CH 3: Installing, Configuring, and Troubleshooting Storage Devices

- Install System Memory
- Install and Configure Mass Storage Devices
- Install and Configure Removable Storage
- Configure RAID
- Troubleshoot Storage Devices

Topic A: Install System Memory Types

System Memory

System Memory

System memory: The main storage area for programs and data when the computer is running.

RAM: (random access memory) The principal storage space for computer data and program instructions.

Volatile: A type of memory where data cannot be stored without power being supplied.

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Virtual Memory

Virtual memory: An area on the hard disk allocated to contain pages of memory.

- If there is not enough system RAM, the memory space can be extended by using disk storage.
- This is referred to as a pagefile or swap space
- The total amount of addressable memory (system RAM plus swap space) is referred to as virtual memory or **virtual RAM.**

Address Space

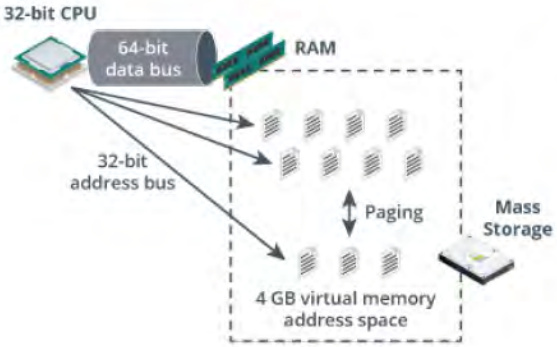
The bus between the CPU, memory controller, and memory devices consists of a data pathway and an address pathway

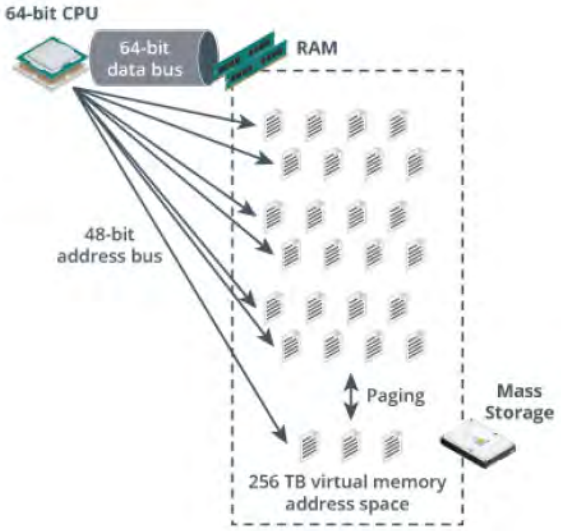
- The width of the data pathway determines how much information can be transferred per clock cycle.
- The data bus is usually 64 bits wide
- The width of the address bus determines how many memory locations the CPU can keep track. This limits to the maximum possible amount of physical and virtual memory.

System Memory

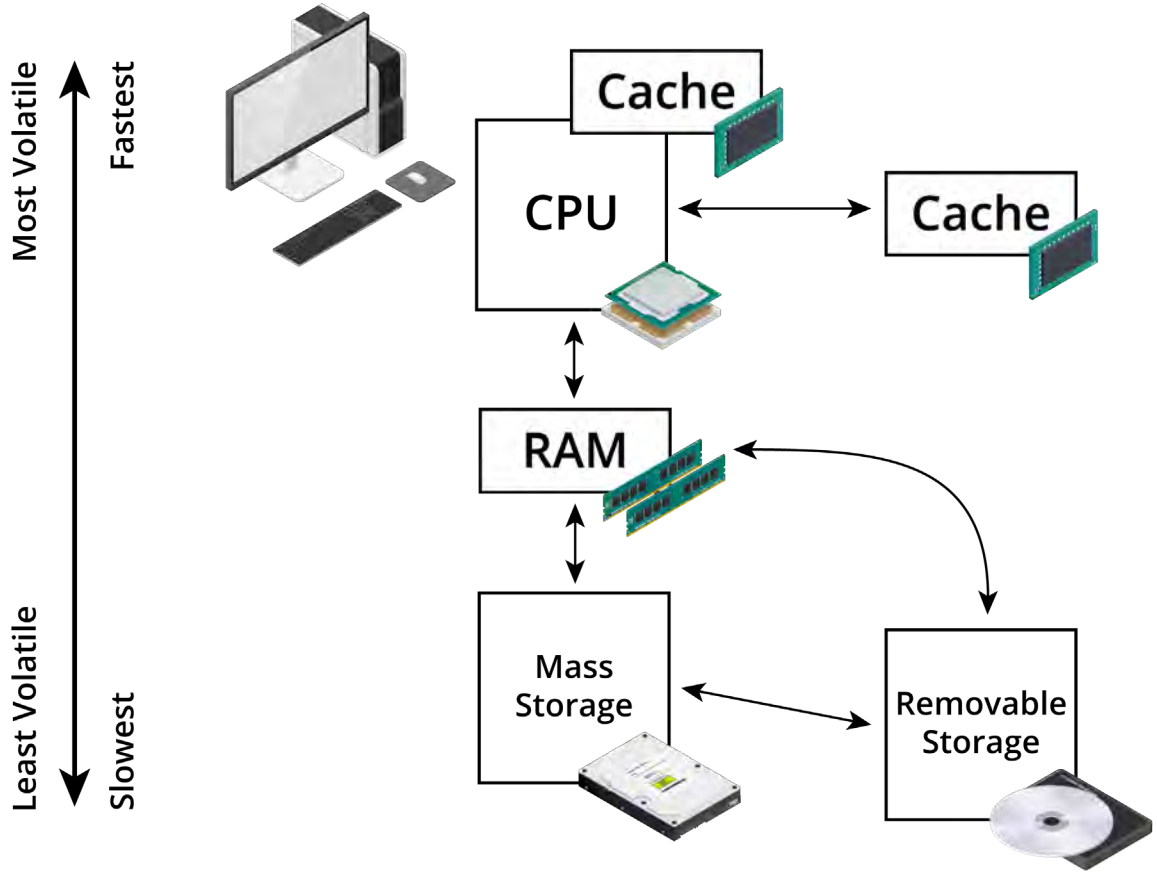
A 32-bit CPU with a 32-bit address bus can access a 4 GB total.

64-bit CPUs uses a 48-bit address bus, allowing up to 256 terabytes of memory.





System Memory



RAM Types

Data and programs can only be used when moved to RAM

One of the most important components of your computer

– Speed, speed, speed

- DRAM:
  - Needs constant refreshing
  - Without refreshing, the data in memory disappears

- SDRAM:
  - Older technology.
  - Synchronized to the system clock.

- DDR SDRAM (Double Data Rate) makes two data transfers per clock cycle.

DDR SDRAM

DDR SDRAM: Standard for SDRAM where data is transferred twice per clock cycle.

- The data rate is double this as there are two operations per clock “tick.” This is expressed in units called megatransfers per second (200 MT/s).
- This gives the DDR-200 designation.

RAM Type	Memory Clock (MHz)	Bus Clock (MHz)	Data Rate (MT/s)	Transfer Rate (Gbps)
DDR-200/PC-1600	100	100 x 2	200 x8	1.6
DDR-26/PC-2100	133	133 x 2	266 x8	2.1
DDR-333/PC-2700	167	167	333	2.7
DDR-400/PC-3200	200	200	400	3.2

DDR2/DDR3/DDR4/DDR5

RAM Type	Memory Clock (MHz)	Bus Clock (MHz)	Data Rate (MT/s)	Transfer Rate (Gbps)
DDR2	100 to 266	200 to 533	400 to 1066	3.2 to 8.533
DDR3	100 to 266	400 to 1066	800 to 2133	6.4 to 17.066
DDR4	200 to 400	800 to 1600	1600 to 3200	12.8 to 25.6

RAM Type	Data Rate	Transfer Rate	Maximum Size
DDR3	800 to 2133 MT/s	6.4 to 17.066 GB/s	16
DDR4	1600 to 3200 MT/s	12.8 to 25.6 GB/s	64
DDR5	4800 to 6400 MT/s	38.4 to 51.2 GB/s	128

DDR3/DDR4 SDRAM

Double Data Rate 3 (**DDR3**) SDRAM

- Twice the data rate of DDR2
- Larger chip capacities - Maximum 16 GB per DIMM
- No backwards compatibilit
- – Speed brings sacrific.

Double Data Rate 4 (**DDR4**) SDRAM

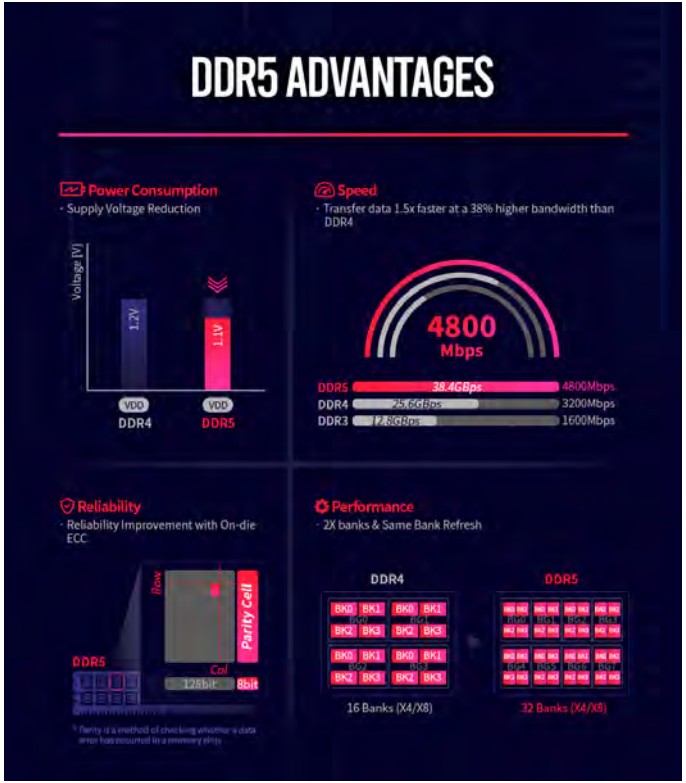
- Speed increases over DDR3
- Faster frequencies
- Maximum 64 GB per DIMM
- Again, no backwards compatibilit

DDR5 SDRAM

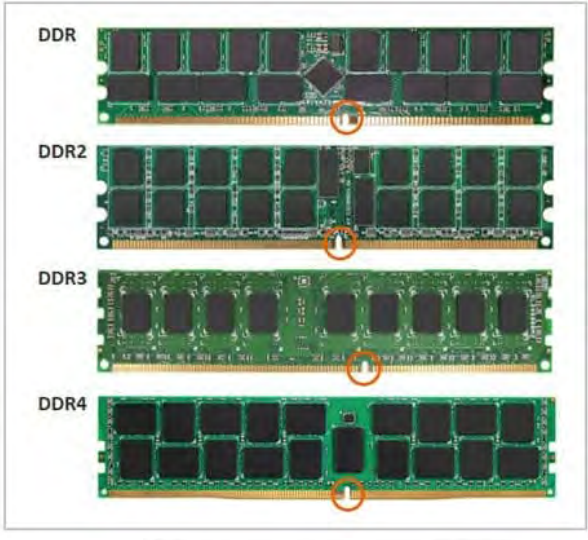
Double Data Rate 5 (**DDR5**) SDRAM

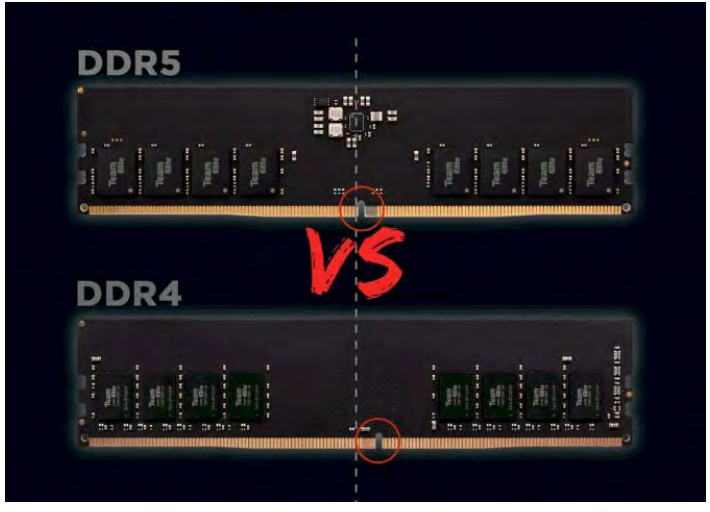
- Faster data transfers between the memory module and motherboard
- The maximum capacity brings with its DIMMs of up to **128GB** per DDR5
- DDR5 expands that to an incredible 512GB on four-slot boards that support that peak amount.
- The key has moved - No backwards compatibility
- **GDDR5** Graphics DDR5 (GDDR5) is an older, DDR3-based technology that's designed for graphics cards.

