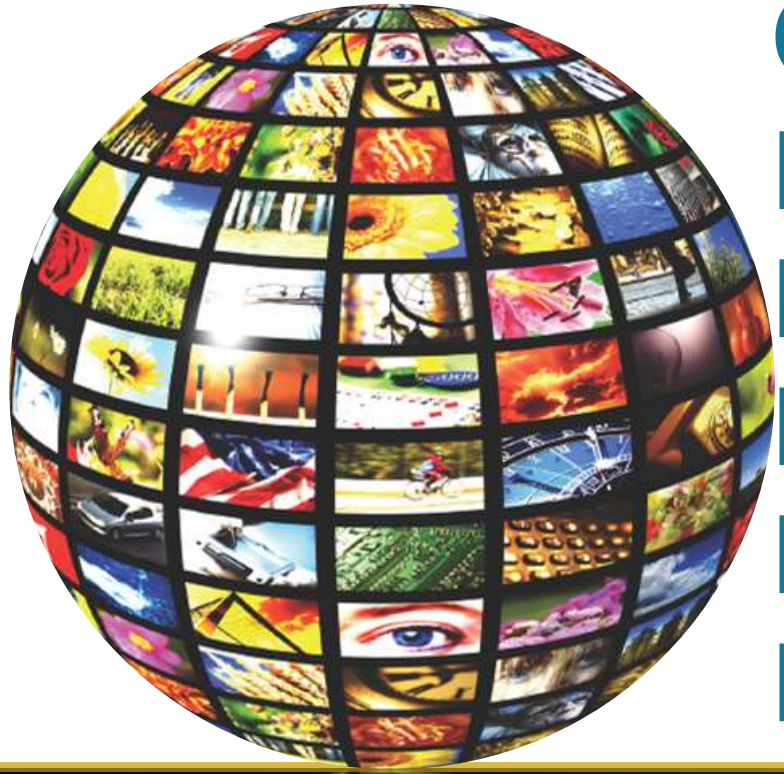
Chapter



Chapter 2 HARDWARE

Part 1 – Evolution

Part 2 – System Unit

Part 3 – Input Output

Part 4 - Secondary Storage

Part 5 –Hardware Trends

Learning Objectives
Part 1 – Evolution of IT Hardware

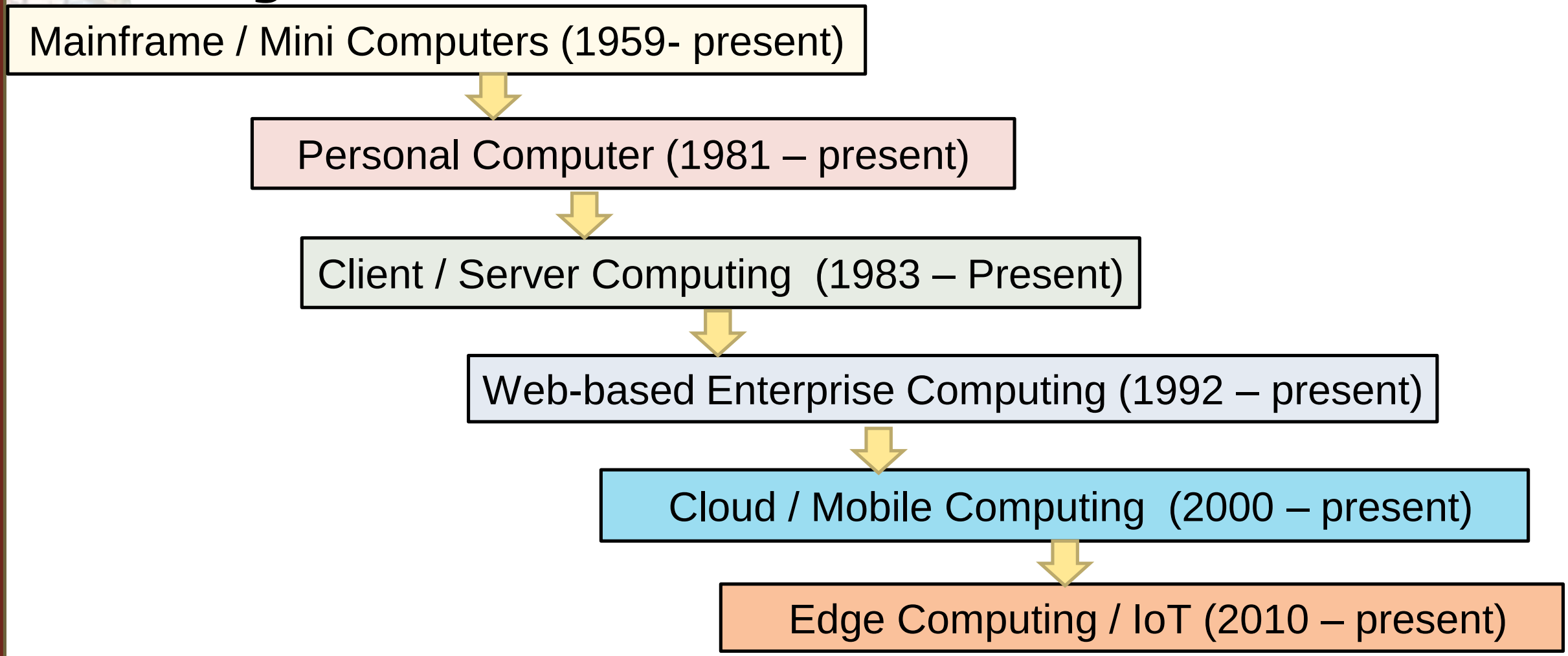
COMPUTERHARDWARE

1. Explain the stage of IT Infrastructure
2. Different type of computer hardware

Evolution of IT Infrastructure

COMPUTERHARDWARE

Stages in IT Infrastructure Evolution



General-Purpose Mainframe and Minicomputer Era: (1959 to Present)

COMPUTERHARDWARE

- The introduction of the IBM 1401 and 7090 transistorized machines in 1959 marked the beginning of widespread commercial use of **mainframe** computers. In 1965, the mainframe computer truly came into its own with the introduction of the IBM 360 series. Mainframe computers became powerful enough to support thousands of online remote terminals connected to the centralized mainframe using proprietary communication protocols and proprietary data lines.
- **Minicomputer** – powerful yet less expensive computers, allowing decentralized computing customizable to individual departments or business units

Personal Computer Era: (1981 to Present)

