A+ Guide to Hardware, 9th Edition

Chapter 6

Supporting Hard Drives and Other Storage Devices

Objectives

- Discuss technologies used inside a hard drive and how a computer communicates with a hard drive
- Install and support a hard drive
- Identify tape drives and tape cartridges
- Support optical drives and flash memory devices
- Troubleshoot hard drives

Hard Drive Technologies and Interface Standards

- Hard disk drive (HDD) or hard drive sizes
  - 2.5" size for laptop computers
  - 3.5" size for desktops
  - 1.8" size for low-end laptops, other equipment

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Technologies Used Inside a Hard Drive

- Solid state drive (SSD) or solid state device (SSD)
  - No moving parts
  - Built using nonvolatile flash memory stored on EEPROM (Electronically Erasable Programmable Read Only Memory) chips
  - Memory in an SSD is called **NAND flash memory**
  - Lifespan is based on the number of write operations to the drive
  - Expensive technology, but faster, more reliable, last longer, and use less power than magnetic drives

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Technologies Used Inside a Hard Drive

- Magnetic hard drive
  - One, two, or more platters, or disks
    - Stacked together, spinning in unison inside a sealed metal housing
  - Firmware controls data reading, writing and motherboard communication
  - Read/write heads are controlled by an actuator
  - Data is organized in concentric circles, called tracks
    - Tracks are divided into segments called sectors
  - Most current drives use 4096-byte sectors
- Hybrid hard drives use both technologies
  - Operating system must support it

Technologies Used Inside a Hard Drive

1.8" solid-state drive

Inside an SSD drive

2.5" solid-state drive
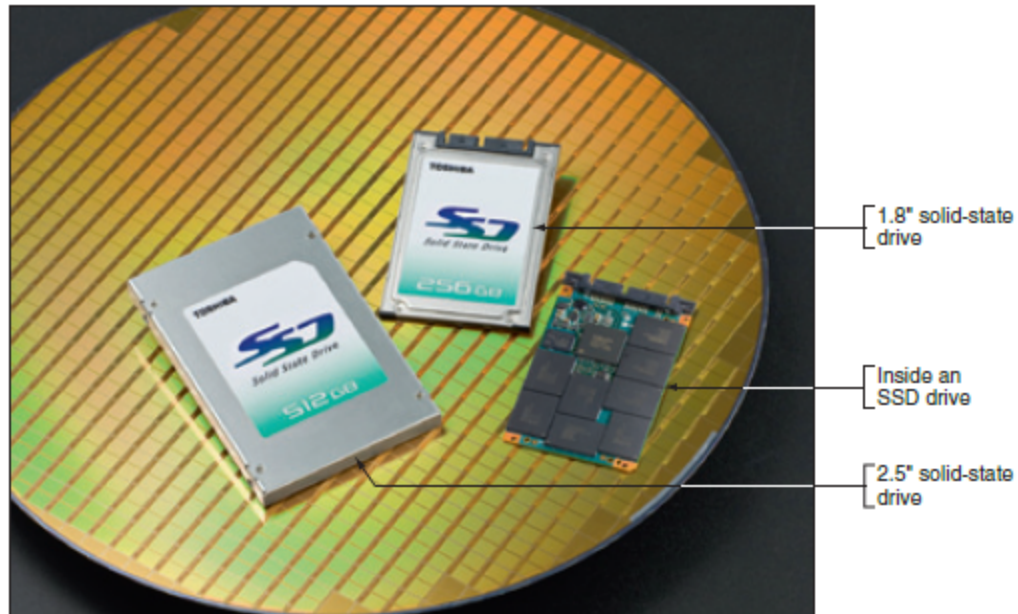
Courtesy of Toshiba America Electronic Components

Figure 6-2 Solid-state drives by Toshiba

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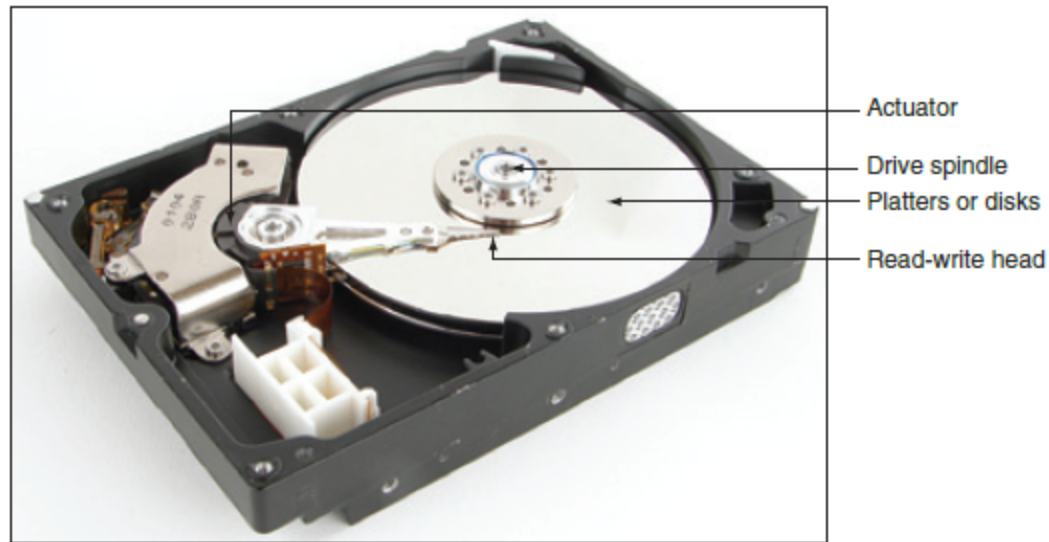
Technologies Used Inside a Hard Drive