DDR5 SDRAM



DDR2/DDR3/DDR4/DDR5





	DDR5	DDR4
Data Rates	3,200 - 6,400 MTps	1,600 - 3,200 MTps
Device Densities	8Gb - 64Gb	2Gb - 16Gb
Max UDIMM Size	128GB	32GB

Memory Modules

Memory module: A printed circuit board that holds a group of memory chips that act as a single unit.

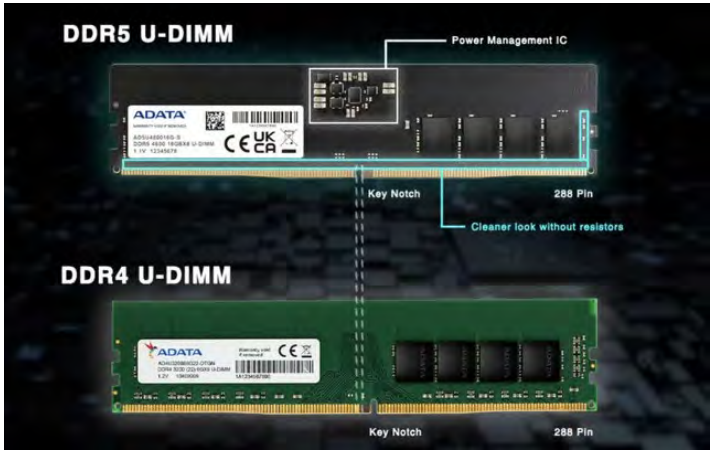
DIMM: (dual inline memory module) Standard packaging for system memory. There are different pin configurations for different RAM types.

- Located in slots on motherboard.
- Removable and replaceable.
- Defined by their design and by the number and type of chips contained.

Memory Modules

RAM Type	Pins	Voltage
DDR	184	2.5 to 2.6 V
DDR2	240	1.8 to 1.9 V
DDR3	240	1.35 to 1.5 V
DDR4	288	1.2 V

Description of Module	Example
A 288-pin DDR4 DIMM is currently the fastest memory with lower voltage requirements. It can support quad or dual channels or function as single DIMMs. It has one notch near the center of the edge connector.	 Source: kingston.com
A 240-pin DDR3 DIMM can support quad, triple, or dual channels or function as single DIMMs. It has an offset notch farther from the center than a DDR2 DIMM.	
A 240-pin DDR2 DIMM can support dual channels or function as single DIMMs. It has one notch near the center of the edge connector.	



SODIMM Memory Modules

SODIMM: Memory that is half the size of DIMMs, is available in 32- or 64-bit data paths, and is commonly found in laptops and iMac systems.

- Laptop RAM.
- DDR and DDR2 have the same number of pins, but the key position is different.
- Typically fits into slots that pop up at a 45º angle to allow the chips to be inserted or removed.

SODIMM Memory Modules

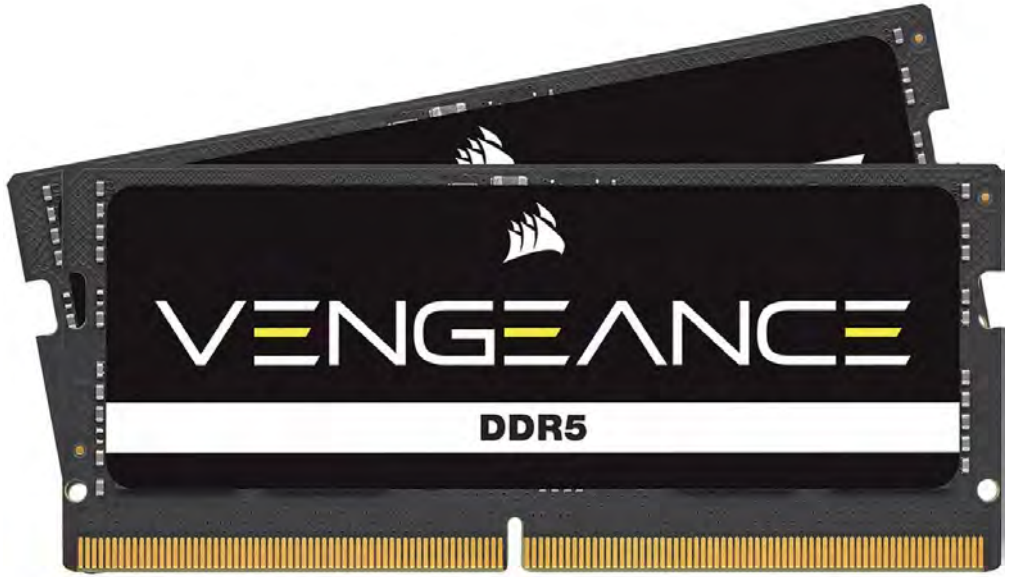
Pins:

- DDR 200 pin packages.
- DDR3 & **3L** 204 pin packages.
- DDR4 260 pin packages.

Memory Module Description	Sample Memory Module
A 2.74" 260-pin SO-DIMM contains DDR4 memory. The one notch on the module is offset from the center of the module.	 Source: crucial.com
A 2.66" 204-pin SO-DIMM contains DDR3 memory. The one notch on the module is offset from the center of the module. A DDR3L SO-DIMM uses less power than a regular DDR3 SO-DIMM.	 Courtesy of Kingston Technology Corporation
A 2.66" 200-pin SO-DIMM contains DDR2 SDRAM. One notch is near the side of the module.	 Courtesy of Kingston Technology Corporation

SO DIMMS Memory Modules

262-Pin **DDR5 SO-DIMM**
DDR5 4800 (PC4 38400)
Laptop Memory Model

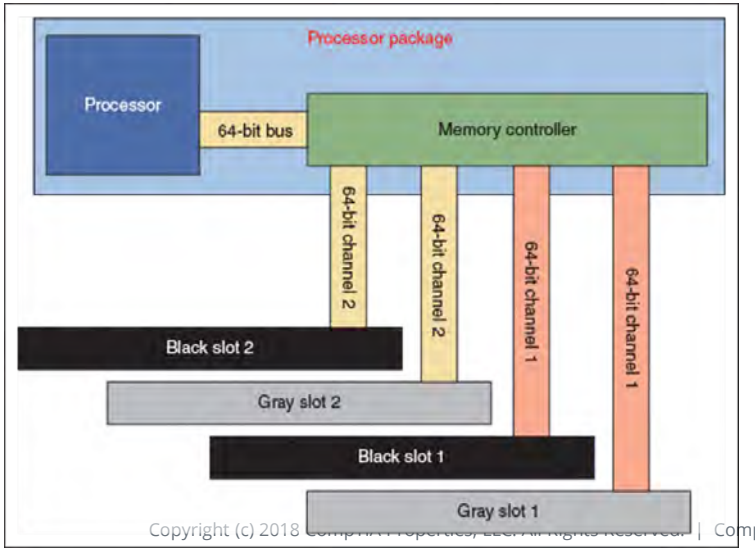


Dual-Channel Memory

Single-channel memory: Memory with one 64-bit bus between the CPU and RAM.

Dual-channel memory: Memory controller with two pathways to the CPU, enabling 128 bits of data transferred per transaction.

- Multiplies the pathways through the bus to the CPU.
- Dule, Triple, and Quad channel



DIMM and SO-DIMM Technologies

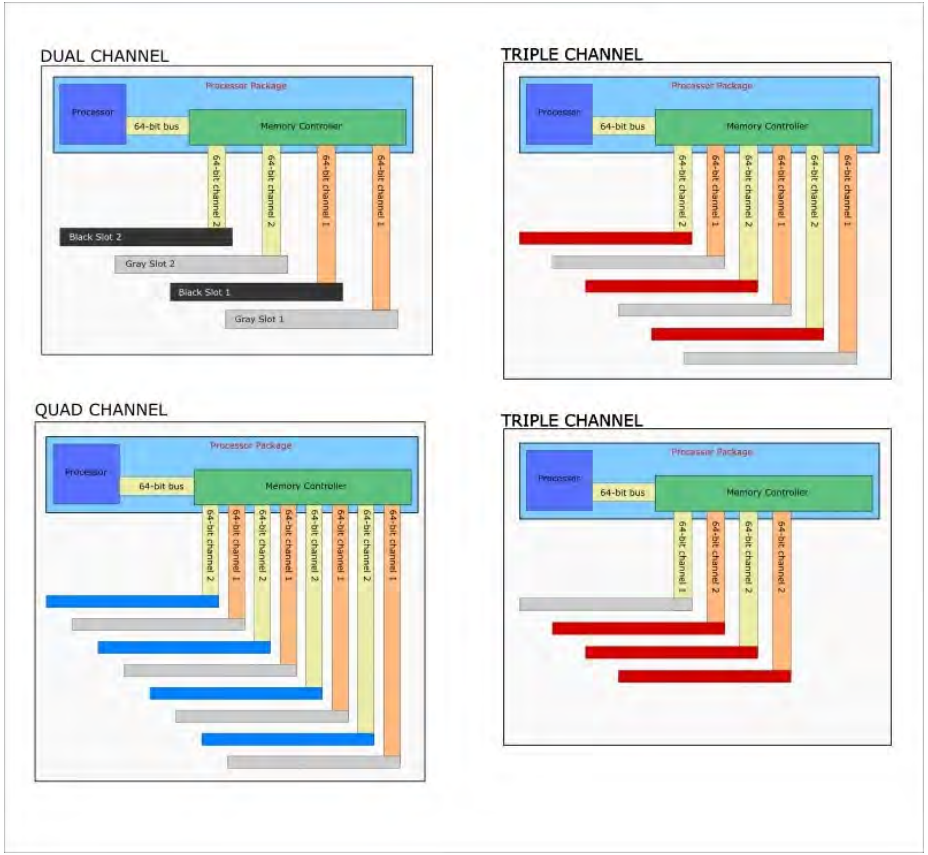
- For dual, triple, or quad channels to work:
  - The motherboard and the DIMM must support the technology
  - Motherboard manufacturer typically color-codes DIMM slots to show you how to configure dual, triple, or quad channeling
- Setting up dual channeling:
  - Pair of DIMMs in a channel must be equally matched in size, speed, and features
    - Use same manufacturer (recommendation)
- Setting up triple-channeling:
  - Three DIMM slots populated with three matching DDR3 DIMMs

DIMM and SO-DIMM Technologies

- Early **single channel** DIMMs:
  - Memory controller is accessed one DIMM at a time
- **Dual channels:**
  - Memory controller communicates with two DIMMs at the same time and doubles speed of memory access
- **Triple channel** motherboards can access three DIMMs at once
- **Quad channel** motherboards can access four DIMMs at the same time

DIMM and SO-DIMM Technologies

- DDR, DDR2, DDR3,DDR4 and DDR5 DIMMs use dual channels
- DDR3 DIMMs can also use triple channels
- DDR3, DDR4 and DDR5 can use quad channels



Channel Memory

Source: gigabyte.com/us/Motherboard/X399-AORUS-Gaming-7-rev-10#f

- Installed memory modules should be identical in terms of:
  - Speed
  - Capacity
  - Chip number
  - Density
  - Location
  - Recommended (same brand)
- Refer to documentation for which slots to insert memory into.