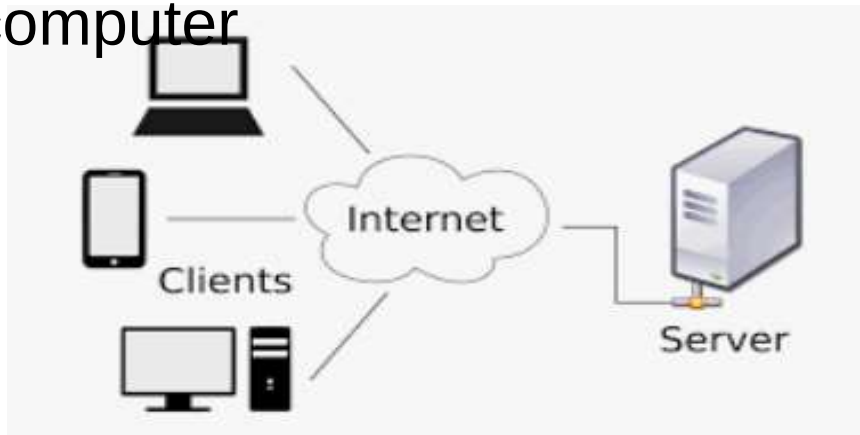
COMPUTERHARDWARE

- Proliferation of PCs in the 1980s and early 1990s launched a spate of personal desktop productivity software tools—word processors, spreadsheets, electronic presentation software, and small data management programs—that were very valuable to both home and corporate users. These PCs were stand-alone systems until PC operating system software in the 1990s made it possible tc link them into networks.

Client/Server Era (1983 to Present)

COMPUTERHARDWARE

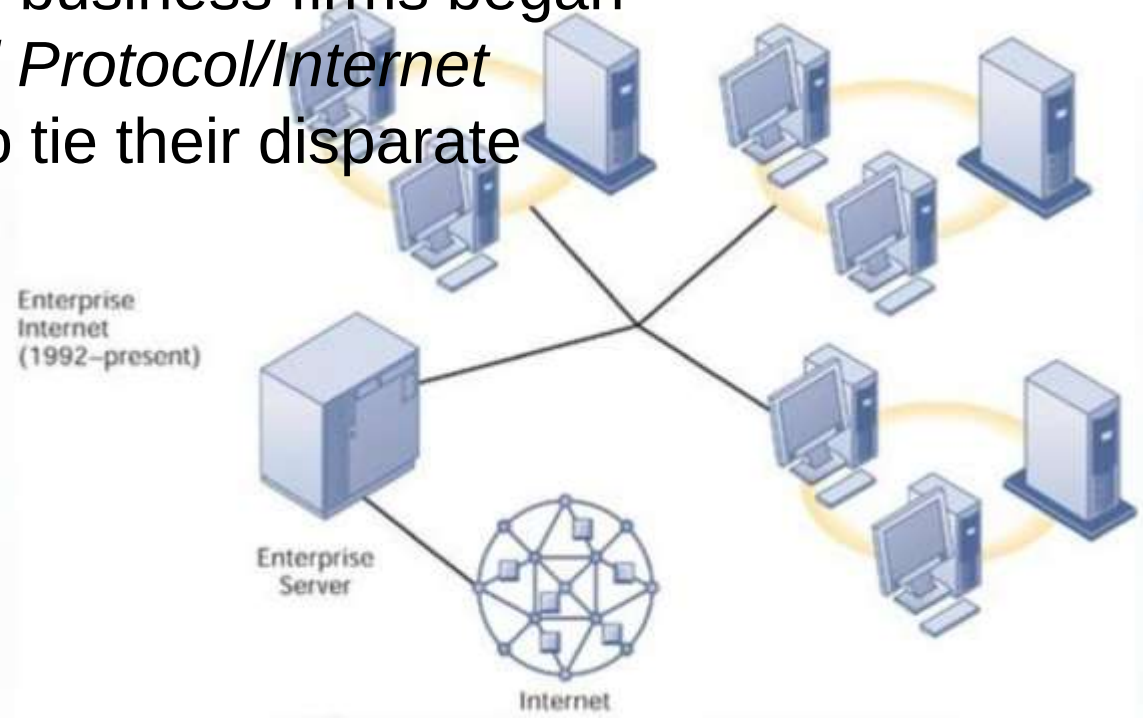
- In **client/server computing**, desktop or laptop computers called **clients** are networked to powerful **server** computers that provide the client computers with a variety of services and capabilities. Computer processing work is split between these two types of machines. **The client** is the user point of entry, whereas the server typically processes and stores shared data, serves up Web pages, or manages network activities. The term "**server**" refers to both the software application and the physical computer on which the network software runs. The server could be a mainframe, but today, server computers typically are more powerful versions of personal computers, based on inexpensive chips and often using multiple processors in a single computer box., or in server racks.



Web-based Enterprise Computing Era (1992 to Present)

COMPUTER HARDWARE

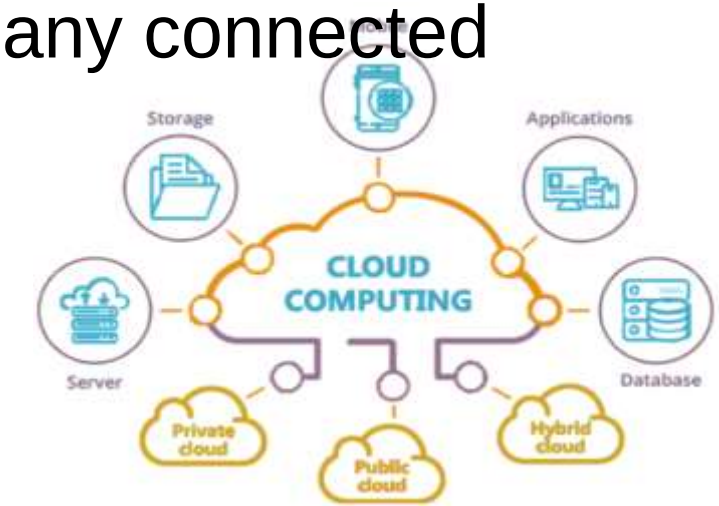
- In the early 1990s, firms turned to networking standards and software tools that could integrate disparate networks and applications throughout the firm into an enterprise-wide infrastructure. As the Internet developed into a trusted communications environment after 1995, business firms began seriously using the *Transmission Control Protocol/Internet Protocol (TCP/IP)* networking standard to tie their disparate networks together.



Cloud and Mobile Computing Era (2000 to Present)

COMPUTERHARDWARE

- The growing bandwidth power of the Internet has pushed the client/server model one step further, towards what is called the "Cloud Computing Model." **Cloud computing** refers to a model of computing that provides access to a shared pool of computing resources (computers, storage, applications, and services) over a network, often the Internet. These "clouds" of computing resources can be accessed on an as-needed basis from any connected device and location.