Figure 6-3 Inside a magnetic hard drive

Technologies Used Inside a Hard Drive

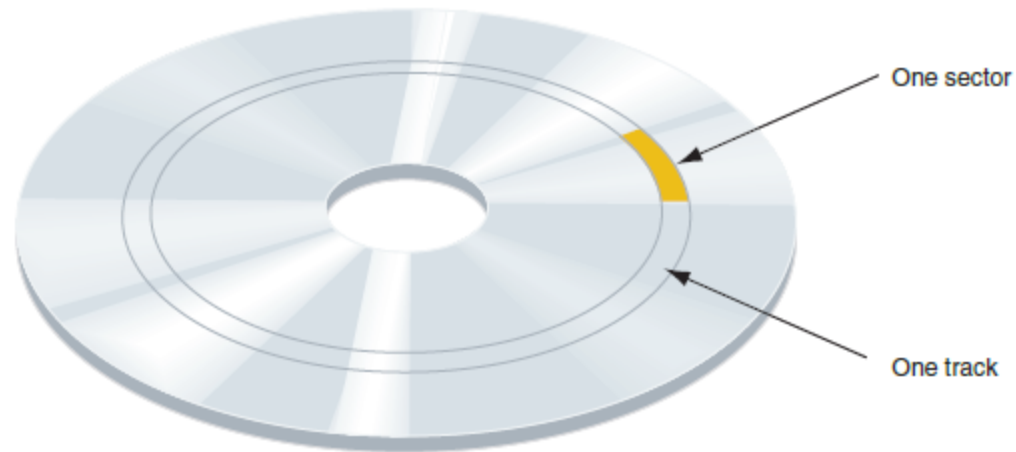**Figure 6-4** A hard drive is divided into tracks and sectors; several sectors make one cluster

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Technologies Used Inside a Hard Drive

- Low-level formatting – sector markings are written to the hard drive at the factory

  - Not the same as high-level formatting performed for Operating System installation

- Firmware, UEFI/BIOS and OS use logical block addressing (LBA) to address all hard drive sectors

  - Size of each sector + total number of sectors determine drive capacity

- S.M.A.R.T – Self-Monitoring Analysis ad Reporting Technology

  - Used to predict when a drive is likely to fail

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SATA Interface Standards Used By a Hard Drive

- All current hard drives use the Serial ATA (SATA) interface standards to connect to the motherboard
- External hard drive methods
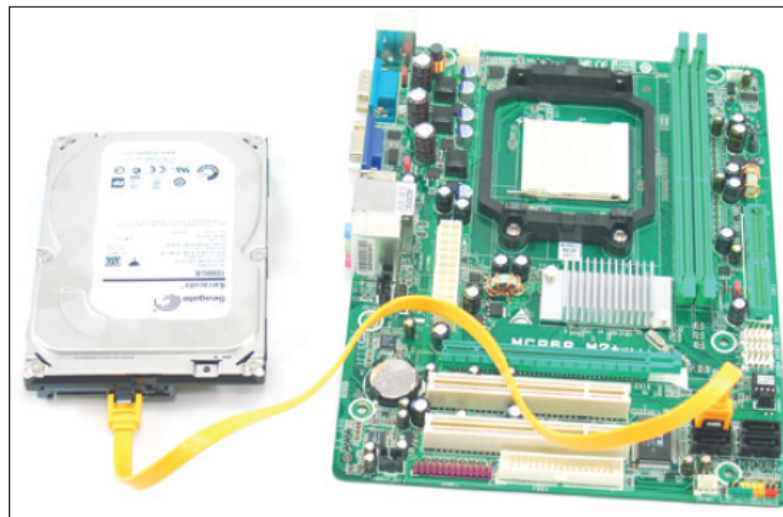 - External SATA (eSATA), FireWire, or USB

Figure 6-5 A SATA cable connects a single SATA drive to a motherboard SATA connector

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SATA Interface Standards Used by a Hard Drive

- Interface standards define data speeds and transfer methods with a computer system
    - Also define types of cables and connectors
- Standards
    - Developed by Serial ATA International Organization (SATA-IO)
    - Have the oversight of the T13 Committee

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SATA Interface Standards Used by a Hard Drive

SATA Standard	Data Transfer Rate	Comments
SATA Revision 1.x* SATA I or SATA1 Serial ATA-150 SATA/150 SATA-150	1.5 Gb/sec	SATA, first introduced as an ATA/ATAPI-7 standard, was published as part of a revision to the older PATA standards managed by the T13 Committee (*t13.org*) that governed the PATA standards.
SATA Revision 2.x* SATA II or SATA2 Serial ATA-300 SATA/300 SATA-300	3 Gb/sec	The first SATA II standards were published by the T13 Committee (*t13.org*) within ATA/ATAPI-8; later revisions of SATA II were published by SATA-IO (*sata-io.org*), which now manages SATA standards. The standard first came out in 2006. Most motherboards used it by 2010.
SATA Revision 3.x* SATA III or SATA3 Serial ATA-600 SATA/600 SATA-600	6 Gb/sec	SATA III was first published by SATA-IO in 2009. Most new motherboards today use this standard.

