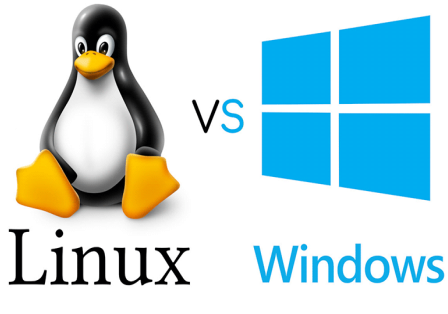
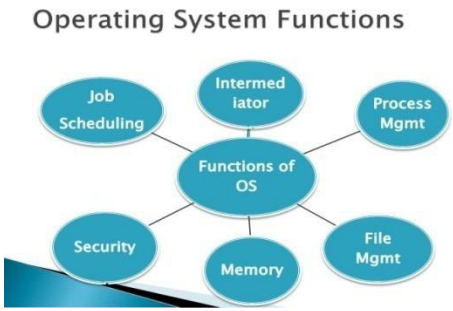
CIT210 OP. SYS. MANAG.

CSUN
COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

Week4Day2 : Managing Disk Partition, GPT and MBR, Simple, Striped, Spanned, Mirrored Volume, Virtual File System, Managing Server Storage Recovering from Disk Failures





Disk Partitions

- When the hard drive is divided into more than one partition, the first partition is referred to as the primary partition and the second is called the extended partition.
- The primary partition is usually the active partition, or the partition Windows refers to during the boot-up process.
- A hard disk can have up to 4 separate primary partitions, or 3 primary and 1 extended.

Building the Root File System

- One of the first tasks of an OS during bootup is to build the root file system

1. Locate all bootable media
   - Internal and external hard disks
   - SSDs
   - CDs, DVDs, USB sticks
2. Locate all the partitions on each media
   - Read MBR(s), extended partition tables, etc.
3. Mount one or more partitions
   - Makes the file system(s) available for access

Mounting a File System

1. **Read the super block for the target file system**
   - Contains meta-data about the file system
   - Version, size, locations of key structures on disk, etc.
2. **Determine the mount point**
   - On Windows: pick a drive letter
   - On Linux: mount the new file system under a specific directory

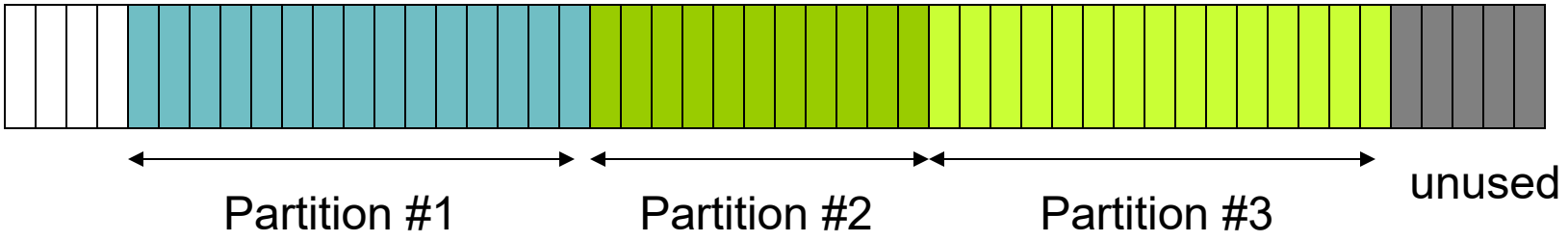
```
Filesystem  Size  Used  Avail Use%  Mounted on
/dev/sda5   127G   86G   42G   68%  /media/cbw/Data
/dev/sda4    61G   34G   27G   57%  /media/cbw/Windows
/dev/sdb1   1.9G  352K  1.9G    1%  /media/cbw/NDSS-2013
```

Virtual File System Interface

- Problem: the OS may mount several partitions containing different underlying file systems
  - It would be bad if processes had to use different APIs for different file systems
- Linux uses a Virtual File System interface (VFS)
  - Exposes POSIX APIs to processes
  - Forwards requests to lower-level file system specific drivers
- Windows uses a similar system

Disk Partitions

- **The total storage-area of the hard disk is usually subdivided into non-overlapping regions called ‘disk partitions’**

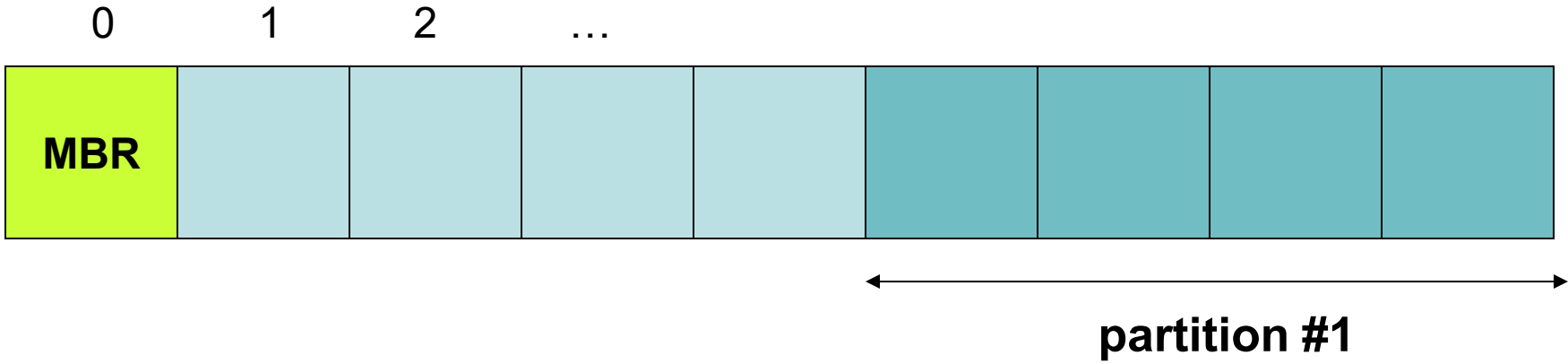


Master Boot Record (MBR)

- The Master Boot Record, created when you create the first partition on the hard disk, is probably the most important data structure on the disk.
- It is the first sector on every disk.
- The location is always track (cylinder) 0, side (head) 0, and sector 1.
- The Master Boot Record contains the Partition Table for the disk and a small amount of executable code.

Master Boot Record

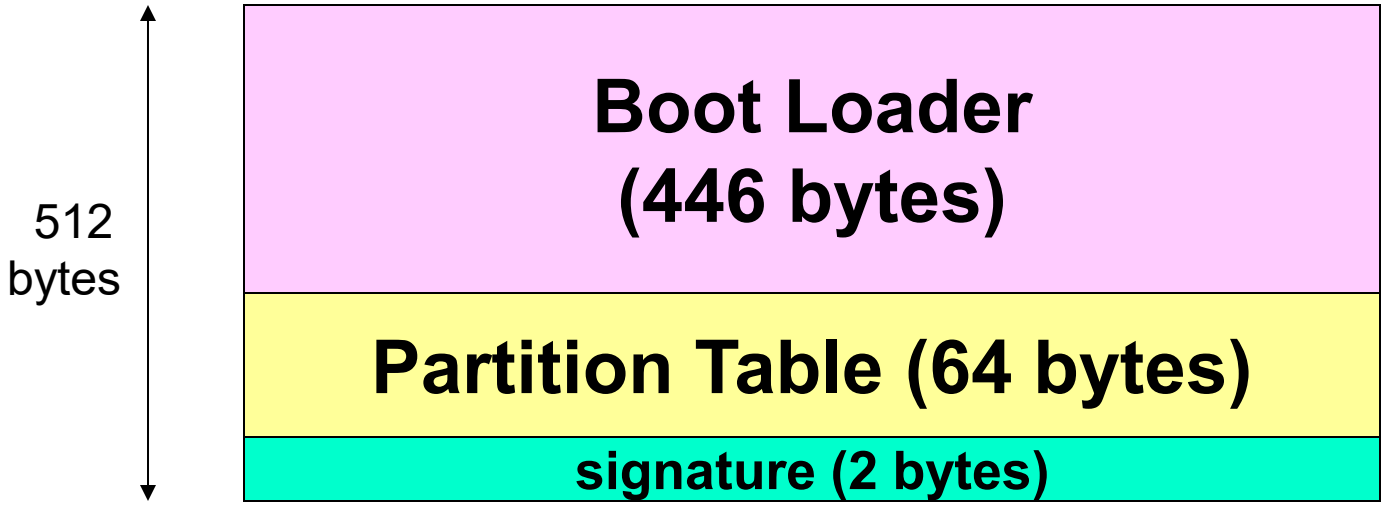
- A small area at the beginning of the disk is dedicated to ‘managing’ the disk partitions



- In particular, sector number 0 is known as the Master Boot Record (very important!)

Format of the MBR

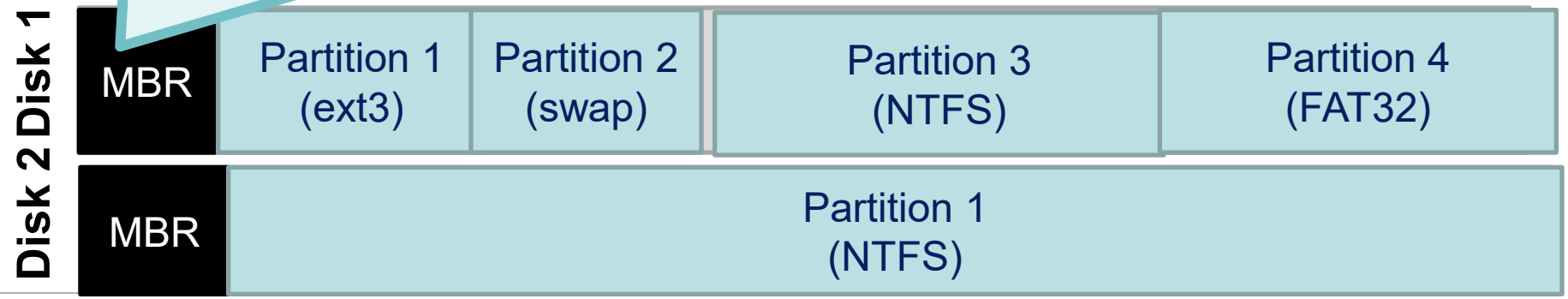
- The MBR is subdivided into three areas:
  - The boot loader program (e.g., GRUB)
  - The 'partition table' data-structure
  - The MBR signature (i.e., 0x55, 0xAA)



The Master Boot Record

Address		Description	Size (Bytes)
Hex	Dec.		
0x000	0	Bootstrap code area	446
0x1BE	446	Partition Entry #1	16
0x1CE	462	Partition Entry #2	16
0x1DE	478	Partition Entry #3	16
0x1EE	494	Partition Entry #4	16
0x1FE	510	Magic Number	2
		Total:	**512**

Includes the starting LBA (Logical Block Addressing) and length of the partition

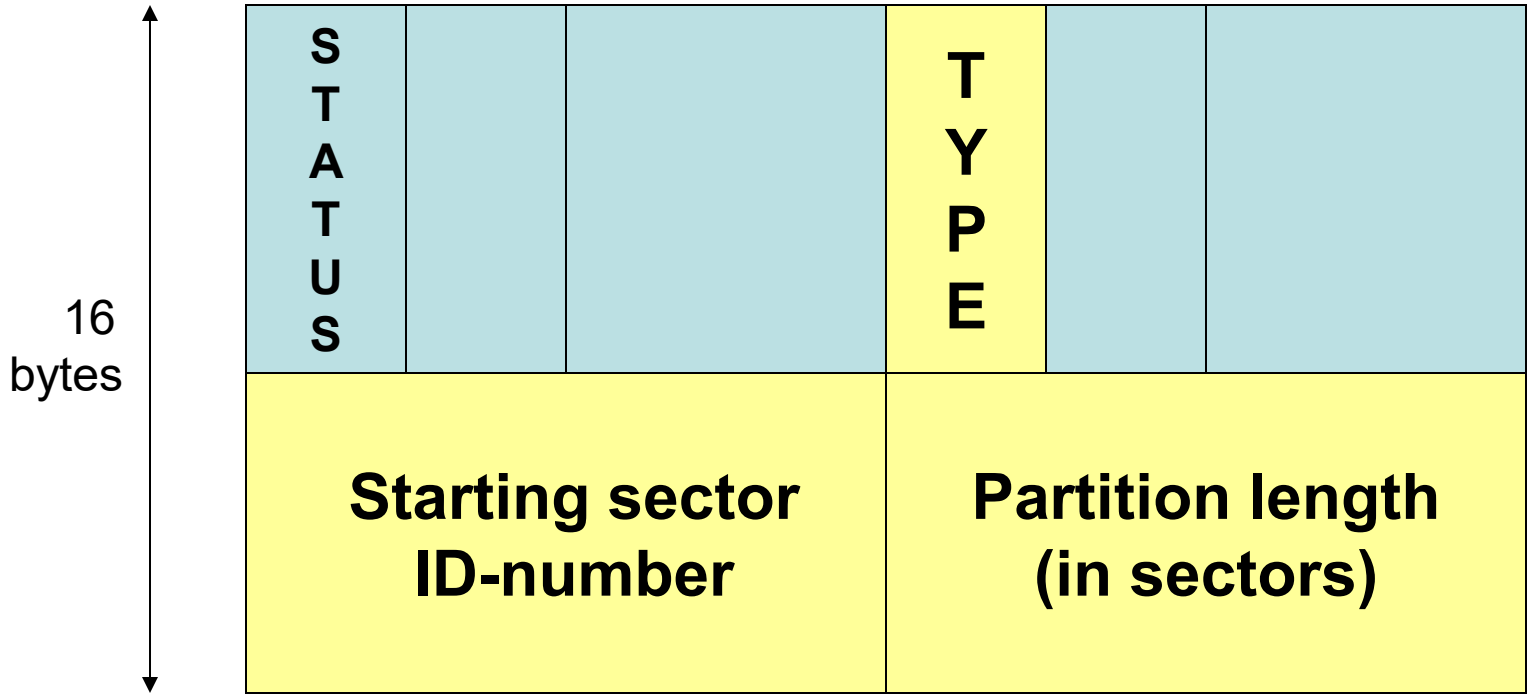


‘Reading’ the MBR

- To see the hard disk’s Partition Table, we must ‘read’ the entire Master Boot Record
- (We ignore the boot-loader and signature)
- But we will need to understand the format of the data stored in that Partition Table
- We first need to know how to devise code that can transfer the MBR (sector 0) from the hard-disk into a suitable memory-area

Partition Table Entries

- **The MBR is an array containing four data-structures (called 'partition-table entries'):**



Some fields contain 'obsolete' information

TYPE-ID

- Each partition-table entry has a TYPE-ID
  - TYPE-ID is 0x07 for a ‘Windows’ partition
  - TYPE-ID is 0x83 for our ‘Linux’ partition
  - TYPE-ID is 0x00 when the entry is ‘unused’

Estimating Storage Requirements

The amount of space you need in a server depends on a variety of factors, not just the requirements of your applications and users:

- Operating system: Depends on roles and features chosen
- Paging file: Depends on RAM and number of VMs
- Memory dump: Space to hold the contents of memory + 1MB
- Log files: From Event Viewer
- Shadow copies: Can utilize up to 10% of space
- Fault tolerance: Disk mirroring versus parity

Selecting a Physical Disk Technology

- Direct-attached storage or external storage
- Review specifications of hard disks:
  - Capacity
  - Rotational speed (10,000 rpm +)
  - Disk interface (to handle large numbers of disk I/O requests)
    - ATA, SATA, SCSI

Using External Drive Arrays

- Hard drives in a separate housing with their own disk controller, power supply, cooling fans, and cache memory.
- Connects to computer using:
  - SCSI (Small Computer System Interface)
  - IEEE 1394 (Fire Wire)
  - External SATA (eSATA)
  - USB (Universal Serial Bus)
  - Network Interface (iSCSI or Fibre Channel)

Using External Drive Arrays

- Enable a server to host more physical hard drives and often include fault-tolerance features, such as:
  - Hot-swappable drives
  - Redundant power supplies
  - Hardware-based RAID
- The more features the array has, the more drives it can hold and the higher the cost.

