**Module 5 – Managing storage**

**Module Overview**

As an IT support professional, it’s important that your understand how to manage storage. Windows 11 supports internal and externally-attached storage. It also supports Storage Spaces. In this module, you’ll learn how to manage storage using Disk Management and command-line tools. You’ll also learn how to create and manage Storage Spaces.

**Objectives**

After completing this module, you will be able to:

* Describe typical storage configurations
* Manage disks, volumes, and partitions
* Create a storage space

Lesson 1

**Overview of storage options**

It’s important to consider that most Windows 11 computers have only a single hard disk installed. Typically, this consists of three partitions. In day-to-day use, users will attach external storage devices, mostly USB memory sticks and SD storage cards. However, some computers are equipped with multiple hard disks.

To help provide for fault tolerance or high-performance disk throughput, these disks are sometimes configured as a single accessible drive through Storage Spaces.

In this lesson, you’ll learn about the storage options that Windows 11 supports, including local internal and external storage, and cloud storage options.

**Lesson Objectives**

After completing this lesson, you will be able to:

* Describe local storage options
* Describe network storage options
* Describe cloud storage options

**Local storage options**

Locally attached storage is often referred to as direct-attached storage (DAS). Typically, Windows 11 computers ship with a single, internal hard disk. However, users often attach additional storage.

**Local hard disks**

These days, internal disks are mostly likely to be solid state disks (SSDs); these offer superior performance, especially during startup. Older computers might still have mechanical hard disk drives (HDDs).

A good upgrade to consider is to replace any HDDs with SSDs. Your users will notice a significant improvement in computer performance.

Most tablet devices use flash storage, although some convertible devices, such as Surface laptops, use SSD storage for optimum performance and to provide more storage capacity.

There are a number of advantages with using local hard disks, including:

* **Availability**. You always have access to local storage, even when there are network connectivity issues.
* **Performance**. The only thing limiting the throughput of the disk is its own performance characteristics. There is no latency due to poor performing network components.

However, there are some disadvantages:

* **Backup**. Unless you set it up, there’s no backup of your disk’s contents.
* **Disk failure**. After a local disk failure, you can’t start your computer.

Windows 11 does provide easy-to-use backup software and versioning recovery tools.

**Virtual hard disks**

Windows 11 supports the attachment and use of virtual hard disks (VHDs). You can attach and work with both .vhd and .vhdx file formats.

Older .vhd format disks are limited to 2 TB of storage. However, .vhdx format disks support a maximum size of 64 TB.

You typically work with VHDs when working with virtual machine (VM) environments. For example, when using VMs in Client Hyper-V, or in Azure.

The significant benefit of using a VHD is that it’s independent of the underlying hardware. This enables you to move the VHD between hosts.

Consider the following advantages of using VHDs:

* **Portability**. VHDs can be easily moved between physical disks, even when those disks are on different computers.
* **Backup**. When you back up the contents of a VHD, you’re backing up a single file on the computer that hosts the VHD.

However, there are some disadvantages:

* **Performance**. There is some I/O degradation in performance due to the overhead of using VHDs.
* **Physical disk failure**. A VHD file doesn’t have any inherent protection against disk failure. If the physical disk that stores the VHD fails, then the VHD is potentially lost.

It’s possible to startup a Windows computer from a VHD by making a simple modification to the boot configuration data (BCD) for your computer.

**Removable storage devices**

Most, if not all, computers provide expansion ports for the attachment of peripheral devices such as printers, scanners, and external monitors. But these ports also support for the attachment of removable storage devices. Removable storage comes in a variety of form factors and capacities, including:

* **External SSDs and HDDs**. You can pick up external SSDs or HDDs pretty inexpensively. They’re usually attached via a USB port. If performance is an issue, ensure that you opt for SSDs, and review the read and write throughput for the device. Also make sure that you have the appropriate USB ports on your device.
* **SD and microSD cards**. Often used in phones and cameras to provide for storage. Your computer requires a card reader to enable you to access these storage devices (although you can obtain an external card reader for attachment by USB). These days, microSD cards are widely supported on Windows computers.
* **USB memory sticks**. Also known as thumb drives, these probably provide the most portable form of storage. However, if portability is important, you’ll need to choose a file system that is supported across the different operating systems you intend to use. The FAT32 file system is a good choice.