*Name assigned by the SATA-IO organization

Table 6-1 SATA standards

SATA Interface Standards Used by a Hard Drive

- Serial ATA standards are used by all drive types
  - Supports hot-swapping (hot-plugging)
    - Connect and disconnect drive while system is running
  - Connects to one internal SATA connector on the motherboard via a 7-pin SATA data cable
    - Uses a 15-pin SATA power connector
  - A motherboard might have two or more SATA connectors
    - Use connectors in the order recommended in the motherboard user guide

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SATA Interface Standards Used by a Hard Drive

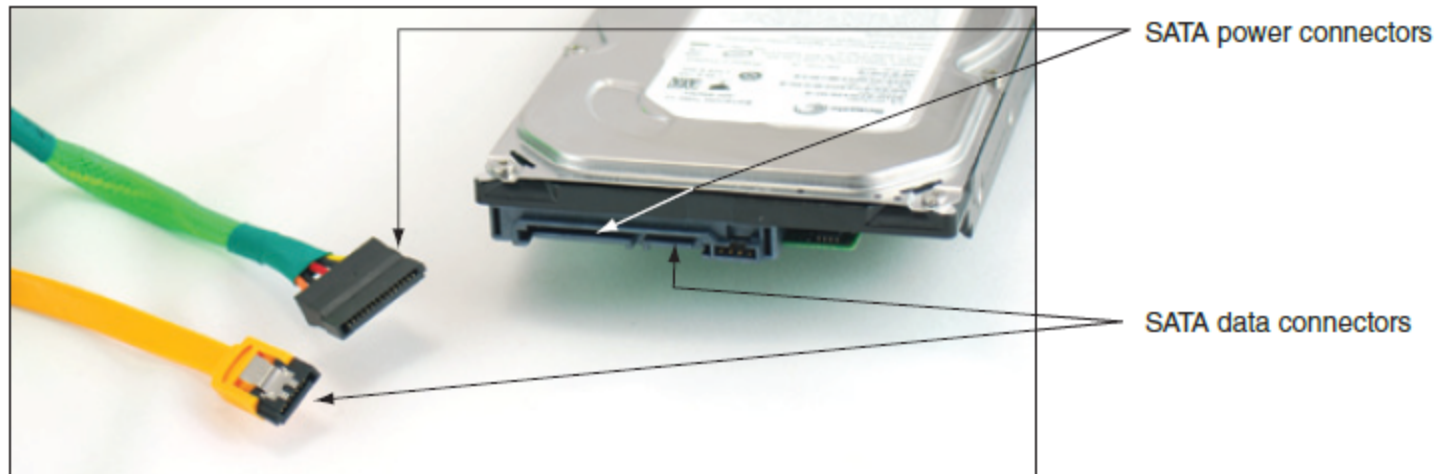SATA power connectors

SATA data connectors

Figure 6-6 A SATA data cable and SATA power cable

SATA Interface Standards Used by a Hard Drive

- Motherboard or expansion card can provide external SATA (eSATA) ports for external drives

- External SATA (eSATA)

  - eSATA drives use special external shielded serial ATA cable up to 2 meters long

- Purchasing considerations

  - SATA standards for the drive and motherboard need to match for optimum speed

  - If no match, system runs at the slower speed

How to Select and Install Hard Drives

- Topics covered
  - Selecting a hard drive
  - Installation details for a SATA drive
  - How to install hard drive in a bay too wide for drive
  - How to set up a RAID system

Selecting a Hard Drive

- Hard drive must match OS and motherboard
  - Need to know what standards the motherboard or controller card providing the drive interface can use
  - Consult documentation for the board or card
- UEFI/BIOS uses autodetection to prepare the device
  - Drive capacity and configuration selected
  - Best possible standard becomes part of configuration

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Selecting a Hard Drive

- Considerations:
  - Drive capacity
    - Today's desktop hard drives range from 1 TB for SSD to more than 6 TB for magnetic
  - Spindle speed
    - Most common is 7200 RPM
    - The higher the RPMs, the faster the drive
  - Interface standard
    - Use standards the motherboard supports
  - Cache or buffer size
    - Ranges from 2 MB to 128 MB

Steps to Install a SATA Drive

- A SATA drive might have jumpers
  - Most likely set by factory as they should be
- Some SATA drives have two power connectors
  - Choose only one to use
  - Never install two power cords at the same time
- May have to purchase controller card when the motherboard drives connectors are not functioning
  - Or the if the motherboard does not support a fast SATA standard that your hard drives uses

Steps to Install a SATA Drive

- Step 1: Know your starting point
    - How is your system configured?
    - Is everything working properly?
    - Write down what you know about the system
- Step 2: Read the documentation and prepare your work area
    - Read all installation instructions first
    - Visualize all the steps
    - Protect against ESD and avoid working on carpet

Steps to Install a SATA Drive

- Step 2: Read the documentation and prepare your work area (cont'd)
  - Handle the drive carefully
  - Do not touch any exposed circuitry
  - Prevent other people from touching exposed microchips
  - Drain static electricity from the package and from your body by touching metal for at least 2 seconds
  - If you must set it down, place it component-side up
  - Do not place the drive on the computer case or on a metal table

Steps to Install a SATA Drive

- Step 3: Install the drive
  - Shut down the computer and unplug it
  - Decide which bay will hold the drive
  - Slide drive in the bay and secure it (use two screws on both sides)
  - Use correct motherboard SATA connector
  - Connect a 15-pin SATA or 4-pin Molex power connector from the power supply to the drive
  - Check all connections and power up the system
  - Verify drive recognized correctly via UEFI/BIOS setup