Edge Computing and IoT Era (2010-present)

COMPUTERHARDWARE

- As IoT devices proliferated, there was a need to process data closer to where it was generated to reduce latency and bandwidth usage, leading to the growth of edge computing.
- improve real-time data processing and real-time decision-making

HARDWARE -Part 2 (System Unit) Introduction

COMPUTERHARDWARE

- Speed, capacity, and flexibility determine the power of personal computers.
- Knowledge of a computer's power allows you to make good buying decisions and to determine if your current system will run new applications.
- Competent end users need to understand the functionality of the basic components of the system unit

Learning Objectives
Part 2 – System Unit

COMPUTER HARDWARE

1. Differentiate between the five basic types of system units.
2. Describe system boards, including sockets, slots, and bus lines.
3. Recognize different microprocessors, including microprocessor chips and specialty processors.
4. Compare different types of computer memory including RAM, ROM, and flash memory.
5. Explain expansion slots and cards.
6. Describe bus lines, bus widths, and expansion buses.
7. Describe ports, including standard and specialized ports.
8. Identify power supplies for desktop, laptop, tablet, and mobile devices.
9. Explain how a computer can represent numbers and encode characters electronically.

System Unit

System Chassis

- Container that houses most of the electronic components that make up a computer system

System Unit

- Contains system's electronic components and selected secondary storage devices

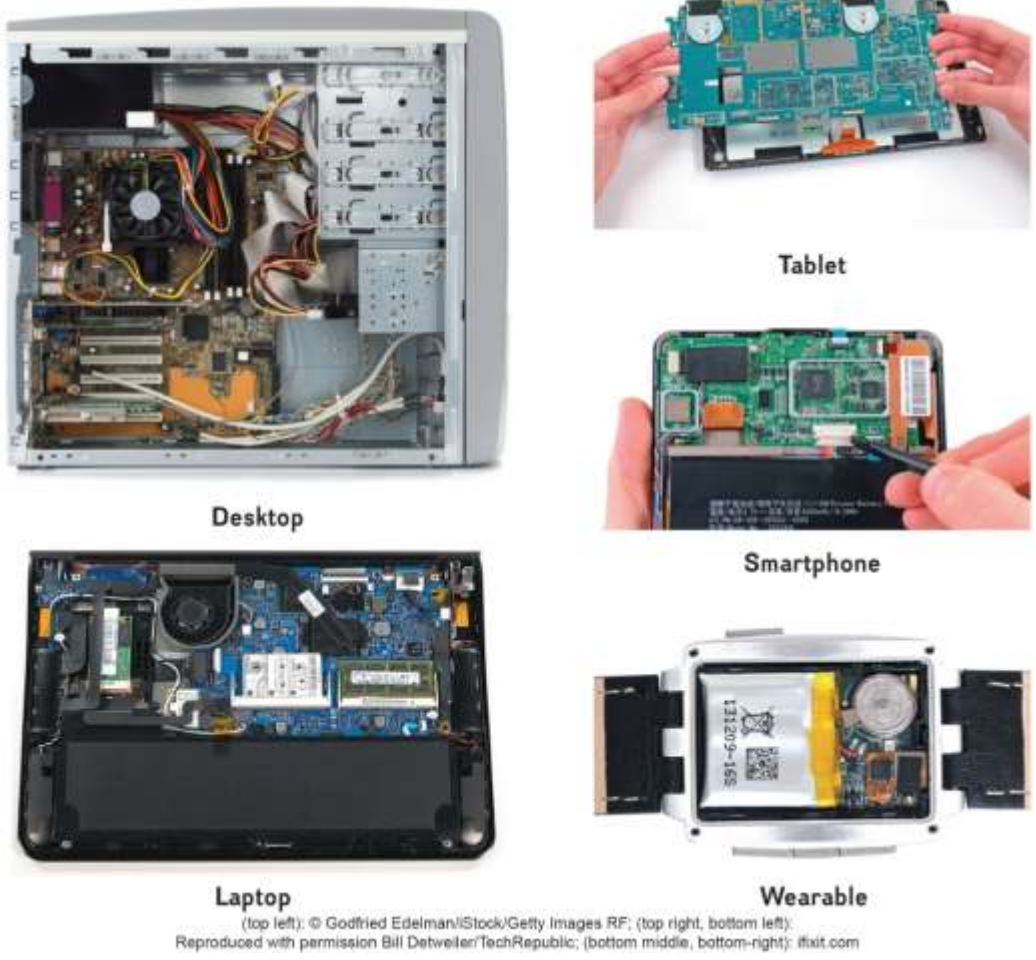
System Unit Types

1. Desktops
   - System unit is in a separate case
     - Tower Units
     - All-in-Ones
       - All components including monitor
2. Laptops
   - Portable and much smaller
     - Ultrabooks – laptop and tablet in one
     - Gaming – high end graphics
3. Tablets
   - Mini tablet
4. Smartphone
   - Most popular device – handheld computer
   - Extend the capabilities of cell phones
5. Wearables
   - Contain embedded computers

Components

COMPUTER HARDWARE

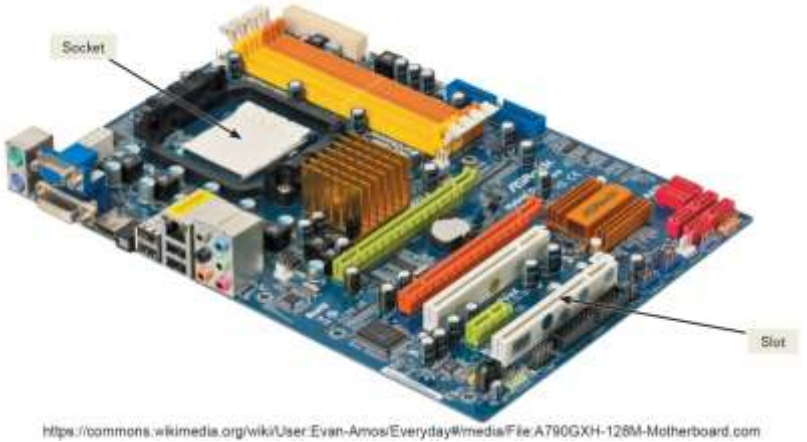
- Although all devices come in many shapes and sizes they have similarities such as
  - System boards
  - Microprocessors
  - Memory



System Board

System board or main board or motherboard controls communication for the entire computer system

