Floppy Drive & Hard Drive

Overview

• In this chapter, you will learn to
  – Learn how the organization of data on floppy drives and hard drives is similar
  – Explain how hard drives work
  – Identify and explain the different hard drive interfaces
  – Configure BIOS for hard drives and controllers
  – Troubleshoot hard drive installation

Introduction

• Hard drive: most important secondary storage device
• Hard drive technologies have evolved rapidly
  – Hard drive capacities and speeds have increased
  – Interfaces with the computer have also changed
• Floppy disk will be presented before hard drives
  – Floppy disk is logically organized like a hard drive
• Practical applications:
  – Managing problems occurring during drive installation
  – Troubleshooting hard drives after installation

Learning from Floppy Drives

• Floppy drives are an obsolescent technology
  – Replacements:
    • CD drives and USB flash memory
• Good reasons for studying floppy drive technology
  – Developing support skills for legacy applications
  – Building a foundation for hard drive support skill set

How Floppy Drives Work

• Secondary storage devices are organized logically and physically
  – Physical storage: how data is written to media
  – Logical storage: how OS and BIOS view stored data
• How data is physically stored on a floppy disk
  – Two types of floppy disk: 5 ¼ inch or 3 ½ inch
  – Subsystem: drive, 34-pin cable, connector, power cord
  – Formatting: marking tracks and sectors on a disk
  – Magnetic read/write heads read/write binary 1s and 0s
  – Heads attach to actuator arm that moves over surface
Inside a floppy disk drive

How Floppy Drives Work (continued)

- How data is logically stored on a floppy disk
  - Floppy drives are always formatted using FAT12
  - Cluster (file allocation unit): smallest grouping of sectors
  - The BIOS manages the disk as a set of physical sectors
  - OS treats the disk as list of clusters (file allocation table)
  - A 3 ½ inch high density floppy disk has 2880 clusters

- Format floppy disk using Format or Windows Explorer
  - Structures and features added to the disk
    - Tracks, sectors, boot record, two FATs, root directory

Clusters, or file allocation units, are managed by the OS in the file allocation table, but BIOS manages these clusters as one or two physical sectors on the disk

How to Install a Floppy Drive

- It is more cost-effective to replace than repair a drive

- A simple seven-step installation procedure:
  - 1. Turn off computer, unplug power cord, remove cover
  - 2. Unplug the power cable to the old floppy drive
  - 3. Unscrew and dismount the drive
  - 4. Slide the new drive into the bay
  - 5. If drive is new, connect data cable to motherboard
  - 6. Connect data cable and power cord to drive
  - 7. Replace the cover, turn on computer, verify status

Connect colored edge of cable to pin 1

What if you can’t read a floppy disk?
How Hard Drives Work

Definition

- A hard disk drive is a sealed unit that a PC uses for nonvolatile data storage.
  - Nonvolatile, or semi-permanent, storage means that the storage device retains the data even when no power is supplied to the computer.
  - What is volatile?
- A hard disk drive contains rigid, disk-shaped platters, usually constructed of aluminum or glass.
  - coated with a magnetic medium

Hard Disk Advancement

- Parkinson’s law
  - “Work expands so as to fill the time available for its completion.”

The Hard Drive

- The closer the read/write heads are to the platter, the more densely the data packs on to the drive
- Hard drives use a tiny, heavily filtered aperture to equalize the air pressure between the exterior and interior of the hard drive

Air Filters

- Nearly all hard disk drives have two air filters.
  - the recirculating filter
  - the barometric or breather filter
- Permanently sealed inside the drive
- Are designed never to be changed for the life of the drive.

Form Factors

- Standardization
- Several standards
  - 5 1/4” drive
  - 3 1/2” drive
  - 2 1/2” drive
  - 1.8” drive
  - 1” drive
  - Microdrive
**Data Encoding**

- Hard drives store data in tiny magnetic fields called *fluxes*.
- The flux switches back and forth through a process called *flux reversal*.
- Hard drives read these flux reversals at a very high speed when accessing or writing data.
  - Fluxes in one direction are read as 0 and the other direction as 1.

