# **Module 10**

**Configuring Web Services and Cloud Technologies**

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| **At a Glance** |

#### Instructor’s Manual Table of Contents

* Overview
* Objectives
* Teaching Tips
* Quick Quizzes
* Class Discussion Topics
* Additional Projects
* Additional Resources
* Key Terms

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| Lecture Notes |

# **Overview**

This module first presents the many different types of cloud configurations and technologies. Students start by learning terminology and definitions related to cloud concepts, and they learn to identify various cloud types, delivery models, and storage methods. This knowledge forms a foundation for the remainder of the module. Next, students are presented with extensive information to prepare them to host websites and Web apps on a Windows Server 2019 system. Specifically, they learn how to install and configure Microsoft’s Internet Information Services (IIS) Web server software. IIS can be used to host websites and Web apps that are used exclusively by organization users or public websites and Web apps available to Internet users, so a solid understanding of how it works is important to tie the material in this module together. Students build on this knowledge by learning about containers and Docker. Because Platform as a Service (PaaS) is the most common method for hosting Web apps in a public or private cloud, knowing these terms and concepts will allow your students to fully understand Web app hosting using a container. As we go deeper into Web app support, students will learn about implementing a Linux Web server using the Windows Subsystem for Linux (WSL). This provides great flexibility. The use of Linux Containers on Windows (LCOW) and how to install and support them is covered next. The use of Windows Subsystem for Linux (WSL) is introduced as well. With this knowledge, students will have an encompassing view of Web app installation. Finally, this module concludes by reviewing scenarios for implementing Windows Server 2019 in the various cloud environments.

# **Module Objectives**

* Describe the available cloud components, types, delivery models, and configurations
* Provide Web services using Internet Information Services (IIS)
* Configure Windows containers
* Implement a Linux Web server using the Windows Subsystem for Linux (WSL)
* Configure Linux Containers on Windows (LCOW)
* Outline scenarios for implementing Windows Server 2019 in a cloud environment

# **Teaching Tips**

**Understanding the Cloud**

1. Introduce this section by emphasizing the need to have a solid understanding of cloud concepts in order to configure Windows Server 2019 cloud technologies.
2. Mention that students will need to be able to define the cloud, as well as identify various cloud types, delivery models, and storage methods.
3. Mention that an understanding of the processes used to deploy new versions of Web apps on cloud servers is necessary to configure and support Windows Server 2019 cloud technologies.

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| ***Teaching*** ***Tip*** | For more information on cloud basics, see the following website. If you have a computer and projector, you can break up the lecture by showing the associated short video. <https://edu.gcfglobal.org/en/computerbasics/understanding-the-cloud/1/>  |

**Defining the Cloud**

1. Provide a brief history of how the original ISPs were formed in the 1990s.
2. Point out that most resources available on the Internet in the 1990s consisted of websites that contained webpages with information and media (e.g., pictures, music, video) for different topics and organizations. Note that these websites were hosted on Web servers and accessed using the HTTP or HTTPS protocols from a Web browser on a client.
3. Refer to Figure 10-1 to illustrate how the World Wide Web (WWW) was a worldwide collection of Web servers on the Internet in the 1990s.
4. Describe the more complex implementation of the World Wide Web (WWW) used today. Note that most Web servers contain one or more Web apps that process and communicate both data and media to clients in complex ways.
5. Refer to Figure 10-2 to illustrate how each Web server that runs a Web app is called a cloud server, and the worldwide collection of cloud servers is called the cloud.
6. Define Apache Web server as a free and open-source Linux operating system and discuss how it contributed to the rapid growth of the WWW in the 1990s.
7. Define a Web app framework as a collection of software packages or modules that allow software developers to write Web apps using a programming language without having to implement many underlying system functionalities, such as network protocol usage and process/thread management.

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| ***Teaching*** ***Tip*** | More information on the Apache Web server project can be found on this website: <https://httpd.apache.org/ABOUT_APACHE.html>  |

1. Discuss how Web technologies have evolved using the free and open-source ecosystem since the 1990s, and that most Web apps in the cloud today run on Linux systems using free and open-source Web app frameworks.

**Cloud Types**

1. Define a cloud provider as any organization that hosts cloud servers.
2. Define a public cloud as a group of cloud servers on the Internet that can be rented by others.
3. Define a private cloud as cloud servers that are used exclusively by the organization that owns them.
4. Define a hybrid cloud as a cloud type that uses both a public and private cloud together for a specific purpose.