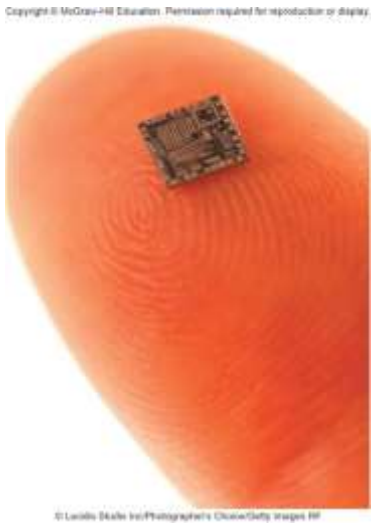
- All components and devices connect to the system board
- Data path and traffic monitor
  - Allows various components to communication efficiently with one another

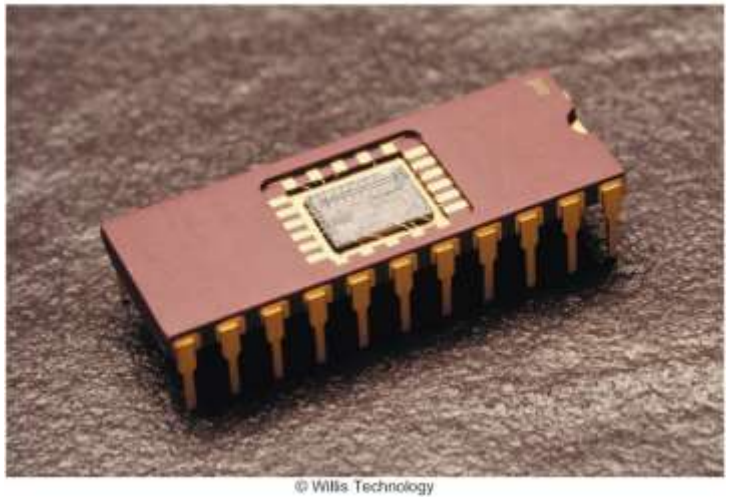


https://commons.wikimedia.org/wiki/User:Evan-Amos/Everyday#/media/File:A790GXH-128M-Motherboard.com

The system board contains a variety of electronic components

- Sockets – the connection point for chips
- Chips
  - Tiny circuit boards etched onto squares of silicon
  - Also called silicon chip, semiconductor, or integrated circuit
  - Mounted on chip carriers





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Slots and Bus Lines

Additional system board components:

- Slots
  - Provide a connection point for specialized cards or circuit boards
  - Provide expansion capabilities for the computer
- Bus lines
  - Connecting lines that provide pathways to support communication among electronic components

Microprocessor

- Central Processing Unit (CPU) or Processor
  - Contained on a single chip call a Microprocessor
  - Brains of the computer
- Two Basic Components of the CPU
  - Control unit
    - Tells the computer system how to carry out a program's instruction
  - Arithmetic-logic unit (ALU)
    - Performs arithmetic and logical operations

Microprocessor Chips

- Chip capacities are expressed in word size
  - Word is the number of bits that can be processed at one time: 16, 32 or 64
- Clock Speed
  - Processing speed or the number of times the CPU fetches and processes data or instructions in a second

Unit	Speed
Microsecond	Millionth of a second
Nanosecond	Billionth of a second
Picosecond	Trillionth of a second
Femtosecond	Quadrillionth of a second

Multicore Chips

- Multicore Processors
  - Two or more separate and independent CPUs within a system unit
    - Quad-core supports 4 core processes
- Parallel Processing
  - Computer's ability to divided tasks into parts that can be distributed across each core
  - Windows 8 and Mac OS X support parallel processing

Processor	Manufacturer
A-Series	AMD
Cortex-A series	ARM
Edison	Intel
i7	Intel

Specialty Processors

- Coprocessors
  - Designed to improve specific computing operations
  - Graphics Processing Unit (GPU) / Graphics coprocessors
  - Designed to handle a variety of specialized tasks
    - 3D images
    - Encrypting data
    - Standard features in gaming computers

Memory

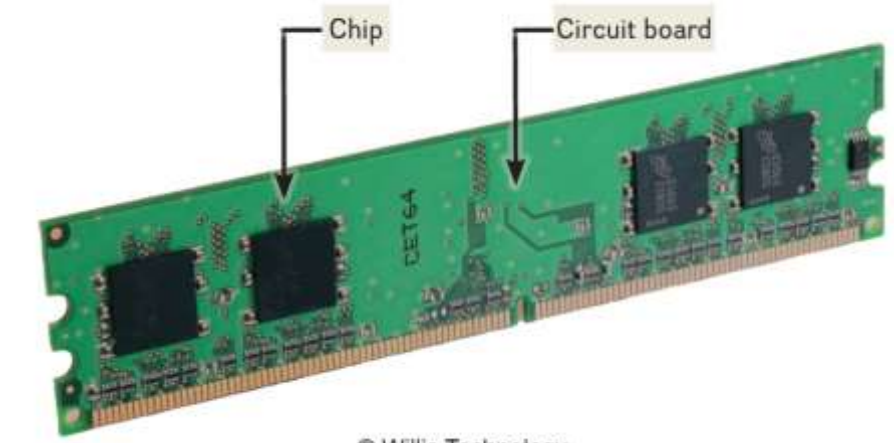
COMPUTER HARDWARE

- Holding area for data, instructions, and information
- Contained on chips connected to the system board
- Three well-known types of memory chips:
  - RAM
    - Random Access Memory
  - ROM
    - Read Only Memory
  - Flash Memory

RAM

COMPUTER HARDWARE

- Random Access Memory (RAM) chips hold programs and data that the CPU is presently processing
  - Volatile or temporary – contents are lost when computer is powered off
- Cache memory – temporary, high-speed holding area between the memory and CPU
  - Additional RAM can be added using an expansion module called a DIMM (Dual in-line memory module)



© Willis Technology

- Virtual Memory
  - Dividing a program between memory and storage enabling the system to run very large programs
- Memory is expressed in bytes

Unit	Capacity
Megabyte (MB)	1 million bytes
Gigabyte (GB)	1 billion bytes
Terabyte (TB)	1 trillion bytes

ROM

- Read-only memory (ROM)
  - Information stored by the manufacturer
  - Non-volatile and cannot be changed
- CPU can read, or retrieve data and programs in ROM but the computer cannot change ROM
- Contain special instructions
  - Start the computer
  - Access memory
  - Handle keyboard input

Flash Memory

- Flash memory combines of the features of:
  - RAM, it can be updated
  - ROM, it is non-volatile
  - Contains startup information
    - BIOS (basic input/output system)
    - Amount of RAM
    - Type of keyboard, mouse, and secondary storage devices connected

