ArcGIS Pro
Virtualization

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ArcGIS Pro Virtualization

Introduction

ArcGIS Pro is successfully used in virtualized environments, both on-premise and in the cloud by many companies and organizations. There are many ways to virtualize ArcGIS Pro such as application virtualization or by delivering in a virtualized Windows Desktop. Virtualization is a powerful and common solution to providing system resources from a hosted solution. Virtualization also allows users to be decoupled from a single device and able to access the same application, data and Windows Desktop from multiple devices.

Modern virtualization options continue to expand, offering multiple on-premise, and cloud hosted solutions capable of delivering a great user experience.
To successfully deploy ArcGIS Pro in a virtualized environment requires a careful look at several factors including:
- The number of ArcGIS users and the type of work they perform on a given day
    - Different Examples: Heavy editors, a lot of 3D viewing, classroom environment
- Use On-premise or cloud
- Desired virtualization vendor or provider
- The availability and delivery of a GPU in the virtualized environment

Given that there are so many options, the goal of this white paper is to help guide you toward a successful deployment of ArcGIS Pro in a virtualized environment. On-premise and Cloud infrastructure ArcGIS Pro has been tested on multiple virtualization platforms, both on-premise and in the cloud. The information provided in this document shows the suitability of a virtualization platform to host ArcGIS Pro based on the results of a comprehensive test effort. Those tests include the ArcGIS Pro Performance Test Suite and hands on testing.
A sampling of the test environments includes:
- VMWare (on-premise)
    - VMWare ESXi – Horizon7
- Citrix (on-premise)
    - Citrix Virtual Apps and Desktops
- Nutanix (on-premise)
    - Nutanix AHV
- Microsoft (on-premise and cloud)
    - Hyper-V
    - Azure NV Series
- Amazon (cloud)
    - Workspaces – Graphics Bundle
    - AppStream 2.0
    - EC2 with Elastic Graphics
- Google (cloud)
    - Google Cloud Platform

Using the test results of both automated load tests and hands-on testing events with real users, Esri has a very good understanding of what it takes to successfully deploy ArcGIS Pro in virtualized environments. We also understand how many virtual machines (VMs) that a virtualization server can host to deliver an acceptable user experience.

The result of this extensive effort is that Esri can confirm that ArcGIS Pro virtualizes well, and virtualized environments deliver a user experience for GIS professionals that is equally as good as using a stand-alone, high-end desktop machine.

ArcGIS Pro in Virtual Environments

ArcGIS Pro is a high-end application that leverages modern hardware and computing technology to display graphics-rich maps and scenes and to perform spatial analysis.

General Recommendations

For the virtualized environment to deliver ArcGIS Pro with a good UX it must provide the resources that ArcGIS Pro requires. The following are general recommendations.

- Central processing unit (CPU) ArcGIS Pro is a multithreaded application that uses as many CPU cores as are available. CPU cores process the threads for everything from disk input and output to geoprocessing tool functionality. In a virtualized environment, virtual CPU cores are used in the same way.
- Random Access Memory (RAM)—An adequate amount of RAM ensures ideal performance on both physical and virtual machines (VMs). Allocate an appropriate amount of RAM based on ArcGIS Pro's minimum and recommended requirements.
- Graphical processing unit (GPU)—ArcGIS Pro leverages the DirectX or OpenGL graphics application programming interfaces (APIs) to deliver an optimal graphic experience, such as when panning and zooming the user experience is smooth and fluid. In a virtualized environment, the GPU can be virtualized, this is referred to as a "virtual GPU", commonly seen as vGPU. In this case, the virtual machine must be provisioned with a shared GPU. Alternatively, a GPU can be "passed through", which means an entire GPU is provided for use by the VM. This results in optimal performance for power-users of 3D capability but reduces scalability of the VM host machine. A GPU that is passed through can be used in both on-premise and cloud virtualized environments.

These hardware resources must be configured in each virtualized environment independently. For on-premise virtualized environments, configuration is managed and maintained by virtualized environment administrators. For cloud-based environments, administrative responsibilities are often managed by a combination of the cloud provider, corporate IT and the individual.