Steps to Install a SATA Drive

- You are ready to prepare the hard drive for first use
  - Boot from Windows setup DVD
    - Follow directions on the screen to install Windows on the new drive
  - If installing a second hard drive with Windows installed on first drive use Windows Disk Management utility to partition and format the second drive

Installing a Drive in a Removable Bay

- Unplug the cage fan from its power source
- Turn handle on each locking device counterclockwise to remove it
- Slide the bay to the front and out of the case
- Insert hard drive in the bay
  - Use two screws on each side to anchor the drive in the bay
- Slide the bay back into the case
- Reinstall the locking pins
- Plug in the cage fan power cord

Installing a Drive in a Removable Bay

Three locking pins used to hold the bay in the case

Figure 6-19 The removable bay has a fan in front and is anchored to the case with locking pins

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Installing a Drive in a Removable Bay
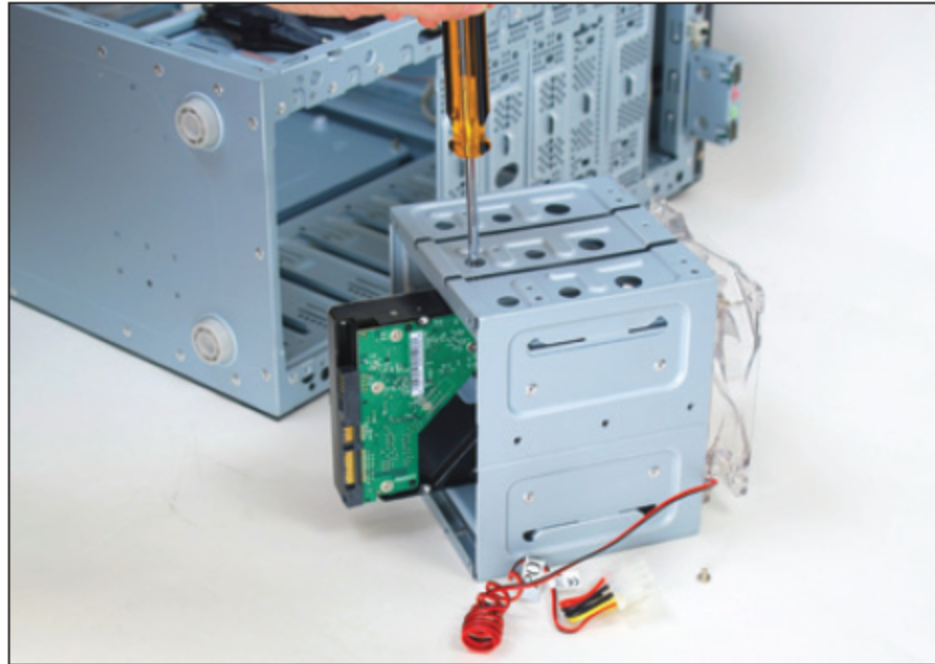
Figure 6-20 Install the hard drive in the bay using two screws on each side of the drive

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Installing a Small Drive in a Wide Bay

- Use a universal bay kit to securely fit a small drive into the bay

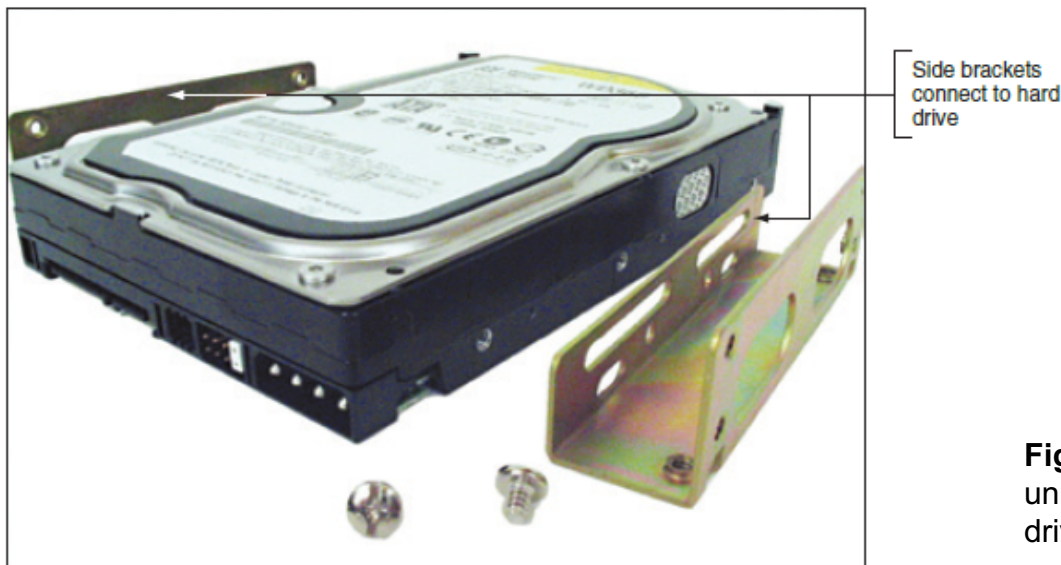- The adapter spans the distance between the sides of the drive and bay

Side brackets connect to hard drive

Figure 6-21 Use the universal bay kit to make the drive fit the bay

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Installing a Hard Drive in a Laptop

- General guidelines:
  - See manufacturer's documentation for drive sizes and connector types
  - Be aware of voiding manufacturer's warranty
- Considerations when shopping for a laptop drive:
  - Laptop drive is 2.5 or 1.8 inches wide
    - May use SSD (solid state device) technology
  - Hard drives connector: SATA or PATA (older laptops)
  - If upgrading, may want to use a USB-to-SATA converter, so both drives can be working and you can copy files from one to the other

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Installing a Hard Drive in a Laptop

- Older laptop computers required disassembly
- Newer notebooks: easy to replace
  - If UEFI/BIOS setup uses autodetect:
    - System boots up and UEFI/BIOS recognizes new drive
    - Searches for an operating system
    - If a new drive: boot from Windows recovery CD and install the OS

Setting Up Hardware RAID

- RAID (Redundant Array of Inexpensive Disks)

    – Also called: Redundant Array of Independent Disks

    – A technology that configures two or more hard drives to work together as an array of drives

- Why use RAID?