Parity and ECC RAM

Parity checking: An error-checking method where each byte of data in memory is accompanied by a ninth bit used to check for corrupted data.

ECC memory: RAM with built-in error correction security.

Parity memory

- – Adds an additional parity bit
- – Won't always detect an error
- – Can't correct an error.

Error Correcting Code (ECC)

- -Detects errors and corrects on the fly
- – Not all systems use ECC
- – It looks the same as non-ECC memory

Memory Compatibility Issues

- The DIMM format must match the motherboard.
- Different capacity modules can be installed.
  - Most vendors recommend installing the largest module in the lowest numbered slot.
- Modules from different vendors can be mixed.
  - This may cause problems with multi-channel configurations.
- For best performance, the modules should be the same speed as the motherboard.
  - Different speeds can be mixed.
  - The system will only operate at the best speed supported by all installed.

Memory Compatibility Issues

For best performance and reliability, configure multi-channel systems with identical memory modules for each channel.

ECC memory cannot be mixed with non-parity memory and must be supported by the motherboard.

Registered memory cannot be mixed with unbuffered modules and must be supported by the motherboard.

Discussing System Memory Installation

- **Why is Synchronous DRAM so-called?**

- **ANSWER:**
  - Because it works at the same speed as the motherboard.

Discussing System Memory Installation

- **What are the principal characteristics of DRAM technology?**

- **ANSWER:**
  - Each cell in Dynamic RAM must be refreshed periodically to preserve its charge. It is high density and low cost.

Discussing System Memory Installation

- **You are configuring a system with dual-channel memory. You have two modules and there are four slots. How would you determine which slots to use?**

- **ANSWER:**
  - Check the system guide—most Intel boards would require the use of slots 1 and 3 to use both channels, but it's best not to proceed without consulting the vendor's documentation.

Discussing System Memory Installation

- **How many pins are there on a DIMM stick of DDR2 SDRAM?**

- **ANSWER:**
  - 240

Discussing System Memory Installation

- **How is laptop system memory typically packaged?**

- **ANSWER:**
  - SODIMM.

Discussing System Memory Installation

- **Additional memory was installed in a user's system, and now it will not boot. What steps would you take to resolve this job ticket?**

- **ANSWER:**
  - First, verify that the correct memory type was installed on the system and in the correct configuration.
  - Check that the new memory module is seated properly in its slot. Try swapping memory around in the memory slots.

Topic B: Install and Configure Mass Storage Devices

Storage Devices

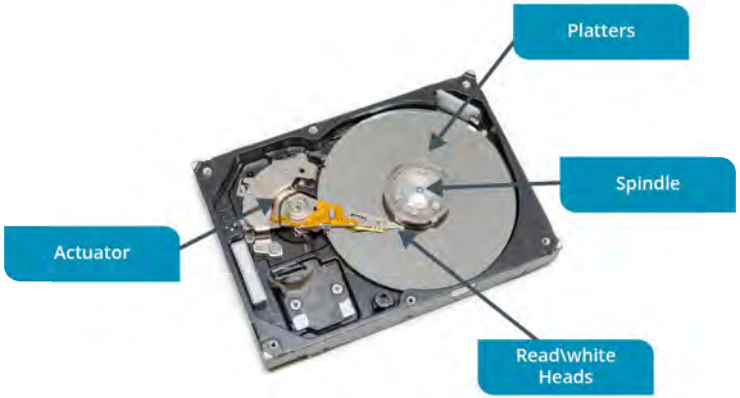
Mass storage devices: Non-volatile storage devices that can hold data when the system is powered off.

- Hold data when system is powered off.
- Can be internal or removable.
- To store data, it uses one of these methods:
  - Magnetic
  - Optical
  - Solid state

Hard Disk Drives

HDD: (hard disk drive) A device that provides persistent mass storage for a PC.

- On workstations, typically stores:
  - OS files.
  - Application program files.
  - Drivers.
  - User data.



- On servers, typically stores:
  - OS files.
  - Individual user files.
  - Shared information sources such as databases.

Hard Disk Drives

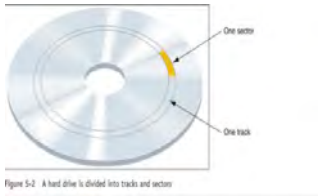


Figure 5-2 A hard drive is divided into tracks and sectors

Tracks: Data written as concentric rings on a disk drive.

Cylinders: The aggregate of all tracks that reside in the same location on every disk surface.

- HDD up to **8 TB**.
- Data is organized on a magnetic hard drive-in concentric circles called tracks
- Each track is divided into segments called sectors.
- Older hard drives used **512** bytes sectors. Newer use **4096**-Byte Sectors

Hard Disk Drives

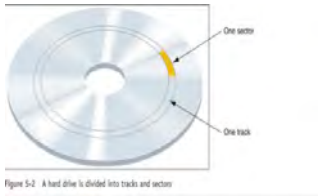


Figure 5-2 A hard drive is divided into tracks and sectors

HDD Sizes:

3.5” for desktops and 2.5” for laptop computers

HDD Speeds:

5,400. 7,200. 10,000. 15,000

HDD Performance Factors

Access time: Speed at which memory or a disk drive can be addressed and utilized.

Internal transfer rate: Measure of how fast read/write operations are performed on the disk platters.

External transfer rate: Measure of how fast data can be transferred to the CPU across the bus.

Early-life Failure Rate: A method of calculating how quickly a device will fail through accelerated testing.

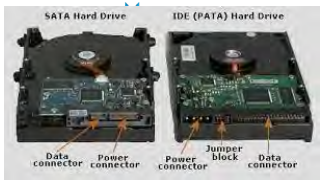
HDD Performance Factors

MTBF: (mean time between failures) The rating on a device or component that predicts the expected time between failures.

Life expectancy: The length of time for which a device can be expected to remain reliable.

S.M.A.R.T.: Technology designed to alert the user to possible hard disk failures before the disk becomes unusable.

Storage Adapters and Cables



HBA: (host bus adapter) A component that allows storage devices to exchange data with a computer system by using a particular interface.

Drive controller: The circuitry in the disk unit that allows it to put data on the bus, which the HBA shuttles to the CPU or RAM.

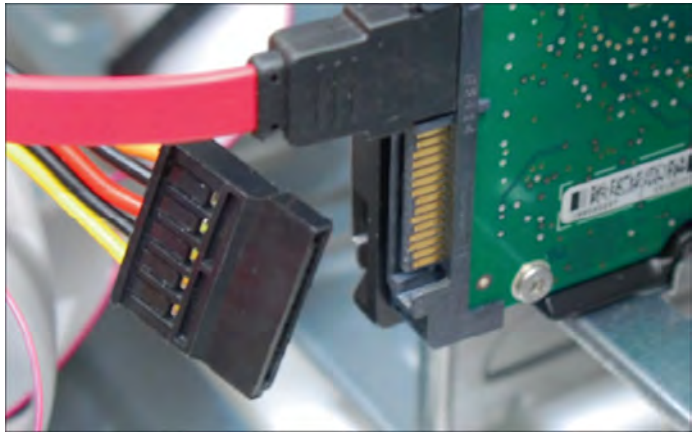
- Connection point for internal mass storage devices.
- Interface between drive, HBA, rest of the system is a type of bus.
  - Old technology included PATA and SCSI.
  - Most systems now use SATA.

SATA

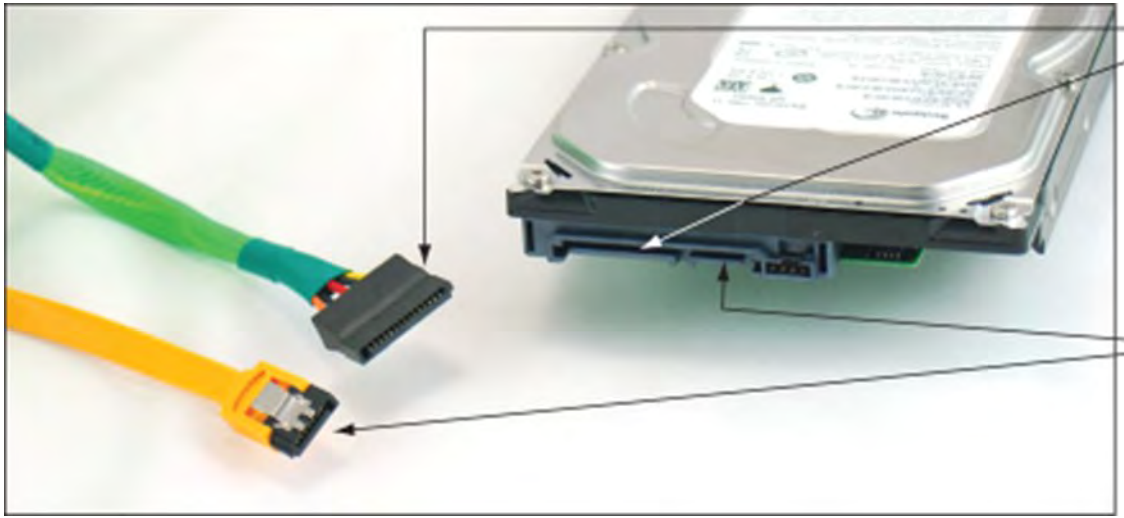
SATA: A widely used hard disk interface using a 7-pin data connector and a 15-pin power connector.

- Transfers data in serial format.
- Cables terminate with 7-pin connectors.
- Each host adapter port supports a single device.
- Drives are hot swappable.

- SATA speeds:
  - SATA 1: up to 1.5 Gbps.
  - SATA 2: up to 3 Gbps.
  - SATA 3: up to 6 Gbps.