For cloud environments a very important step is the selection of appropriately sized and configured instances. The on-premise virtualization and cloud virtualization sections of the ArcGIS Pro System Requirements page detail requirements for each environment and describe how the configuration is managed.

GPU Over the past decade, and most noticeably in the last three years, successful retailers have used information technology (IT) to increase customer retention and improve marketing affinity and operational excellence. The core enterprise technologies retailers use to accomplish this typically revolve around customer relationship management (CRM), marketing, merchandising, pricing, business intelligence (BI), and supply chain systems.

Customers expect a seamless experience as they research, engage, and purchase even as they move between mobile, web, and physical store locations. Back-end IT systems are used to try and make sense of these behaviors across every customer touch point and interaction with the retailer. They are used to try and integrate messaging and operations across channels with data-driven processes and solutions allowing marketing, distribution, merchandizing, e-commerce, and brick-and-mortar retail operations to work together. Despite spending hundreds of millions of dollars collectively, the results haven't always lived up to the hype. Why?

First, technology has added both cost and complexity to business operating environments. Second, most of these systems cannot effectively execute on the requirements of omni-channel campaigns. They don't usually deliver real-time insights such as individual attribution and reporting. Despite enormous effort, cost, and business pain bringing these systems and services together, most technology has failed to deliver significant value and progress.

On-Premise Virtualization As of 2019 several hypervisor options are available which support the need of ArcGIS Pro. Solutions from VMware, Citrix, Microsoft and Nutanix. This document won't provide specific instructions for installing a hypervisor, configuring VMs, etc. It assumes that the hypervisor installation has been installed and configured. This document will provide information on specific steps or requirements that are necessary for virtualizing ArcGIS Pro.

Using ArcGIS Pro in On-Premise virtualization environments is very common. ArcGIS Pro provides unparalleled geospatial functionality with a dynamic user experience that provides smooth panning and zooming of detailed 2D and 3D data. To deliver this capability, the virtualization environment must support e virtual graphics processing units (GPUs) or pass-through GPUs.

This is accomplished with virtualized desktop infrastructure (VDI) VMs. VDI environments continue to evolve and encompass more options beyond On-Premise solutions and have broadened into the cloud with solutions from Amazon, Microsoft Azure and Google and use GPU resources to power the VM and provide the same graphical user experience as a physical workstation.
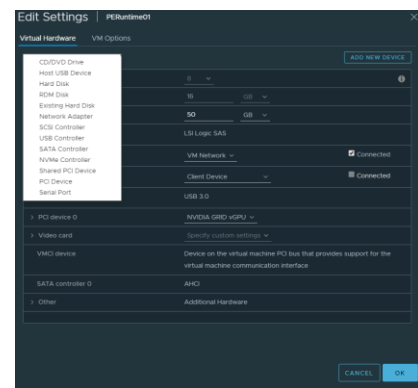
VMware   VMware Horizon is an effective on-premise virtual desktop infrastructure (VDI) solution for virtualizing ArcGIS Pro. Horizon is a heavily used VDI platform and supports one of the most important requirements for virtualizing ArcGIS Pro: to effectively provide a shared or pass-through graphics processor unit (GPU) to the virtual machine (VM).

The VMware ESXi hypervisor GPU support enables the VM to adequately service the DirectX or OpenGL calls generated by ArcGIS Pro. The VMware Horizon client provides the technology to quickly deliver the graphics generated on the server.