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| ***Teaching*** ***Tip*** | Private clouds vary in size from one organization to another; they may consist of many cloud servers in a data center, or a single cloud server in a DMZ. |

**Cloud Delivery Models**

1. Mention that the different methods used to host Web apps on a server are known as cloud delivery models and list some common models:
* Infrastructure as a Service (IaaS)
* Platform as a Service (PaaS)
* Software as a Service (SaaS)
1. Refer to Figure 10-3 and describe the Infrastructure as a Service (IaaS) model.
2. Refer to Figure 10-4 and describe the Platform as a Service (PaaS) model.
3. Refer to Figure 10-5 and describe the Software as a Service (SaaS) model.
4. Point out that unlike IaaS and PaaS, SaaS is not used to configure virtual machines or containers.

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| ***Teaching*** ***Tip*** | IaaS and PaaS can be used together. In this case, containers are run on the operating system in a virtual machine hosted on a cloud provider. |

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| ***Teaching*** ***Tip*** | Most public cloud providers allow an administrator to choose between SaaS, PaaS, and IaaS. |

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| ***Teaching*** ***Tip*** | The words “as a service” are commonly used for marketing purposes. For example, Mobile as a Service (MaaS) can be used to describe Web apps that manage smartphone devices, whereas Database as a Service (DBaaS) can be used to describe Web apps that provide access to a database. These terms are collectively referred to as Anything as a Service (XaaS) and represent specific uses of either SaaS, PaaS, or IaaS. |

**Cloud Storage**

1. Introduce this topic by pointing out that many Web apps need to store large amounts of data on a cloud provider.
2. Define block storage as data on a filesystem on the cloud provider. Discuss how public cloud providers charge an organization based on the total amount of storage selected for the filesystem. Explain that because block storage is fast, it is often used for storing database files, but it is normally associated with a single Web app, virtual machine, or container only.
3. Describe object storage as a cloud storage option that allows Web apps to directly store objects such as pictures, files, and video using an HTTP request that is sent to an object storage service. Note that object storage is slower than block storage and explain why it is less expensive. Mention that object storage can easily be shared by several different Web apps, virtual machines, or containers.

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| ***Teaching*** ***Tip*** | When purchasing storage from a public cloud provider, block storage is often referred to as a persistent volume, and object storage is often called Binary Large Object (BLOB) Storage. |

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| ***Teaching*** ***Tip*** | Most public cloud providers also charge an organization egress fees to move their data to a private cloud or another public cloud provider. |

**Understanding Continuous Deployment**

1. Introduce this topic by mentioning that most Web apps that are created by developers in an organization are hosted in a container (PaaS) or virtual machine (IaaS).
2. Discuss how Web apps must be revised on a continual basis to fix bugs and incorporate new features.
3. Refer to Figure 10-6 to illustrate the continuous deployment (CD) workflow process. Explain that the server administrators that manage this workflow are called devops because they are system operators (ops) that support Web app development (dev).
4. Describe each step in the CD process.
* Step 1: Developers push a new version of their Web app code to a code repository server.
* Step 2: Orchestration software running on a server at the cloud provider obtains the new version of the Web app from the code repository server, converting it to executable form if necessary (a process called compiling).
* Step 3: The Web app is then sent to a build automation server, which creates a new container or virtual machine on the cloud server
* Step 4: The Web app is sent for testing.
* If this new version does not work as expected, the container or virtual machine is removed and the whole process is repeated for another new version of the Web app.
* If this new version of the Web app works as expected, the container or virtual machine used to test the Web app will replace the publicly accessible container or virtual machine running the old version of the Web app, and Internet users will immediately have access to the new version.

**Configuring Web Services**

1. Introduce this section by explaining that to host websites and Web apps on a Windows Server 2019 system, an administrator can install and configure Microsoft’s Internet Information Services (IIS) Web server software.
2. Review some of the Microsoft Web apps that have been installed and used in previous modules. Emphasize that for these Web apps, IIS was automatically installed and configured during the Web app installation.
3. Point out that many third-party Web apps that an administrator might install on Windows Server 2019 will also require that IIS be installed.
4. Mention that IIS allows any Web app that adheres to the Common Gateway Interface (CGI) standard to interface with it.
5. Explain that if a Web app supports Internet Server Application Programming Interface (ISAPI), a group of dynamic-link libraries (DLLs) can also be generated to provide closer interaction with IIS as well as better performance.
6. Emphasize that most Web apps that interface with IIS are written using the ASP or ASP.NET Web app framework. Explain that this is because Microsoft provides additional IIS features for ASP and ASP.NET Web apps, including the ability to isolate different Web apps using application pools for security and management.
7. Point out that Web app developers will often require access to an organization’s Web server to upload and modify website and Web app content.
8. Discuss how access to the server is provided, and how this varies depending on where the server is located.
* If the server is within the organization, an administrator can share folders using SMB or NFS to provide this access.
* If the server is located in the cloud environment across the Internet, File Transfer Protocol (FTP) is often used to transfer website and Web app content.
1. Mention that IIS contains an FTP server service that an administrator can optionally install to provide FTP access on their Web server. Alternatively, Web app developers can use Web Distributed Authoring and Versioning (WebDAV) to upload and modify website content (but not Web app content). WebDAV uses the standard HTTP and HTTPS protocols to transfer information.