It’s a good idea to eject externally attached storage before physically disconnecting it. This helps protect the integrity of the file system and your files.

When considering external storage, particularly with storage cards and memory sticks, make sure that your Windows computer supports the storage device format. More recent cards and sticks support larger capacities. However, older computers might not be able to read large capacity cards and sticks.

Caution: Be sure to remove external storage when you restart your computer. Most computers support startup from externally attached devices, such as memory sticks.

**Networked storage options**

It’s rare to find a computer that’s not attached to a network. Consequently, connecting to network storage is also common.

In a workplace network, there are a number of networked storage options, including:

* File server attached storage
* Network attached storage (NAS)
* Storage area networks (SAN)

File servers are ubiquitous in most workplace networks. Providing shared access to server storage is therefore very common. Windows Server provides folder sharing capabilities that enable and control access to files stored on your servers’ storage.

Not all organizations, however, use NAS or SAN. You typically use NAS for client-based and server-based computing scenarios. But SAN is generally reserved for server-based computing scenarios.

**Using file servers to provide storage**

Perhaps the easiest way of providing for network attached storage is to make your storage available by using a Windows Server shared folder.

Windows Server supports the attachment of a variety of high performance disk drives. You can configure attached disks to support fault tolerant and high throughout scenarios, depending on specific configuration details.

Windows Server shared folders are accessed through the SMB protocol, much like NAS. Windows Server also provides additional features, such as backup, synchronization through the Distributed File System (DFS), and Work Folders, a method of syncing work content to users’ personal devices.

The advantages of using server storage include:

* **Performance**. You can configure server disk storage in such a way as to optimize throughput. This can be easier to accomplish than with Windows 11 DAS.
* **Recovery**. On-premises file server-based backup systems are commonly available. Windows Server also includes a built-in backup capability. These can help guard against data loss.
* **Redundancy**. You can configure high-availability through the use of Storage Spaces on your Windows Server computers.

There are a few disadvantages, including:

* **Availability**. On-premises storage, including storage attached to file servers, requires direct network access. Typically, you also need AD DS domain-joined devices so that authentication and permissions can be managed effectively. By provisioning storage in the cloud, you can mitigate this issue.
* **Performance**. While performance of server-attached storage often surpasses DAS on client devices, in some workloads, the file server can be overwhelmed with simultaneous requests. You can mitigate to some extent using high performance networking components, and features such as NIC teaming. Using either NAS or SAN can also mitigate this problem.

**Using NAS**

When using NAS, you connect your NAS to dedicated storage devices rather than a server computer. You can access your storage over the network using standard networking storage protocols, such as:

* Server Message Block (SMB)
* Network File System (NFS)
* Common Internet File System (CIFS)

Each NAS device:

* Is installed with a dedicated operating system. This OS controls access to the data on the device.
* Provides file-level access to the storage. This means you can access the data on the storage only as files using the file access protocols already mentioned.
* Is assigned a network configuration.
* Is then configured across the network rather than interactively.
* Requires that you create network shares on the device.

NAS is an on-premises storage solution, but it might help address some of the shortcomings of storage directly attached to your file servers.

**Using SAN**

SAN is a high‐speed network that:

* Connects computer systems or host servers to high-performance storage subsystems.
* Includes various components such as host bus adapters (HBAs), special switches to help route traffic, and storage disk arrays with logical unit numbers (LUNs) for storage.
* Enables multiple servers to access a pool of storage in which any server can potentially access any storage unit.
* Enables you to connect many different devices and hosts and provide access to any connected device from anywhere.
* Implements block-level access. This means that instead of accessing the content on the disks as files by using a file access protocol, SANs write blocks of data directly to the disks by using protocols such as Fibre Channel over Ethernet or Internet Small Computer System Interface (iSCSI).