Many ROM chips are being replaced by flash memory

Expansion Slots and Cards

COMPUTER HARDWARE

Expands your system's capabilities

- Graphics cards for high quality 3D graphics
- Network interface cards (NIC) connect devices to networks via cables
- Wireless network cards connect devices to networks without cables
- SD cards
  - Expansion cards for mobile devices

Bus Lines / Bus Expansion Buses

Connect parts of the CPU to each other and various other components on the system board

- Pathway for bits representing data and instructions
- Bus width
  - Number of bits that can travel simultaneously down a bus
- Architecture and design are tied to the speed and power for the computer
- Two basic categories of buses
  - System bus – connects CPU to memory
  - Expansion bus – connects CPU to other components

Principle types:

- Universal Serial Bus (USB)
  - Connects external USB devices onto the USB bus
- FireWire
  - Primarily used to connect audio and video equipment to the system board
- PCI Express (PCIe)
  - Single dedicated path for each connected device

Ports

Socket for connecting external devices to the system unit

- Ports connect directly
  - To the system board
  - To cards inserted into slots on the system board
- Two Types
  - Standard Ports
  - Specialized Ports

Standard Ports

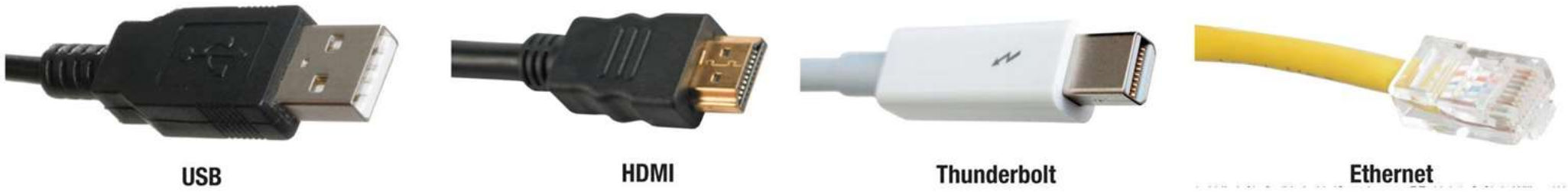
- USB
  - Keyboards, mice, printers, storage devices
- Ethernet
  - High speed networking
- HDMI – High Definition Multimedia Interface
  - High definition video and audio
- Thunderbolt
  - Provides high-speed connections
  - Can connect up to 7 separate devices through 1 port

Specialized Ports

- External Serial Advanced Technology Attachment (eSATA)
  - High-speed connection for external secondary storage
- Musical Instrument Digital Interface (MIDI)
  - Connect musical instruments
- Mini DisplayPort (MiniDP or mDP)
  - Connection to large monitors
- VGA & DVI
  - Connections to analog and digital monitors
- FireWire
  - High-speed connections to FireWire devices

Cables

- Used to connect external devices to the system unit via the ports
- One end of the cable is attached to the device and the other end has a connector that is attached to a matching connector on the port



Making IT Work for You ~ TV Tuners

- Using Windows Media Center as a DVR
- Install TV Tuner to connect your computer or cable to your computer

Courtesy of Hauppauge

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Power Supply

- Computers require direct current (DC) power converting alternating current (AC) from wall outlets or batteries
  - Desktop computers have a power supply unit in the system unit
  - Laptops use AC adapters in the system unit
  - Tablets and mobile devices use internal AC adapters
  - Smartphones can use wireless charging platforms

Electronic Data and Instructions

COMPUTER HARDWARE

- Digital electronic signals
  - Recognized by computers
- Analog signals
  - Continuous signal
  - Created by voices
- Conversion must take place from analog to digital before processing can occur

Numeric Representation

- Two-state binary system consists of only two digits called bits
  - On = 1; negative charge
  - Off = 0; no charge
- Byte = 8 bits grouped together
- Hexadecimal system
  - Uses 16 digits to represent binary numbers

(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F)

Decimal	Binary	Hex
00	00000000	00
01	00000001	01
02	00000010	02
03	00000011	03
04	00000100	04
05	00000101	05
06	00000110	06
07	00000111	07
08	00001000	08
09	00001001	09
10	00001010	0A
11	00001011	0B
12	00001100	0C
13	00001101	0D
14	00001110	0E
15	00001111	0F

HARDWARE -Part 3 (Input and Output) Introduction

COMPUTERHARDWARE

- Have you ever wondered how information gets into your computer or comes out in a form you can use?
  - Input devices convert what we understand into what the system unit can process
  - Output devices convert what the system unit has processed into a form that we can understand

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Learning Objectives
Part 3 – Input and Output

COMPUTER HARDWARE

1. Define input.
2. Describe keyboard entry including types and features of keyboards.
3. Identify different pointing devices including game controllers and styluses.
4. Describe scanning devices including optical scanners, RFID readers and recognition devices.
5. Recognize image capturing devices and audio-input devices.
6. Define output.
7. Identify different monitor features and types including flat-panels and e-books.
8. Define printing features and types including inkjet and cloud printers.
9. Recognize different audio and video devices including portable media devices.
10. Define combination input and output devices including multifunctional devices, telephones, drones, robots, and VR headgear and gloves.
11. Explain ergonomics and ways to minimize physical damage.

What is Input?

- Any data or instructions used by a computer
- Input devices translate data into a form that the system unit can process
- Some hardware input devices include:
  - Keyboards
  - Mice
  - Pointing
  - Scanning
  - Image capturing
  - Audio-input

Keyboard Entry

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- Keyboards
  - Traditional keyboards
  - Laptop keyboards
  - Virtual keyboards
  - Thumb keyboards

Pointing Devices

COMPUTER HARDWARE

Provide an intuitive interface by accepting pointing gestures and converting them into machine-readable input

- Wide variety of devices such as Mouse, Touch screen, Game controller, Stylus

Mouse Types

- Optical mouse
  - Has no moving parts
  - Emits and senses light to detect mouse movement
  - Can be used on any surface

- Wireless mouse
  - Battery operated
  - Uses radio waves or infrared light waves

- ch pads
  - Controls pointer by moving and tapping your fingers on the surface of the pad

Touch Screen

- Can be touched with more than one finger
- Common on mobile devices
  - Apple iPhone
  - Notebook computers
  - Desktop monitors
- Stylus is a pen-like device
  - Used on tablets
  - Uses handwriting recognition software

