is running. After closing the application session, a user can change the resolution of the Desktop Viewer window in 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 ensure 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 60-Mbps connection, the bandwidth available to each user can vary between 3 Mbps and 60 Mbps, 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 Citrix article CTX128190.

Use GPU acceleration for Microsoft Windows Server DirectX, Direct3D, and WPF rendering

DirectX, Direct3D, and WPF rendering are available only on servers with a GPU that supports display driver interface (DDI) Version 9ex, 10, or 11.

Use the 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 may not work with some applications and is intended as a solution to try if the Windows OpenGL rasterizer does not provide adequate performance. If the OpenGL Software Accelerator works with your applications, you can use it to avoid the cost of GPU hardware.

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

Try the OpenGL Software Accelerator in the following cases:

- If the performance of OpenGL applications running in virtual machines is a concern, try using 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 versions up to Version 2.1.
- For applications running on a workstation, first try the default version of OpenGL provided by the workstation's graphics adapter. If the graphics card is the latest version, in most cases it will deliver the best performance. If the graphics card is an earlier version or does not deliver satisfactory performance, then try the OpenGL Software Accelerator.
- 3D OpenGL applications that are not adequately delivered using CPU-based software rasterization may benefit from OpenGL GPU hardware acceleration. This feature can be used on bare-metal devices and virtual machines.

Conclusion

The combination of Cisco data center hardware, Cisco UCS Manager, Cisco UCS C240 M5 Rack Servers and B200 M5 Blade Servers, and the customer's choice of storage array and NVIDIA Tesla cards running NVIDIA GRID 6.2 on Citrix XenServer 7.5 and Citrix XenDesktop 7.15 provides a high-performance platform for virtualizing real-world enterprise graphics-intensive applications.

SPECviewperf 13 provides a method for comparing the performance of different GPUs and NVIDIA GRID profiles on the same server hardware and across different hardware platforms. It can be run in benchmark mode or in individual application mode. The tool provides guidance that organizations can use as a starting point to optimize the end-user experience for professional graphics workloads.

By following the guidance in this document, our customers and partners can be assured that they are ready to host the growing list of graphics applications that are supported by our partners.

Further performance tuning by application, which is outside the scope of this document, can enhance end-user experience for each of the applications in the SPECviewperf 13 test suite. We encourage customers and partners to categorize the users of their graphics applications and develop sizing and tuning optimizations to provide each user with an excellent great experience.

For more information

- Cisco UCS C-Series Rack Servers and B-Series Blade Servers:
 - <http://www.cisco.com/en/US/products/ps10265/>
- Cisco Desktop Virtualization Design Navigator
 - <http://cisco.com/go/vdi-cdv>
- NVIDIA:
 - <http://www.nvidia.com/object/grid-technology.html>
- Citrix XenApp, XenDesktop, and XenServer:
 - <https://docs.citrix.com/en-us/xenapp-and-xendesktop/7-15-ltsr.html>
 - <https://docs.citrix.com/en-us/xenserver/7-5.html>
 - <http://blogs.citrix.com/2014/08/13/citrix-hdx-the-big-list-of-graphical-benchmarks-tools-and-demos/>
- Microsoft Windows and Citrix optimization guides for virtual desktops:
 - <http://support.citrix.com/article/CTX125874>
 - <https://support.citrix.com/article/CTX216252>
 - <https://labs.vmware.com/flings/vmware-os-optimization-tool>
- SPECviewperf 13:
 - <https://www.spec.org/gwpg/gpc.static/vp13info.html>

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