**Installing IIS**

1. Mention that to configure Windows Server 2019 as a Web server using IIS, an administrator must first install the Web Server (IIS) server role.

1. Refer to Figure 10-7. Mention that after the Web Server (IIS) server role is selected, the wizard prompts the administrator for the necessary IIS role services.
2. Refer to Table 10-1 and review the subcomponents available for each role service.

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| ***Teaching*** ***Tip*** | If an administrator installs a server role that provides a Web app using the Add Roles and Features Wizard, IIS is also installed (if necessary) and the IIS role services and subcomponents needed by the Web app are automatically selected. |

1. Refer to Figure 10-8 and explain how to use the Add Roles and Features Wizard to add IIS role services after the Web Server (IIS) server role has been installed.

**Configuring IIS**

1. Explain that after IIS has been installed, an administrator can manage Web server and website configuration using the IIS Manager tool.
2. Refer to Figure 10-9 to illustrate the IIS Manager tool.
3. Explain how to start the IIS Manager tool.
4. Refer to Figure 10-9 again. Discuss the purpose of the website called *Default Web Site*, which is created by default under the Sites folder in the Connections pane of IIS Manager.
5. Explain how to allow public (anonymous) access to *Default Web Site*.
6. Refer to Figure 10-9 and Figure 10-10. Explain how to configure *Default Web Site* to respond to HTTPS requests if an HTTPS encryption certificate is installed on the Web server.
7. Point out that the Features View pane in Figure 10-9 displays the *Default Web Site* features that an administrator can configure for each IIS role service subcomponent.
8. Refer to Table 10-2 and explain how to configure a feature.
9. Note that most server administrators create a virtual directory under *Default Web Site* for each Web app on the Web server. Explain that a virtual directory associates a directory name in a Uniform Resource Locator (URL) to a folder on the filesystem that contains website and Web app content. Refer to Figure 10-9 and Figure 10-11 to illustrate how to create this virtual directory under *Default Web Site*.

**Configuring Containers**

1. Introduce this section by mentioning that Platform as a Service (PaaS) is the most common method for hosting Web apps in a public or private cloud. Note that in addition to a Web app, most containers include a Web server and one or more Web app frameworks that are required by the Web app.
2. Remind students that Docker is the most common container software used to run containers on operating systems today, and that Windows containers is the component of Windows Server 2019 that allows an administrator to install and use Docker.
3. Define a Docker daemon as the service that runs and manages Docker containers.
4. Explain that the term *Docker client program* refers to the docker command that performs nearly all configurations.
5. Note that Docker provides an online repository of preconfigured container images that an administrator can download and run on his or her system to create one or more containers.
6. Describe the Docker Hub as the repository of preconfigured container images.
7. Mention that the repository can be used to host public container images available to anyone, or private container images that are only available to specific user accounts on Docker Hub. Point out that containers can be customized with settings and software beyond those provided by the container image from which they are created.

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| ***Teaching*** ***Tip*** | A user can create a free Docker Hub user account at hub.docker.com.  |

**Installing Docker**

1. Emphasize that before an administrator can use Docker to provide for containers on a Windows Server 2019 system, the administrator must first download and install the Docker Enterprise Edition (EE) package for Windows Server from either Microsoft or Docker.
2. Review the two different Windows PowerShell modules for this package.
* DockerMsftProvider allows an administrator to obtain a stable (widely tested) version of Docker EE provided by Microsoft.
* DockerProvider allows an administrator to obtain the latest version of Docker EE provided by Docker.
1. Explain how to download and install the Docker EE package from Microsoft using the DockerMsftProvider module.
2. Explain how to download and install the latest Docker EE package from Docker using the DockerProvider module.
3. Mention that after installing the Docker EE package, an administrator must reboot the system.
4. Explain that if an administrator installed Docker EE using the DockerMsftProvider module, the Docker daemon is configured to automatically start at boot time.
5. Explain that if an administrator installed Docker EE using the DockerProvider module, the Docker daemon is not started by default. Describe the commands that need to be executed to start the Docker daemon and to configure it to start automatically at boot time.