SATA


SATA power connectors
SATA data connectors


Data Cable
Power Cable

SATA & IDE

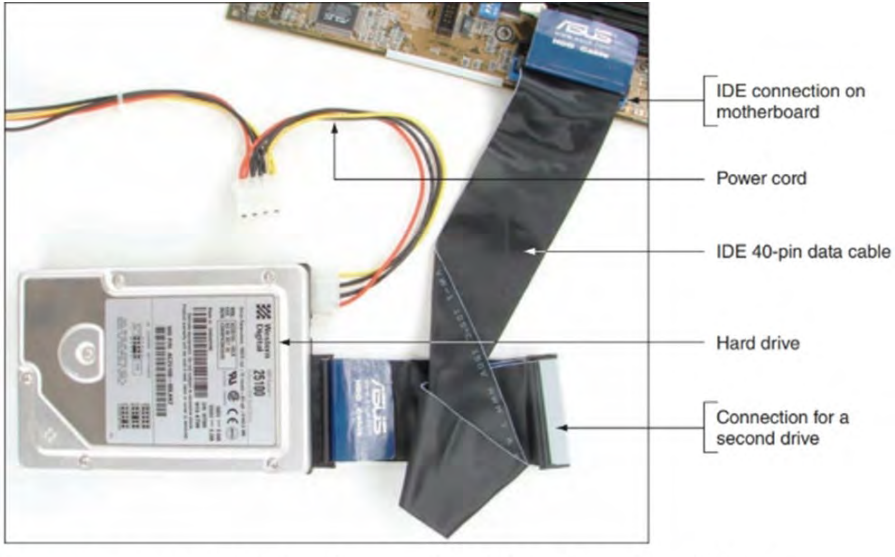
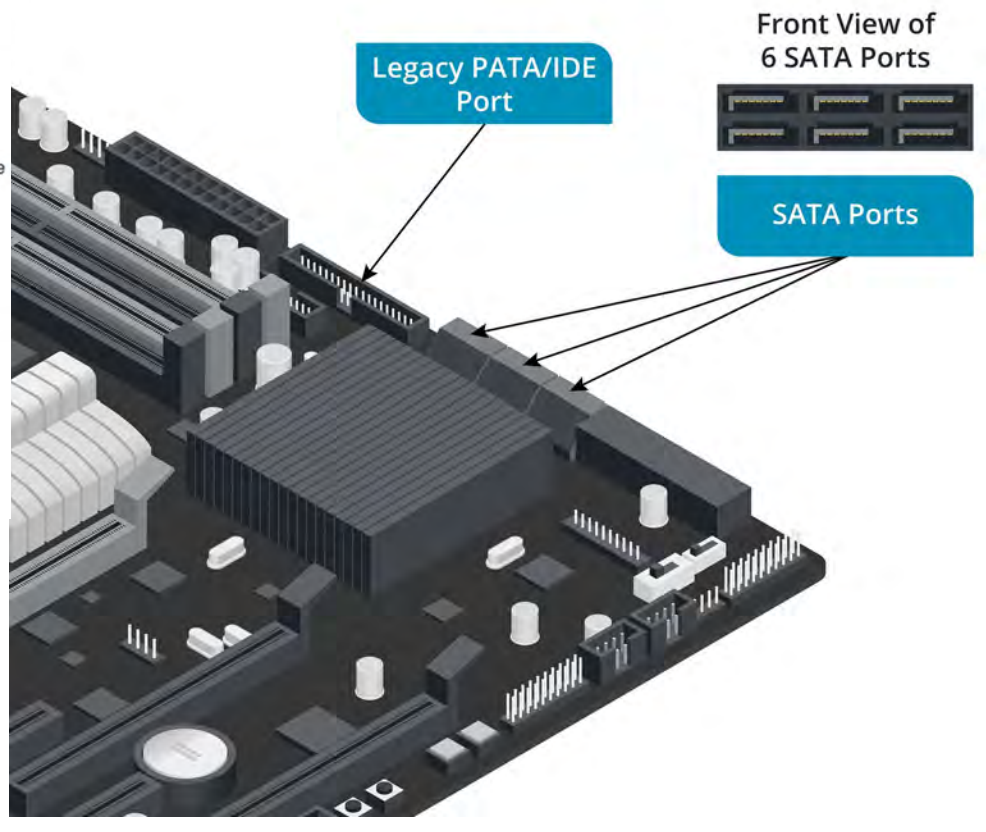


Figure 5-7 A computer's hard drive subsystem using an IDE interface to the motherboard



Solid State Drives

SSD: (solid state drive) A personal computer storage device that stores data in non-volatile special memory instead of on disks or tape.

- Advantages:
  - No moving parts.
  - Quieter and more power efficient than HDD.
  - Less prone to failure due to shock.
  - File fragmentation is eliminated

Source: istock.com/AlexLMX

Figure 5-4 A circuit board with NAND memory inside an SSD

SSD Interfaces and Form Factors

AHCI: (Advanced Host Controller Interface) A logical interface (language) created for use by **SATA** drives to communicate with the Mobo.

This language is cap at SATA 3: **6**GB

NVMe: (NVM Express) A newer (protocol) created for connecting flash memory devices, such as SSDs, directly to a PCI Express bus.

This new language (Protocol) can reach speeds of **32**GBps and more....

Source: istock.com/AlexLMX

Figure 5-4 A circuit board with NAND memory inside an SSD

Interface Standards Used by Hard Drives

- Remember, M.2 is just the form factor. M.2 drives can come in SATA versions

This is using the AHCI-SATA language! Capped at 6GB

- NVMe versions which communicate over PCI Express bus.

This is using the NVMAe language! Capped at 32GB

Interface Standards Used by Hard Drives

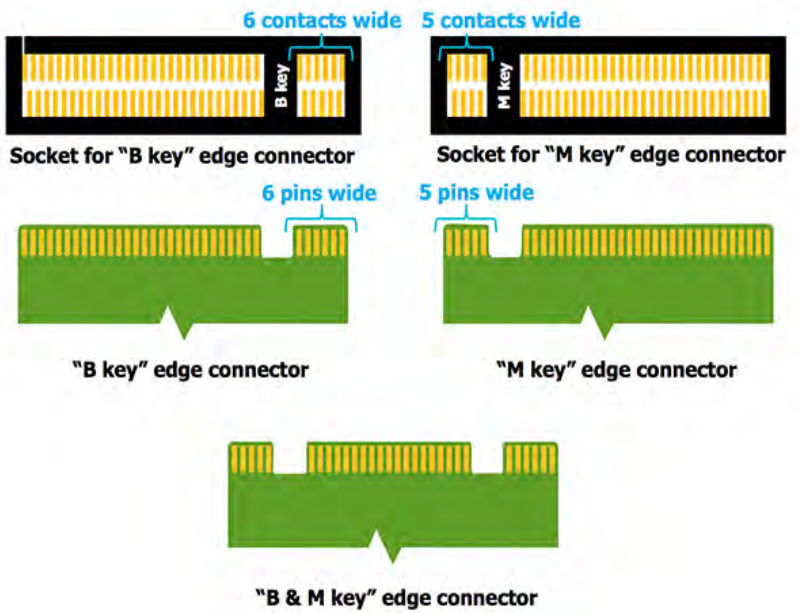
M.2 Interfaces Keys

- M.2 was called the Next Generation Form Factor (**NGFF**).
  - M.2 can use a PCI Express X 4 bus connection or faster.

Different connector types

- Needs to be compatible with the slot connector. Check Doc's

- – B key, M key, or B & M key – Some M.2 drives will support both



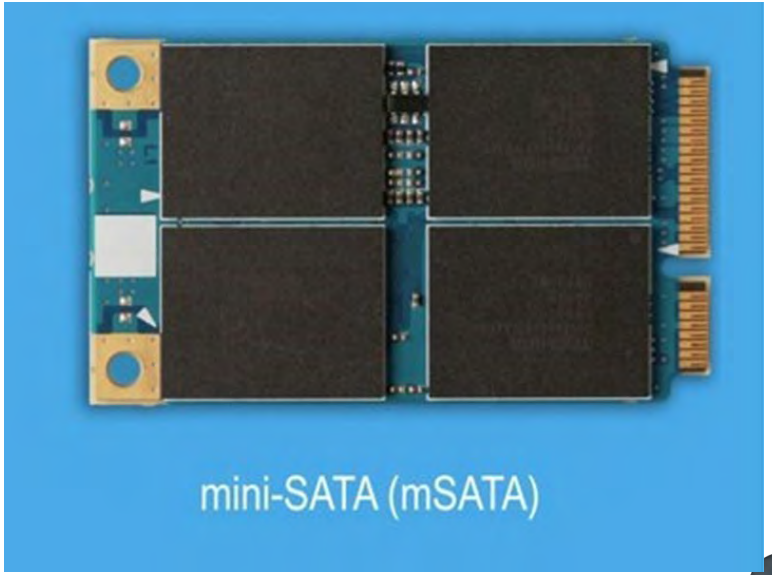
SSD Interfaces and Form Factors

- PCIe-based M.2:
  - Can be implemented as regular PCIe adapter
  - Uses the M.2 adapter interface.

- M.2 adapters:
  - Are not hot-swappable or hot-pluggable.
  - Are smaller than a PCIe adapter.
  - Supply the power over the bus.
  - Can use up to 4 PCIe lanes.

mSATA Interfaces and Form Factors

- mSATA:
  - A mSATA SSD has a smaller form factor than a standard SSD and is designed for use with portable, power-constrained devices.
  - The maximum bandwidth of a mSATA SSD is 6 gigabits per second (Gbps).



SDD Performance Factors

Wear leveling: Routines used by flash drives to prevent any single storage location from being overused and to optimize the life of the device.

- Flash chips are susceptible to degradation.
- Use wear leveling:
  - Prevents any single location from being overused.
- Wear leveling helps optimize life of the drive.

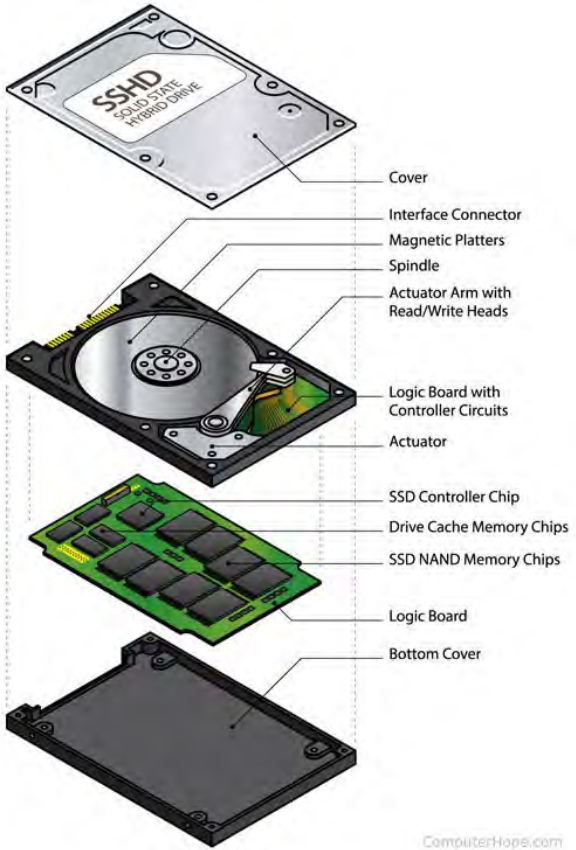
Source: istock.com/AlexLMX

Figure 5-4 A circuit board with NAND memory inside an SSD

Hybrid Drives

- **Hybrid drive:** A drive that contains an SSD portion, which functions as a large cache, containing frequently accessed data.