Planning for Storage Fault Tolerance

- Fault tolerance is immediate redundancy.
- Variety of fault tolerance mechanisms:
  - Redundant blocks
  - Redundant files
  - Redundant volumes
  - Redundant drives
  - Redundant servers
- It is a tradeoff between performance and expense.

Fault Tolerance Technologies

- **Disk mirroring/Disk duplexing**
  - A computer writes the same data to identical volumes on two different disks.
  - Disk duplexing also uses duplicate host adapters.
- **RAID with Windows Server**
  - RAID 0: Stripe set without parity
  - RAID 1: Mirror set without parity
  - RAID 5: Stripe set with distributed parity

Parity is a mathematical algorithm that is used to provide redundancy, so that data from a failed drive or volume can be reconstructed.

Using Storage Spaces

- Enables a server to concatenate storage space from individual physical disks to create virtual disks of any size.
- Storage pools can span multiple drives invisibly that can be expanded or reduced as needed.
- Virtual disks of any size can be created.
    - Once created, they behave just like a physical disk, and you can create volumes.

Windows Disk Settings

The Windows Setup program automatically prepares the primary hard disk for the system, but when you add new hard disks, you must:

- Select a partitioning style.
- Select a disk type.
- Divide the disk into partitions or volumes.
- Format the partitions or volumes with a file system.

Selecting a Partition Style

- Master Boot Record (MBR)
  - Common partition style for x86- and x64-based computers
- GUID Partition Table (GPT)
  - New since the late ’90s
  - Most operating systems now support GPT

GPT and MBR

- Supports up to 128 primary partitions
- Supports volumes up to 18 exabytes
- Partitions store data critical to platform operation
- Replication and CRC protection of the partition table provide increased reliability

- Supports up to 4 primary partitions or 3 primary partitions and 1 extended partition, with unlimited logical drives on the extended partition
- Supports volumes up to 2 terabytes
- Hidden (unpartitioned) sectors store data critical to platform operation
- Replication and cyclical redundancy checks (CRCs) are not features of MBR's partition table

Windows Server Storage Options

- Windows Server supports two essential disk storage types:
  - Basic disk - One that uses traditional disk management techniques and contains primary partitions, extended partitions, and logical drives
  - Dynamic disk - One that does not use traditional partitioning
- Dynamic disk architecture provides more flexibility than basic disks
  - So there is virtually no restriction on the number of volumes that can be on one disk

Basic Disks (1 of 7)

- **Partitioning**
  - A process that allocates a group of tracks and sectors to be used by a particular file system, such as NTFS
- **Formatting**
  - A process that creates a table containing file and folder information for a specific file system in a partition
- **Volume**
  - A logical designation of disk storage that is created out of one or more physical disks
  - Is partitioned and formatted with one file system

Basic Disks (2 of 7)

- Basic disks recognize primary and extended partitions
- Basic disks also can be configured for any of three RAID levels:
  - Disk striping (RAID level 0)
  - Disk mirroring (RAID level 1)
  - Disk striping with parity (RAID level 5)
- RAID stands for redundant array of inexpensive (or independent) disks
  - A set of standards for lengthening disk life and preventing data loss
- Disk striping
  - The ability to spread data over multiple disks or volumes
- Disk mirroring
  - The practice of creating a mirror image of all data on an original disk, so that the data is fully copied or mirrored to a backup disk

Basic Disks (3 of 7)

- **MBR and GPT support**
  - **When a drive is partitioned, a Master Boot Record (MBR) and a partition table are created**
    - At the beginning track and sectors on the disk
  - **The MBR is located in the first sector and track of the hard disk**
    - Has startup information about partitions and how to access the disk
  - **The partition table contains information about each partition created**
  - **Globally Unique Identifier (GUID) Partition Table or GPT**
    - A newer way to partition disks, without imposing the same type of limits on the number of partitions as with MBR
  - **GPT disks store partition information in each partition using main and backup tables**

Basic Disks (4 of 7)

- Instead of storing partition information in an MBR and a partition table, GPT disks store partition information using main and backup tables
  - Each partition is identified by a different GUID or reference number
- In Windows Server systems:
  - A GPT partition can theoretically be up to 18 exabytes
  - A GPT disk can hold up to 128 partitions
  - You can convert an MBR disk to GPT and vice versa

Basic Disks (5 of 7)

- **Primary and extended partitions on MBR disks**
  - **A primary partition is one from which you can boot an operating system**
  - **At least one primary partition must be marked as active**
    - Only one primary partition can be active at a given time
  - **The active partition is the partition where your computer will look for the hardware-specific files to start the operating system**
  - **An extended partition is created from space that is not yet partitioned**
  - **The purpose of an extended partition is to enable you to exceed the four-partition limit of a basic disk**
  - **Only one extended partition can exist on a single basic disk**
- **A computer with multiple partitions boots from the partition that is designated as the active partition**
  - **Must also be the system partition**

Basic Disks (6 of 7)

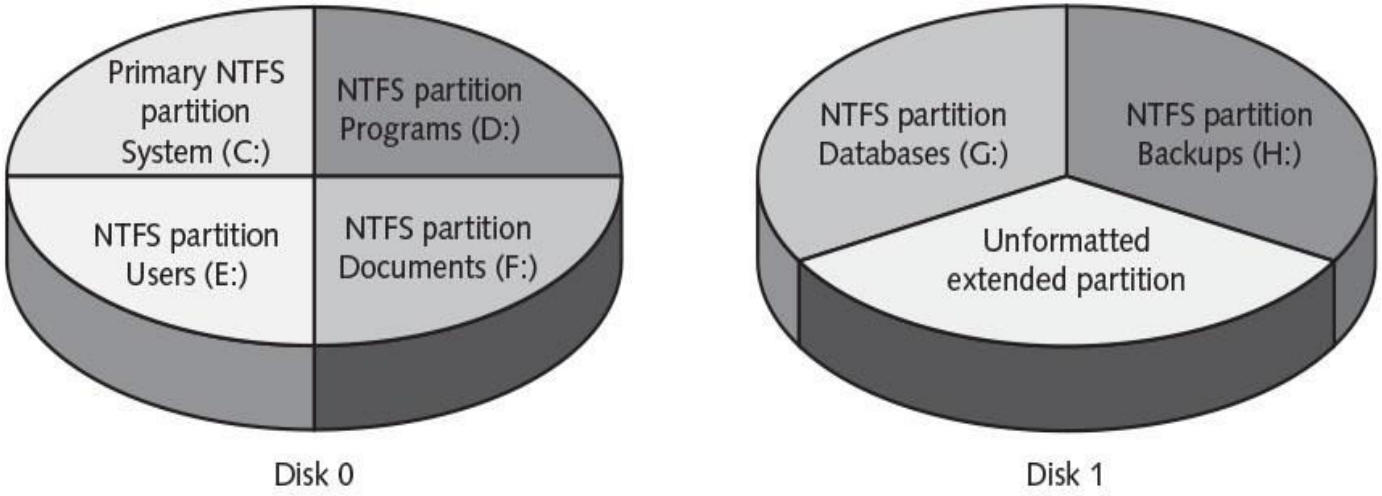


Figure 7-1 Partitions on two disk drives

Basic Disks (7 of 7)

- **Volume and Stripe Sets**
  - **Volume set**
    - Consists of two or more partitions that are combined to look like one volume with a single drive letter
  - **Stripe set**
    - Two or more disks that are combined like a volume set, but that are striped for RAID level 0 or RAID level 5
- **Windows Server 2016/2022 provides backward compatibility with basic disk volume and stripe sets that have previously been created through legacy Windows Server systems**
  - **However, you should plan to convert basic disks to dynamic disks in order to implement any new multidisk volumes**

Dynamic Disks (1 of 5)

- A dynamic disk does not use traditional partitioning
  - Makes it possible to set up a large number of volumes on one disk
  - Provides the ability to extend volumes onto additional physical disks
- The number of disks that can be incorporated into one spanned volume is limited to 32
- Dynamic disks support RAID levels 0, 1, and 5
- Plan to convert basic disks to dynamic disks after you install Windows Server
- On dynamic disks
  - The volume that contains the \Windows folder of system files is called the boot volume
  - The volume that contains the files used to boot the computer is called the system volume

Dynamic Disks (2 of 5)

- **Simple volume**
  - A portion of a disk or an entire disk that is set up as a dynamic disk
  - Can be extended onto multiple sections of the same disk
  - Does not provide fault tolerance because it cannot be set up for any RAID level
- **Spanned volume**
  - Stored on 2 to 32 dynamic disks that are treated as one volume
  - As you add new disks, the spanned volume can be extended to include each disk
  - Advantage: the ability to more easily manage several small disk drives or to maximize the use of scattered pockets of disk space across several disks

Dynamic Disks (3 of 5)

- **Striped volumes**
  - Often referred to as RAID-0
  - Extend the life of hard disk drives by spreading data equally over two or more drives
  - Another advantage: increases disk performance
  - In Windows Server 2016, striping requires at least two disks and can be performed over as many as 32
  - Useful for volumes that store large databases or for data replication from one volume to another
  - Data can be lost when one or more disks in the striped volume fail because the system has no automated way to rebuild data

Dynamic Disks (4 of 5)

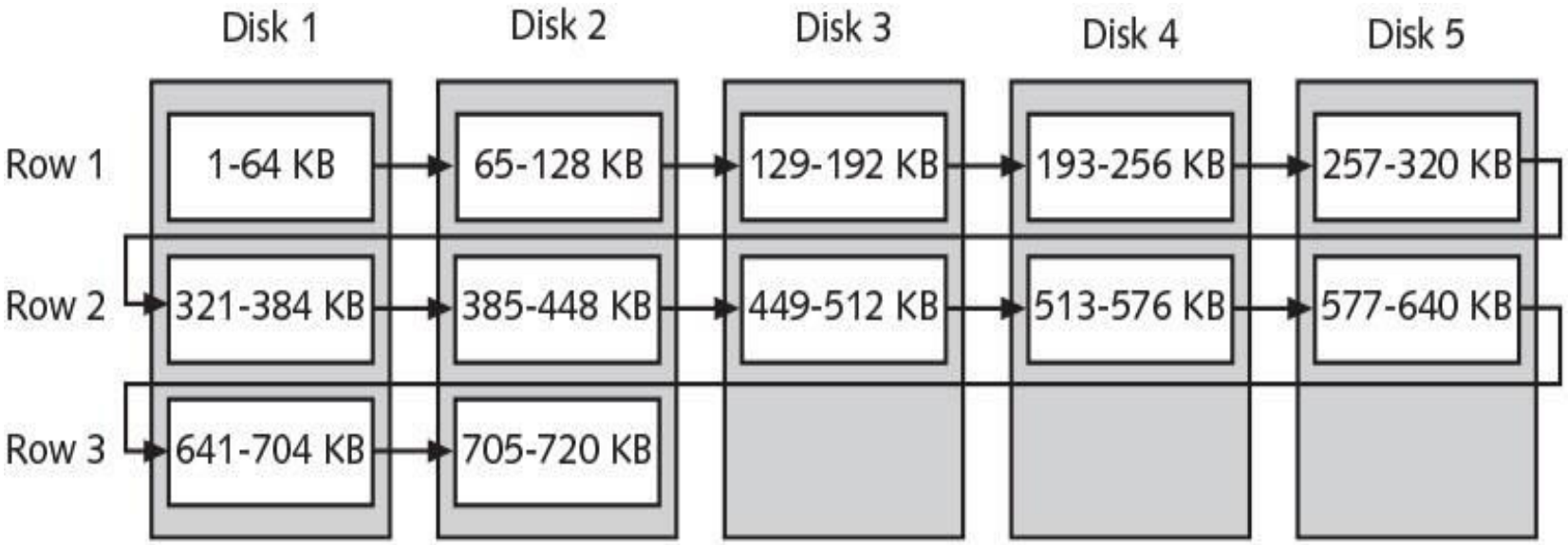


Figure 7-4 Disks in a striped volume

Dynamic Disks (5 of 5)

- **Shrinking a volume**
  - Windows Server comes with the ability to shrink a basic or dynamic disk volume
  - Shrinking a volume enables you to create a new partition when one is needed and you don't have extra disks
  - When you shrink a volume, Windows Server starts from the end of that volume
    - Works its way back through contiguous space to create unallocated disk space
  - You can specify the amount of space to recover

Disk Types

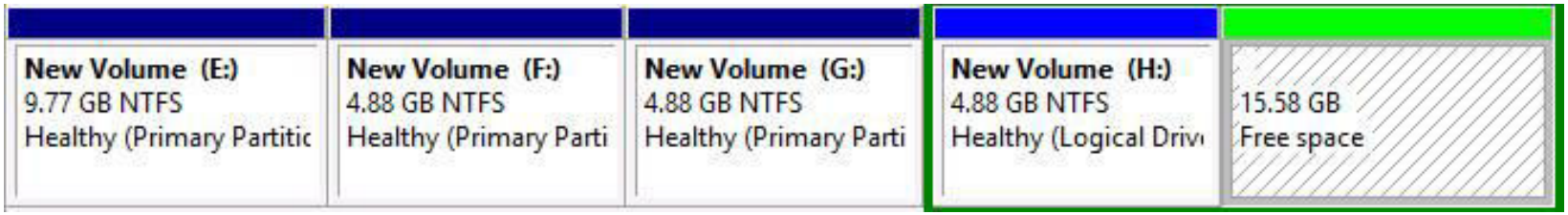
Basic Disk

- Compatible with older OS
- Consists of primary and extended partitions
- Supports up to 4 partitions (per single hard drive)
- Basic disks also can be configured for any of 3 RAID levels:
  - Disk striping (RAID 0)
  - Disk mirroring (RAID 1)
  - Disk striping with parity (RAID 5)

Dynamic Disk

- Supported by Windows 2000 and up
- Does not use traditional partitioning
- Dynamic disks can combine two or more physical disks into one dynamic disk
- Dynamic disks divided into volumes

Primary and Extended Partitions with MBR



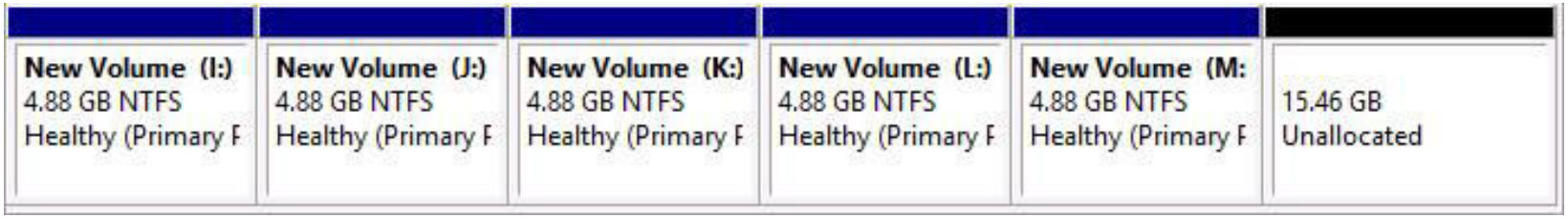
Primary and extended partitions on a basic disk using MBR

Partitions Compared: Primary versus Extended

- A primary partition functions as though it is a physically separate disk and can host an operating system.
- It can be marked as an active partition.
- On a basic disk using MBR, you can create up to 4 primary partitions or 3 primary partitions and 1 extended partition.
- You format each primary partition and assign a unique drive letter.

- Extended partitions cannot host an operating system.
- You cannot mark an extended partition as an active partition.
- A basic disk using MBR can contain only 1 extended partition, but unlimited logical drives.
- You do not format the extended partition itself, but the logical drives it contains. You assign a unique drive letter to each logical drive.