**Obtaining Container Images**

1. Mention that after installing the Docker EE package, an administrator can use the docker command at a Windows PowerShell or Command Prompt window to search for and download container images from Docker Hub.
2. Explain how to log into Docker Hub, specifying Docker Hub credentials when prompted.
3. Explain how to use the docker search command to search Docker Hub for container images by keyword.
4. Explain how to download the latest version of the official IIS container image from Docker Hub.
5. Note that container images on Docker Hub can have different versions. Explain how to download older versions of a container.
6. Explain where downloaded container images are stored by default. Mention that an administrator should ensure that container images are stored on a volume that contains enough space for the number and size of container images he or she wishes to use.
7. Explain how to modify the default folder used to store container images.
8. Explain how to view downloaded container images.
9. Explain what a Docker alias is and discuss how using an alias can simplify commands that work with container images. Explain how to create an alias using the docker tag command.

**Running Containers**

1. Mention that after a container image has been downloaded, an administrator can create containers from it using the docker run command.
2. Provide an example illustrating how to run a Web app.
3. Provide an example of a command run at the Windows Command prompt that displays the filesystem, hostname, and IP configuration of a container until it is closed using the exit command.
4. Mention that during the installation of Docker EE, a virtual NAT router is created on the Windows Server 2019 system for use by containers. Refer to Figure 10-12 and discuss how Docker assigns unique IPv4 and IPv6 addresses.

**Running Hyper-V Containers**

1. Mention that the three containers run in the previous example and shown in Figure 10-12 are executed using the same kernel on the underlying Windows Server 2019 system.
2. Remind students that in Module 1 we learned that we could use Hyper-V to provide each container with a separate copy of the kernel for greater stability, performance, and security.
3. Explain how to run a Hyper-V container.
4. Refer to Figure 10-13 to illustrate the Hyper-V container configuration.

**Common Docker Commands**

1. Explain that nearly all Docker configuration and management is provided by the docker command, with many different versions of the docker command available.
2. Refer to Table 10-3 to review a list common docker commands and their descriptions.

**Quick Quiz 1**

1. Which cloud delivery model merely executes the Web app that is provided to it?
2. Infrastructure as a Service (IaaS)
3. Platform as a Service (PaaS)
4. Software as a Service (SaaS)
5. Database as a Service (DBaaS)

Answer: c. Software as a Service (SaaS)

1. True or false: Object cloud storage is fast and often used for storing database files.

Answer: False

1. Docker containers are run and managed by a service called the \_\_\_\_\_\_\_\_\_\_.
	1. Docker server
	2. Docker client
	3. Docker hub
	4. Docker daemon

Answer: d. Docker daemon

1. True or False: Container images that are based on Nano Server must be run as Hyper-V containers.

Answer: True

**Configuring the Windows Subsystem for Linux**

1. Open this topic by reminding students that most Web apps that are run on cloud servers today are created for the Linux operating system.
2. Explain that in organizations that develop Web apps for Linux systems, an administrator can host those Web apps (and associated Web servers and Web app frameworks) on a Windows Server 2019 server using the Windows Subsystem for Linux (WSL).
3. Explain that WSL is a set of operating system components that allows 64-bit Linux programs to execute directly on the Windows kernel without virtualization.
4. List some common Linux distributions.
* Ubuntu
* Debian GNU/Linux
* Kali Linux
* OpenSUSE Leap
* SUSE Linux Enterprise Server
* Fedora

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| ***Teaching*** ***Tip*** | There are many different distributions (or distros) of Linux. Each distribution shares the same Linux operating system kernel and libraries but contains different software packages that make up the remainder of the operating system.  |

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| ***Teaching*** ***Tip*** | WSL 2 is a new version of WSL that was recently released. It runs a Linux kernel alongside the Windows kernel to provide additional performance benefits and features. However, at the time of this writing, WSL 2 is only available for testing purposes to Windows Server Insider Preview members. |