**Arm Movement in the Hard Drive**

- Two technologies have been used for moving the actuator arm:
  - The stepper motor technology
    - Moves the arm in fixed increments or steps
    - Cold/warm
  - The voice coil technology
    - Uses a permanent magnet surrounding the coil on the actuator arm to move the arm.

  With a stepper motor, it was important to park the drive in a non-data area to prevent damage to the surface of the drive. Today that is not necessary with voice coil technology.

**Geometry**

- **Geometry** is used to determine the location of the data on the hard drive.
- The geometry for a particular hard drive is described with five special values:
  - Heads
  - Cylinders
  - Sectors per track
  - Write precomp
  - Landing zone

**Heads**

- **Heads**
  - Number of read/write heads used by the drive to store data.
  - Two heads per platter (top and bottom).
  - Most hard drives have an extra head or two for their own usage, so the number may not be even.

  Two tracks - one on top and another underneath.

**Cylinders**

- **Cylinders**
  - Group of tracks of the same diameter going completely through the drive.

  A hard drive with two platters.

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Sectors per Track

- **Sectors per track**
  - Number of slices in the hard drive
  - 512 bytes per sector

Floppy drives and older hard drives use a constant number of sectors per track.

Zone bit recording can have more sectors per track as the tracks get larger.

Geometry

- **Write precompensation cylinder**
  - Obsolete
  - The specific cylinder from where the drive would write data a little farther apart
    - Sectors towards the inside of the drive would physically occupy less space than sectors on the outside of the drive. Therefore, older drives would write data farther apart on the outside cylinders.

- **Landing zone**
  - Unused cylinder as a ‘parking place’ for read/write heads
    - Referred to as Lzone, LZ, Park
    - Meaningless in today’s PCs

The Big Three

- **CHS refers to Cylinders, Heads, Sectors/track**
  - You used to have to manually enter this information in CMOS, but now drives have that information on the drive itself and the BIOS queries it automatically

Hard Drive Interfaces
Hard Drive Interfaces

- Integrated Drive Electronics (IDE) / Enhanced IDE (EIDE) interfaces dominate today’s market
  - Parallel ATA (PATA) drives dominate the industry
  - Serial ATA (SATA) since 2003
- Small Computer System Interface (SCSI) interfaces are fading away

Early Hard Drives

- Early drives did not have the controller card integrated with the drive. The hard drive controller was a separate card
- To prepare an older drive you had to erase all the geometry (including the data) and reinstall the geometry using a low-level format
- Then you had to enter the geometry into CMOS

IDE / EIDE

- Integrated Drive Electronics and Enhanced IDE
  - Hard drive controller is integrated with the drive
  - Uses the AT Attachment (ATA) interface and a 40/80-pin ribbon cable
  - Everyone calls ATA drives IDE
  - EIDE added some enhancements to IDE
    - Higher capacities
    - Support for non-hard drive devices like CD-ROMs
    - Support for up to 4 hard drives
  - ATA, IDE, and EIDE are used interchangeably today to describe all ATA devices

IDE/EIDE

- EIDE drives connect to the computer via a 40/80-pin cable and a controller
- The controller acts as an intermediary between the hard drive and the external data bus
- When the BIOS talks to the hard drive, it talks to the circuitry onboard the hard drive
  - But we still call the connection on the motherboard the hard drive controller (a misnomer)
- Most PCs provide two onboard EIDE controllers to support up to four hard drives
  - Use the primary controller if you are only connecting one device
  - The other controller is the secondary controller

Controller Cards

- Expansion controller card

Primary and Secondary Controllers
IDE/EIDE

Cabling EIDE Drives:
- EIDE drives connect to the controller via a simple 40/80-pin cable
- A single cable can connect up to two hard drives: master and slave based on the jumper settings.
- Cable-select may be set on both drives if you have a cable-select cable

Jumpers and Labels

Master or Slave – it doesn’t matter which connector you use.