Primary Partitions with GPT



Primary partitions on a basic disk using GPT

Volume Types

- Simple volume
- Spanned volume
- Striped volume
- Mirrored volume
- RAID-5 volume

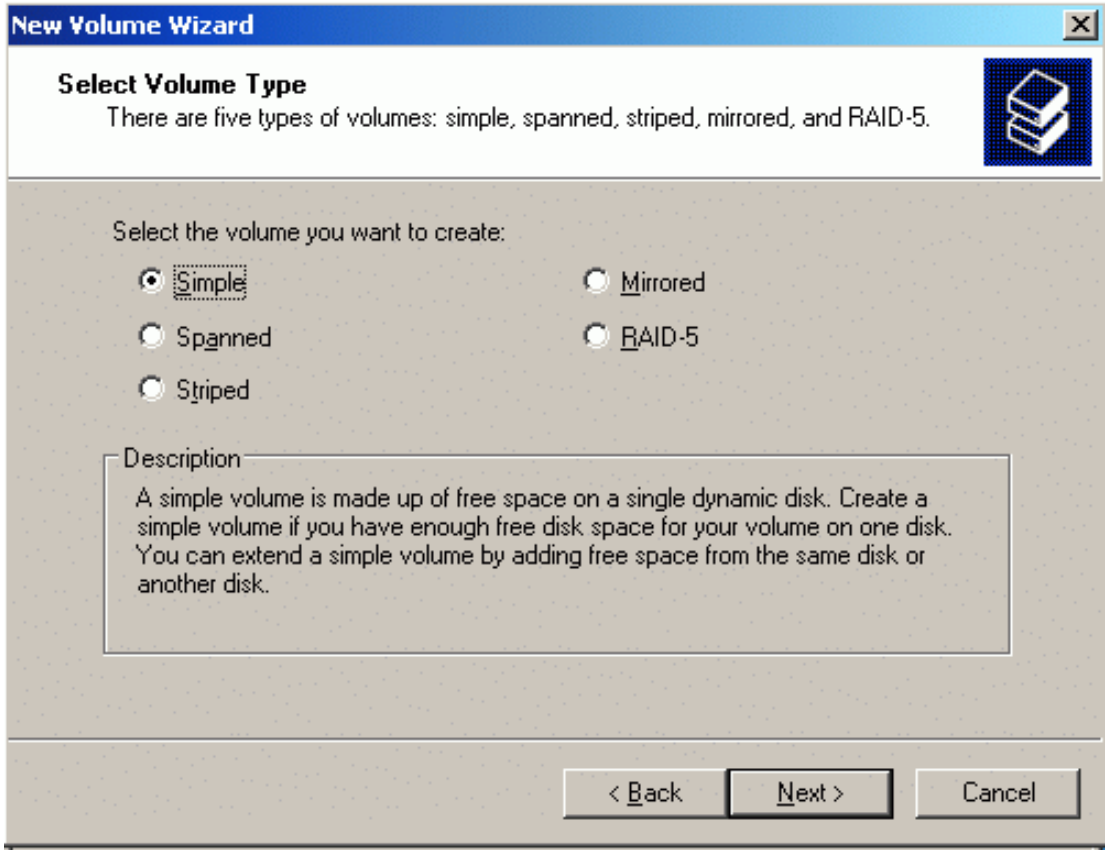
Simple Volume

- A portion of a disk or an entire disk that is set up as a dynamic disk.
- Can be extended onto multiple sections of the same disk.
- Can be extended to multiple disks to be a part of a spanned or striped volume.

Creating a Simple Volume

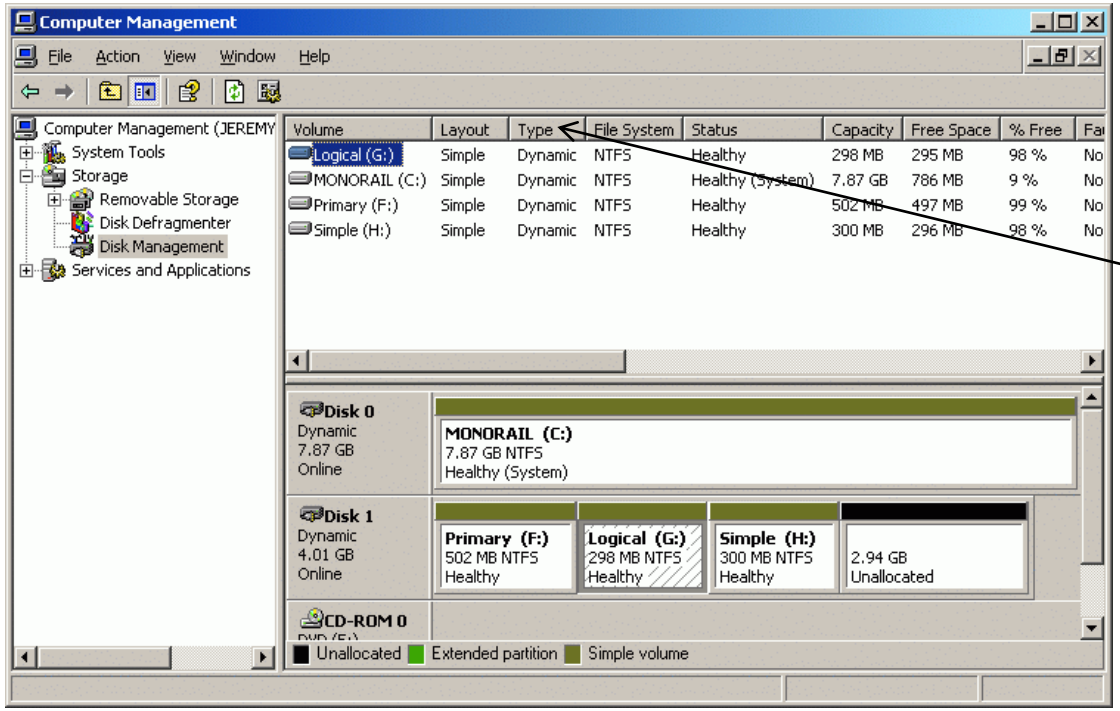
- Upgrading a basic disk to a dynamic disk
  - Any existing partitions are converted to volumes
  - Any free space that is left on the drive can be used to create additional volumes
- Simple volume
  - Can be part of a disk or an entire disk
  - Can be created only on a single dynamic disk

Creating a Simple Volume



Creating a simple volume

Creating a Simple Volume



Note that if you created the primary partition and the logical drive on the extended partition on the same disk, they were converted to simple volumes when the disk was upgraded to dynamic

Newly created simple volume

Spanned Volume

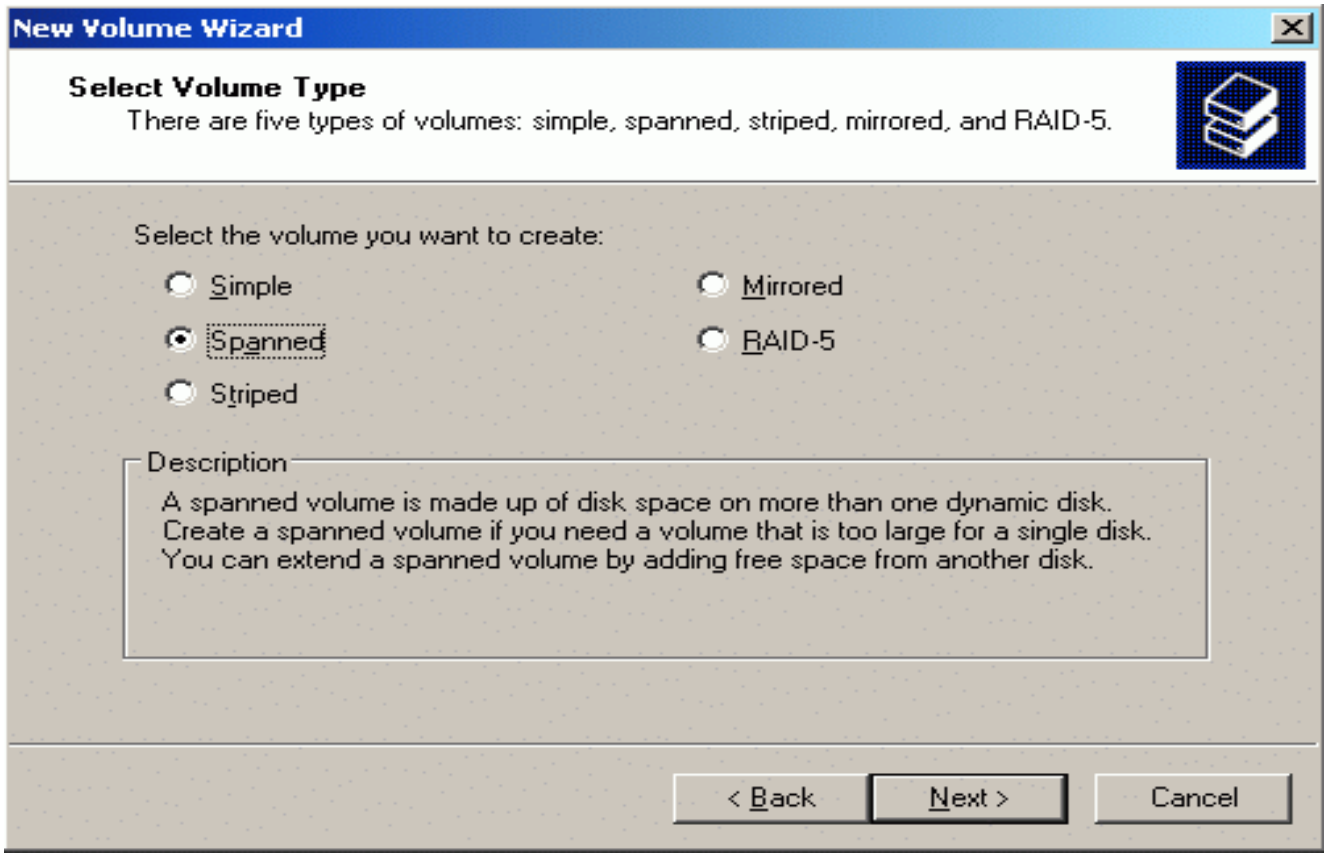
- Combines space from multiple dynamic disks to a singe large volume.
- Can contain space on 2 to 32 dynamic disks.
- As new disks are added, the spanned volume can be extended to include new disks.
- One disk is filled before moving onto the space of another disk.
- It does not increase performance.
- It does not provide fault tolerance.

Creating a Spanned Volume

Spanned volumes

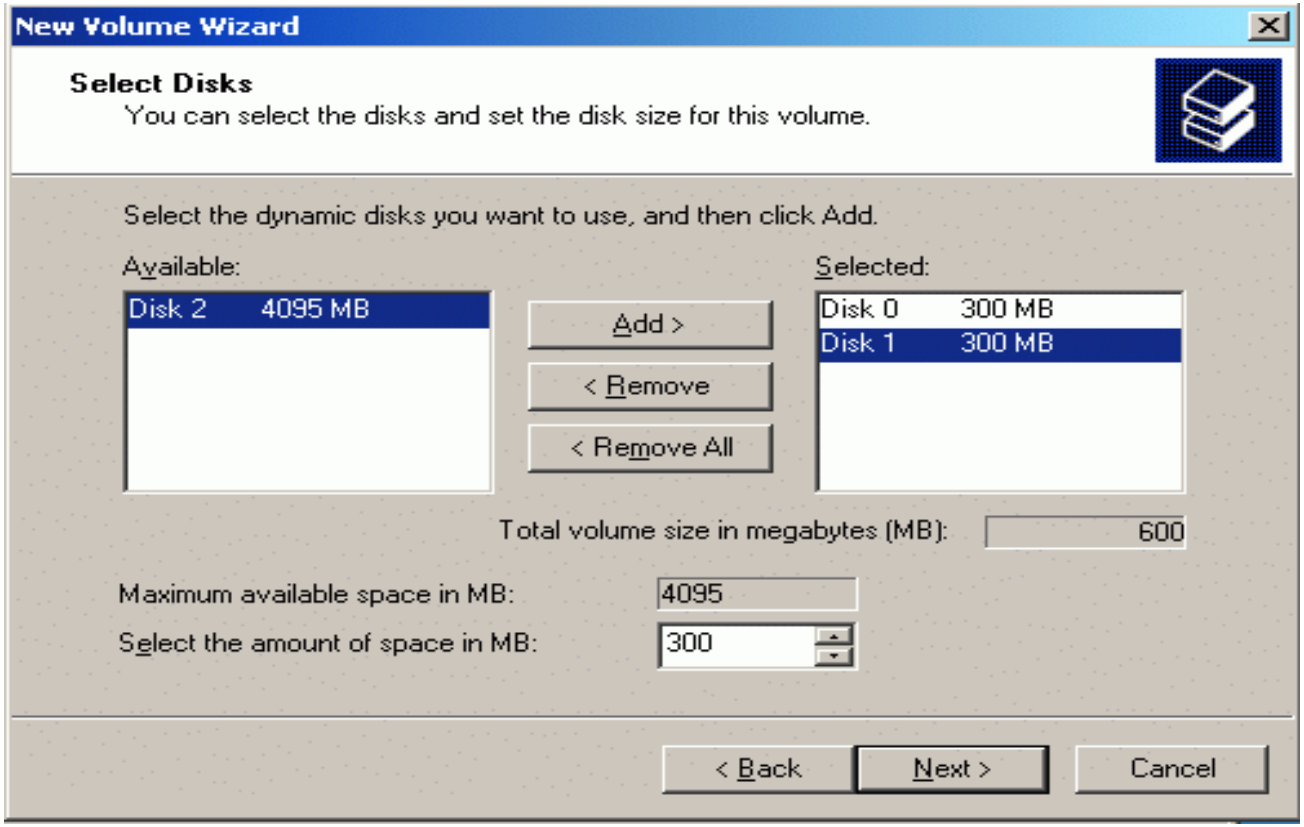
- Creating a spanned volume
  - Combines the unallocated space on multiple disks into one logical volume
  - A spanned volume can organize disk space on up to a maximum of 32 disks
- Spanned disks allow you to combine the space used by multiple, smaller volumes, on multiple disks, into one spanned volume represented by a single drive letter