Beyond the capacity of the hypervisor to maintain and control the functionality of the needed resources. Horizon helps to create a method of delivery with an agent using either PCoIP or VMWare's Blast Extreme. These 2 protocols push rendered content of ArcGIS Pro to the user, without a lag or delay and help to deliver an optimal user experience. The steps needed as well as VMWare Horizon agent installs needed are details in the link found in the NVIDIA GPU section of this document.
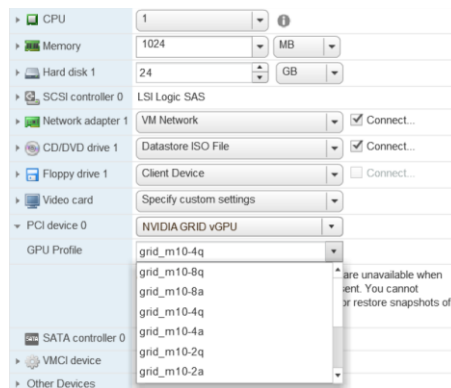
vCenter Java Interface   vCenter HTML5 Interface

When configuring the VM, use the very user-friendly interface to add a shared PCI device, the 1q profile being the minimum specification designed for use with ArcGIS Pro. Greater workloads may require different profiles. See the Application Sizing guide listed in the NVIDIA GPU section for additional details on profiles.

https://docs.vmware.com/en/VMware-vSphere/6.7/vsphere-esxi-67-installation-setup-guide.pdf

https://docs.vmware.com/en/VMware-Horizon-7/index.html

Citrix   Citrix provides an On-Premise virtual desktop infrastructure (VDI) solution that can deliver ArcGIS Pro with a powerful user experience.

Citrix Virtual Applications and Desktops (formerly XenDesktop) is designed to deliver a shared or pass-through graphics processing unit (GPU) that can be utilized by a VM to support DirectX and OpenGL graphics capability. This support allows the VM the capability to process DirectX or OpenGL calls generated by ArcGIS Pro on a GPU instead of the CPU.

Using Citrix Virtual Apps and Desktops offers flexibility to be delivered with several options. Installation can be done using a host running Citrix Hypervisor (formerly XenServer) or as some customers have chosen on VMWare ESXi.

Note Citrix Virtual Apps (Formerly XenApp) is not recommended for ArcGIS Pro. This delivery method is reliant on a single hosted operating system and resources that can hinder the delivery to users and not provide the best user experience. This method can be used for ArcMap.

https://docs.citrix.com/en-us/xenserver/7-0/downloads/installation-guide.pdf

https://docs.citrix.com/en-us/citrix-virtual-apps-desktops/install-configure.html

Hyper-V   Microsoft Hyper-V is a native hypervisor to the Windows Server operating system. This hypervisor is built into the operating system and can be enabled by accessing a server role. GPU support for Hyper-V requires a GPU being installed in a Pass-through mode using DDA, this adequately provides ArcGIS Pro with the necessary GPU resources.

The following installation documents are published by Microsoft to assist enabling Hyper-V and configuring DDA:

https://docs.microsoft.com/en-us/windows-server/virtualization/hyper-v/get-started/install-the-hyper-v-role-on-windows-server

https://docs.microsoft.com/en-us/windows-server/virtualization/hyper-v/hyper-v-technology-overview

Cloud Hosted Virtualization

Cloud-based virtualization environments are adding and improving the technology required to support ArcGIS Pro. This includes GPU resources—either shared or pass-through—just like On-Premise environments. Providers such as Microsoft Azure, Google and AWS support GPU pass-through instances that provide users of ArcGIS Pro with the same user experience as they see on a physical workstation.

ArcGIS Pro can be used for more than just 3D.   Deep learning inferencing offers additional features which can leverage the GPU. Based on current GPU offerings, the choice between the 3D rendering option and compute functionality is at the forefront of the decision-making process.   However, if this line of work up to and including CUDA processing is needed, then the GPU compute functionality can be the focus, each cloud provider offers various options capable of supporting these needs.

The Microsoft Azure and AWS products that have been tested with ArcGIS Pro provide full Windows Desktop environments. An important part of cloud virtualization is using an adequate remote display protocol to deliver the server-generated graphics to the users' endpoint. Both the AWS and Microsoft environments have a solution.

AWS Workspaces

ArcGIS Pro can be used from Amazon Web Services (AWS) cloud environments. In the AWS environment, the Workspaces Graphics Bundle instance type should be used. The WorkSpaces Graphics Bundle instance offers an NVIDIA GPU to deliver the necessary GPU support needed by ArcGIS Pro to provide a rich user experience. The GPU used in the WorkSpaces Graphics Bundle instance is passed through to the instance, it is not shared. This provides the capability to successfully support graphics rendering in ArcGIS Pro.