    – To improve fault tolerance by writing two copies of it, each to a different hard drive

    – To improve performance by writing data to two or more hard drives to that a single drive is not excessively used

Types of RAID

- Spanning – sometimes called JBOD (just a bunch of disks)

  – Uses two hard drives to hold a single Windows volume

  – When one drive is full, data is written to second drive

- RAID 0 – uses two or more physical disks

  – Writes to physical disks evenly across all disks so that no one disk receives all activity

  – Windows calls RAID 0 a **striped volume**

Types of RAID

- RAID 1: Mirroring
  - Duplicates data on one drive to another drive and is used for fault tolerance (**mirrored volume**)
- RAID 5: uses three or more drives
  - Stripes data across drives and uses parity checking
  - Data is not duplicated
- RAID 10: RAID 1+0 (pronounced RAID one zero)
  - Combination of RAID 1 and RAID 0
  - Takes at least 4 disks
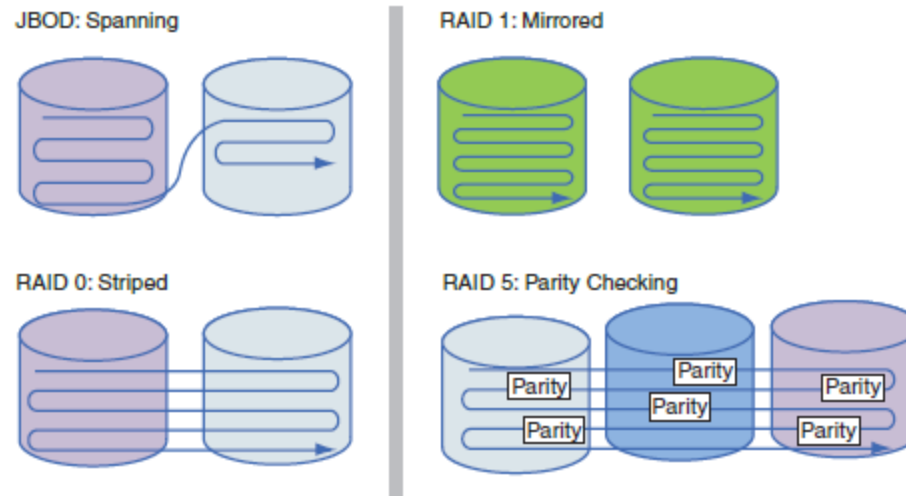 - Data is mirrored across pairs of disks