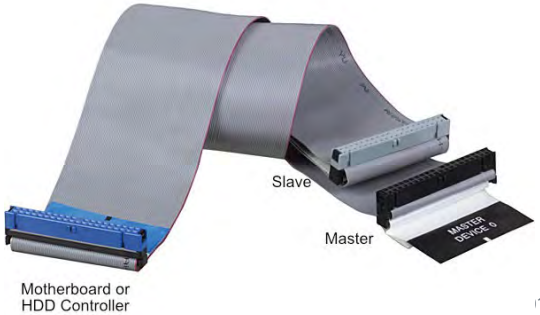
- And a magnetic disk portion, which is spun up only when non-cached data is accessed.



Legacy Storage Technologies

PATA: Older drive technology that supported two devices per channel: master and slave. Also referred to as IDE or EIDE.

- Uses parallel data transfers,
- Motherboards supporting PATA include 1 or 2 host adapters (“channels”).
- Each PATA channel supports 2 devices.
  - Master and slave.
  - 40 pin



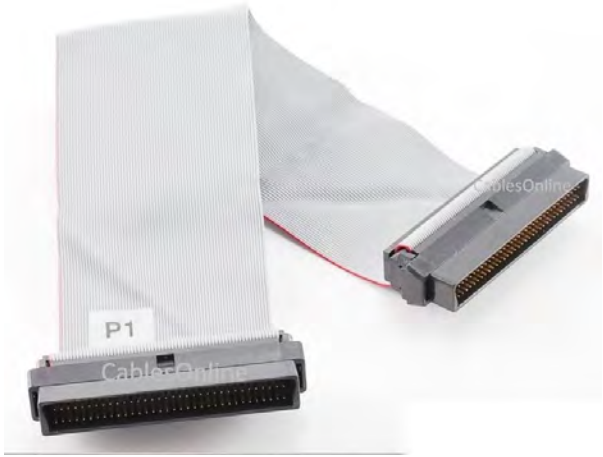
Dual-Drive Configurations

- Install separate SSD and HDD devices.
- System chipset and storage drivers make caching decisions.
  - User does not have control over use of the SSD cache.

Legacy Storage Technologies

SCSI: (Small Computer Systems Interface) An older personal computer connection standard that provides high-performance data transfer between the SCSI device and the other components of the computer.

- One SCSI HBA can control multiple devices.
  - Attach with internal ribbon or external SCSI cables. 50,68 ex… pin



Guidelines for Installing Mass Storage Devices

- Does the computer have existing internal storage devices?
- Does the computer have an available power supply cable to supply power to the device?
- Does the computer have an available drive bay for the storage device?
- Do you have the necessary data cables to connect the storage device to the controller?
- Does the placement of the device interrupt the air flow of the case?

Discussing Mass Storage Device Installation and Configuration

- **True or false? SATA is an interface for hard drives only.**

- **ANSWER:**
  - False. Optical Drives ex..

Discussing Mass Storage Device Installation and Configuration

- **What is a S.M.A.R.T. hard disk?**

- **ANSWER:**
  - One with Self Monitoring Analysis and Reporting Technology. This means that it can provide status reports to diagnostic software.

Discussing Mass Storage Device Installation and Configuration

- **How many storage devices can be attached to a single SATA port?**

- **ANSWER:**
  - Only One.

Topic C: Install and Configure Removable Storage

Removable Storage

Removable storage: A storage device that can be removed from the computer.

- Can be attached or inserted in different computers to move or copy files.
- Can be used to create a backup.

Optical Media

CD: (compact disc) An optical storage technology that can hold 700 MB of data.

DVD: (digital versatile disc) An optical storage technology that can hold 4.7 GB per layer.

- CD has 700 MB capacity. (Legacy)
  - Capable of delivering most software applications.
- DVD has about 17 GB capacity.
  - Often used for:
    - Software installs.
    - Games.
    - Multimedia.

Optical Media

Pits 0: In optical storage media, recessed areas on the disk.

Lands 1: In optical storage media, raised areas on the disk.

CD-R: Compact disks containing a layer with photosensitive dye in which a laser transforms the dye to mimic the pits and lands of a premastered CD.

Burning: In optical disks, the process of using a special laser used to transform the dye to mimic the pits and lands of a premastered CD.

CD-RW: disks can be changed multiple times.

Standards Used By Optical Discs and Drives

- CDs, DVDs, and BDs use similar laser technologies
  - Tiny lands and pits on surface represent bits read by a laser beam

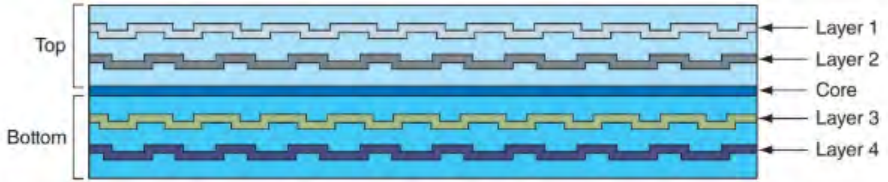


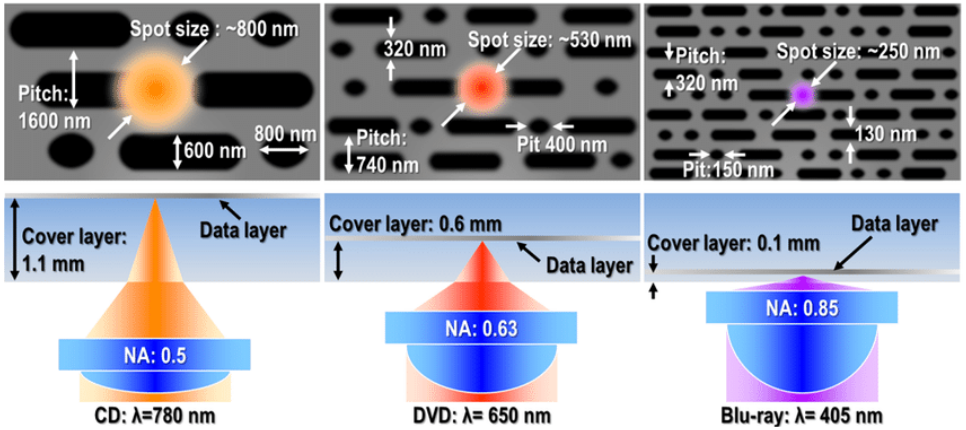
Figure 5-46 A DVD can hold data in double layers on both the top and bottom of the disc, yielding a maximum capacity of 17 GB

- Optical Discs:
  - Data can be written to:
    - One side of a CD
    - One or both sides of a DVD or Blu-ray disc
- DVD or Blu-ray disc can hold data in two layers on each side

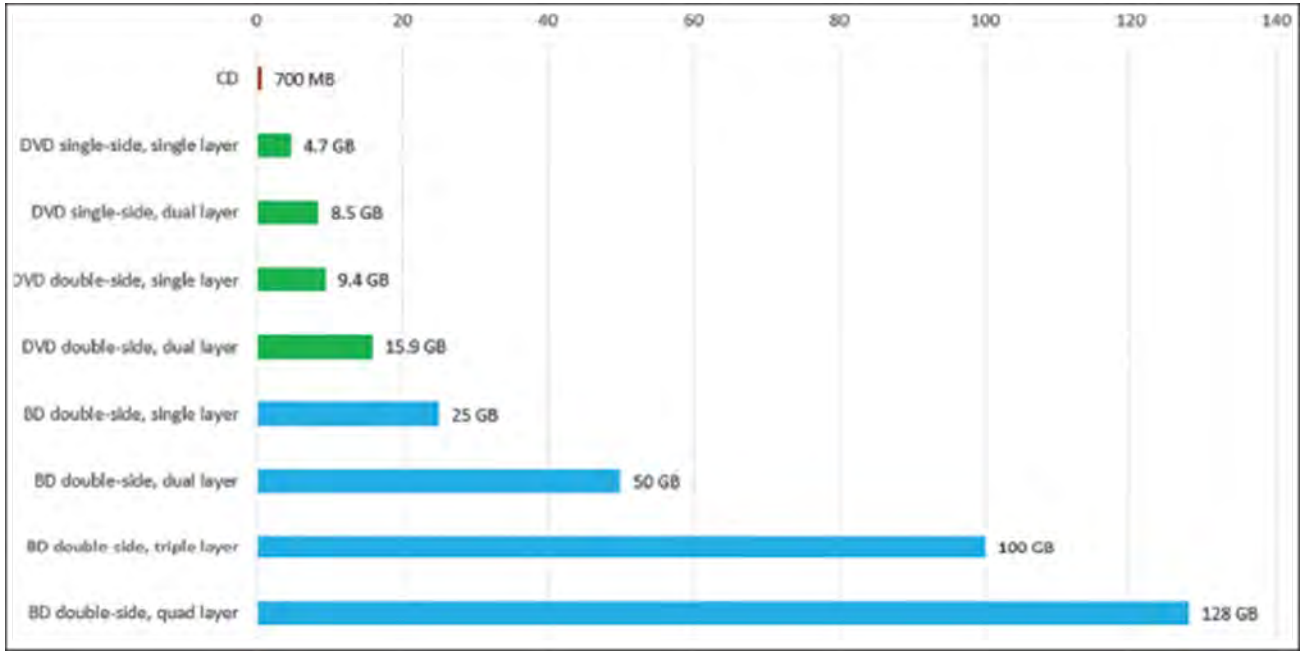
Optical Media

BD: (Blu-ray disc) Latest generation of optical drive technology, with disc capacity of 25 GB per layer.

- Used for High Definition (HD) video recording and playback.
- Shorter wavelength laser than DVD uses, so has higher density.



Optical Media



Flash Memory Devices

Solid state storage: Any type of persistent digital storage technology that does not use mechanical parts.

Flash memory: Like a ROM chip in that it retains information even when power is removed, but it adds flexibility in that it can be reprogrammed with new contents quickly.

Memory card: Flash drives typically used for digital cameras and smartphones; typically, small and flat.

Flash Memory Devices

- Non-volatile EEPROM or NAND flash
- 3D NAND over 2D NAND. It provides faster performance, a longer lifespan, and lower power consumption. Lower price!
- Small and light compared to other types of storage.
- Storage capacity typically ranges up to 256 GB.
  - Larger drives are available but are very expensive.
- Packaging of flash memory varies:
  - USB thumb or pen drive. Memory cards.

Flash Memory Devices (SD Not on test)

Type of Memory Card	Description
Secure Digital (SD)	Maximum capacity • Original SD cards up to 2 GB. • SDHC is up to 32 GB. • SDXC is up to 2 TB. Speed • Original specification is up to 25 MBps. • UHS allows up to 108 MBps. • UHS-II is rated at up to 312 MBps.
Mini-SD	Smaller version of SD cards, with the same capacity and speed designations.
Micro-SD	Smallest version of SD cards, using the same capacity and speed designations.
Compact Flash (CF)	• Supports up to 512 GB, but no cards were created larger than 256 GB. • Speed is multiples of 150 Kbps (the same rating as CDs). • Fastest devices work at 1066x read speeds (160 MBps).
xD	Format for Olympus cameras that has been discontinued.

Memory Card Readers

Memory card readers: A device containing one or more slots to accommodate reading (and writing) memory cards.

- Can be an internal component with slots on the face, accessed externally.
  - Supports most common memory card formats.
  - Usually designed to fit in 3.5” or 5.25” drive bay.

External Storage Drives

Drive enclosure: An external case that holds one or more disks and typically connects to the computer through USB or Thunderbolt ports.

- Enclosure for external drives usually has USB or Thunderbolt ports.
- eSATA can also be used to attach external drives to an eSATA external port.
  - Power is not supplied over the cable.
- Some enclosures support Ethernet connections.
  - Referred to as Network Attached Storage (NAS).
  - Enclosure might hold multiple disks configured as RAID.