ATAPI

Advanced Technology Attachment Packet Interface (ATAPI)
- Extension to the ATA specification
- Enables non-hard drive devices to connect to the PC via ATA controllers
- Same rules on jumper settings
- Hard drives get BIOS thru the System BIOS and CMOS
- Non-hard drives get BIOS thru an option ROM or software driver

Serial ATA

- Serial ATA (SATA) creates a point-to-point connection between the device and the controller
  - Data is sent serially
  - Thinner cables resulting in better air flow and cable control in the PC
  - Maximum cable length of 39.4 inches compared to 18 inches for PATA cables

Serial ATA

- More on SATA
  - Hot-swappable
  - Throughput of 150 MBps (with potential of 600 MBps)
  - A parallel ATA device (PATA) may be connected to SATA using a SATA bridge
  - Add SATA functionality via a PCI card
  - Only one device per controller
    - No master/slave/cable-select

Hard Disk Performance

- Transfer Rate
- Average Access Time
**Hard Disk Performance**

- **Transfer rate**
  - Media transfer rate
  - Raw maximum
  - Raw minimum
  - Raw average
  - Formatted maximum
  - Formatted minimum
  - Formatted average

- Interface transfer rate
- Two contributing factors
  - Rotational speed
  - Linear recording density or sectors per track
  - 7200 rpm, average 672 sectors per track, what's the average media transfer rate?

- **Average access time**
  - Average seek time
  - Movement of arm
  - Latency
  - RPM

- **Some other factors**
  - Cache programs and cache controllers
  - MTBF
  - SMART
  - Self-Monitoring, Analysis, and Reporting Technology

**BIOS Support: Configuring CMOS and Installing Drivers**

**CMOS**

- The CMOS setup should be updated with the drives geometry after the hard drive is installed in the system:
  - With today's hard drives you may simply set the type to Auto and the hard drive and CMOS will work it out – up to four ATA devices may be connected
  - With much older hard drives you must manually enter all of the geometry – support for only two hard drives maximum

**User and Auto Types**
Autodetection

Storage Technologies

- Logical Block Addressing (LBA) and Enhanced CHS (ECHS)
  - LBA/ECHS is an advanced type of sector translation
  - The onboard circuitry of the drive translates the logical geometry into physical geometry. This function is called sector translation.
  - LBA provides support for a maximum hard drive size of 8.4 GB

<table>
<thead>
<tr>
<th>Table 10.4</th>
<th>Western Digital WD2160’s Physical and Logical Geometries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Logical</td>
</tr>
<tr>
<td>Cylinders</td>
<td>Cylinders 1024</td>
</tr>
<tr>
<td>Heads</td>
<td>Heads 64</td>
</tr>
<tr>
<td>Sector/Track</td>
<td>Sector/Track 64</td>
</tr>
<tr>
<td>Total Capacity</td>
<td>Total Capacity 2.1 GB</td>
</tr>
</tbody>
</table>

Storage Technologies (continued)

- LBA and ECHS works the same way as LBA, but has different values
  - LBA was developed by Western Digital
  - ECHS was developed by Seagate
- Interrupt 13 extensions (INT13) were a set of BIOS commands introduced by Phoenix Technologies
- A system with INT13 can handle drives up to 137 GB

CMOS

- The LBA setting for a drive indicates that the drive is capable of logical block addressing
- The Normal setting notifies the system to use the physical geometry, rather than the logical geometry
  - Used with OS’s that don’t use the BIOS such as NetWare and some versions of UNIX
- The Large setting indicates that the device is capable of ECHS
  - Not all systems support ECHS but all systems do support LBA – use LBA

ATA/ATAPI-6

- INT13 extensions provided an upper limit of 137 GB for hard drive size
- ANSI ATA committee has now adopted a new standard called Big Drives with the official name ATA/ATAPI-6
  - Supports a maximum size of 144 petabytes (144,000,000 GB)