Creating a Spanned Volume



Creating a spanned volume

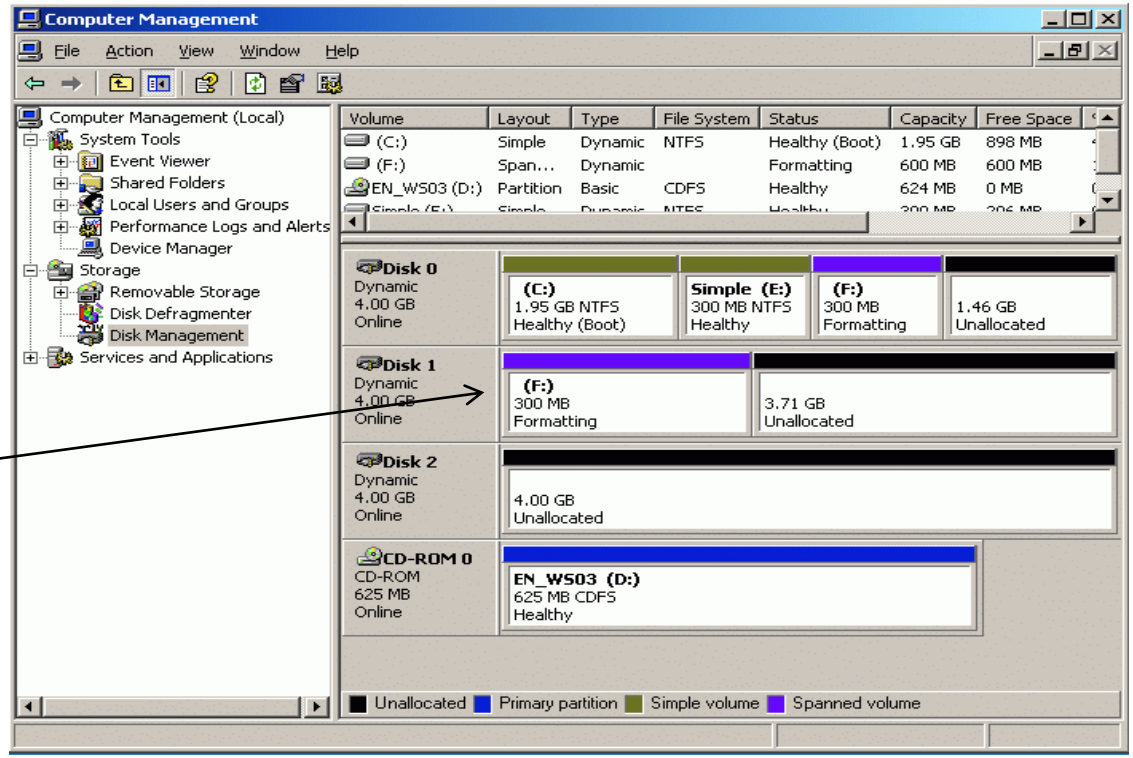
Creating a Spanned Volume



Selecting the disks to create a spanned volume

Creating a Spanned Volume

Spanned volume created using 300 MB of disk space from two hard disks on your machine



created spanned volume

Striped Volume

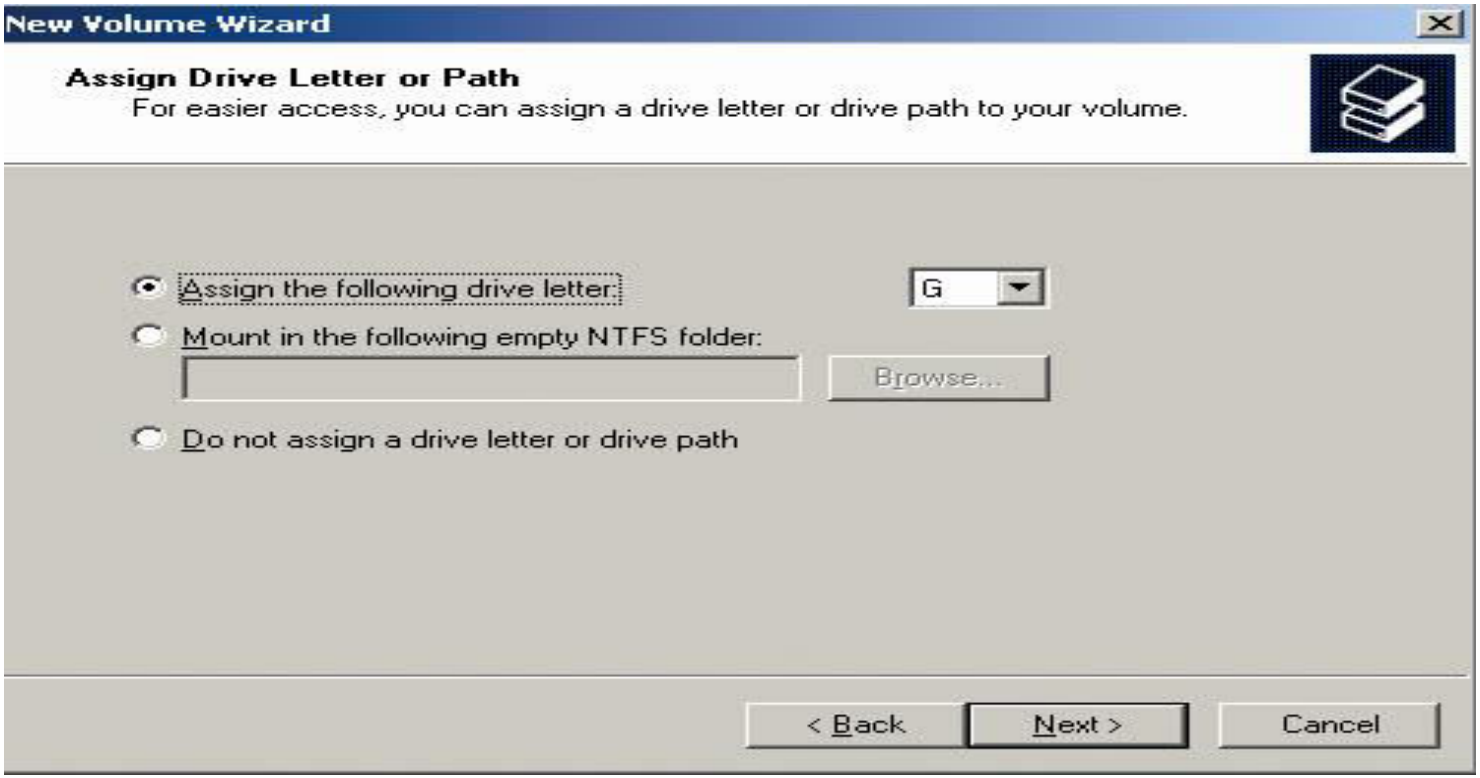
- Combines space from multiple dynamic disks to a singe large volume.
- Can contain space on 2 to 32 dynamic disks.
- You cannot extend it after creation.
- Data is written equally across all disks.
- Increases disk performance.
- No fault tolerance.
- Referred to as RAID-0.

Creating Striped Volume

Striped volumes

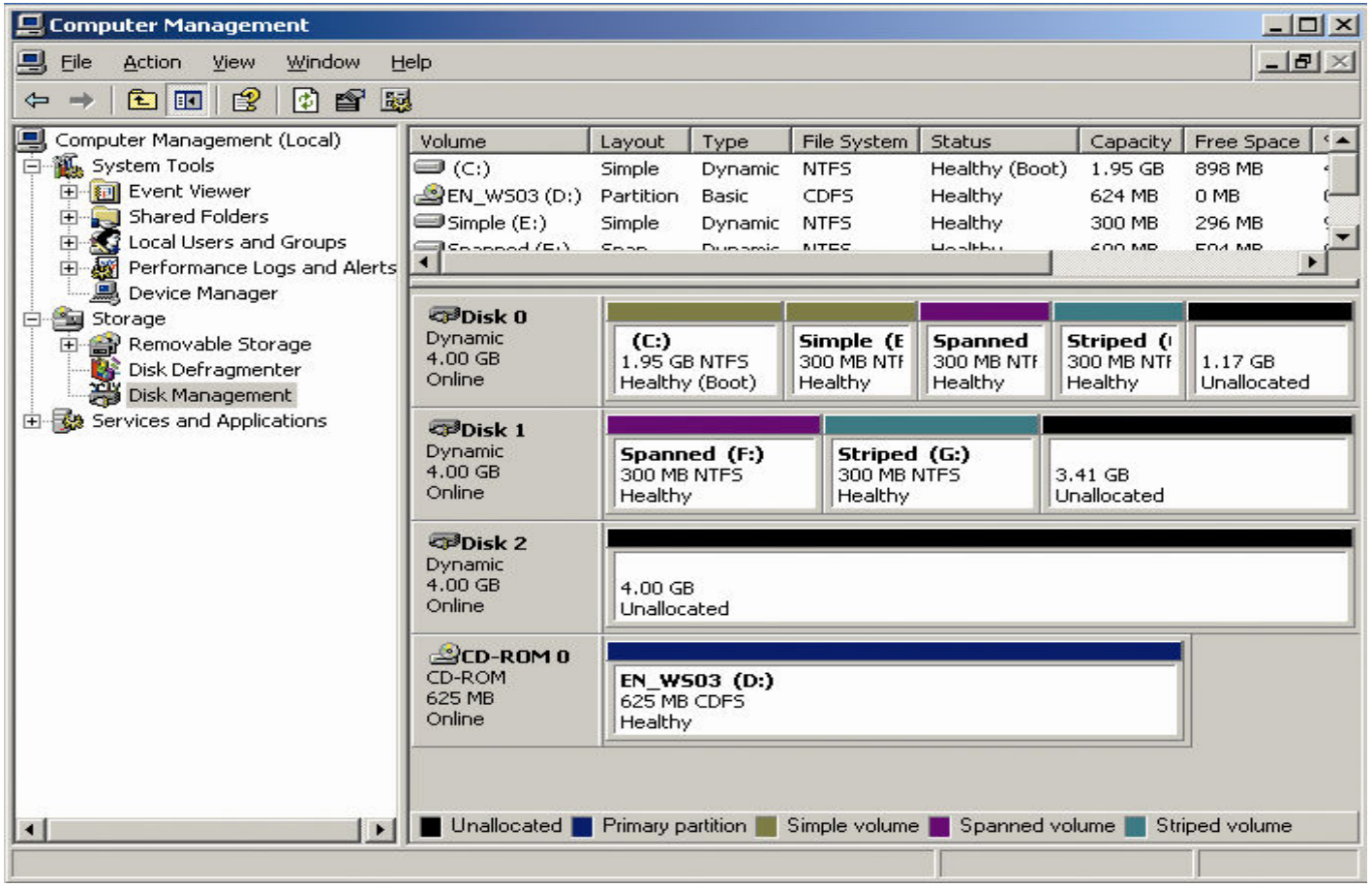
- As with spanned volumes, you can combine disk space from a maximum of 32 disks to create a striped volume
- On a striped volume, data is divided in blocks of 64 KB across each segment of the volume
- Data is simultaneously written across all of the disks so that it is added to the disks at the same rate

Creating Striped Volume



Assigning a drive letter to the striped volume

Creating Striped Volume



Newly created striped volume

Mirrored Volume

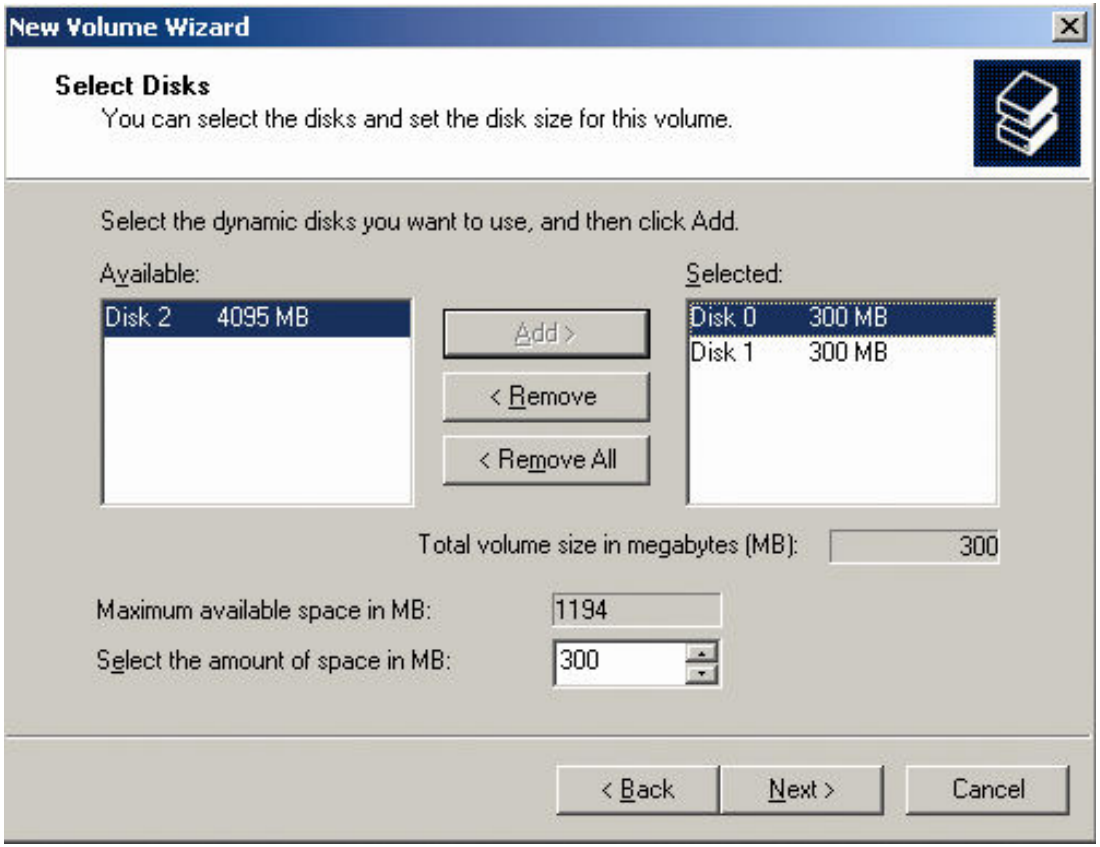
- Consists of an identical amount of space on 2 physical disks, which must be dynamic.
- The system performs read/write operations on both disks simultaneously.
- One of the most guaranteed forms of disk fault tolerance.
- Referred to as RAID-1.

Creating Mirrored Volume

Mirrored volumes

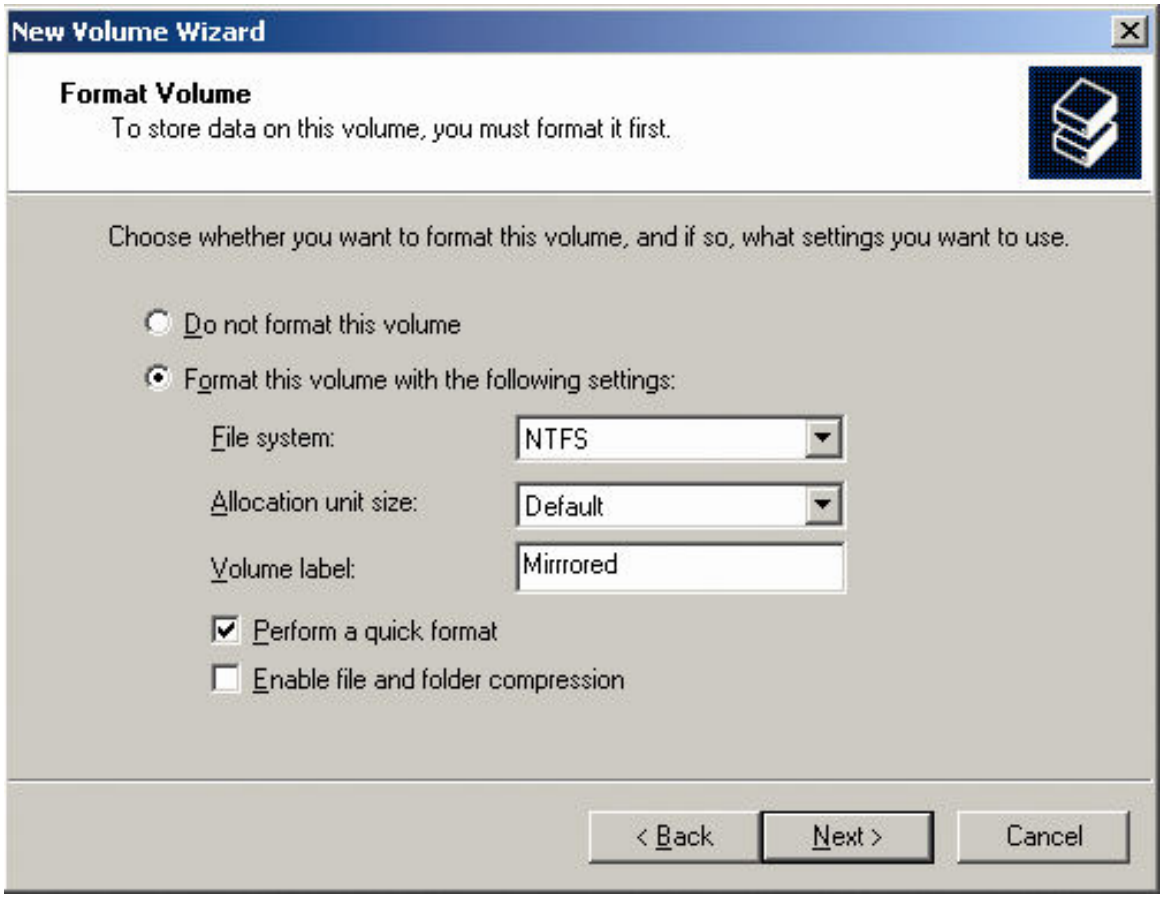
- A mirrored volume provides fault tolerance because you create two drives that are duplicates of each other
- Mirrored volumes are inefficient in some respects because fifty percent of the available disk space is consumed by fault tolerance