For the most part, modern SAN solutions provide elements of both SAN and NAS. The architectural components that provide the storage are the same in each solution; however, the access method differs.

Windows 11 does includes the iSCSI initiator. This allows you to connect to SANs from Windows 11.

**Cloud-based storage**

Cloud-based storage is available anywhere so long as you can connect your device to the internet. Microsoft provides a number of possible storage solutions for the cloud. These are:

* OneDrive
* OneDrive for Business
* Azure storage

**OneDrive**

OneDrive is provided for users that have a Microsoft consumer account, such as an Outlook.com account. Currently, users get 5 GB of free space to use in their account. Access to OneDrive storage is easy for Windows 11 users because a OneDrive client is built-in to the operating system.

A OneDrive node exists in File Explorer, and any files saved to this location, and its subfolders (Documents, Pictures, Music and so on), are automatically synced to the cloud.

Users can customize which folders are synced.

Users can also access their OneDrive content from their other devices running iOS and Android. Apps exist for both platforms in their respective stores.

**OneDrive for Business**

If your users have a Microsoft 365 account and an appropriate license, they’ll have access to OneDrive for Business. This typically provides up to 2 TB of storage, although this can be extended by your Microsoft 365 administrator.

Microsoft 365 is a cloud SaaS solution that includes Exchange, SharePoint, Teams, and OneDrive for Business).

Again, access to OneDrive for Business is simple. Users of Windows 11 can access the OneDrive node in File Explorer. Content saved to the libraries in this node are synced to the cloud. The same apps can be used on users’ phones and tablets to access their synced content.

You can use both OneDrive and OneDrive for Business on Windows 11 at the same time. In this situation, two nodes are displayed in File Explorer: OneDrive – Personal, and OneDrive – *Organizational name*.

The cloud icon used to represent OneDrive in the taskbar corner overflow area is blue for OneDrive for Business, and grey for OneDrive.

**Azure storage options**

Microsoft Azure provides a number of storage solutions. These are described in the following table:

|  |  |
| --- | --- |
| Storage type | Description |
| Blob | Stores any type of text or binary data, such as documents and images |
| Table | Stores structured datasets |
| Queue | Provides messaging for workflows, for example, communication between different components of cloud services |
| Files | Uses the standard SMB protocol. Azure VMs and cloud services can share file data with Files storage. On-premises applications can also access file data in a share via Files storage |

Perhaps Azure Files provides the most interesting storage solution for users of Windows in an on-premises context. Since Azure Files is accessible using the SMB protocol, much like both file server shared folders and NAS, it’s simple to connect users’ devices to the storage.

In addition, you can use a feature called *Azure File Sync*. This enables you to add your on-premises servers as endpoint nodes in a synchronization architecture that uses Azure to distribute content. In some ways, this behaves a little like DFS – which is perhaps why some organizations are migrating from DFS to use Azure File Sync.

Lesson 2

**Managing local storage**

It’s important that you know how to manage local storage. Management tasks might include installing and configuring internal and external disks. In addition, you’ll probably need to know how to manage removable storage. In this lesson, you’ll learn about these management tasks.

**Lesson Objectives**

After completing this lesson, you will be able to:

* Explain disk management fundamentals
* Describe a typical Windows 11 computer’s disk configuration
* Manage local disks

**Disk management fundamentals**

Before we discuss how to manage disks and removable storage, we should take a moment to learn about storage component fundamentals.

It’s important that you understand what a partition, volume, and disk is; what role the partition table performs; the difference between basic and dynamic disks; how to choose a file system.

**MBR and GPT**

When you install a physical disk in Windows, you must create a partition table. This process is often referred to as initializing the disk.

The partition table exists at a predefined location – the first sector of the disk – and defines the logical structure of the disk; in other words, the size and location of partitions on the disk.