Transferring Data

- Two modes through which ATA devices transfer data to and from the hard drive and memory
  - Programmable input/output (PIO)
  - Direct Memory Access (DMA)
- It is essential to set the proper PIO mode for the drives to get the best performance out of them
  - PIO modes define the data transfer rate between RAM and the hard drive
  - The slower of the PIO modes supported by the hard drive, controller, BIOS, or device driver should be used
- DMA data transfers can be 16-bit wide or 32-bit wide
**PIO Speeds**

<table>
<thead>
<tr>
<th>PIO Mode</th>
<th>Cycle Time (μs)</th>
<th>Transfer Rate (MBps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>600</td>
<td>3.3</td>
</tr>
<tr>
<td>3</td>
<td>385</td>
<td>5.2</td>
</tr>
<tr>
<td>2</td>
<td>240</td>
<td>6.5</td>
</tr>
<tr>
<td>3</td>
<td>190</td>
<td>11.1</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
<td>16.6</td>
</tr>
</tbody>
</table>

**ATA/66 and ATA/100**

- Advanced DMA modes are:
  - Ultra DMA mode 4 (called ATA/66) – 66 MBps
  - Ultra DMA mode 5 (called ATA/100) – 100 MBps
  - Ultra DMA mode 6 (called ATA/133) – 133 MBps

- The ATA/66 and ATA/100 require special controllers and 80-wire (40-pin) ribbon cables
- All higher-end drives can run on lower-end controllers; most controllers can handle lower-end drives

**DMA and Ultra DMA Speeds**

<table>
<thead>
<tr>
<th>DMA Mode</th>
<th>Cycle Time (μs)</th>
<th>Transfer Rate (MBps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>480</td>
<td>2.0</td>
</tr>
<tr>
<td>1</td>
<td>240</td>
<td>5.0</td>
</tr>
<tr>
<td>Ultra DMA</td>
<td>Cycle Time (μs)</td>
<td>Transfer Rate (MBps)</td>
</tr>
<tr>
<td>0</td>
<td>240</td>
<td>3.6</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>7.0</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>11.1</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>15.5</td>
</tr>
</tbody>
</table>

**Motherboards**

- Many motherboards come with a variety of controllers
  - ATA-66 controllers are usually blue
  - ATA-100 controllers are usually red
- Plug the blue or red connector on the cable into the motherboard, the black connector into the master drive, and the gray connector into the slave drive

**80-wire Ribbon Cables**

- 80-wire ribbon cables still have 40 pins – the extra wires are used to reduce noise

**Device Drivers**

- ATAPI Devices show up in CMOS but true BIOS support comes from a driver at boot-up
- Serial ATA require loading drivers for an external SATA controller and configuring the controller Flash ROM settings for the specific drive
The most important part of a PC is the data it holds
- Companies have gone out of business because of losing the data on their hard drive
- Since hard drives will eventually crash and die, it is important to find a way to save the data when a hard drive fails
  - This can be done by having multiple hard drives that work together
  - Redundant Array of Inexpensive Disks (RAID) is one such technology

Protecting Data

RAID Level 0
- Disk Striping
  - Writes data across multiple drives at once
  - Requires at least 2 hard drives
  - Does not provide redundancy
  - If any drive fails, the data is lost

RAID Level 1
- Disk Mirroring/Duplexing is the process of writing the same data to two drives at the same time
  - Requires at least two drives
  - Produces an exact mirror of the primary drive
  - Mirroring uses the same controller
  - Duplexing uses separate controllers

RAID Level 2
- Disk Striping with Multiple Parity Drives
  - Not used

RAID Levels 3 and 4
- Disk Striping with Dedicated Parity
  - Dedicated data drives and dedicated parity drives
  - Quickly replaced by RAID 5

RAID Level 5
- Disk Striping with Distributed Parity
  - Distributes data and parity evenly across the drives
  - Requires at least 3 drives
  - Most common RAID implementation
**RAID Level 6**

- **Super Disk Striping with Distributed Parity**
  - RAID 5 with asynchronous and cached data capability