Types of RAID

Figure 6-26 Ways that hard drives can work together

Types of RAID

RAID 1: Two pairs of mirrored disks

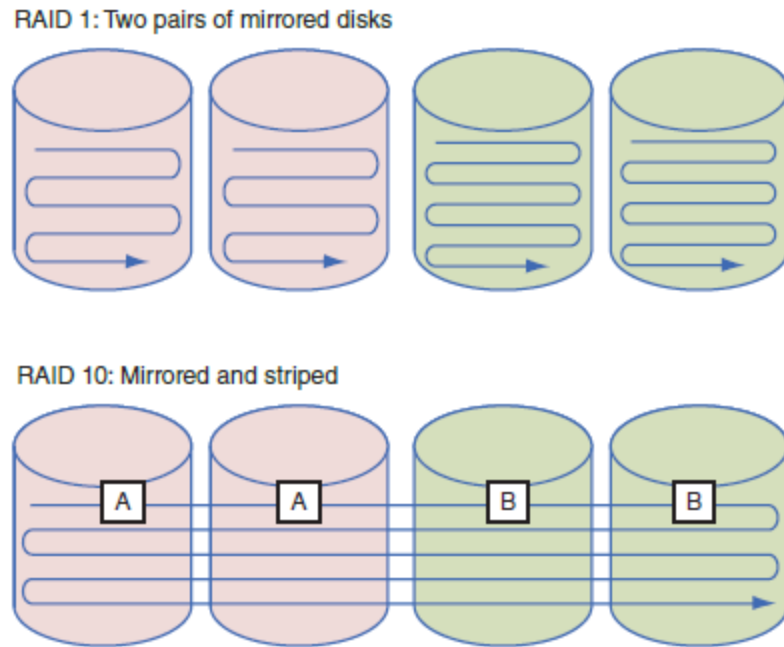RAID 10: Mirrored and striped

Figure 6-27 RAID 1 and RAID 10

How to Implement Hardware RAID

- Hardware implementation
  - Hardware RAID controller or RAID controller card
    - Motherboard does the work
- Software implementation uses operating system
- Best RAID performance
  - All hard drives in an array should be identical in brand, size, speed, other features
- If Windows is to be installed on a RAID hard drive
  - RAID must be implemented before Windows installed
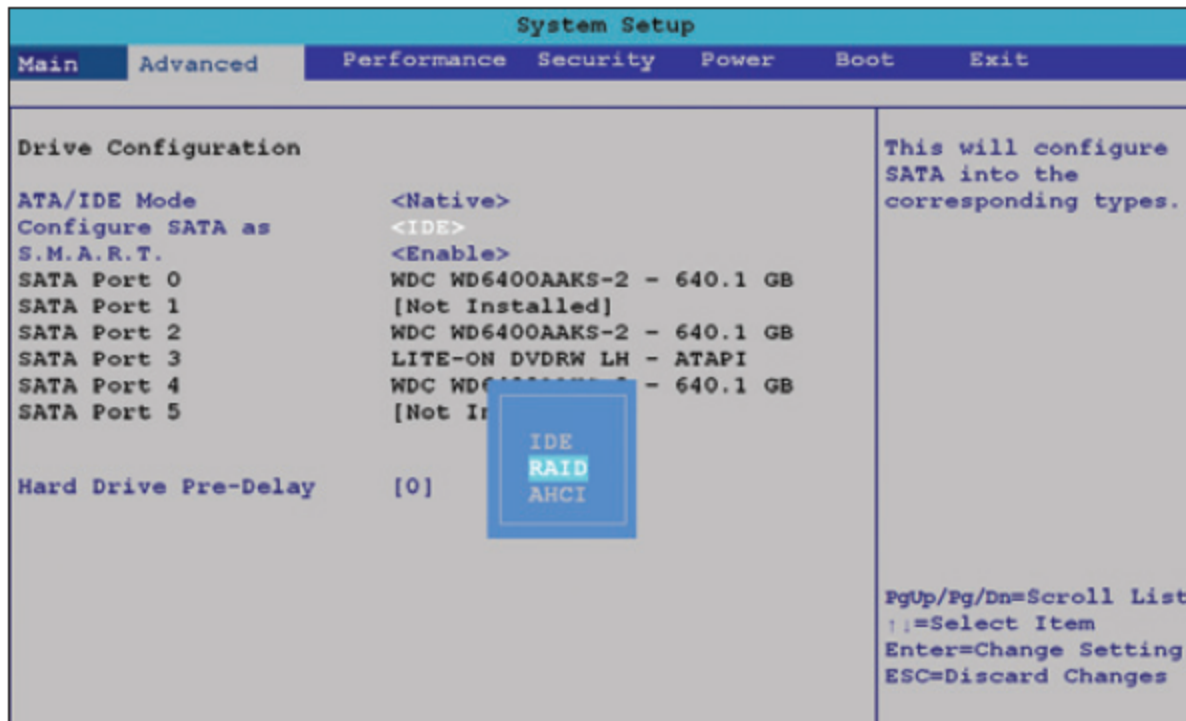
How to Implement Hardware RAID

Figure 6-28 RAID controller card provides four SATA internal connectors

How to Implement Hardware Raid

- General directions to install RAID 5 array using three matching SATA drives
  - Install drives in the computer case and connect each to motherboard
  - Boot system and enter UEFI/BIOS setup
    - Verify drives recognized, select option to configure SATA, and select RAID
  - Reboot the system
    - Press Ctrl and I to enter the RAID configuration utility
  - Select option 1 to "Create RAID Volume"
    - Select RAID 5 (Parity), stripe size value, volume size
    - Create volume

How to Implement Hardware Raid

Figure 6-30 Configure SATA ports on the motherboard to enable RAID

How to Implement Hardware Raid

Figure 6-31 BIOS utility to configure a RAID array

How to Implement Hardware Raid
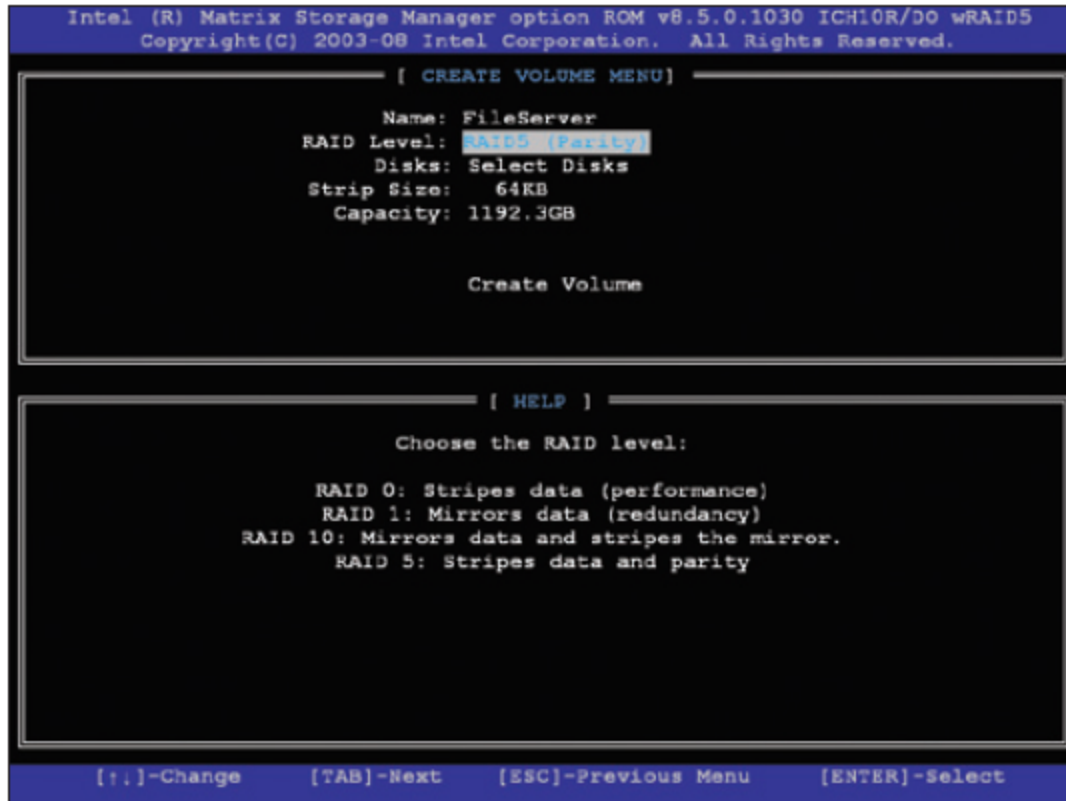
Source: Intel