Creating Mirrored Volume



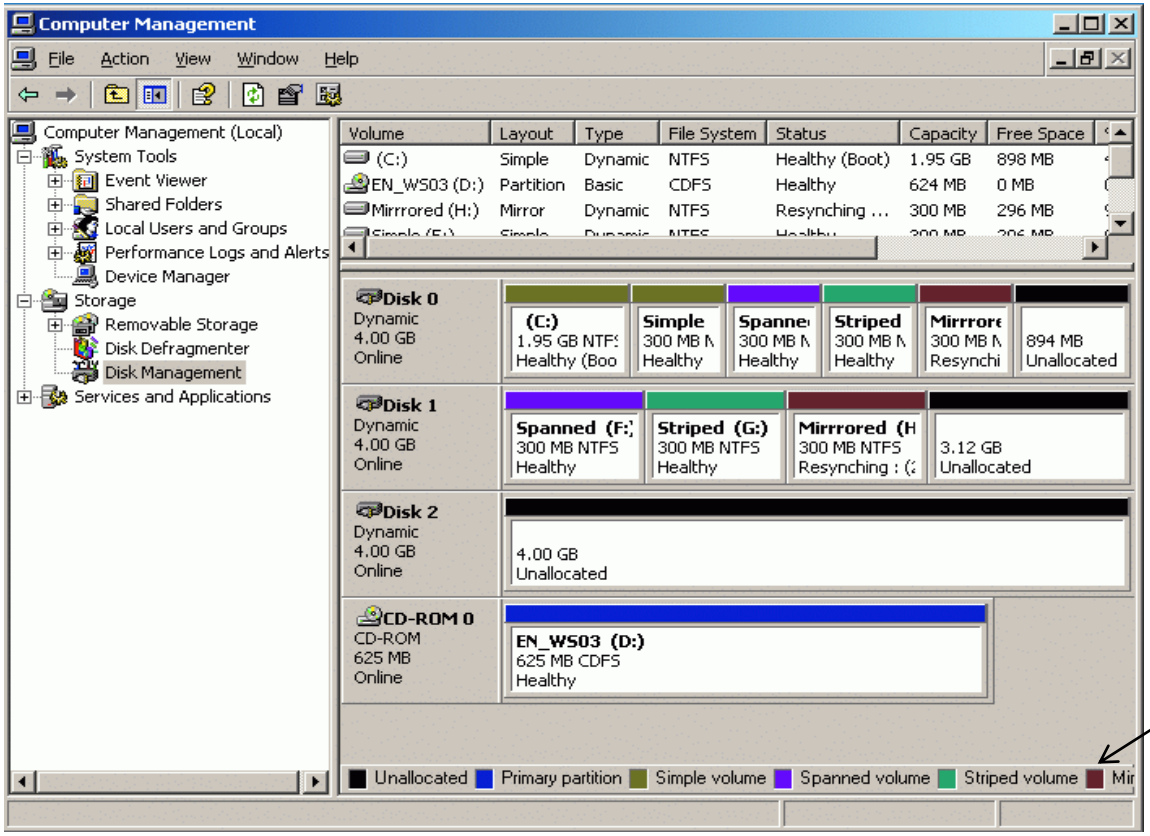
Selecting the disks for a mirrored volume

Creating Mirrored Volume



Selecting the file system, name, and format the volume

Creating Mirrored Volume



Mirrored volume created by combining free space from two hard disks

Newly created mirrored volume

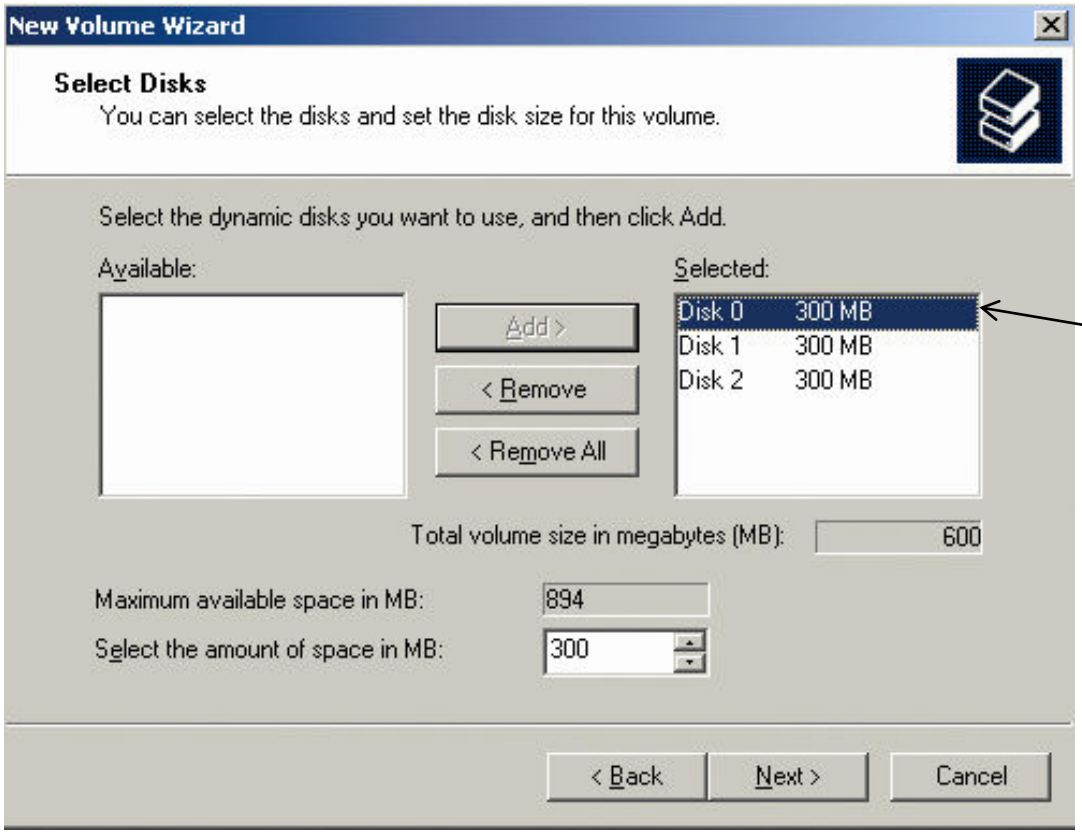
RAID-5 Volume

- Requires a minimum of 3 disk drives.
- Parity information is distributed on each disk.
  - If one disk fails, the information on that disk can be reconstructed.
- Improved read performance because of disk striping.
- Slower write performance because of the parity calculations.

Implementing a RAID-5 Volume

- Consists of disk space on at least three physical hard disks
- Provides fault tolerance by writing one block of parity information for each stripe of data
- If a disk fails, the system uses the parity information and the data from the remaining disks and performs a logical XOR (Exclusive OR) operation to determine what the missing section of data should be

Implementing a RAID-5 Volume

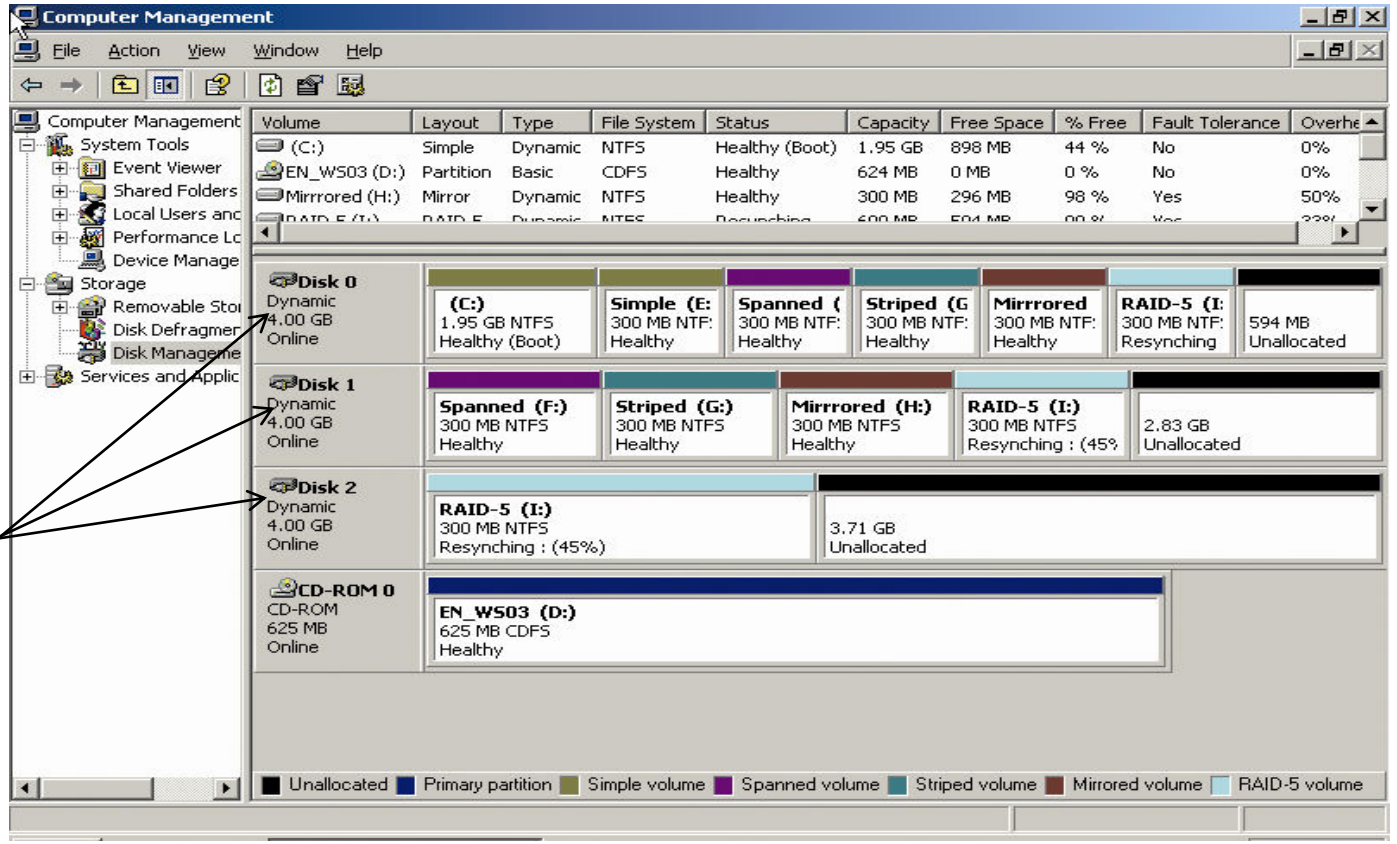


300 MB of space will be used from each disk for a total of 600 MB of usable storage space 1/3 (300 MB) will be lost to parity data

Setting the size for a RAID-5 volume

Implementing a RAID-5 Volume

A RAID-5 volume created using disk space from three hard disks



Newly created RAID-5 volume

Choosing a Volume Size

- Server supports volumes larger than 1 exabyte (over 1,000,000 terabytes).
- Split volumes into manageable sizes.
- Match volume size to the capacity of your backup solution to facilitate easier recovery.
- Larger volumes take longer to repair in the event of an error or failure.
- Many small volumes can create other administrative problems.

Working with Disks

- Disks can be managed from the command line or through graphical tools.
- Server Manager contains a File and Storage Services submenu to manage storage pools, create virtual disks, and perform some standard disk and volume management tasks.

Recovering from Disk Failures

- In the event of disk or volume failures, it is important to repair the disk or volume as quickly as possible to minimize the damage
- Disk Management snap-in
  - Used to monitor the status of a disk or volume to determine if it is functioning normally
  - Used to review information about the disk including its status

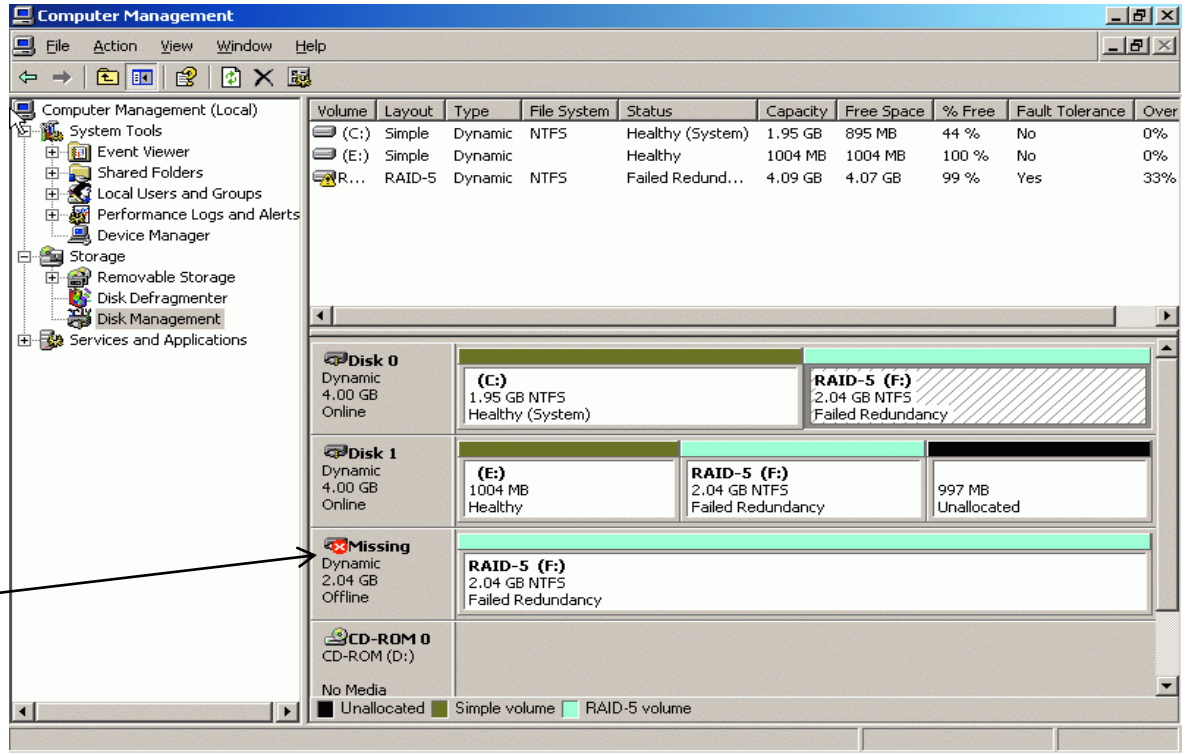
Recovering from Disk Failures (2)

Corrective actions

- Offline or Missing Status
  - Make sure the disk is plugged in and attached to the computer
  - If Windows cannot locate the disk, use the Reactivate Disk command to bring the disk online
- Online Disks (w/Errors) Status
  - A disk with the Online Disks (w/Errors) status is accessible, but may contain I/O errors
  - In such a situation, you can try to reactivate the disk to bring it back online