**Implementing RAID**

- RAID provides a general framework but does not say how to implement RAID
- Multiple hard drives hooked together is the first step...whether SCSI or ATA
- Next, should you use hardware or software to control the array?
  - Software is cheaper and does not require special controllers – but taxes the OS and is slower
  - Windows NT and Windows 2000 Server provide software RAID solutions
  - Hardware provides speed with data redundancy at a price
    - Most common implementations
    - Includes hot swapping

**Personal RAID**

- ATA RAID controller chips have gone down in price
- Some motherboards are now coming with RAID built-in
- RAID has been around for 20 years but is now less expensive and moving into the desktop system

**Troubleshooting Hard Drive Installation**

- With autodetection in CMOS, if you don’t see the drive, there’s a hardware configuration issue
  - Jumpers: master, slave, cable select settings
  - Data cable: pin 1 to pin 1
  - Power: be sure the drive has power
  - BIOS: provide BIOS for the controller and drive (CMOS)
  - Other items:
    - Is the controller enabled?
    - PIO and DMA modes
    - Does the motherboard support the drive

**Partitioning and Formatting Drives**
Partitioning

- **Partitioning** is the process of electronically subdividing the physical hard drives into groups of cylinders called partitions
  - Windows assigns these partitions names like C: or D:
  - A hard drive must have at least one partition
  - Partitioning enables organization of a drive that suits your personal taste
  - Partition size are limited by the file system and the operating system

- It enables a single hard drive to store more than one operating system
- The **boot sector** is the first sector of the physical drive and contains information regarding the master boot record (MBR) and the partition table
  - MBR's job is to look for valid operating systems
  - Up to four bootable partitions – only one is marked active at a time and contains the OS that is booted

Primary partitions:
- Store the operating system
- A hard drive can have up to four primary partitions
- An active partition is a partition on which the MBR finds the operating system
- Only one primary partition can be active at a time

Extended partitions:
- Extended partitions are not bootable and one hard drive can have only one extended partition
- Optional
- They can be divided into many logical drives
- Make the partition extended and then create logical drives within it

FDISK

- **FDISK** is used to partition hard drives by DOS, Windows 3.x, Windows 95, Windows 98, and Windows Me
- Boot to a floppy and then type FDISK to start the program
- Win95 ver 2 and later support FAT32
  - When the long message comes up saying you have a disk larger than 512 MB...
    - Choose Yes to use FAT32
    - Choose No to use FAT16
  - If you don't get the message you are using an older version of FDISK that only supports FAT16

FDISK Opening Screen

- Your computer has a disk larger than 512 MB... This version of Windows requires support for large disks, resulting in more efficient file allocation; you, 16 bits drives, and allows drives over 2 GB to be used.
  - Press the F10 key to continue...

- FDISK will now configure the disk in the system BIOS. If you are using an extended virtual memory system you can use both the extended partition and free hard disk space...

- Y means Yes for FAT32
- N means No for FAT16

FDISK Main Menu

- Microsoft Windows 98
  -Fixed Disk Setup Program
  -©Copyright Microsoft Corp 1993 - 1998

  FDISK Options
  - Current fixed disk device: S
  - Choose one of the following:
    - Create DOS partition or logical DOS drive
    - Add active partition
    - Create partition or logical DOS drive
    - Display partition information

  Enter choice [1]:

  Press F10 to exit FDISK
FDISK Main Menu
Option 4

Blank drive indicated. If not, you may choose option 3 on the main menu to delete any unwanted partitions. Note that you will lose all data in the partition.

Es esc always takes us back!

Main Menu Option 1

Create DOS Partition or Logical DOS Drive

Current fixed disk drive: 4
Choose one of the following:
1. Create Primary DOS Partition
2. Create Logical DOS Partition on the Extended DOS Partition

Enter choice (1)

Press Esc to return to FDISK Options

Disk Management

- Used by Windows 2000 and XP to manage partitions

Formatting

- Low-level formatting
  - Now done in the factory
  - Mark tracks, sectors
- High-level formatting
  - Configuring a partition, in order to enable it to hold files and folders in a form suitable to the operating system
  - Creating and configuring the file system