For additional information related to the options and features offered by Amazon, see the following resources:

- Amazon WorkSpaces Product Details
- GPU-Powered Amazon Graphics WorkSpaces

To get started with an Amazon Workspace:

Select Bundle – Graphics with Windows 10

If you have an Amazon account with the proper access, you can create workspaces.

The creation of a WorkSpaces Graphics Bundle instance is basically the same as the steps for Launch WorkSpaces in the Amazon Console. It is important to note that from the console, you can set up various options or bundles. However, to get the best rendering performance from ArcGIS Pro, you need the WorkSpaces Graphics bundle with Windows 10. Once your WorkSpaces instance setup is complete, download and connect to the instance with the Amazon WorkSpaces Client.

AppStream 2.0

AppStream 2.0 is a managed service from Amazon. ArcGIS Pro can be used with AppStream 2.0, which offers a browser-based user experience. ArcGIS Pro can be deployed into this VDI based system and provide the experience of a Streamed Application. Like a streaming application experience, ArcGIS Pro can be installed on the AppStream stack and delivered to any HTML5 based browser. This browser-based experience brings ArcGIS Pro from a strictly windows installed desktop application to the browser from a cloud hosted system, any phone, tablet, Chromebook, or laptop with an HTML5 browser can then be used and deliver the needed functionality and user experience GIS users need. For Additional information see the Amazon AppStream 2.0: Esri ArcGIS Pro Deployment Guide:

https://aws.amazon.com/appstream2/

EC2 Elastic Graphics with NICE DCV

Amazon Elastic Compute Cloud (EC2) is a service that provides scalable computing options from the cloud. This option with various configurations can be used to deliver a hosted VDI solution. A base starting instance sample would be the c5. Xlarge. Using the combination of EC2 and elastic graphics will give ArcGIS Pro the needed capacity to create and maintain a successful user experience. Basic remote connection functionality is available and can be done using RDP from Microsoft, it is however recommended that in addition to using this EC2 setup, that the NICE DCV client be installed on the EC2 and used to connect. This combination smooths out the user experience and is like clients used by Workspaces, or other On-Premise systems such as VMWare.

For additional information on both EC2 types and NICE DCV see the links below:

https://aws.amazon.com/ec2/instance-types/

https://aws.amazon.com/hpc/dcv/

Azure   ArcGIS Pro can be used from a cloud environment with Microsoft Azure NV series instances. The NV series instance delivers the important graphics capability of an NVIDIA GPU. The GPU is a pass-through to the instance, not a resource shared with other instances. This means the instance has the full capability of the GPU, making it possible to render rich 3D graphics and animation from ArcGIS Pro.

The NV series VM comes in three sizes. The NV6 has one M60 GPU, NV12 has two M60s, and the NV24 has four M60s. To successfully use ArcGIS Pro from Azure, ArcGIS Pro only needs 1 GPU, so the NV6 will work. Supporting the compute efforts of deep learning and inferencing the NC series offers a variety of capable GPU systems.

For additional information related to the options and features offered by Azure, see the following resources:

- Azure N-Series availability
- Azure N-Series VMs and NVIDIA GPUs

To get started with an Azure instance:
Select a VM Size

Select a VM size
Browse available virtual machine sizes and their features

🔍 n   ✕   Restore default filters

⊹ Add filter

Showing 28 of 217 VM sizes. | Subscription: SW Prod Performance Engineer | Region: South Central US | Current size: Standard_D2s_v3