There are two formats for this partition table: Master Boot Record (MBR) and GUID Partition Table (GPT). For modern computers that are installed with Unified Extensible Firmware Interface (UEFI) firmware, you can use either format. However, older computers with only a BIOS cannot use GPT partitioned disks, and must use MBR partition tables.

When you first install a disk and open the Disk Management console, you’re prompted to initialize the disk, and can choose between MBR and GPT.

Before we discuss how each of these works, it’s worth considering why they’re necessary. You need a partition table to:

* **Locate the startup files for an OS**. When the BIOS or firmware wants to locate the startup files, it accesses the partition table to determine the which partition is marked as active (there can be only one). It then reads the first sector of the active partition to load the OS startup files.
* **Determine what partitions exist on the disk, their size and their location**. Historically, it was necessary to divide a physical disk into manageable pieces that an OS could access. This was primarily due to limitations in early OS software.

Although both MBR and GPT do the same job, they work slightly differently, and have specific characteristics.

**Partitioning with MBR**

The MBR partition scheme has been around since MS-DOS back in the early 80s. You can use MBR on pretty much any OS and it’s the default portioning scheme in Windows 11.

Perhaps due to its historical background, the scheme imposes some restrictions, including:

* **Only four partitions**. MBR-based disks are limited to four partitions. All can be primary partitions, which means you can mark any one of them as active.
* **2 TB-maximum partition size**. Partitions cannot exceed 2 TB. Currently, for most Windows client operating systems, that’s unlikely to be a problem. For servers, though, that could present an issue as disks tend to be larger on Windows Server.
* **No redundancy**. The MBR is a single point of failure. If it gets corrupted, your computer’s BIOS can’t locate the active partition and the boot files for the OS.

**Partitioning with GPT**

GPT has the following characteristics:

* Each GPT can contain multiple partition entries, each of which describe the start and end location of each partition on a disk.
* Each GPT partition has a unique GUID and partition-content type.
* You can only startup a Windows 11 computer from a GPT partition if the computer is UEFI-equipped.
* You can access data disks from a GPT partition on both UEFI and BIOS systems.

The GPT partition scheme is more modern, and so isn’t affected by historical constraints. Additional features of GPT partitioned disks include:

* **More partitions per disk**. You can have up to 128 partitions per disk. In reality, the need for so many partitions is dubious, but the ability to support more than four might prove useful.
* **Larger volumes**. You can achieve much larger volumes using GPT disks, theoretically up to 18 exabytes per volume. However, current disk technology makes that maximum somewhat unlikely.
* **Redundancy**. The GPT is duplicated and protected, helping to eliminate it as a single point of failure.

For most computers running Windows 11, you’ll probably find that the primary disk is configured for GPT. You can check by using Disk Management:

1. Right-click the disk you want to check.
2. Click **Properties**.
3. Select the **Volumes** tab and review the status. The Partition style value will display as either MBR or GPT.

If you opt to use MBR, you can convert the disk to use GPT. However, you’ll need to delete any volumes on the disk.

**What are disks, drives, partitions, and volumes?**

It can sometimes be confusing when talking about storage, particularly when some of the terminology is used vaguely. Let’s review some of the more common storage terms.

A *disk* is a physical storage device. It can be either an HDD or an SSD. You can subdivide a disk into partitions.

A *partition* is a logical area that uses all or only some of a physical disk’s capacity. There are two types of partition:

* **Primary**. A primary partition can be marked as active. MBR disks support four primary partitions, or three primary and one extended partition. GPT disks support 128 partitions, all primary.

There can only be one active partition on a disk.

* **Extended**. An extended partition is designed to get around an historical limitation. An extended partition can contain multiple volumes, enabling you to have more than four volumes per disk.

A *volume* is a formatted area of disk space that can contain files. A volume can use all the available space in a partition, or it can be configured to span multiple partitions on different disks. If you configure a volume to span partitions across multiple disks, you can optimize your volume for performance or fault tolerance, depending on your needs.