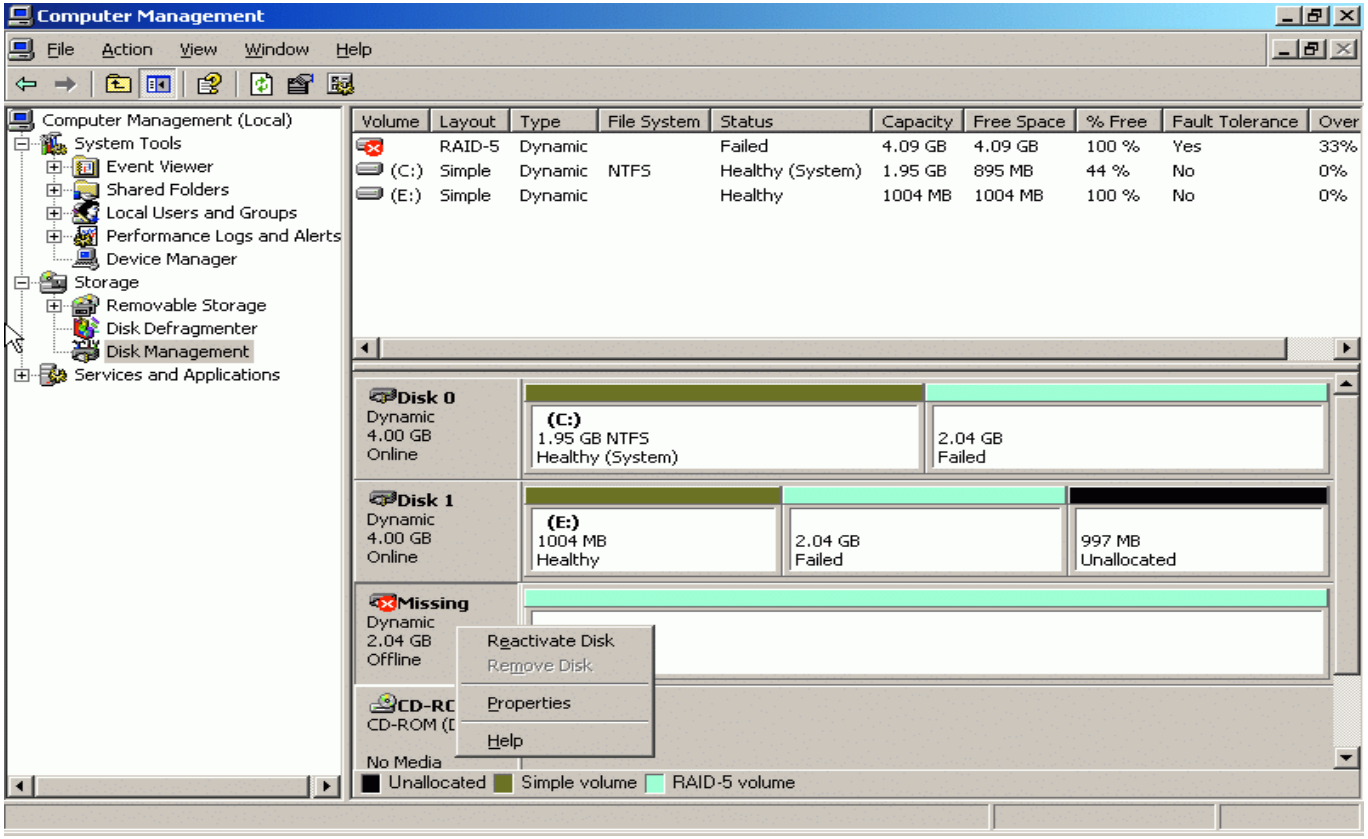
Recovering from Disk Failures (3)

One disk in a 3-disk RAID array has failed because the disk is Offline, so redundancy has failed



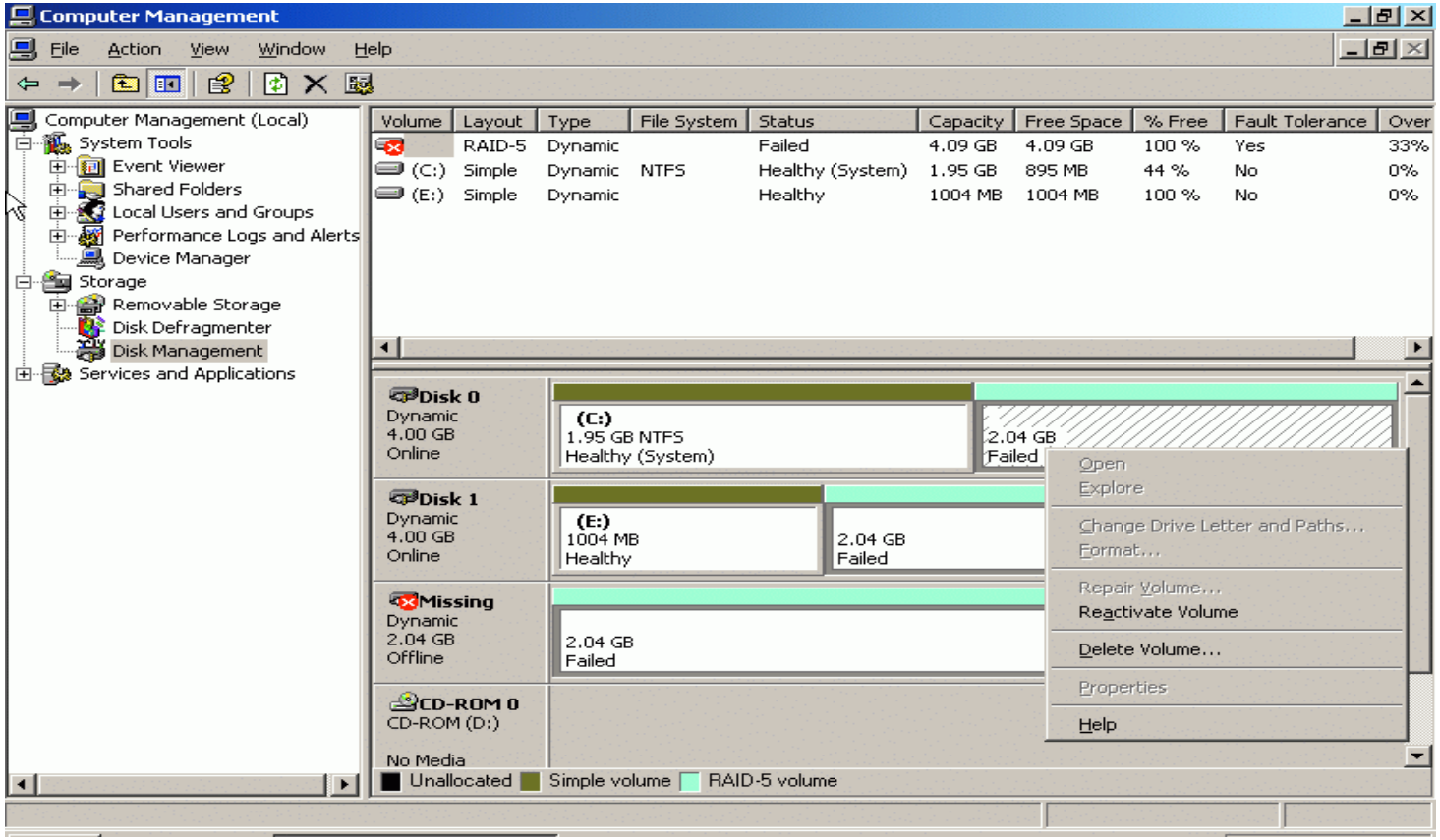
Failed Redundancy

Recovering from Disk Failures (4)



Failed disks and Reactivating a Missing disk

Recovering from Disk Failures (5)



Reactivating a Volume

Windows Server - File & Storage Services Mgt

- Rationalize diverse tools
- Manage end-2-end scenarios
- Integrate experience where MMC tools remain

Unified Experience

- Unified management of storage

Device Management

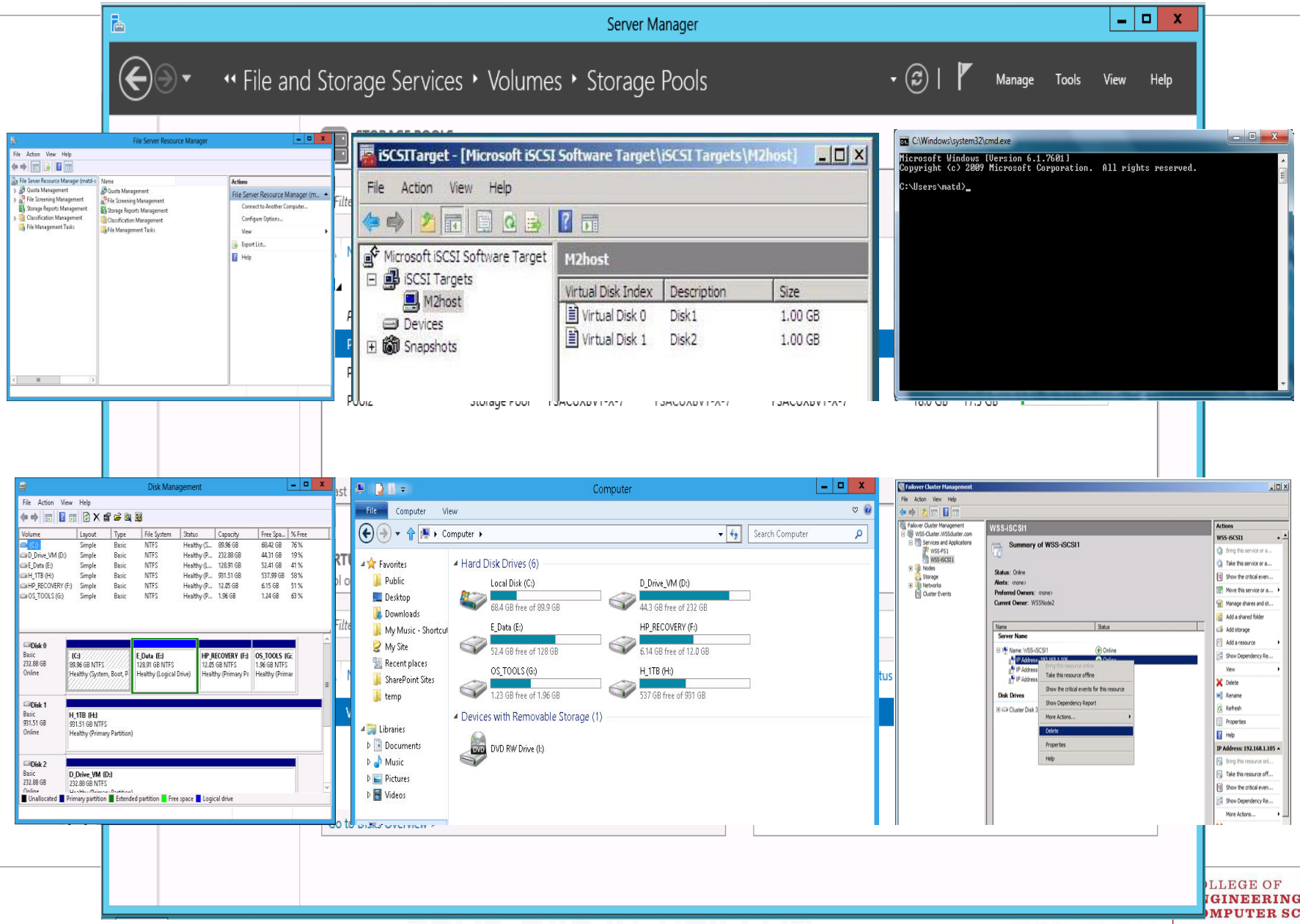
- PowerShell for all admin tasks

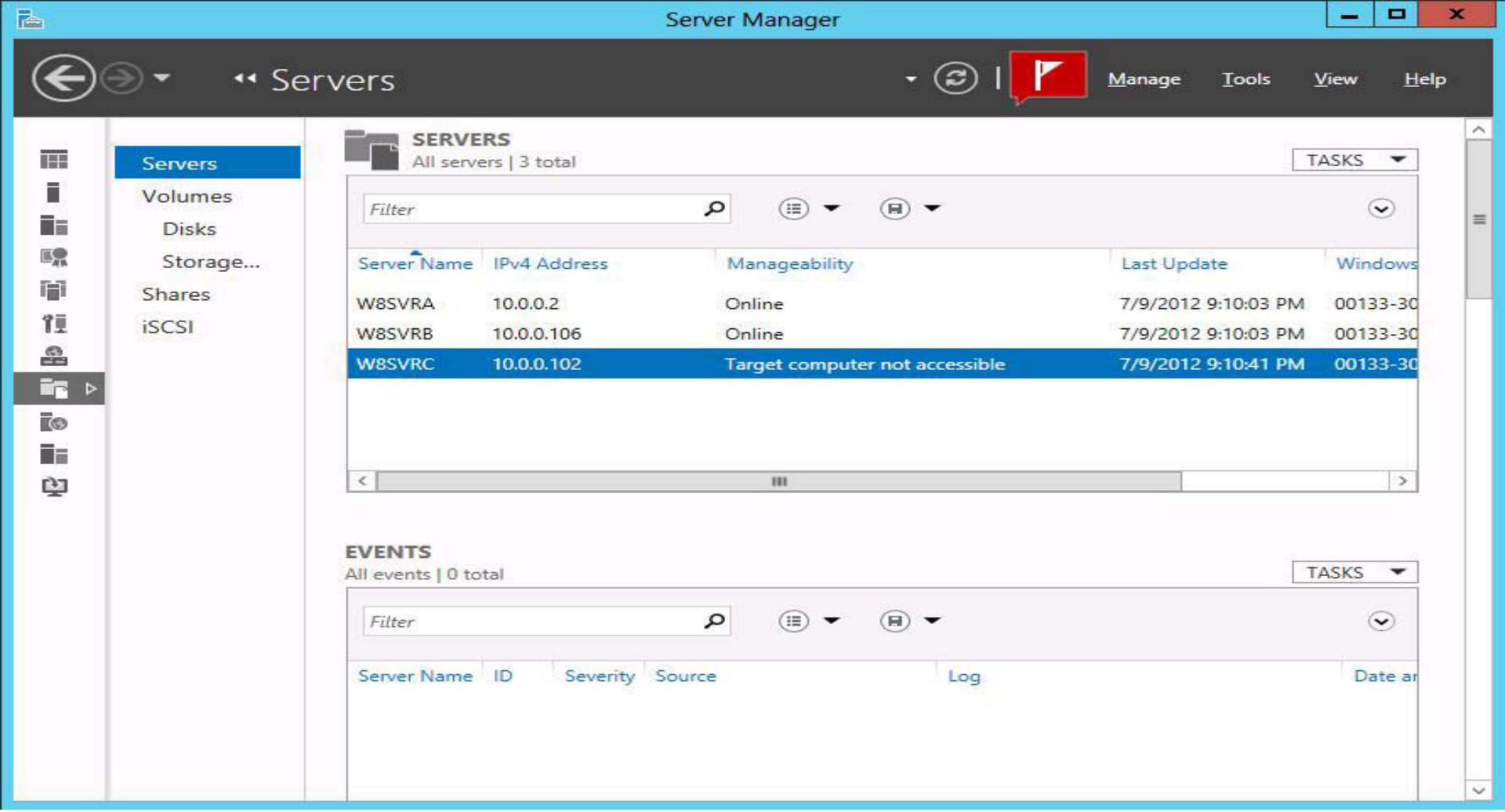
Robust Automation

- Centralized administration
- Single ‘pane of glass’ experience for standalone & clustered servers
- Remote management