VM SIZE	OFFERING	FAMILY	VCPUS	RAM (GI...	DATA DISKS	MAX IOPS	TEMPORARY STOR...	PREMIUM DISK SUP.
NC12	Standard	GPU	12	112	48	40000	680	No
NC12s_v2	Standard	GPU	12	224	24	40000		Yes
NC24	Standard	GPU	24	224	64	80000	1440	No
NC24r	Standard	GPU	24	224	64	80000	1440	No
NC24rs_v2	Standard	GPU	24	448	32	80000		Yes
NC24s_v2	Standard	GPU	24	448	32	80000		Yes
NC6	Standard	GPU	6	56	24	20000	380	No
NC6s_v2	Standard	GPU	6	112	12	20000		Yes
NV12	Standard	GPU	12	112	48	40000	680	No
NV24	Standard	GPU	24	224	64	80000	1440	No

Assuming you have a Microsoft Azure account, you can select a VM and set it up.

- Log in to the Azure Dashboard.
- Click **Virtual Machines** to add a new VM. Keep the following information in mind:
  - NV series VMs currently have several options to deploy a rich ArcGIS Pro experience. The NV6 delivers effective performance for ArcGIS Pro 3D projects.
  - Microsoft RDP can be used to connect to ArcGIS Pro in a NV series instance.

- o The Teradici Cloud Access software can be used for connecting to the Azure NV series instance. Teradici Cloud Access uses the PCoIP technology as the remote display protocol. This requires the VM to have an agent installed and accessing workstations to have clients installed.

ArcGIS Pro System Requirements

During each update to ArcGIS Pro the system requirements are reviewed and tested to maintain the integrity of the needs of the platform and to keep current with industry trends. During each release cycle supported systems and virtualization platforms are reviewed and tested to ensure ideal results and maintain an expected user experience.

https://pro.arcgis.com/en/pro-app/get-started/arcgis-pro-system-requirements.htm

During each release cycle, testing is conducted against the virtualization platforms (hypervisors) to maintain a list of options that are deployable and supportable. This information and more can be found on the ArcGIS Pro System Requirements webpage.

Sample Server Configuration

The ArcGIS Pro Virtualization Appliance from Dell is designed and tested to successfully Virtualize ArcGIS Pro. This hardware platform provides the capability to deliver a rich graphical experience using 2D, 3D data and more. Buying direct delivers a hardware platform for On-Premise virtualization of ArcGIS Pro off the shelf. This system and specifications have been developed and tested with 3D application virtualization in mind, giving it the ideal resources to support ArcGIS Pro implementations. This design is configured based on the hardware needs from the ArcGIS Pro system requirements and focuses on delivering an on-premise hosted system that will handle the needs of virtualized GIS Users. This architecture is configured with powerful CPUs, 256 GB of RAM and several NVIDIA T4 GPUs. This appliance is updated periodically to stay up to date with changes in technology.

The ArcGIS Pro Virtualization Appliance is an off the shelf designed system that can and will support the needs of virtualization. This can also be used to spec out a server from another vender as needed, such as Cisco or HPE. The appliance can then be used as a recipe or a guide that can be used to design a system that can support the deployment.
https://www.esri.com/content/dam/esrisites/en-us/media/pdf/hardware-partners/dell/DellVirtualizationAppliance.pdf

Additional Server design resource:

https://www.nvidia.com/en-us/data-center/tesla/tesla-qualified-servers-catalog/

NVIDIA GPU

Running ArcGIS Pro requires the use of a GPU. Making the best use of a resource such as a GPU involves scalability in sharing the GPU functionality. This is where the GPU profiles come into play. In order to achieve the best return on investment, density, or functionality, profiles are assigned to each VM. To get the best ArcGIS Pro user experience the minimum recommended frame buffer is 1024 MB (1 GB), which is shown as the 1Q profile. A 1Q or 1 GB frame buffer profile allows for the overall needed functionality. As workloads increase, as well as the additional needs from the operating system, additional frame buffer can be needed. Additional profiles offer more frame buffer from the GPU which can positively affect the user experience.