Figure 6-32 Make your choices for the RAID array

External Enclosures

- Hard drives are sometimes stored in external enclosures

  – Make it easy to expand storage capacity of a single computer or make available hard drive storage to an entire network

- For network attached storage (NAS)

  – Enclosure connects to the network via Ethernet port

- Hard drives inside the enclosure might use a SATA connection

External Enclosures

- What to know about supporting external enclosures:
  - Enclosure might contain firmware that supports RAID
  - To replace a hard drive in an enclosure, see the documentation for the enclosure
  - If a computer case is overheating, remove hard drives from the case and install them in an external enclosure
    - It is better to leave the hard drive that contains the Windows installation in the case

About Tape Drives

- Tapes drives – an inexpensive way of backing up a hard drive

- WORM (write once read many) – assures data written will not be deleted or overwritten

- Disadvantage: data is stored by sequential access
  - To read data from anywhere on the tape, you must start at the beginning of the tape and read until you find the data you want
  - Slow and inconvenient

About Tape Drives

- Two kinds of tapes:
  - Full-sized data cartridges
  - Minicartridges - popular because their drives can fit into a standard 3-inch drive bay of a PC case
- Common types of tape cartridges:
  - DDS (Digital Data Storage)
  - LTO (Linear Tape-Open)
  - DLT (Digital Linear Tape)
  - SDLT (Super Digital Linear Tape)
  - Travan

About Tape Drives

- Common types of tape cartridges (cont'd):
    - AIT (Advanced Intelligent Tape)
    - SLR (Scalable Linear Recording)
- When selecting a tape drive, consider:
    - How many and what type of cartridges the drive can use
    - How it interfaces with the computer
- External drives can connect to a computer using a USB, FireWire, SCSI, SAS, or eSATA port

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Supporting Other Types of Storage Drives

- Storage devices to support might include:
  - Optical discs
  - USB flash drives
  - Memory cards

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File Systems Used by Storage Devices

- File system – used to manage data stored on a device
  - Overall structure the OS uses to name, store, and organize files on a drive
  - In Windows, each storage device is assigned a driver letter
- Formatting – installing a new file system on a device
- Types of file systems:
  - NTFS, exFAT, FAT32 and FAT

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Standards Used by Optical Drives and Discs

- CDs, DVDs, and Blu-ray discs (BD) use similar laser technologies

  - Tiny lands and pits on surface represent bits read by a laser beam

- CD drives use CDFS (Compact Disc File System) or UDF (Universal Disk Format) file system

- DVD and Blue-ray drives use UDF

- Internal optical drive interfaces with motherboard via a SATA connection

  - External might use eSATA, FireWire, or USB

Standards Used by Optical Drives

- 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 in two layers on each side

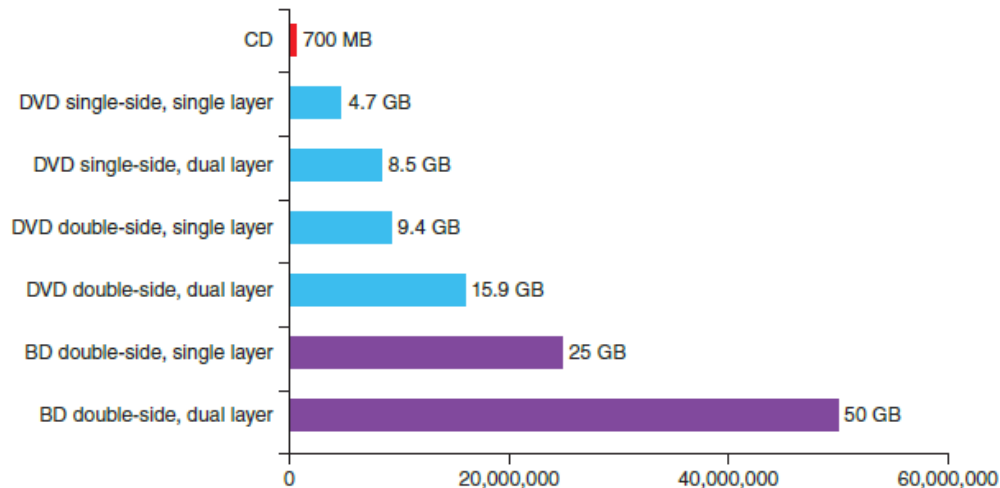|	
CD	700 MB
DVD single-side, single layer	4.7 GB
DVD single-side, dual layer	8.5 GB
DVD double-side, single layer	9.4 GB
DVD double-side, dual layer	15.9 GB
BD double-side, single layer	25 GB
BD double-side, dual layer	50 GB