**Installing and Using WSL**

1. Mention that to install WSL on a Windows Server 2019 system, an administrator must install the Windows Subsystem for Linux server feature.
2. Mention that after this feature is installed, the system must be rebooted.
3. Explain that after the reboot process, an administrator must download and install at least one package that includes a WSL-supported Linux distribution.
4. As an example, demonstrate this process by downloading and installing the Ubuntu 18.04 Linux distribution package from Microsoft.
5. Mention that as part of the installation process, the administrator will be prompted to create a Linux user account that will be used each time he or she accesses the Linux distribution.
6. Refer to Figure 10-14 to illustrate the Linux command prompt that allows an administrator to run commands on the Ubuntu Linux distribution.
7. Refer to Table 10-4 to illustrate common Linux commands that an administrator can run on Linux distributions.
8. Mention that the Administrator user on a Linux system is called the super user and assigned a user name of root. Point out that as a security precaution, no password is assigned to the root user by default to ensure that users cannot log into the Linux system using the super user account.
9. Discuss how system administration is accomplished after installing the Ubuntu Linux distribution. Note that to allow for system administration, the Linux user account that an administrator created when installing the Ubuntu Linux distribution is automatically granted the ability to run administrative commands as the root user using the sudo (super user do) command.
10. Explain how to use the su (substitute user) command to open a Linux command prompt as the root user to run administrative commands without having to prefix them with the sudo command.
11. Emphasize that Linux systems do not mount filesystems to a drive letter. Explain that the filesystem that contains the Linux operating system files is mounted to a single root folder (/), and additional filesystems can be mounted to folders under this root folder.
12. Review the actual locations of Windows and Linux folders.

**Hosting Web Services using WSL**

1. Introduce this topic by mentioning that after an administrator has a Linux distribution installed using WSL, he or she can add software packages to it from a Linux software repository on the Internet.
2. As an example, review the steps that should be taken to add the Apache Web server software.
* Ensure that the latest list of packages available on the Linux software repository is downloaded to the system
* Download and install the Apache Web server
* Note where the configuration files are stored
* Modify Web server configuration parameters if necessary
* Check for syntax errors
* Restart the Apache Web server
* Stop the Apache Web server if necessary

**Configuring Linux Containers on Windows**

1. Introduce this section by explaining that in addition to running Windows containers on a Windows Server 2019 system, an administrator can also run Linux containers using the Linux Containers on Windows (LCOW) feature introduced in Windows Server 2019.
2. Discuss some of the unique characteristics of LCOW.
* Linux containers cannot use the WSL for execution
* Linux containers rely on a Linux kernel provided by a Docker component called LinuxKit
* LCOW requires that each Linux container run on a separate Linux kernel
1. Explain how each Linux container runs on a separate Linux kernel.
2. Refer to Figure 10-15 and explain how LCOW maximizes performance.
3. Describe how to enable LCOW using a Windows PowerShell window.
4. Explain how to use the commands in Table 10-3 to obtain Linux container images from Docker Hub, and to create and manage containers.
5. Explain that the Docker client cannot run and manage Windows and Linux containers simultaneously.

**Implementing Windows Server 2019 in a Cloud Environment**

1. Mention that an administrator can implement Windows Server 2019 in a cloud environment using many different configuration options.
2. Note that these options vary depending on whether the Web app is hosted in a public or private cloud.

**Hosting Web Apps in a Public Cloud**

1. Mention that to run a Windows Web app in a public cloud using SaaS, the public cloud provider configures and maintains all aspects of the underlying Windows Server 2019 operating system, including IIS and any Web app frameworks.
2. Note that the administrator must provide the Web app, as well as configure the block or object storage required by the Web app on the public cloud provider.
3. Explain that if the Web app was created by the administrator’s organization, the administrator will also need to implement orchestration and build automation software to provide for continuous deployment. Mention that many public cloud providers provide this software in a SaaS configuration for a fee; however, an administrator can instead choose to configure virtual machines or containers that provide the necessary orchestration and build automation software packages.
4. Mention that to run a Windows Web app in a public cloud using IaaS, the administrator will need to create, configure, and maintain the associated Windows Server 2019 virtual machine on the public cloud provider’s hypervisor.
5. Note that because public cloud providers charge based on resource usage, an administrator can install a small footprint virtual machine that contains Server Core, IIS, and the necessary Web app frameworks to reduce the cost.
6. If the organization’s Web apps use object storage exclusively, the organization only needs to purchase enough block storage to support the needs of the virtual machines the organization uses because object storage charges are based on consumption. Mention that most public cloud providers offer a large selection of virtual machine templates with Windows Server 2019, IIS, and Web app frameworks preinstalled to make the process of creating a new virtual machine easier.
7. Finally, to provide continuous deployment for Web apps created by an organization, the administrator will need to purchase access to orchestration and build automation software from their public cloud provider, or configure additional virtual machines or containers that run the necessary orchestration and build automation software packages.
8. Mention that to run a containerized Windows Web app on a public cloud provider using the PaaS cloud delivery model, an administrator must first configure any block or object storage required by the Web app on the public cloud provider.
9. Note that the administrator must also obtain the appropriate Windows container image from a container repository, such as Docker Hub. Point out that if the container image contains the Web app and necessary Web app frameworks, the administrator can create containers from it on the cloud provider.
10. Mention that for Web apps created by the organization, orchestration and build automation software is often used to create containers and add the necessary Web app and Web app frameworks.