Discussing Removable Storage Device Installation and Configuration

- **What is the primary benefit of using removable solid-state storage?**

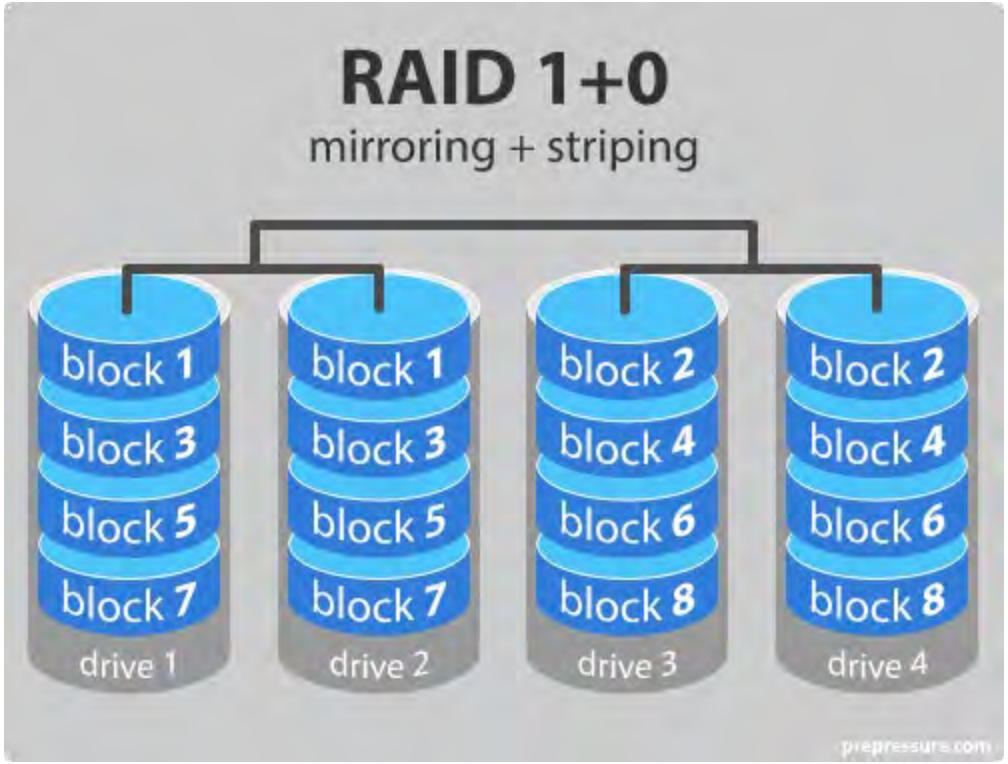
- **ANSWER:**
  - Portability, and easier and faster rewriting compared to optical media.

Discussing Removable Storage Device Installation and Configuration

- **True or false? A memory card reader is needed to attach a USB flash memory drive to a PC.**

- **ANSWER:**
  - False—the "drive" will plug into any USB port.

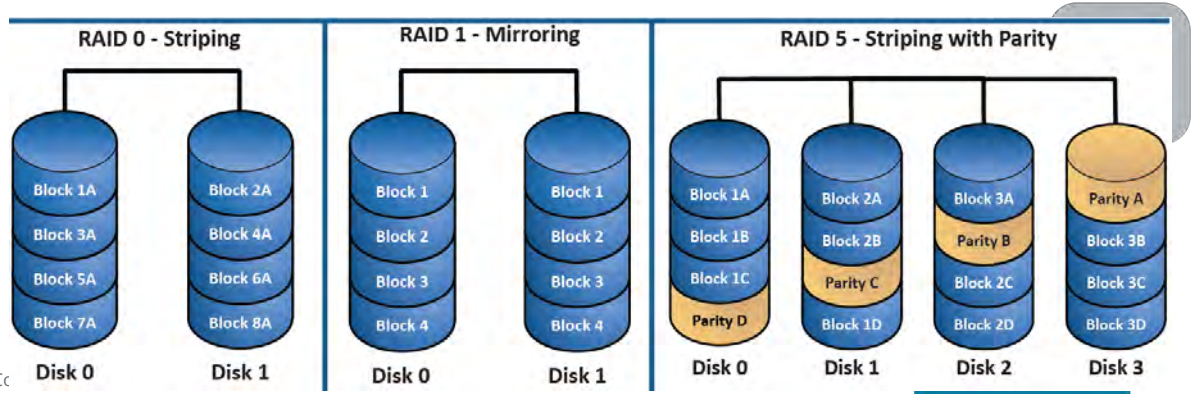
Topic D: Configure RAID



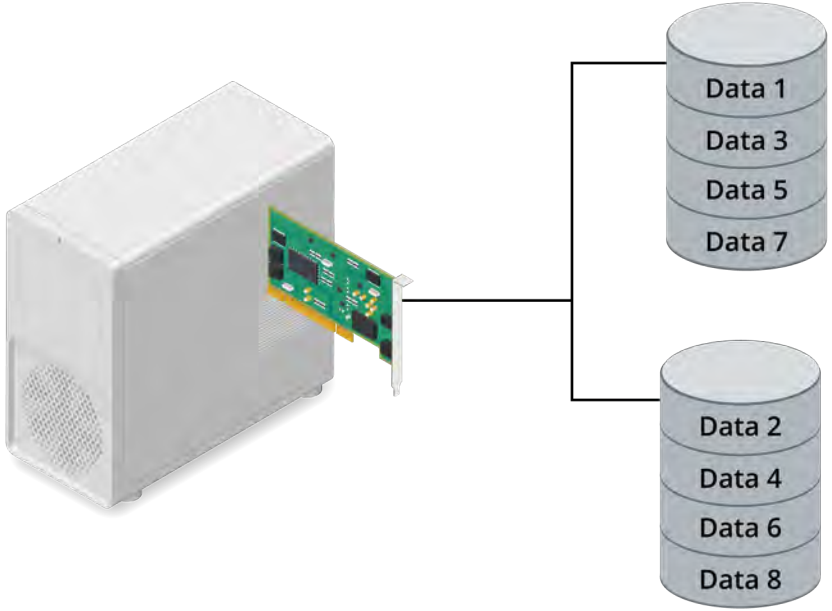
RAID

RAID: (redundant array of independent disks) A set of vendor-independent specifications for fault-tolerant configurations on multiple-disk systems.

- Can act as backups for each other to increase reliability.
- Can act together to create one very large drive.
- To the OS, the RAID array appears as a single storage resource



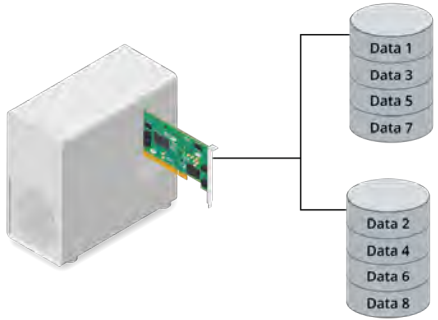
RAID 0 Disk striping



RAID 0 Levels

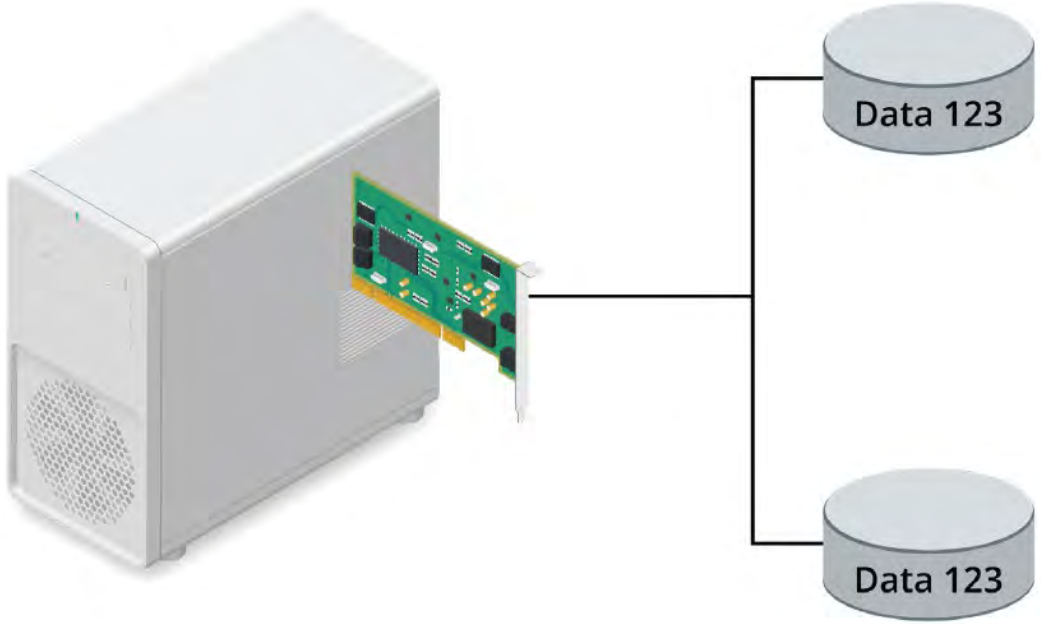
Disk striping: A disk array access pattern where data is written in stripes to two or more disks sequentially, improving performance.

- RAID 0 (Striping without Parity):
  - File blocks are split between
  - 2 or more physical drives
  - – High performance
  - – Data written quickly.



No redundancy
- – A drive failure breaks the array
- – Raid 0 is zero redundancy

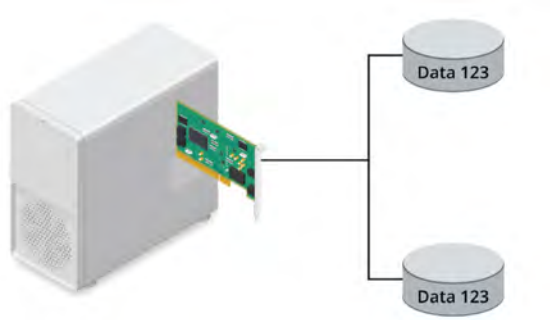
RAID 1 Disk mirroring



RAID 1 Levels

Disk mirroring: A type of RAID (RAID 1) that uses two hard disks, providing the simplest way of protecting a single disk against failure.