A *drive* is a generic term used to describe disks and volumes. Strictly speaking, in Windows, a drive is volume that’s been allocated an identifying letter, such as Drive C.

**What are basic and dynamic disks?**

A *basic disk* is a disk that contains a volume that exists only on that specific disk. A *dynamic disk* is one that contains a volume that spans multiple disks.

This distinction is required because in order to determine where blocks of data are actually located, the OS needs a location map of the volume that stores that data. In a single disk volume, the OS is only concerned with the local partition table.

However, in a spanned, striped, or mirrored volume, the OS needs to know in which disk as well as in which partition the data resides. In order to achieve this, the disks that form part of a multi-disk volume must be converted to dynamic disks.

Dynamic disks use a database to store information about volumes in the computer, and each dynamic disk stores a replica of this database.

You can perform the following operations only on dynamic disks:

* Create and manage spanned, striped, and mirrored volumes.
* Extend a simple volume to a noncontiguous space or spanned volume.
* Repair mirrored volumes.
* Reactivate a missing or offline disk.

You should be aware of the following considerations regarding dynamic disks:

* You can’t convert a basic disk to a dynamic disk unless there’s at least 1 MB of unused space to store the database.
* You can convert a basic disk to a dynamic disk without data loss, but you can’t convert a dynamic disk to a basic disk without losing data.

Attempting to create a volume across disks automatically prompts you to perform the conversion from basic to dynamic.

**Choosing a file system**

Having decided on your local storage configuration, it’s necessary to create the required partitions, volumes, and format them to store data. You’ll be prompted during the volume creation process to choose a file system for your volume. Windows 11 supports three file systems:

* FAT
* NTFS
* ReFS

**FAT**

The FAT file system has been around since personal computers have been around. It’s named after the File Allocation Table index which contains basic file attributes and a pointer to the disk cluster that contains the first part of a file. Each cluster contains data and a pointer to the next cluster.

FAT has evolved over the years to accommodate changes in hardware, such as the introduction of hard disks and then larger hard disks. It’s ubiquitous, and you’ll probably find that most operating systems support the FAT file system, making it an ideal choice for removable and portable storage.

The FAT file system comes in three flavors: FAT, FAT32, and exFAT. Typically, most memory sticks use the FAT32 file system. You can create partitions up to a maximum of 32 GB in size on FAT32, and the maximum file size is 4 GB. Larger, external hard disks usually require a partition size beyond FAT32’s capabilities to address. exFAT supports larger partitions, but is less widely supported.

Although Windows limits partition size to 32 GB, you can work with larger FAT32 partitions if created using other operating systems.

The following table provides a comparison between these FAT32 and exFAT file systems.

|  |  |  |
| --- | --- | --- |
|  | FAT32 | exFAT |
| Max volume size | 32 GB | 232-1 clusters |
| Max file size | 4 GB | 16 exabytes |
| Max files per volume | 4,177,920 | Practically unlimited |

A cluster is the smallest unit of disk space that you can allocate to store a file

The greatest benefit of FAT is that you can use the storage device in pretty much any computing or media device. However, FAT (and its derivatives) doesn’t support file system security. For most modern computing needs, file-level security is critical.

**NTFS**

Microsoft introduced the New Technology File System in the early 1990s with Windows NT. It’s key benefits were to address the shortcomings of FAT. NTFS introduced:

* File system security
* Quota management
* File compression
* File encryption
* Additional file attributes

NTFS uses an indexing object known as the Master File Table (MFT). This is similar to the File Allocation Table in FAT, but supports more information about files. NTFS is the default file system for Drive C, the operating system drive, in Windows 11.

If you have FAT volumes, you can convert them to NTFS without data loss using the **Convert /FS:NTFS** command-line tool.

**ReFS**

The Resilient File System was introduced to enable support for larger volumes. It has a structure much like that of NTFS, but doesn’t support the following features:

* Quota management
* File compression
* File encryption

Fortunately, none of these features is especially useful.