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| ***Teaching*** ***Tip*** | Because public cloud providers also offer a Linux SaaS platform, as well as the ability to run Linux virtual machines and containers, the same considerations apply when running Web apps created for the Linux operating system on a public cloud provider. |

**Hosting Web Apps in a Private Cloud**

1. Mention that Windows Server 2019 provides several different options for running both Windows and Linux Web apps on a private cloud in an organization.
2. Describe one option where an administrator could install Windows Server 2019 on a physical server that is dedicated for running Windows Web apps or both Windows Web apps and Linux Web apps using the WSL.
3. Note that this configuration uses a SaaS cloud delivery model, and the physical server must contain adequate hardware resources and storage to support the Web apps. Mention that because organizations can use SANs and other storage technologies (e.g., Storage Spaces Direct) to provide fast, scalable, fault-tolerant block storage to cloud servers, private clouds typically use block storage exclusively.
4. Describe a second option where an administrator can use Windows Server 2019 Datacenter Edition or Hyper-V Server to run a large number of virtual machines in a private cloud using the IaaS cloud delivery model.
5. Explain that Windows Server 2019 virtual machines can be configured to host Windows Web apps, as well as Linux Web apps using the WSL.
6. Mention that an administrator can choose to create Linux virtual machines on Hyper-V to host Linux Web apps.
7. Explain how to make the deployment of multiple Windows Server 2019 virtual machines easier.
8. Explain how to make the deployment of multiple Linux virtual machines easier.

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| ***Teaching*** ***Tip*** | Currently no software package provides object storage on Windows Server 2019. However, Web apps that must use object storage can be hosted in a private cloud. In this case, the Web apps can be configured to access object storage on a public cloud provider, or object storage on a Linux system in the private cloud. Ceph is a popular object storage system that can be installed on Linux in a private cloud. |

**Quick Quiz 2**

1. Which term refers to a set of operating system components that allows 64-bit Linux programs to execute directly on the Windows kernel without virtualization?
	1. Windows Subsystem for Linux (WSL)
	2. Web Distributed Authoring and Versioning (WebDAV)
	3. Linux Containers on Windows (LCOW)
	4. continuous deployment (CD)

Answer: a. Windows Subsystem for Linux (WSL)

1. The Administrator user on a Linux system is called the \_\_\_\_\_\_\_\_\_\_.
	1. super user
	2. admin
	3. root
	4. operator

Answer: a. super user

1. Linux containers cannot use the WSL for execution, and instead rely on a Linux kernel provided by a Docker component called \_\_\_\_\_\_\_\_\_\_.
	1. WebSocket
	2. Docker Hub
	3. LinuxKit
	4. Docker Daemon

Answer: c. LinuxKit

1. True or False: Because organizations can use SANs and other storage technologies (e.g., Storage Spaces Direct) to provide fast, scalable, fault-tolerant block storage to cloud servers, private clouds typically use block storage exclusively.

Answer: True

# **Class Discussion Topics**

1. Why would an organization choose object storage over block storage in each of the three main cloud delivery models?
2. Compare IT automation and IT orchestration. How are they different? How are they similar?
3. When would you choose to use containers in Windows and when would you choose to use containers in Linux? How are they different? How are they similar?

# **Additional Projects**

1. Ask your students to read the following three related articles about WSL and WSL 2 and write a report summarizing the most important points, focusing on the new WSL 2.
* <https://docs.microsoft.com/en-us/windows/wsl/about>
* <https://docs.microsoft.com/en-us/windows/wsl/wsl2-index>
* <https://docs.microsoft.com/en-us/windows/wsl/compare-versions>
1. Ask your students to research a devops orchestration tool and prepare a short report summarizing its strengths and weaknesses. This article can serve as a starting point for finding orchestration software: <https://phoenixnap.com/blog/container-orchestration-tools>.