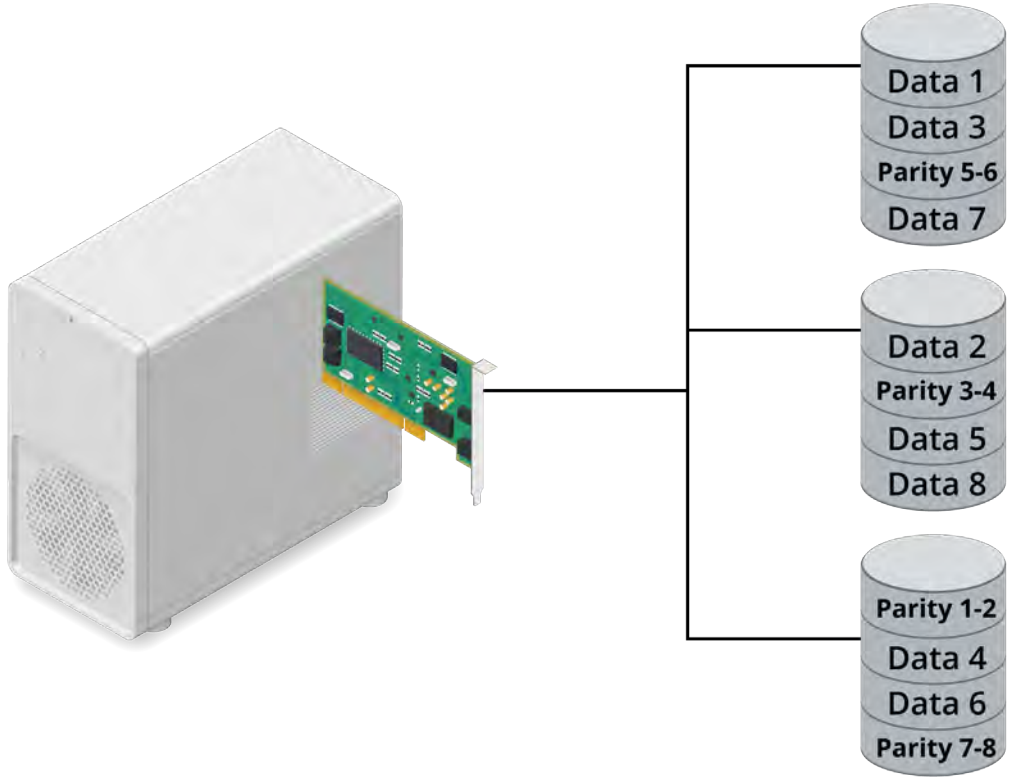
- RAID 1 (Mirroring):
  - File blocks are duplicated between
  - 2 or more physical drives



High disk utilization
- – Every file is duplicated
- – Required disk space is doubled

High redundancy
- – Drive failure does not affect data availability

RAID 5 Disk Stripe with Parity



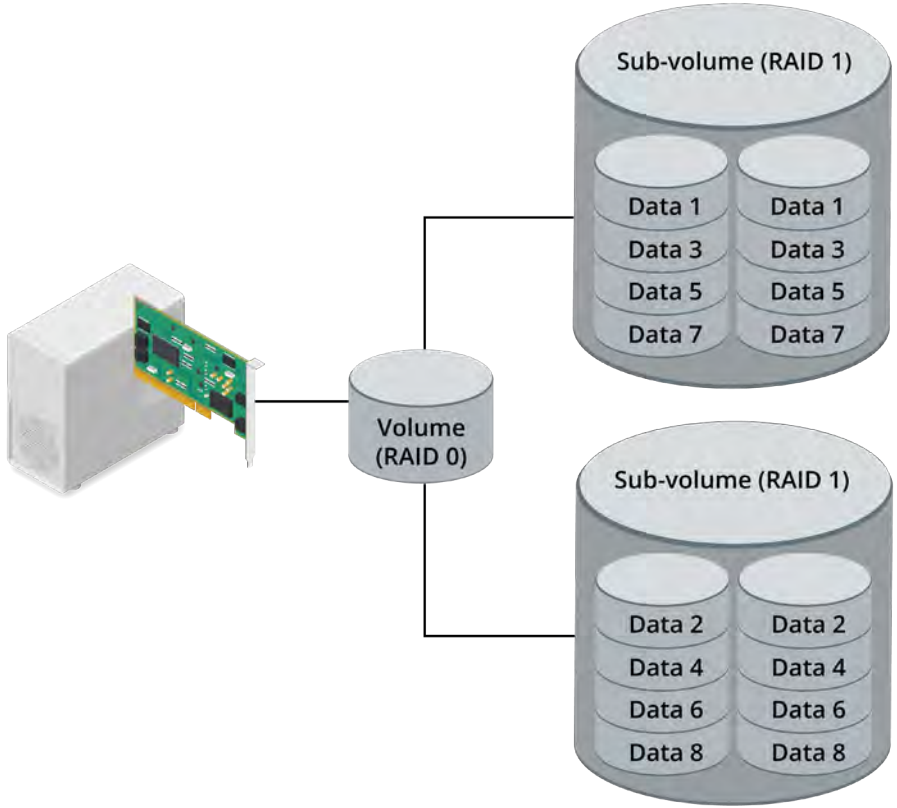
RAID 5 Levels

Disk Stripe with Parity: Writes error checking data across all disks with striping in the array.

- RAID 5 (Striping with Parity)
  - Write operations suffer reduced performance due to the parity calculation
  - If a 1 disk fails, information spread on the other 2 disks allows data to be completely reconstructed.

  High disk utilization
  - If more than one disk fails, the volume will be unavailable
  - If you configure a RAID 5 set using 3 disks, a third of each disk is used for parity.
  - Requires at least 3 disks.

Nested RAID 0 & 1 A stripe of mirrors



RAID 10 Levels

(Stripe of Mirrors): A Nested RAID configuration combines. RAID striped volume (RAID 0) with 2 mirrored arrays (RAID 1).

- RAID 1+0 10 (Striping with Mirrors)
  - Write operations suffer reduced performance due to the mirror calculation
  - Offers excellent fault tolerance, as one disk in each mirror can fail.
  - Requires 4 disk

High disk utilization

- If more than one disk fails, the volume will be unavailable
- If you configure a RAID 5 set using 3 disks, a third of each disk is used for parity.
- Requires at least 3 disks.

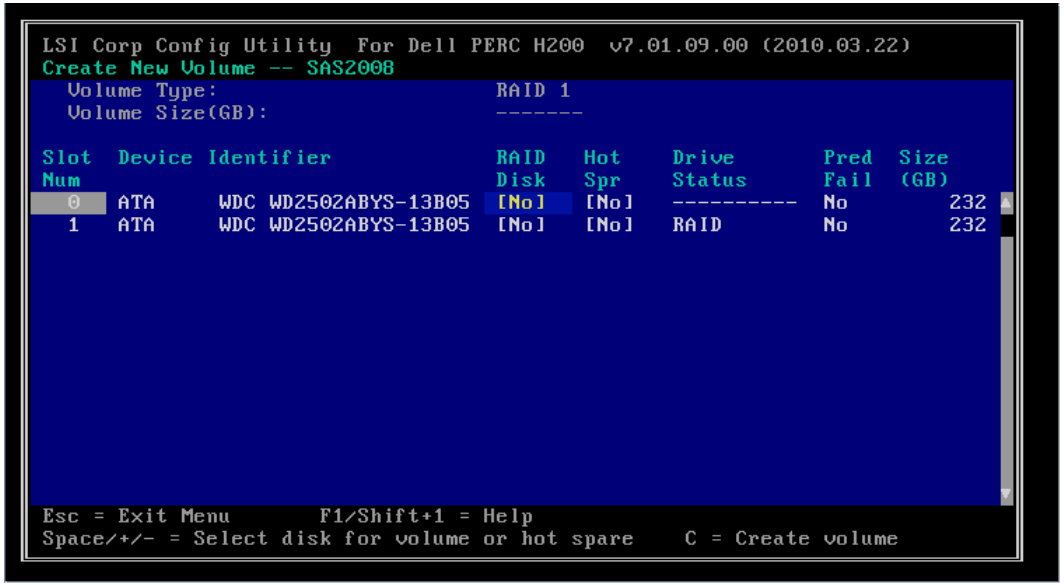
RAID Configuration Options

Hardware RAID solution: A method of creating volumes from an array of physical disks by using a plug-in controller card or the motherboard's UFFI setup

- Entry-level controllers typically support only RAID 0 or RAID 1.
  - Typically use SATA drives.
  - Mid-level controllers might add support for RAID 5 or RAID 10.
  - Hot swap features are available with high-end hardware.
  - Requires compatible controllers and disk units.
  - New disks sync with other disks in the set.
  - Typically uses SCSI (SAS).
- More expensive than a software RAID solution.

RAID Configuration Options

- Hardware RAID:
  - Usually configured through firmware configuration utility.
  - Sometimes RAID controller configuration tools are available within the OS.



RAID Configuration Options

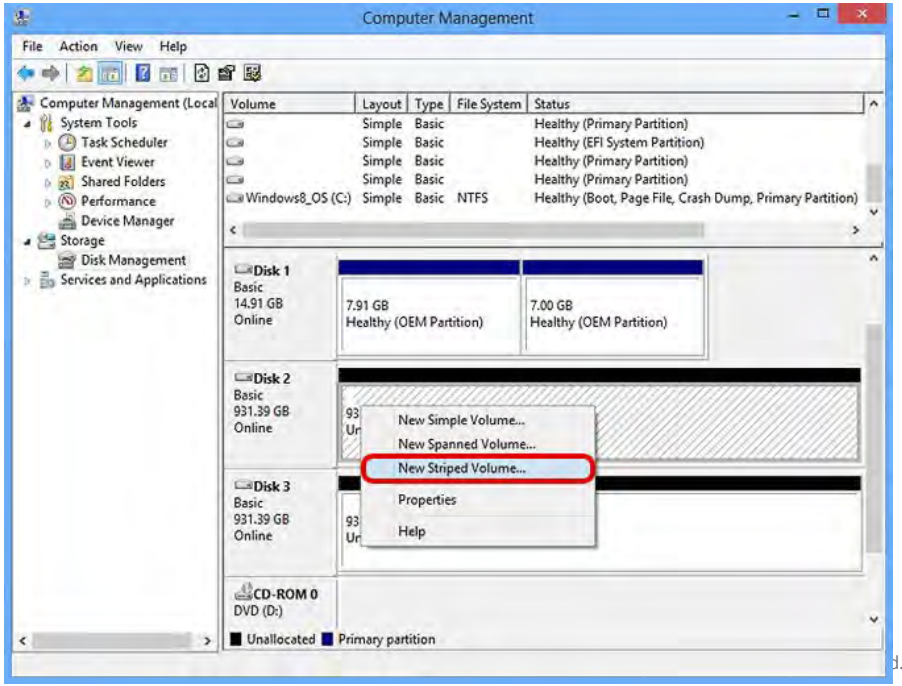
Software RAID: Windows provides options to set up software RAID. Uses standard disks and controllers.

Windows Server and Windows Professional/Enterprise editions support RAID 1 and RAID 5.

- Can use internal disks on varying interfaces.
- Typically, cannot use external disks connected through USB or Thunderbolt.
- Windows 10 Storage Spaces feature provides RAID-like functionality for external disks.
- Software RAID less expensive than hardware RAID.

RAID Configuration Options

- Software RAID:
  - Usually configured Disk management utility in Windows.
  - Windows Storge Space



RAID Configuration Options

Hot swappable drive: A device that can be added or removed without having to restart the operating system.

- Hot swappable drives:
  - Usually a server-level or high-end workstation feature.
  - Drives mate into combined data/power port.
  - Drives can be added from the front of the case without opening the chassis.
  - Drives are secured and released with a latch.

Hot swap drive enclosure

RAID Troubleshooting

Hot swappable drive: A device that can be added or removed without having to restart the operating system.

RAID	Disks Required	Failure Condition
RAID 0	2 or more	A single drive failure breaks the array with data loss
RAID 1	2 or more	Array will work as long as one drive is operational
RAID 5	3 or more	Need all drives operational but one
RAID 10	4 or more	Can lose all but one from each set of mirrors

Discussing RAID Configuration

- **What is the minimum number of disks required to implement RAID 10 and how much of the disks' total capacity will be available for the volume?**

- **ANSWER:**
  - RAID 10 requires at least four disks (two mirrored pairs)
  - 50% capacity overhead so the volume will only be half the total disk capacity.