COMPUTERHARDWARE

Gaming Controllers

- Provide input to computer games
- Joysticks use pressure and direction of the stick
- Gaming mice are similar to a mouse but high precision
- Game pads use both hands
- Motion sensing device control games by user movement

Joystick

Gaming mouse

Gamepad

Motion-sensing device

Scanning Devices

Scanners convert scanned data into a form the system unit can process

- Optical scanners
  - Flatbed scanners
  - Document scanners
  - Portable scanners
  - 3D scanners

Card Readers

Interpret encoded information that is stored on debit, credit and identification cards

- Magnetic card reader
  - Information read from strip when swiped through reader
  - Smart cards hold additional security information

Bar Code Readers

Contain photo-electric cells that scan or read bar codes or the zebra striped marks printed on product containers

- Wand readers
  - Hand –held readers
- UPCs and MaxiCode readers
  - UPC are heavily used in grocery stores for automated checkout and inventory control
  - MaxiCode used by shipping companies for routing packages

COMPUTER HARDWARE

RFID Readers

Radio-frequency identification

Tiny chips embedded in most anything contain electronically stored information that can be read using an **RFID reader** located several yards away.

- Tracking pets
- Update and control inventories
- Read passports

Character and Mark Recognition Readers

Recognize special characters and marks

- Character and mark recognition devices
  - Magnetic-ink character recognition (MICR)
    - Used by banks to read encoded characters on checks
  - Optical-character recognition (OCR)
    - Reads preprinted characters such as wand scanners
  - Optical-mark recognition (OMR)
    - Sense the presence of absence of marks used for test scoring

Image Capturing Devices

COMPUTERHARDWARE

Create or capture original images

- Digital Camera
  - Capture images digitally and store in memory
- Web Cams
  - Capture images and send to a computer

Audio-Input Devices

- Voice recognition systems
  - Use a microphone, sound card, and special software
  - Users can operate computers and create documents using voice commands
  - Included in many smart phones
    - Siri in iPhones
    - Cortana in Windows phones
    - Google Now in Google phones

Output

COMPUTER HARDWARE

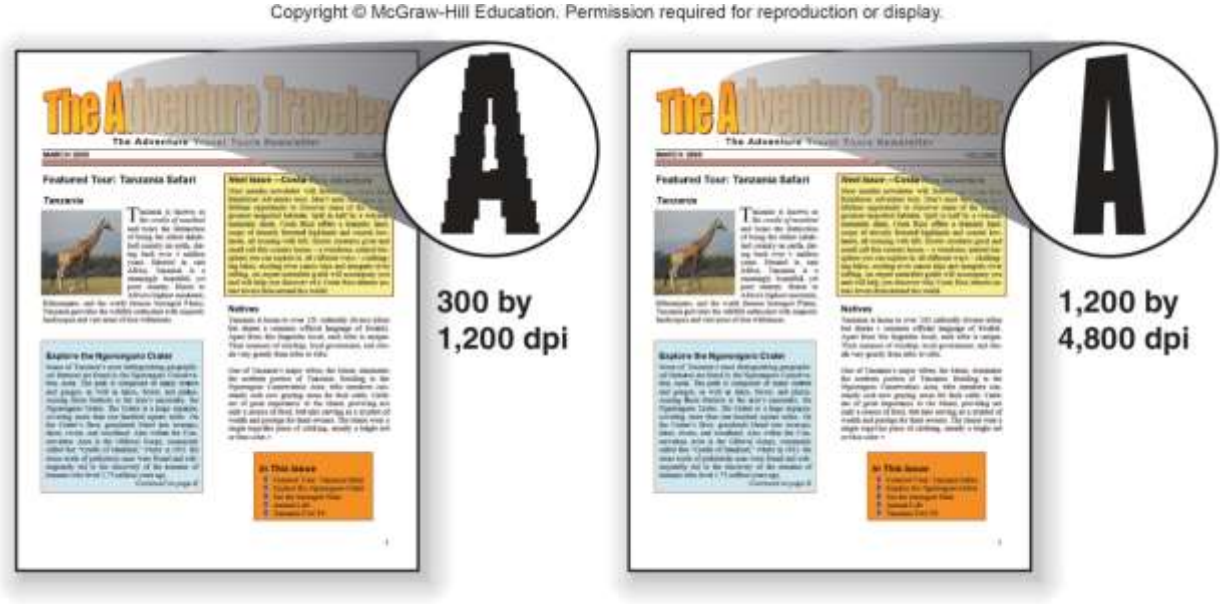
Processed data or information

- Types of output (Text, Graphics/photos, Audio & video)
- Output devices – Monitors, Printers, Audio-output devices

Monitors	Monitor Types	Curved Monitors	E-book Readers	Other Monitor Types
-Known as screens or display screens and present visual images of text and graphics -Output referred to as soft copy -Features: a) Clarity b) Resolution/pixels c) Dot pitch d) Contrast ratios e) Size f) Aspect ratio	Flat-panel monitors: -Require less power to operate -Portable and thin -Most are backlit Three types: 1. Liquid Crystal Display (LCD) - Older monitors 2. Light Emitting Diode (LED) - More advanced backlighting 3. Organic Light Emitting Diode (OLED) - Thin layer organic compound that produces light	Has a concave screen that provides better viewing angles near the edges of the screen - Used by high-end gamers - Used for smart watch displays	An e-book is a traditional books printed in electronic form E-book readers are dedicated mobile devices for storing and displaying e-books Use e-ink technology -Produce images that reflect light (Kindle, Nook)	Other monitors: i) Digital/interactive whiteboards - Connects to a computer or project - Controlled using a special pen or even your finger (used in Classrooms and corporate boardrooms) ii) Ultra High-definition television (UHDTV) - Digital output delivering a much clearer and more detailed image that regular HDTV iii) Digital Projector - Project the images from a traditional monitor onto a screen or wall

Printers

- Translates information that has been processed by the system unit
- Output referred to as hard copy
- Features
  - Resolution
  - Color
  - Speed
  - Memory
  - Duplex printing



Printer Types

COMPUTER HARDWARE

- Ink-jet printers spray ink at a high speed
  - Reliable, quite and inexpensive
- Laser printers uses a laser light beam to produce images
  - Fast, excellent quality
  - Personal or shared
- 3D Printers create 3-D shapes with a thin layer of material repeatedly until created
  - Additive manufacturing

Other Printers

- Cloud printers (Connected to the Internet to provide services to others on the Internet
- Thermal printers
- Plotters

Audio and Video Devices

- Translates audio information from
  the computer into sounds that people can understand
  - Speakers and headphones
- Bluetooth Technology
  - Wireless technology
    - Used to connect to speakers and headsets