Multi-Server management

Windows Server Manager – File & Storage Services

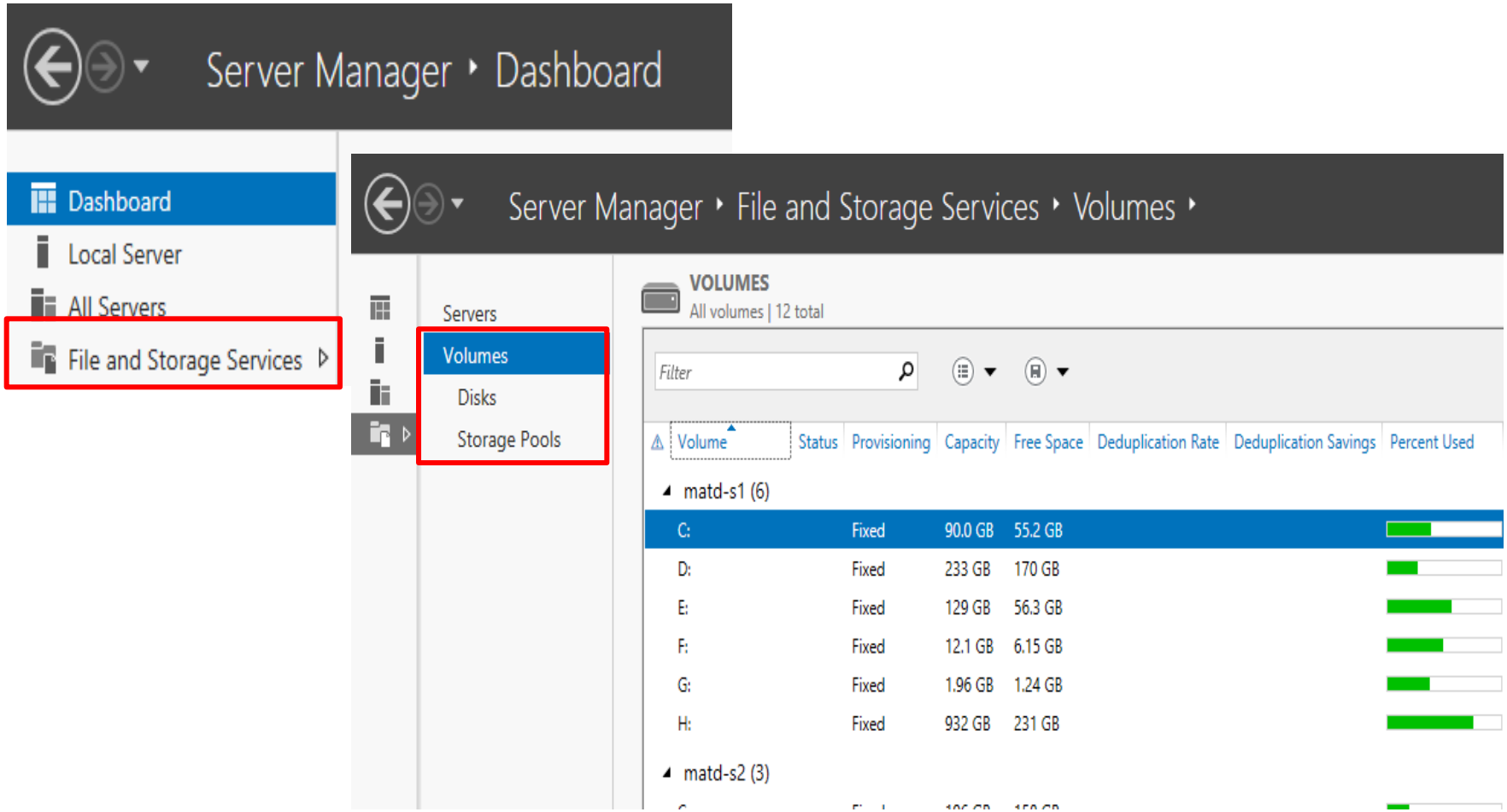




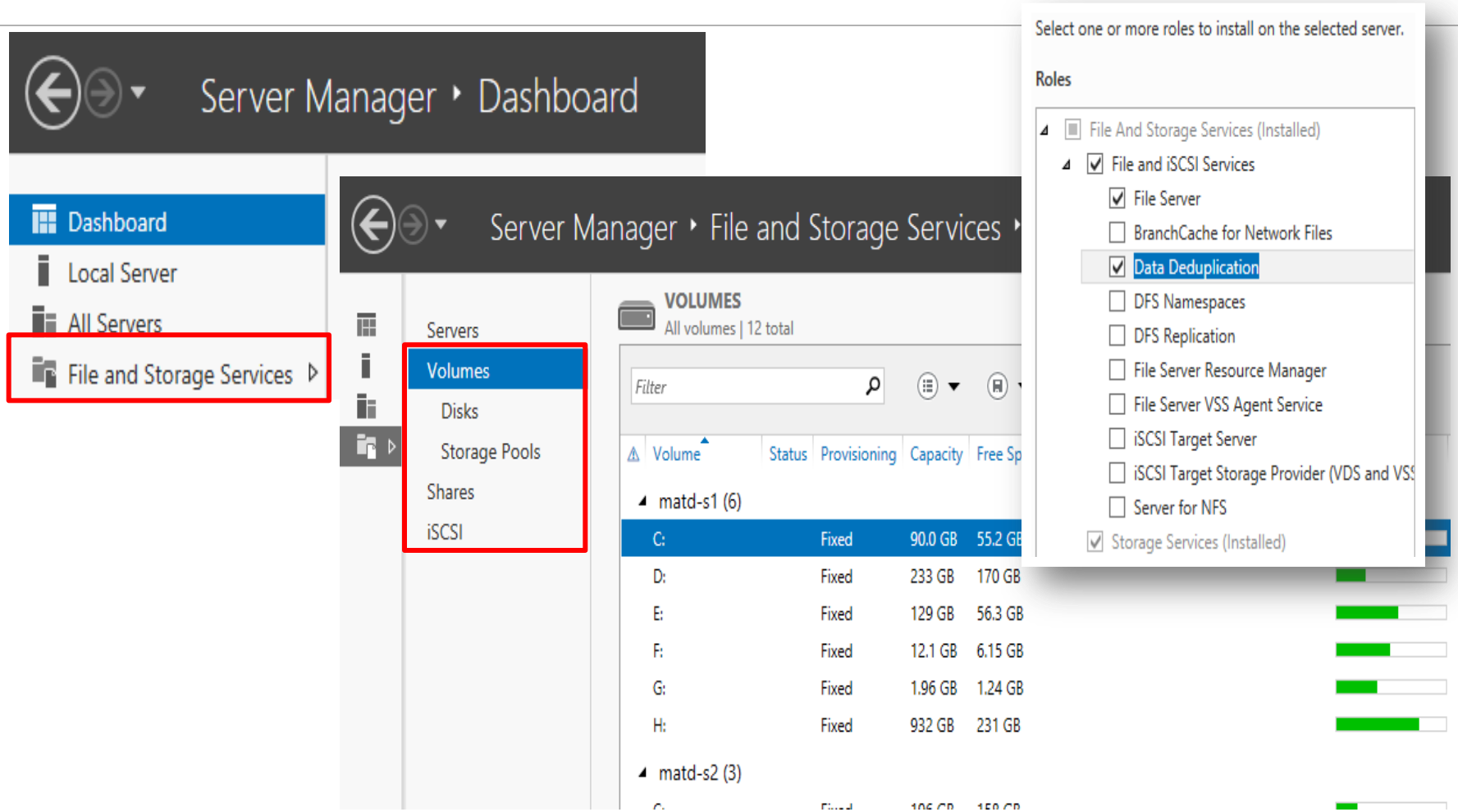
Working with Disks

The File and Storage Services submenu in Server Manager

Managing Windows Server Storage



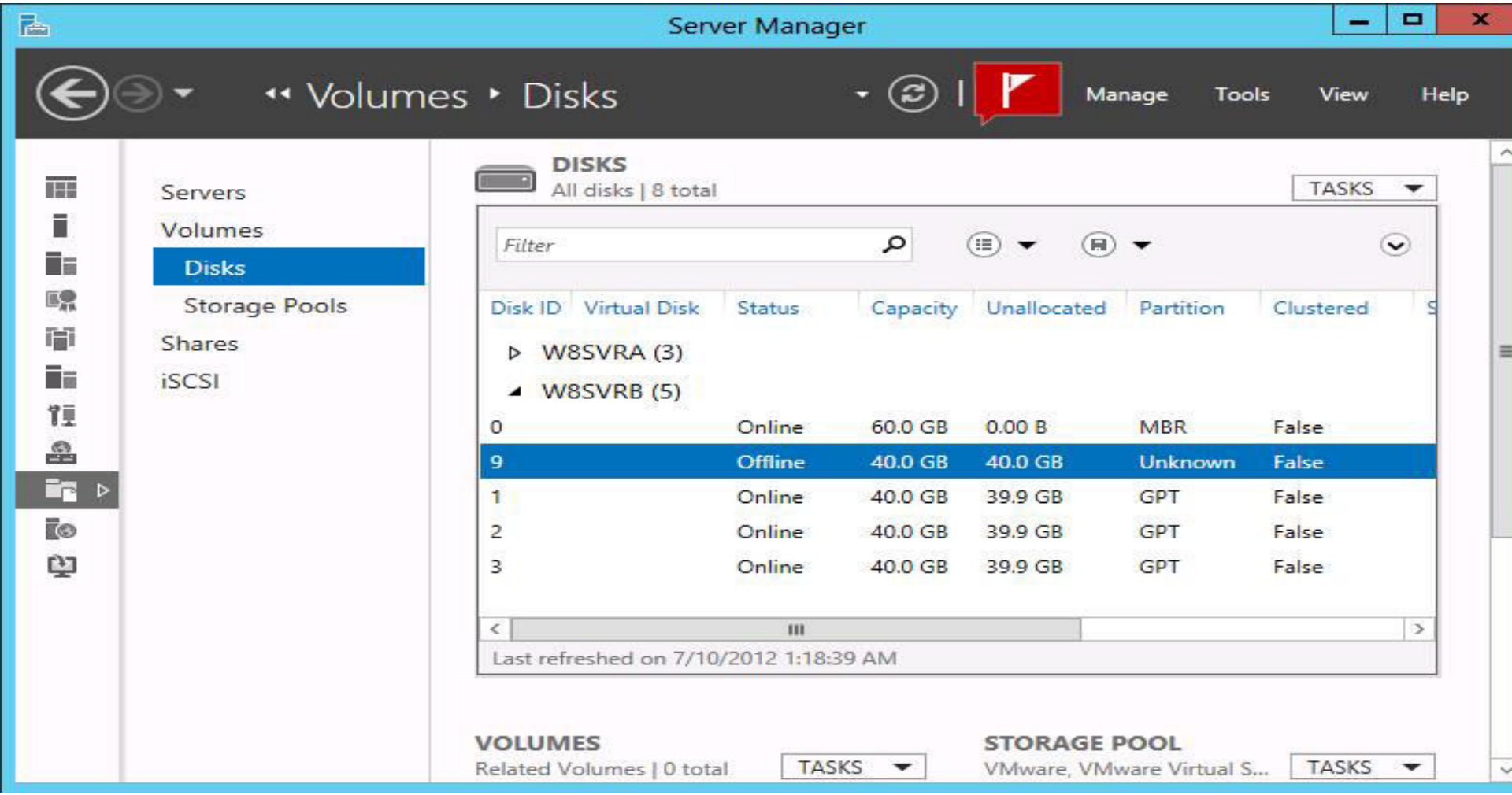
Managing Server File & Storage Services



Working with Disks

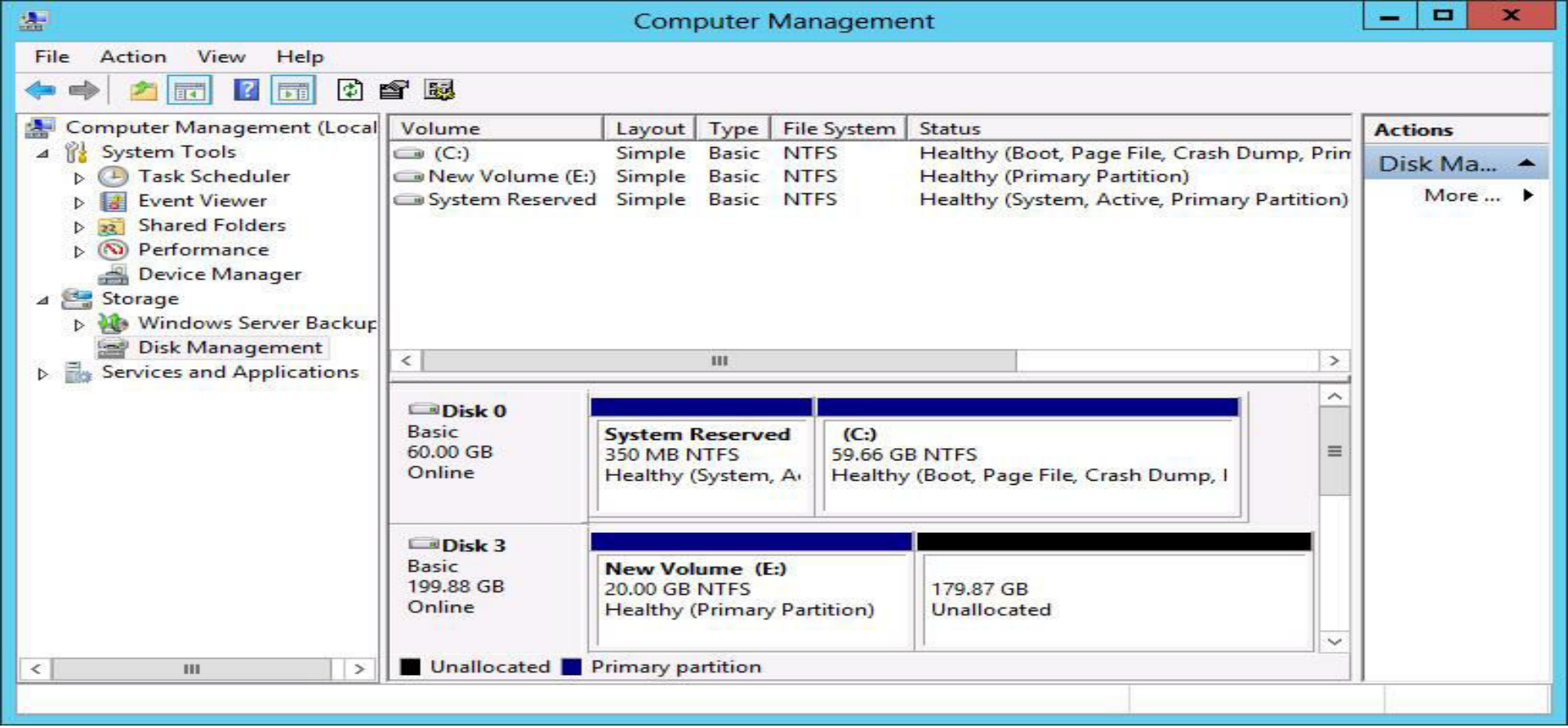
Disk Management MMC snap-in is the traditional tool for performing disk-related tasks:

- Initializing disks
- Selecting a partition style
- Converting basic disks to dynamic disks
- Creating partitions and volumes
- Extending, shrinking, and deleting volumes
- Formatting partitions and volumes
- Assigning and changing driver letters and paths
- Examining and managing physical disk properties, such as disk quotas, folder sharing, and error checking