Figure 6-42 Storage capacities for CDs, DVDs, and BD discs

Replacing an Optical Drive on a Laptop

- Replacing optical drives:
  - Unplug the AC adapter and remove the battery pack
  - Remove keyboard (not all laptops require this step)
  - Remove screw holding DVD drive to the laptop
  - Slide drive out of the bay and new drive into the bay
    - Ensure connection with drive connector
    - Replace the screw

Solid State Storage

- Solid-state storage:
  - SSD hard drives, USB flash drives, and memory cards
- USB flash drives go by many names:
  - Flash pen drive, jump drive, thumb drive, and key drive
  - Might work at USB 2.0 or USB 3.0 speed
  - Use FAT or exFAT file system
  - Windows 8/7/Vista has embedded drivers to support flash drives

Solid State Storage

- Memory cards might be used in:
  - Digital cameras, tablets, cell phones, MP3 players, digital camcorders, etc…
  - Most laptops have memory card slots
- SD (Secure Digital) Association is responsible for standards:
  - 1.x (regular SD)
  - 2.x (SD High Capacity or SDHC)
  - 3.x (SD eXtended Capacity or SDXC)
- SD cards come in three physical sizes

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Solid State Storage

- SDHC and SDXC slots are backward compatible with SD cards

- Cannot use:
  - SDHC card in an SD slot
  - SDXC card in an SDHC or SD slot

- SD and SDHC cards use FAT file system

- SDXC cards use exFAT file system

Troubleshooting Hard Drives

- Problems caused by hard drive during the boot can be caused by:
  - Hard drive subsystem
  - File system on the drive
  - Files required by Windows when it begins to load
- When trying to solve a problem with the boot
  - Decide if the problem is caused by hardware or software

Slow Performance

- Common complaint:
  - Computer is running slowly
- Try running the defragmentation tool on the hard drive
  - The Windows defragmentation tool rearranges fragments or part of files in contiguous clusters so files are easier and faster to find

Hard Drive Problems During the Boot

- Hardware problems usually show up at POST

- Could be due to the drive, data cable, electrical system, motherboard, or a loose connection

- Things to do and check before opening case:
  - Check to see if UEFI/BIOS displays a numeric error code or other message during POST
  - Check UEFI/BIOS setup for errors in the hard drive configuration
  - Try booting from another bootable media
  - For a RAID array, use the firmware utility to check the status of each disk in the array and check for errors

Hard Drive Problems During the Boot

- If the problem is still not solved, open case and check these things:
  - Remove and reattach all drive cables
  - If using a RAID, SATA, PATA, or SCSI controller card, remove and reseat it or place in a different slot
  - Inspect drive for damage
  - Determine if hard drive is spinning by listening to it
  - Check the cable for frayed edges
  - Check installation manual
  - S.M.A.R.T. errors mean data should be backed up and drive replaced as soon as possible

Hard Drive Problems During the Boot

- If the problem is still not solved, open case and check these things (cont'd):
  - Use Windows tools for checking a hard drive
  - Check the drive manufacturer's web site for diagnostic software
  - Move the device to a working computer and install it as a second drive
  - Exchange the three field replaceable units
    - Reconnect or swap the data cable
    - Reseat or exchange the controller card
    - Exchange the hard drive for a known good drive

Hard Drive Problems During the Boot

- If the problem is still not solved, open case and check these things (cont'd):
  - Use Windows tools for checking a hard drive
  - Check the drive manufacturer's web site for diagnostic software
  - Move the device to a working computer and install it as a second drive
  - Try these things to clean the drive and get a fresh start:
    - Format the drive
    - Use *diskpart* to start over with a fresh file system

Hard Drive Problems During the Boot

- If the problem is still not solved, open case and check these things (cont'd):
    - Exchange the three field replaceable units
        - Reconnect or swap the data cable
        - Reseat or exchange the controller card
        - Exchange the hard drive for a known good drive
    - If your drives whines loudly, try replacing it
    - A bad power supply or a bad motherboard also might cause a disk boot failure

Summary

- A hard disk drive (HDD) comes in 3.5" for desktop and 2.5" and 1.8" for laptops

- A hard drive can be magnetic, solid-state, or hybrid

- Most hard drives, tape drives, and optical drives use the SATA interface standards

- Three SATA standards provide data rates of 1.5 Gb/sec, 3.0 Gb/sec, and 16.0 Gb/sec

- S.M.A.R.T is a self-monitoring technology whereby the BIOS monitors the health of a hard drive

Summary

- When selecting a hard drive, consider storage capacity, technology, spindle speed, interface standard, and buffer size

- SATA drives require no configuration and are installed using a power cord and a data cable

- Laptop hard drives plug directly into a SATA connection on the system board

- RAID technology uses an array of hard drives to provide fault tolerance and/or improvement in performance

Summary

- Hardware RAID is implemented using the motherboard UEFI/BIOS or a RAID controller card

- Software RAID is implemented in Windows

- Tape drives are an inexpensive way to back up an entire hard drive or portions of it

- File systems a storage device might use in Windows include NTFS, exFAT, and FAT

- Optical discs can be recordable (CD-R) or rewritable (DVD-RW)

Summary

- Types of flash memory standards include SD, MiniSD, MicroSD, SDHC, MiniSDHC, MicroSDHC, SDXC, MicroSDXC

- Other memory cards include Memory Stick PRO Duo, Memory Stick PRO, Memory Stick Micro M2, CompactFlash I and II, and xD-Picture Card

- Problems caused by the hard drive during a boot can be caused by the hard drive subsystem, file system, or by files required by Windows to load