Combination Input and Output Devices

- Headsets
  - Combine a microphone and headphones
- Multifunctional devices (MFD)
  - Cost efficient but lower quality
  - All-in-one printers are a good example
- Telephones
  - Known as Telephony and Internet Telephony
  - Voice-over IP (VoIP)
    - Hangouts
    - Face Time
    - Skype

3D visual

COMPUTERHARDWARE

- Hologram
  - created using light interference patterns.
  - 3D image that can be seen without a screen or special glasses, appearing to have depth in space and being visible from multiple angles.
- Virtual Reality (VR) headsets

- provide a fully immersive 3D experience, E.g –Oculus Quest, HTC vive

- Augmented Reality (AR)/ Mix Reality (MR) headsets
  - overlay 3D virtual objects onto the real world, blending virtual and physical environments. E.g – Magic Leap
- Projection Mapping (3D projection System)
  - Projecting 3D visual onto physical surfaces such as building or objects to create depth and dimension

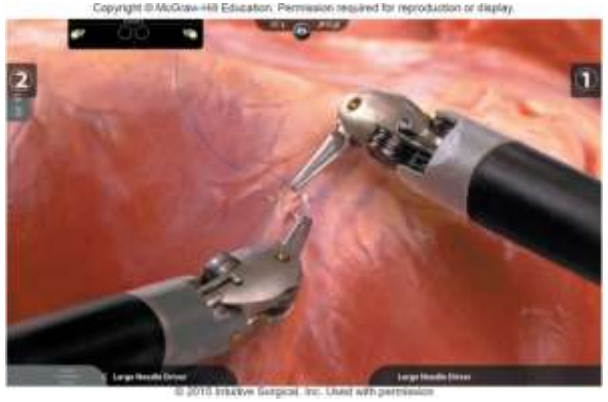
Drones and Robots

Drones or unarmed aerial vehicles

- Take input from a controller and send back video and sound to the user
- Very cost effective now

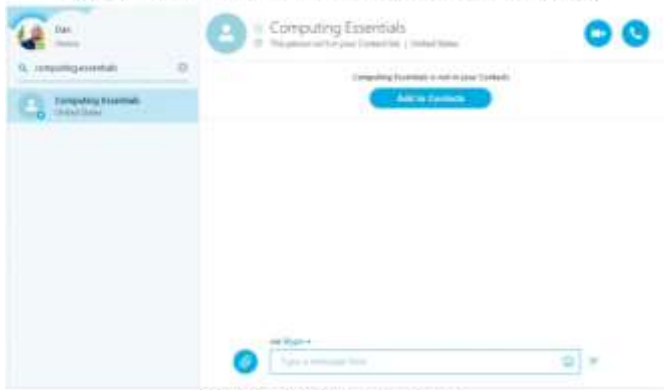
Robots

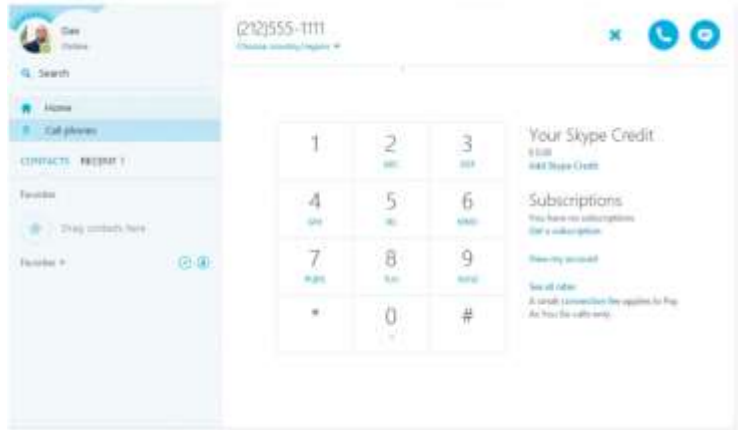
- Use microphones, cameras and other sensors as input
- Output is dependent on the use for the robot
  - Assists in surgery



Making IT Work for You ~ Skype

- Communications tool using VoIP
- www.skype.com





COMPUTERHARDWARE

Ergonomics

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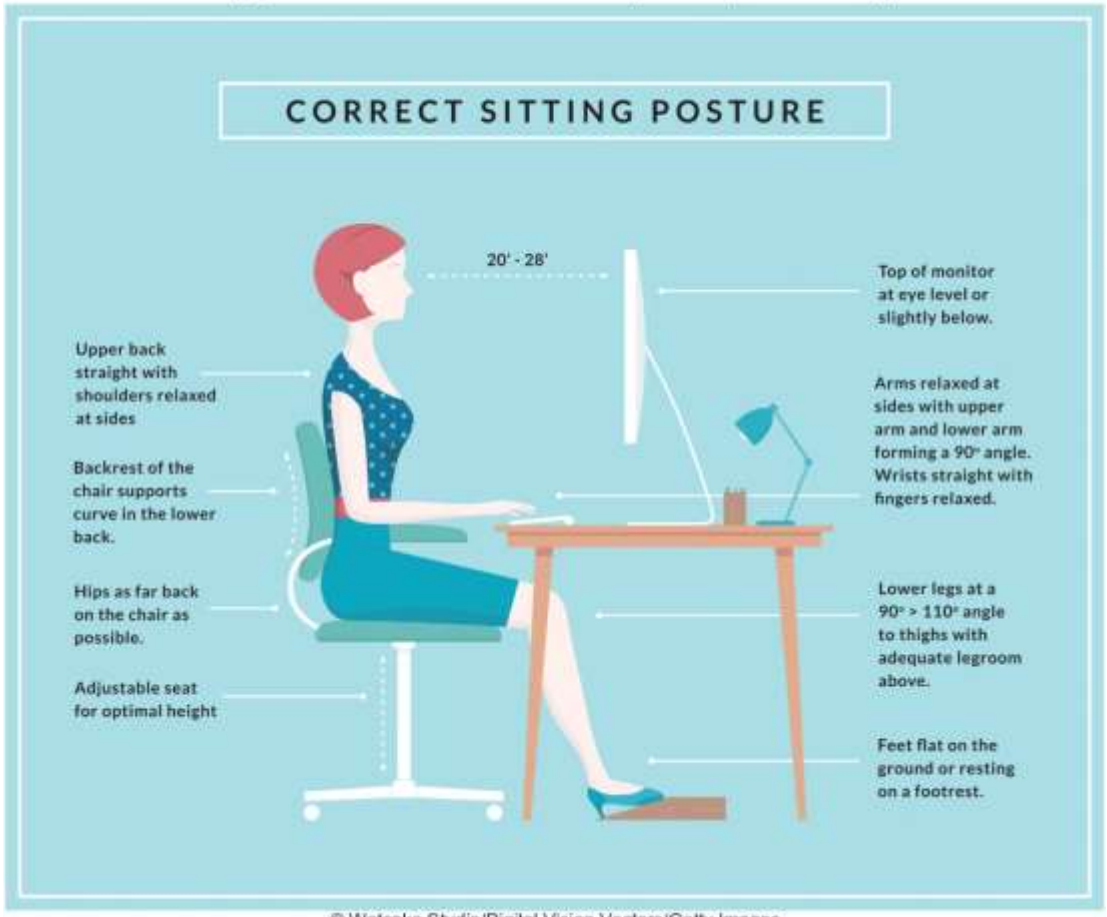
- Study of human factors related to things people use
- Fit the task to the user to avoid:
  - Eyestrain and headache
  - Back and neck pain
  - Repetitive strain injury