# **Additional Resources**

1. The Internet Society

<https://www.internetsociety.org/internet/history-internet>

1. Containers on Windows Documentation

<https://docs.microsoft.com/en-us/virtualization/windowscontainers/>

1. Windows Subsystem for Linux Documentation

<https://docs.microsoft.com/en-us/windows/wsl/>

1. File storage, block storage, or object storage?

<https://www.redhat.com/en/topics/data-storage/file-block-object-storage>

**Key Terms**

* **Advanced Research Projects Agency Network (ARPANET)** ARPANET was the first wide-area packet-switching network with distributed control and the first network to implement the TCP/IP protocol suite. Both technologies became the technical foundation of the Internet.
* **Anything as a Service (XaaS)** A term for services and applications that users can access on the Internet upon request.
* **Apache Web server** A free and open-source cross-platform Web server software, released under the terms of Apache License 2.0. Apache is developed and maintained by an open community of developers under the auspices of the Apache Software Foundation.
* **application pool** A group of one or more URLs that are served by a worker process or set of worker processes. Application pools are used to separate sets of IIS worker processes that share the same configuration and application boundaries.
* **Binary Large Object (BLOB) storage** A collection of binary data stored as a single entity in a database management system.
* **block storage** Block storage, sometimes referred to as block-level storage, is a technology that is used to store data files on Storage Area Networks (SANs) or cloud-based storage environments. Developers favor block storage for computing situations where they require fast, efficient, and reliable data transportation. Block storage breaks up data into blocks and then stores those blocks as separate pieces, each with a unique identifier.
* **build automation** The process of automating the creation of a software build and the associated processes including: compiling computer source code into binary code, packaging binary code, and running automated tests.
* **cloud delivery model** Specifies the capabilities offered to users and the applications supported. There are three basic cloud delivery models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS clients use applications supplied by the service provider.
* **cloud provider** Any organization that hosts cloud servers.
* **code repository** A file archive and web hosting facility for source code of software, documentation, web pages, and other works, accessible either publicly or privately. Code repositories are often used by open-source software projects and other multi-developer projects to maintain revision and version history, or version control. Many repositories provide a bug tracking system and offer release management, mailing lists, and wiki-based project documentation. Software authors generally retain their copyright when software is posted to a code hosting facilities.
* **Common Gateway Interface (CGI)** An interface specification for web servers to execute programs like console applications running on a server that generates web pages dynamically. Such programs are known as CGI scripts or simply as CGIs. CGIs provide the middleware between WWW servers and external databases and information sources.
* **compiling** Translating computer code written in one programming language into another language.
* **container image** A Docker container image is a lightweight, standalone, executable package of software that includes everything needed to run an application: code, runtime, system tools, system libraries, and settings.
* **continuous deployment (CD)** A software release process that uses automated testing to validate if changes to a codebase are correct and stable for immediate autonomous deployment to a production environment.
* **devop** A set of practices that combines software development and IT operations. It aims to shorten the systems development life cycle and provide continuous delivery with high software quality.
* **distribution** A version of Linux. Each distribution shares the same Linux operating system kernel and libraries but contains different software packages that make up the remainder of the operating system.
* **distro** Short for the word *distribution*.
* **Docker client** The primary way that many Docker users interact with Docker. When you use commands such as docker run, the client sends these commands to dockerd, which carries them out. The docker command uses the Docker API. The Docker client can communicate with more than one daemon.
* **Docker daemon** A service that runs and manages Docker containers.
* **Docker Enterprise Edition (EE)** A package for Windows Server from either Microsoft or Docker that you must download and install before you can use Docker to provide for containers on a Windows Server 2019 system. This package can be obtained using one of two different Windows PowerShell modules: DockerMsftProvider and DockerProvider.
* **Docker Hub** An online repository of preconfigured container images that you can download and run on your system to create one or more containers.
* **dynamic-link library (DLL)** Microsoft's implementation of the shared library concept in the Microsoft Windows and OS/2 operating systems. These libraries usually have the file extension DLL, OCX, or DRV.
* **egress fee** The costs organizations pay to move data from the cloud to another area, which vary by provider.
* **File Transfer Protocol (FTP)** A standard network protocol used for the transfer of computer files between a client and server on a computer network. FTP is built on a client-server model architecture using separate control and data connections between the client and the server. FTP users may authenticate themselves with a clear-text sign-in protocol, normally in the form of a username and password, but can connect anonymously if the server is configured to allow it. For secure transmission that protects the username and password, and encrypts the content, FTP is often secured with SSL/TLS (FTPS) or replaced with SSH File Transfer Protocol (SFTP).