You’ll likely only see ReFS formatted fault tolerant volumes in Storage Spaces. This is because they tend to be large volumes for which ReFS is the ideal choice.

**Typical disk configuration**

Most Windows 11 computers are installed with a single disk. These days, that’s almost certainly going to be an SSD rather than an HDD.

Assuming that your computer is a UEFI computer, and that the primary disk is GPT, this disk is divided into four partitions. These are:

* EFI System Partition
* Microsoft reserved partition
* Boot Partition
* Recovery Partition

**The EFI System Partition**

This partition contains the startup files. It is formatted with FAT32, and must have a size of no less than 100 MB.

For Advanced Format (4K) drives, the minimum size is 260 MB. This is due to a limitation of the FAT32 file format. The minimum partition size of FAT32 drives is calculated as sector size (4KB) x 65,527 = 256 MB.

This partition is not assigned a drive letter.

Secure Boot is used to help protect your computer against low-level malware that might infect files in this partition.

**The Microsoft reserved partition**

This partition doesn’t store data and has no partition ID. It’s used to help with partition management for GPT disks.

**The Boot Partition**

This partition is also sometimes called the Windows partition. It’s the volume that contains the Windows operating system. Windows 11 requires a minimum of 64 GB on the OS drive. Typically, this partition uses all available space after the other partitions have been created. The contents of this drive are, by default, protected by BitLocker whole drive encryption. The Windows partition is formatted using NTFS.

**The Recovery Partition**

This partition contains a runtime version of Windows used in recovery situations. Known as Windows RE, the partition must be at least 52 MB, although often the partition is larger. It’s not unusual to see a recovery partition of around 850 MB.

When your computer fails to start correctly, it will attempt to failover to use the recovery partition. From Windows RE, you can access various recovery tools which we’ll discuss later in the course.

**Managing local disks**

You can use the following tools to manage Windows 11 disks and the volumes or partitions that they contain:

* **Disk Management**. A management console snap-in that enables you to manage disks, partitions, and volumes. You can choose to manage the local computer, or select a remote computer to manage.
* **DiskPart**. This is a command-line tool that runs in an elevated Command Prompt window. It provides the same sort of capabilities as using Disk Management, but can be scripted. This tool always runs locally.
* **Windows PowerShell**. There are numerous cmdlets that you can use to manage your local disks.

Managing a remote computer’s disks requires that the Remote Volume Management firewall exception is enabled.

**Using the Disk Management console**

Using Disk Management, you can perform the following tasks quickly and easily:

* Initialize disks
* Create partitions
* Create simple, spanned, striped, and mirrored volumes
* Extend or shrink volumes
* Recover failed mirrored volumes
* Create virtual hard disks

Attach and detach virtual hard disks

* Convert basic to dynamic disks
* Convert MBR to GPT disks

To access Disk Management, right-click **Start**, and then click **Disk Management**.

**Using DiskPart**

From an elevated Command Prompt, you can use DiskPart to manage your local disks. You can use the following commands in DiskPart.

|  |  |
| --- | --- |
| Command | Description |
| List disk | Displays all the disks on the computer |
| List volume | Displays all the volumes on the computer |
| List partition | Displays the partitions on the selected disk |
| Select disk  Select partition  Select volume | Enables you to set the focus on the selected object (disk, volume, and partition). Focus remains on the selected object until you change the focus. You usually select the disk, then the partition, and then the volume you want to work with |

After you’ve listed and selected the appropriate object, you can use the following commands to manage your object:

* **Active**. Marks the selected partition as active.
* **Assign**. Assigns a drive letter to the selected volume.
* **Clean**. Removes any and all partitions from a selected disk.
* **Convert**. Converts the file system to NTFS from FAT.
* **Create**. Creates a partition on the selected disk.
* **Delete**. Deletes a partition from the selected disk.
* **Extend**. Extends the volume or partition with focus.
* **Offline**. Takes a disk offline.
* **Online**. Brings a disk online.
* **Shrink**. Reduces volume size by amount specified.