Geoprocessing as well can make use of the GPU. New tools continue to be introduced that can be used for GPU compute. Tools such as Slope, Aspect and Viewshed2 take advantage of the GPU and offset the CPU usage. The GPU can also be used for inference when configured to use TensorFlow.
ArcGIS Pro user types could be broken down in three categories:

> Light, Map creation and interactions. 2d, and light 3D Multipatch Rendering.
> Medium, Advanced data management and analysis, Deep Learning Inferencing.
> Heavy, High-end cartography and extensive analysis

For Additional information on GPU Profiles and Sizing Deployments:

NVIDIA Quadro Virtual Data Center Workstation Application Sizing Guide for Esri ArcGIS Pro

For information on installing and configuring the NVIDIA drivers:

https://docs.nvidia.com/grid/latest/grid-software-quick-start-guide/index.html

ArcGIS Pro Performance and UX Testing

To determine how suitable various on-premise and cloud infrastructure is for hosting ArcGIS Pro, the Esri Performance Engineering team uses two types of testing.

The first is a subset of the ArcGIS Pro Performance Test Suite. This is a set of performance tests that gather and analyze multiple metrics including overall elapsed time of a test, time between bookmarks, frames per second and startup time. This is the same test suite that is run every day against daily builds of ArcGIS Pro.

The second are hands-on tests by Product Engineers that work on ArcGIS Pro development teams.

Using both methods delivers a good understanding of the user experience that a virtualization platform can deliver. This testing continues with each release cycle as we look to continue to improve on the developments for desktop GIS users. As changes in technology come about, additional testing is developed, and added to emulate the needs of the Esri user community.

Additional Systems Tested

The Esri Performance Engineering team routinely researches and works with different vendors, works with alternate technology options, and technologies that meet with the desires of our user's needs. We test for functionality and learn about the technology to allow us to speak to these needs. In some cases, this research is done over a short term and then blogs are created. In some of these cases these solutions are tested only at that point in time. The blogs document that point in time, after which some of these systems are no longer tested due to hardware availability, or other circumstances.

Below are some examples of systems tested but are not necessarily tested in an ongoing manner.

Nutanix

Nutanix and AHV (Acropolis Hypervisor) is a hyper converged infrastructure which offers the flexibility to host various hypervisors with its software and systems. AHV is the company's offering which allows additional integrations. Esri worked directly with Nutanix to test an implementation and learn about the technology. Nutanix with its abilities offered another On-Premises platform capable of hosting virtual machines that meet the needs of the ArcGIS Pro community.

https://www.esri.com/arcgis-blog/products/arcgis-pro/3d-gis/virtualizing-arcgis-pro-on-nutanix-hyper-converged-infrastructure/

https://nutanixbible.com/

Google Cloud Platform

Google like the other cloud providers offers is own hosted platform and delivers with a suite of GPU options. Google was the first to offer the NVIDIA T4 from the cloud. GCP backed by a T4 offered a very worthy system that can deliver ArcGIS Pro from the cloud. Testing with this system had indicated the use of the windows RDP client was enough to provide the desired user experience.

https://cloud.google.com/gcp/getting-started/

VMWare App Volumes

Application Volumes offer an ability to place application in storage or in stacks allow a rapid deployment. The common concern had been that the application would become slower or hindered. Esri testing determined that this was a viable option that IT departments could use with ArcGIS Pro, it does require UAT (User Acceptance Testing) as each environment is going to be different from the testing environment used at Esri, and as such results could vary.

https://www.esri.com/arcgis-blog/products/arcgis-pro/uncategorized/virtualizing-arcgis-pro-leveraging-vmware-app-volumes/

https://docs.vmware.com/en/VMware-App-Volumes/index.html

Conclusion The world of Desktop Virtualization has expanded and grown and will continue to do so as the need for hosted resources expands. Desktop solutions continue to move to data centers, either On-Premise or in the cloud. Benchmarking ArcGIS Pro performance in these environments and with the addition of new hardware and software options continues to expand the options of delivery and scalability, density and user experience in virtual platforms. Esri remains committed to working with vendors and testing the most relevant systems for our user community, additionally researching and working to identify and test platforms that can meet or anticipate user needs.

Esri, the global market leader in geographic information system (GIS) software, offers the most powerful mapping and spatial analytics technology available.

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