* **hybrid cloud** A cloud computing environment using both public and private clouds together for a specific purpose.
* **Hypertext Markup Language (HTML)** Thestandard markup language for documents designed to be displayed in a web browser. It can be assisted by technologies such as Cascading Style Sheets and scripting languages such as JavaScript.
* **IIS Manager** An extensible web server software created by Microsoft for use with the Windows NT family. IIS supports HTTP, HTTP/2, HTTPS, FTP, FTPS, SMTP, and NNTP. It has been an integral part of the Windows NT family since Windows NT 4.0, though it may be absent from some editions (e.g., Windows XP Home edition), and is not active by default.
* **Infrastructure as a Service (IaaS)** An instant computing infrastructure, provisioned and managed over the Internet. It is one of the four types of cloud services, along with software as a service (SaaS), platform as a service (PaaS), and serverless.
* **Internet Server Application Programming Interface** **(ISAPI)** An N-tier API of Internet Information Services (IIS), Microsoft's collection of Windows-based Web server services. The most prominent application of IIS and ISAPI is Microsoft's Web server.
* **Linux Containers on Windows (LCOW)** A feature introduced in Windows Server 2019 that allows one to run Linux Containers on Windows.
* **LinuxKit** A toolkit for building secure, portable, and lean operating systems for containers.
* **National Science Foundation Network (NSFNET)** A program of coordinated, evolving projects sponsored by the National Science Foundation (NSF) from 1985 to 1995 to promote advanced research and education networking in the United States.
* **object storage** Also known as object-based storage, object storage breaks data files up into pieces called objects. It then stores those objects in a single repository, which can be spread out across multiple networked systems. In practice, applications manage all of the objects, eliminating the need for a traditional file system.
* **Open Database Connectivity (ODBC)** A standard application programming interface for accessing database management systems. The designers of ODBC aimed to make it independent of database systems and operating systems.
* **orchestration** The automated configuration, coordination, and management of computer systems and software. A number of tools exist for automation of server configuration and management, including Ansible, Puppet, Salt, Terraform, and AWS.
* **persistent volume** Another name for block storage when purchasing storage from a public cloud provider.
* **Platform as a Service (PaaS)** The most common method for hosting Web apps in a public or private cloud.
* **private cloud** A term for cloud servers that are used exclusively by the organization that owns them.
* **programming language** A vocabulary and set of grammatical rules for instructing a computer or computing device to perform specific tasks.
* **public cloud** A cloud consisting of cloud servers on the Internet that can be rented by others.
* **Server Side Includes (SSI)** A simple, interpreted server-side scripting language used almost exclusively for the World Wide Web. It is most useful for including the contents of one or more files in a Web page on a Web server, using its #include directive.
* **Software as a Service (SaaS)** Unlike IaaS and PaaS, SaaS is not used to configure virtual machines or containers. Instead, the SaaS cloud provider maintains all aspects of the network, hardware, and operating system; it merely executes the Web app that you provide.
* **Uniform Resource Locator (URL)** Colloquially termed a Web address. It is a reference to a Web resource that specifies its location on a computer network and a mechanism for retrieving it. A URL is a specific type of Uniform Resource Identifier (URI), although many people use the two terms interchangeably.
* **virtual directory** A folder that appears in a path but is not actually a subfolder of the preceding folder in the path.
* **Web app** A software application that runs on a Web server, unlike computer-based software programs that are stored locally on the operating system of the device. Web applications are accessed by the user through a Web browser with an active Internet connection.
* **Web app frameworks** Frameworks that provide a standard way to build and deploy Web applications on the World Wide Web.
* **Web Distributed Authoring and Versioning (WebDAV)** An extension of the Hypertext Transfer Protocol that allows clients to perform remote Web content authoring operations. WebDAV is defined in RFC 4918 by a working group of the Internet Engineering Task Force.
* **Web Server (IIS)** Internet Information Services (IIS) is a flexible, general-purpose Web server from Microsoft that runs on Windows systems to serve requested HTML pages or files. An IIS Web server accepts requests from remote client computers and returns the appropriate response.
* **WebSocket** A computer communications protocol providing full-duplex communication channels over a single TCP connection. The WebSocket protocol was standardized by the IETF as RFC 6455 in 2011, and the WebSocket API in Web IDL is being standardized by the W3C. WebSocket is distinct from HTTP.
* **Windows Subsystem for Linux (WSL)** A compatibility layer for running Linux binary executables natively on Windows 10 and Windows Server 2019. In May 2019, WSL 2 was announced, introducing important changes such as a real Linux kernel, through a subset of Hyper-V features.
* **World Wide Web (WWW)** Commonly known as the Web; an information system where documents and other Web resources are identified by Uniform Resource Locators, which may be interlinked by hypertext, and are accessible over the Internet.