This is just a small subset of the available command set.

**Using Windows PowerShell**

You can use Windows PowerShell to perform disk management tasks. Open an elevated PowerShell window, and then use the cmdlets described in the following list to manage your storage.

* **Get-Disk**. Returns information on specified disks.
* **Clear-Disk**. Cleans a disk by removing all partition information.
* **Initialize-Disk**. Prepares a disk for use, and, by default, creates a GPT partition.
* **Set-Disk**. Updates a selected disk with the specified properties.
* **Get-Volume**. Returns information on volumes that you specify.

**Managing local volumes**

Using Disk Management, DiskPart, or Windows PowerShell, you can manage disks, partitions, and volumes. Windows 11 supports the following types of volumes:

* **Simple volumes**. A simple volume is created from a contiguous area of free space on a disk. The operating system drive, C, is an example of a simple volume. Simple volumes can be created on basic disks. They provide no fault tolerance or I/O performance benefits.
* **Spanned volumes**. A spanned volume consists of two or more areas of unallocated space on between two and 32 disks. Spanned volumes provide no fault tolerance and no performance benefit. However, they are a convenient way of using non-contiguous, unequal areas of disk space in a single volume.

You can extend a simple volume across additional disks to create a spanned volume.

* **Striped volumes**. Also consist of areas of unallocated space on between two and 32 disks. However, the areas must be equal in size. Striped volumes are designed to increase throughput. However, this comes at the cost of introducing multiple points of failure in a single volume.
* **Mirrored volumes**. These provide a high level of fault tolerance. To create a mirrored volume, you will need two areas of equal size across two disks. Write operations are repeated across both disks in the mirror.

You can create a mirrored volume from an existing simple volume.

**Demonstration: Managing local storage**

Lesson 3

**Managing Storage Spaces**

It’s important to remember that while it’s interesting to consider the various ways in which you can combine areas of unallocated space across multiple physical disks, the truth is, you probably won’t do it. It’s far more likely that you’ll use the single disk, three partition configuration discussed earlier. If you do add storage, it will likely be external removable storage. However, if you do need to create additional storage in Windows 11, you could consider using Storage Spaces.

**Lesson Objectives**

After completing this lesson, you will be able to:

* Describe Storage Spaces
* Create and manage Storage Spaces

**What is the Storage Spaces feature?**

Storage Spaces breaks the direct link between a disk volume in Windows and the physical disk it resides on. With Storage Spaces, your physical disks can be grouped into a storage pool. You can then create a virtual disk (storage space) from the available storage in a pool.

This separation enables you to manage your disks as a single entity rather than as individual units. And although Windows 11 sees the storage space as a single disk, you have great flexibility. For example, you can:

* Configure fault tolerance through mirroring or striping with parity.
* Use thin provisioning, and add physical disks only when needed.

The following table describes the key elements in a Storage Space solution.

|  |  |
| --- | --- |
| Element | Description |
| Physical disks | Without physical storage, you can’t create a storage pool. You can use pretty much any type of physical disk, but you should choose disks based on their longevity and performance, based on the requirements of your storage pool. |
| Storage pool | This is a collection of your disks from which you create your virtual disks. The disks you add mustn’t be formatted, nor attached to another pool. |
| Storage space | From the Windows 11’s perspective, this is a single physical disk. |
| Disk drive | When you create your storage space, you allocate a drive letter, and configure a file system. This is what Windows sees. |

**Requirements**

There are a number of requirements of your physical disks for use in Storage Spaces. Your Storage Space must have:

* At least one physical disk.
* At least two physical disks to create a resilient mirror virtual disk.
* At least three physical disks to create a virtual disk with resiliency through parity.
* At least five physical disks to create a virtual disk with three-way mirroring.
* Blank and unformatted disks when they’re added to a pool.

You can attach your physical disks using a variety of interface types, such as SAS, SATA, USB, or SCSI.