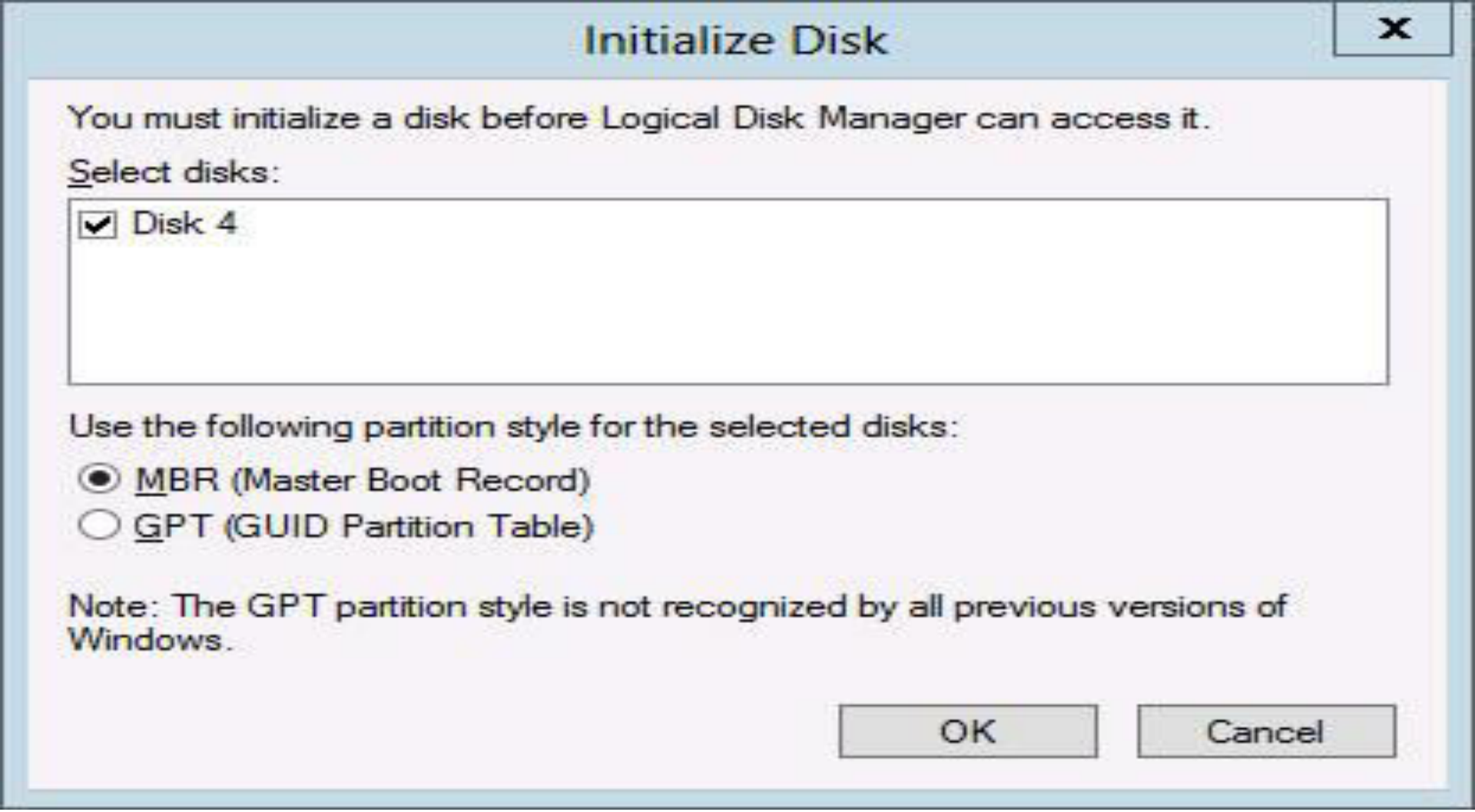
Adding a New Physical Disk

A new physical disk in Server Manager



Adding a New Physical Disk

The Disk Management snap-in



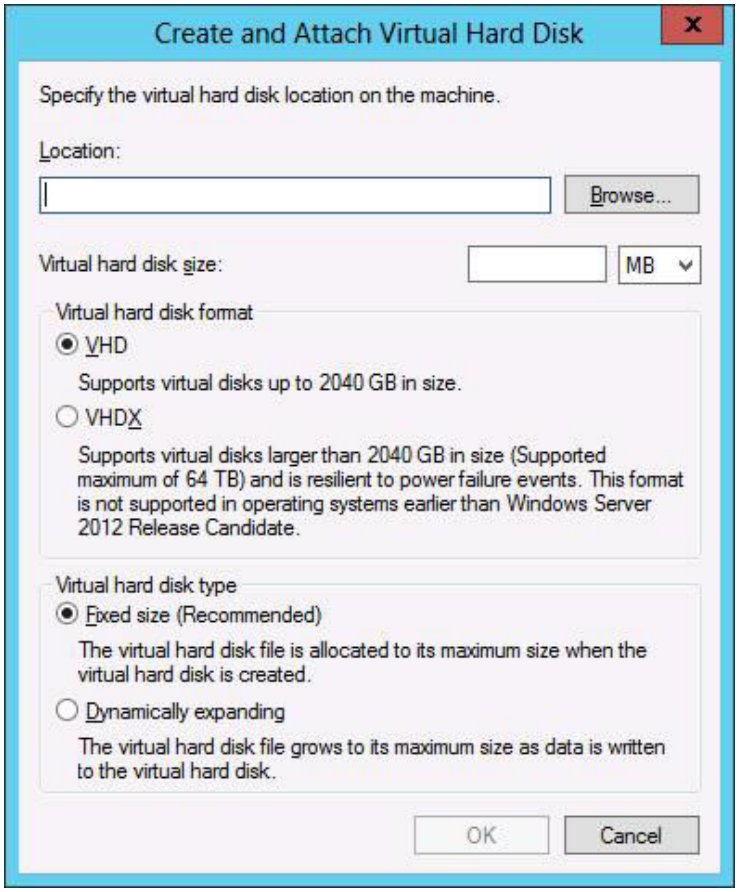
Adding a New Physical Disk

The Initialize Disk dialog box

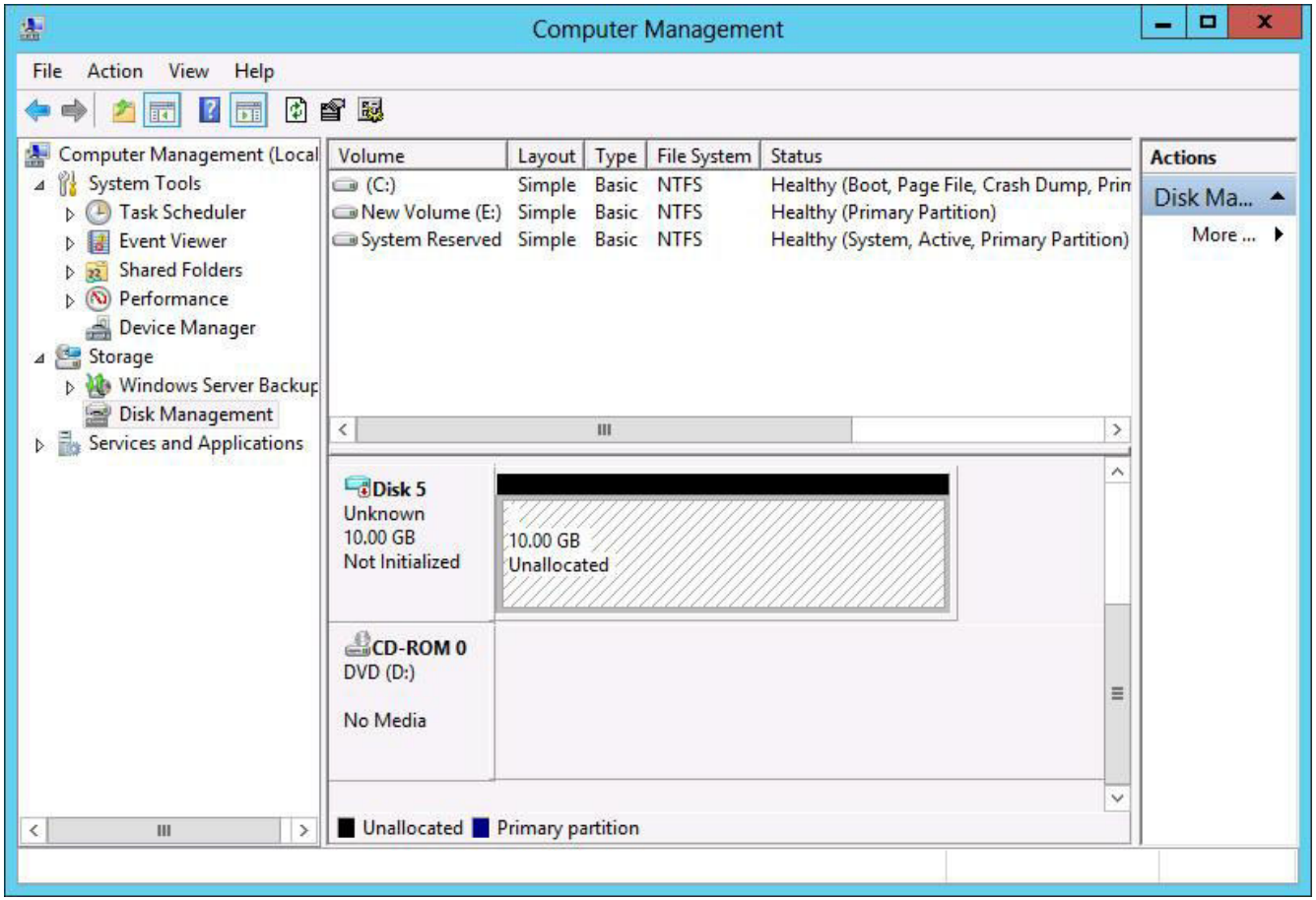
Creating and Mounting VHDs

- Hyper-V relies on the Virtual Hard Disk (VHD) format to store virtual disk data in files that can easily be transferred from one computer to another.
- The Disk Management snap-in in Windows Server enables you to create VHD files and mount them on the computer.
- A dismounted VHD can be moved or copied as needed.

Create a VHD



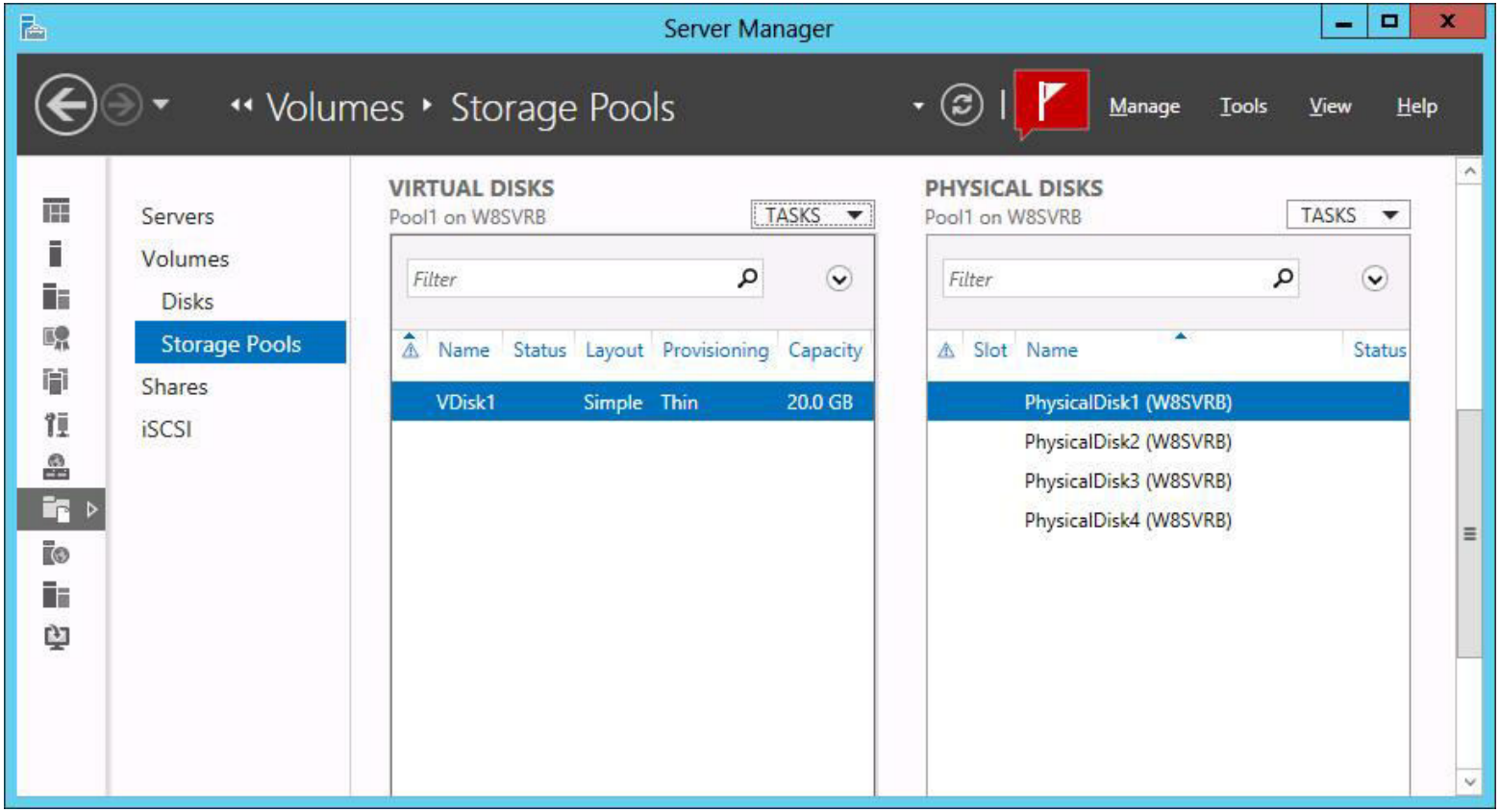
The Create and Attach Virtual Hard Disk dialog box



A newly created and attached VHD

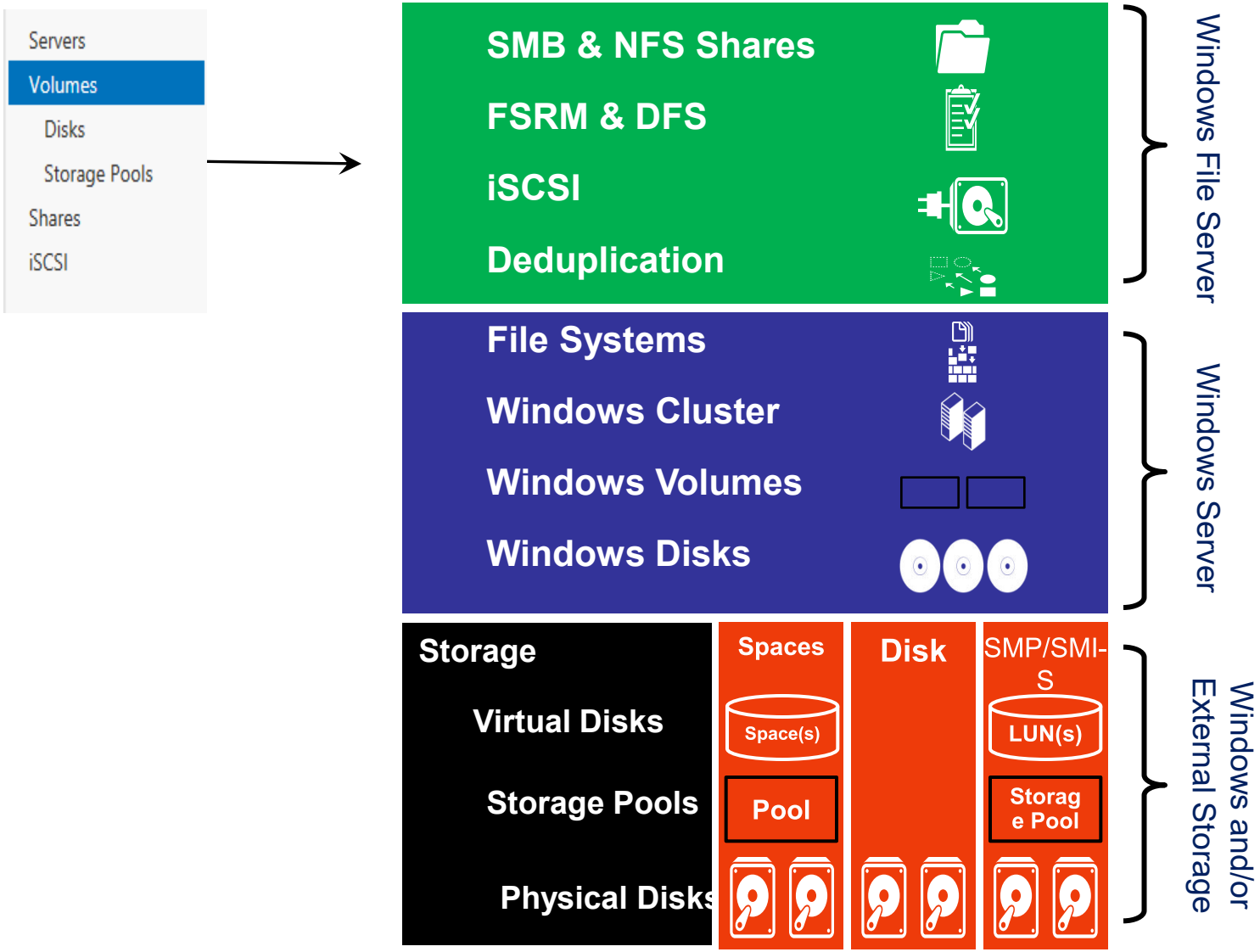
Creating a Storage Pool

Once you have installed your physical disks, you can concatenate their space into a storage pool, from which you can create virtual disks of any size.



A new disk in the Virtual Disks tile in Server Manager

Unified Management Concepts



Manage File Server Settings

- NFS
- Deduplication
- iSCSI
- FSRM
- DFS