Discussing RAID Configuration

- **If you have a computer with three hard disks, what type of RAID fault-tolerant configuration will make best use of them?**

- **ANSWER:**
  - RAID 5 (striping with parity)
  - RAID 0 is not fault-tolerant
  - RAID 1 and RAID 10 require an even number of disks.

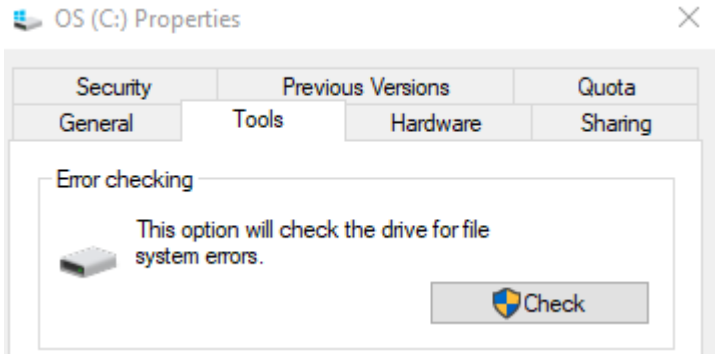
Topic E: Troubleshoot Storage Devices

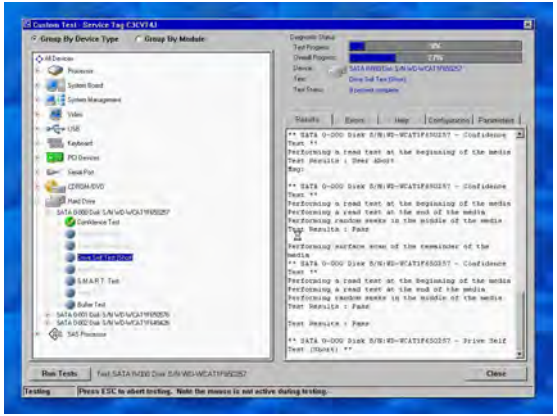
Disk Failures

- A hard drive that is failing symptoms:
  - Read/write failure – Event log System log
  - Blue Screen of Death (BSoD) – Remove new device or driver
  - Bad sectors - chkdsk
  - Constant LED activity – virtual ram
- Grinding noises
  - Computers should hum, not grind
  - Rattling - Loose components
  - Scraping - Hard drive issues
  - Clicking sounds - Fan problems
  - Pop - Blown capacitor

Disk Integrity Testing

- Disk Integrity Tools:
  - Chkdsk or Error Checking
  - S.M.A.R.T. CMD-
    wmic /node:localhost diskdrive get status
  - Run advanced diagnostic tests
  - Obtain disk program from hard drive vendor or PC manufacturer
  - Check basic cables connection





Boot Failures

- If the hard drive is not detected at boot or if a second hard drive is not shown under Windows:
  - Verify that the storage device is powering up.
  - If inactive, check that the drive has a power connector attached.
  - If drive is powered up:
    - Check that the boot sequence is set correctly in the PC firmware system setup program.
    - Check that there are no removable disks.
    - Check the data cables.
    - Check that it has not been disabled by a jumper or via system setup.

Boot Block Repair

These are two different systems for storing the partitioning information on hard drives

MBR: (master boot record) Sector on a hard disk storing information about partitions configured on the disk.

GPT: (globally unique ID partition table) Modern disk partitioning system allowing large numbers of partitions and very large partition sizes.

Boot Repair

- Damage to boot information results in boot errors, including:
  - OS not found. Invalid drive specification

- Try booting using the repair options on the Windows product disk.

1. Boot from the product disk and select **Repair**.
2. Try using the **Startup Repair** option.
3. If necessary, select the **Command Prompt** option.
   1. Enter cd/c:**bootrec /fixmbr** to attempt repair of the MBR.
   2. Enter **bootrec /fixboot** to attempt repair of the boot sector.
   3. Enter **bootrec /rebuildbcd** to add missing Windows installations to the Boot Configuration Database (BCD).
4. Reboot the PC.

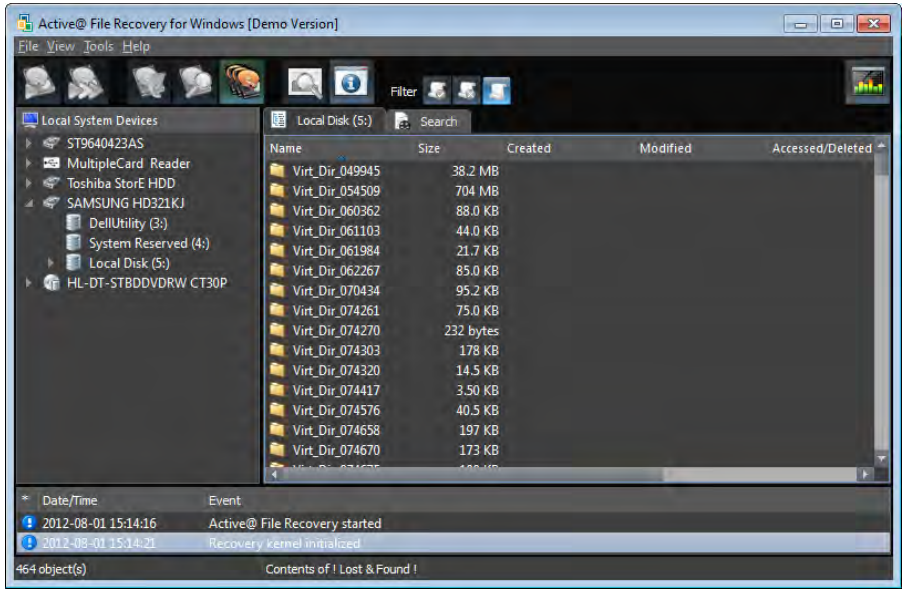
Boot Block Repair

- Damage to boot information results in boot errors, including:
  - OS not found. Invalid drive specification
- Try booting using the repair options on the Windows product disk.
  1. Boot from the product disk and select Repair.
  2. Try using the Startup Repair option.

File Recovery Options

- Remove the hard disk from the computer and insert into an external enclosure.
- Connect external enclosure to a PC via a USB port.
- Mount the externally connected drive through Disk Management or analyze through file recovery software.

File Recovery Options



Data Recovery Solutions	Platform	File system/structure
Wondershare Recoverit	Windows & Mac.	NTFS, FAT, HFS+, APFS.
Stellar	Windows & Mac	NTFS, FAT, FAT16, FAT32, and exFAT HFS, HFS+, and APFS.
Disk Drill	Windows & Mac	FAT, NTFS, HFS+, EXT4.
System Mechanic Ultimate Defense	Windows	NA

Disk Performance Issues

Disk defragmentation: A software routine that compacts files back into contiguous areas of the disk.

- Slow disk performance can be a bottleneck.
- Often improved by adding more RAM.
- Ensure file fragmentation is minimized.
- Low disk capacity can cause slow performance.

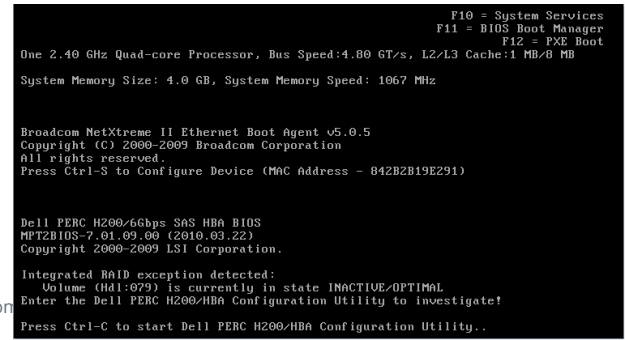
Discussing Storage Device Troubleshooting

- **You are trying to install Windows from the setup disc/USB but the computer will not boot from the CD. What should you do?**

- **ANSWER:**
  - Check the boot order in system setup is set correctly.
  - Check that the disc is not dirty or scratched.

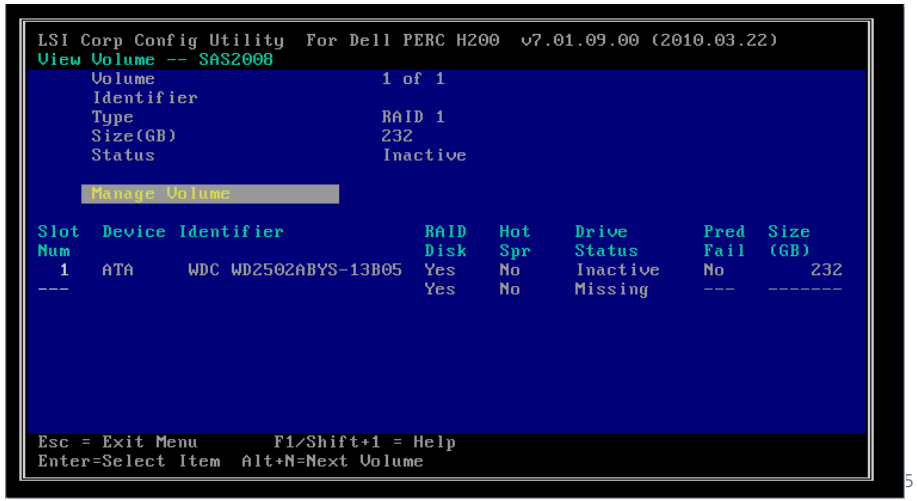
Guidelines for Troubleshooting RAID Issues

- If Windows doesn't detect RAID during setup or at boot:
  - Verify RAID controller drivers are installed.
  - Use the RAID configuration utility to verify the status.
  - If the configuration utility cannot be accessed, the controller may have failed.



Guidelines for Troubleshooting RAID Issues

- If RAID stops working:
  - Volume is listed as degraded, but the data on the volume is still accessible.
  - Replace failed disks as soon as possible.
  - If the volume is unavailable, too many disks may have failed, or the controller may have failed.



Discussing Storage Device Troubleshooting

- **A user complains that a "Buffer underrun" error keeps occurring when they try to write to recordable DVDs. What would you suggest?**

- **ANSWER:**
  - Do not use other applications at the same time as DVD writing.
  - Make sure that the source files are on the local hard disk (not a removable or network drive).
  - Try using a slower write speed.

Discussing Storage Device Troubleshooting

- **If you experience an error such as “BCD missing" when booting the computer, what action could you take?**

- **ANSWER:**
  - Use the Startup Repair tool in Win RE, or run `bootrec /rebuildbcd`.

Discussing Storage Device Troubleshooting

- **A user reports that there is a loud clicking noise when she tries to save a file. What should be your first troubleshooting step?**

- **ANSWER:**
  - Data Backup!

Discussing Storage Device Troubleshooting

- **A PC displays the message "Invalid media type" when you try to access it from a command prompt. What is the likely cause and how might you attempt to fix it?**

- **ANSWER:**
  - The file system is corrupt. You can try using the Startup Repair tool or run `bootrec /fixboot` to recover it without losing data.

Discussing Storage Device Troubleshooting

- **A RAID utility reports that the volume is degraded. What should you do?**

- **ANSWER:**
  - A degraded volume may be a lost of one of its disks.
  - In most RAID configurations, so you should add a new disk as soon as possible

Discussing Storage Device Troubleshooting

- **You are investigating a disk problem. The system can no longer access the C: drive. What command could you use to try to repair the error?**

- **ANSWER:**
  - `bootrec /fixmbr`