**Layout and provisioning options**

When you create your storage space, there are two features you must configure. These are the layout of your storage space, and the type of provisioning you want to use.

There are three layout options described in the following table.

|  |  |
| --- | --- |
| Layout | Description |
| Simple | Provides striping capabilities that can improve disk throughput. However, there’s no resiliency in this layout, and failure of a single disk in the storage pool results in failure of the whole storage space. |
| Two-way or three-way mirroring | Enables you to maintain two or three copies of your data, depending on specific configuration. This helps maintain the availability of the storage space even if a disk fails in the pool. Because data is written across all disks in the pool, there’s a performance benefit, too. |
| Parity | Writes data and parity information across all disks in the pool. The parity provides for fault tolerance against physical disk failure. |

There are two provisioning options available.

|  |  |
| --- | --- |
| Provisioning option | Description |
| Thin | Enables you to allocate more usable space than is actually physically available in your storage pool. As users and apps consume the available space, more capacity is added to the pool to satisfy their requirements. The storage pool uses provisioning slabs to perform this allocation. It’s worth considering that the allocation of storage just-in-time can impact performance of the storage space linked to the pool. |
| Fixed | Creates a fixed pool for your storage space. This has the advantage of reducing the latency that arises with thin provisioning. However, by provisioning more storage than you need, you increase the costs associated with the storage pool. |

**Creating and managing a storage space**

To create a storage space, use the following procedure:

1. Open **Disk Management** and verify that the physical disks you want to use aren’t initialized.
2. If they are, open an elevated **Windows PowerShell**command prompt, and run the following command:

* Get-Disk | Clear-Disk -RemoveData

1. Open **Control Panel** and search for and select **Storage Spaces**.
2. In Control Panel, on the **Manage Storage Spaces** page, select the **Create a new pool and storage space** link.
3. If prompted by **User Account Control**, click **Yes**.
4. Your blank, uninitialized disks are displayed. Click **Create pool**.
5. On the Enter a name, resiliency type, and size for your storage space page, enter the following information, and then click **Create storage space**:

* **Name**. Enter the name of your storage space.
* **Drive letter**. Choose a driver letter for your virtual disk.
* **File system**. Choose between NTFS and REFS, depending on configuration options.
* **Resiliency type**. Under the Resiliency heading, select the **Resiliency type**. The options vary according to the number of disks you have in your pool.
* **Size**. Under the Size heading, enter the **Size**. You can enter more space than is currently available in the pool to use Thin provisioning.

You can perform the following tasks on your storage pool, depending on current configuration and availability of additional disks:

* Create a new storage space.
* Add drives.
* Rename the pool.
* Optimize drive usage.

Within a specific storage space, you can:

* View files.
* Change the configuration (but not the resiliency type).
* Delete the storage space.

Under the Physical drives heading, you can:

* Rename your disks.
* Prepare your disks for removal.

To modify the configuration, for example, to add a disk, open **Control Panel** and use the following procedure:

1. Search for and select **Storage Spaces**.
2. On the **Storage Spaces** page, in your **Storage Pool**, select **Add drives**.
3. On the **Select drives to add to the storage pool** page, select any disk that you want to add to the pool and click **Add drives**.

**Demonstration: Creating a storage space**

**Lab: Managing storage**

**Question:**In the lab, you worked with uninitialized disks. What’s the difference between using MBR and GPT disks?

**Module Review and Takeaways**

Review Questions

**Question:**On a Windows 11 computer, what’s a typical disk configuration?

**Question:**True or false. When you implement NAS, files are saved across the network using SMB, NFS, or CIFS?

**Question:**What type of Azure storage supports connectivity over the SMB protocol?

Tools

The following table lists the tools that this module references.

| **Tool** | **How used** | **Where found** |
| --- | --- | --- |
| Diskpart.exe | * Manage disks using command-line interface | Command Prompt |
| Convert.exe | * Convert FAT volumes to NTFS volumes without data loss | Command Prompt |