Ergonomic Challenged Devices

Portable devices are not set up for ergonomics

- Laptops
  - Because the keyboard and monitor are connected, they cannot be set up ergonomically
- Tablets
  - Tablet hunch is caused by the users head being improperly aligned to the viewing surface
- Smartphones
  - Blackberry thumb results from using thumbs to type on a tiny keyboard

HARDWARE -Part 4 (Secondary Storage) Introduction

COMPUTERHARDWARE

- Data storage has expanded from text and numeric files to include digital music files, photographic files, video files, and much more.
- These new types of files require secondary storage devices with much greater capacity.
- In Part 3 (hardware), you learn about the many types of secondary storage devices including their capabilities and limitations.

Learning Objectives
Part 4 – Secondary Storage

COMPUTERHARDWARE

1. Distinguish between primary and secondary storage.
2. Identify the important characteristics of secondary storage, including media, capacity, storage devices, and access speed.
3. Describe hard-disk platters, tracks, sectors, cylinders, and head crashes.
4. Compare internal and external hard drives.
5. Compare performance enhancements including disk caching, RAID, file compression, and file decompression.
6. Define optical storage including compact discs, digital versatile discs, and Blu-ray discs.
7. Define solid-state storage, including solid-state drives, flash memory cards, and USB drives.
8. Define cloud storage and cloud storage services.
9. Describe mass storage, mass storage devices, enterprise storage systems, and storage area networks.

Storage

COMPUTERHARDWARE

- Primary storage is:
  - Volatile storage
    - Loses content when the computer loses power
  - Temporary storage
  - Random Access Memory (RAM)
- Secondary storage is:
  - Nonvolatile storage
    - Stores programs and data regardless of power
  - Permanent storage
    - Permanently saves information for future use

Secondary Storage Characteristics

- Secondary storage characteristics
  - Media
    - Physical materials that holds data and programs
  - Capacity
    - How much the media can hold
  - Storage devices
    - Hardware that reads data and programs
  - Access speed
    - Amount of time required to retrieve data from storage
    - Writing is the process of saving information to storage
    - Reading is the process of accessing information from storage

Hard Disks

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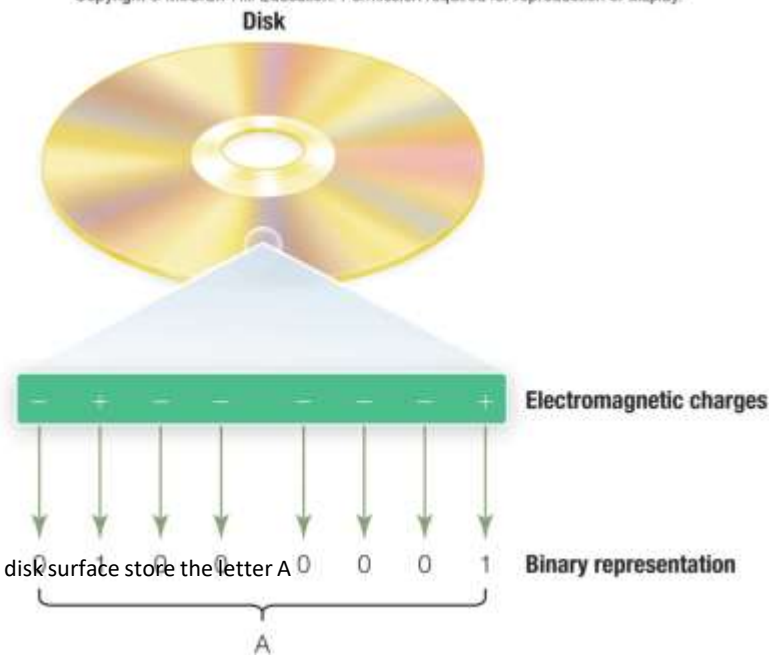
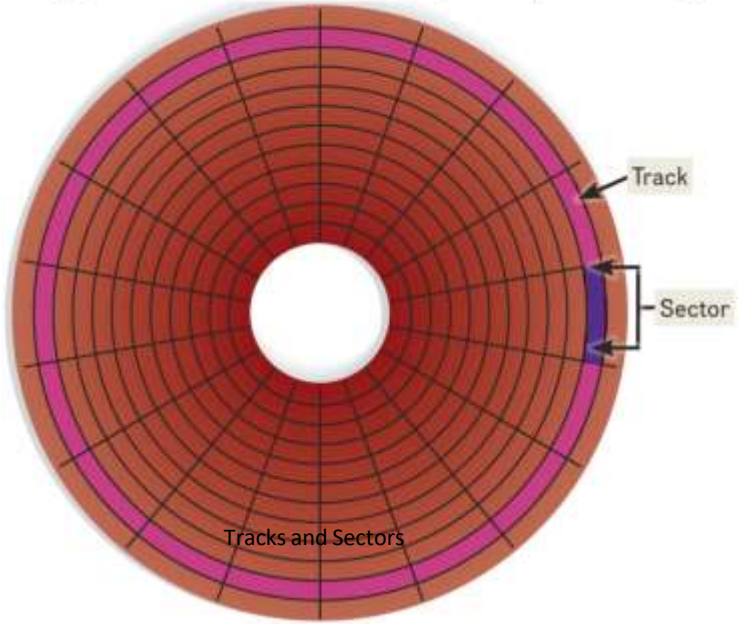
Save files by altering the magnetic charges of the disk's surface to represent 1s and 0s

- Use rigid, metallic platters that are stacked one on top of one another
- Store and organize files using tracks, sectors, and cylinders



How charges on a disk surface store the letter A

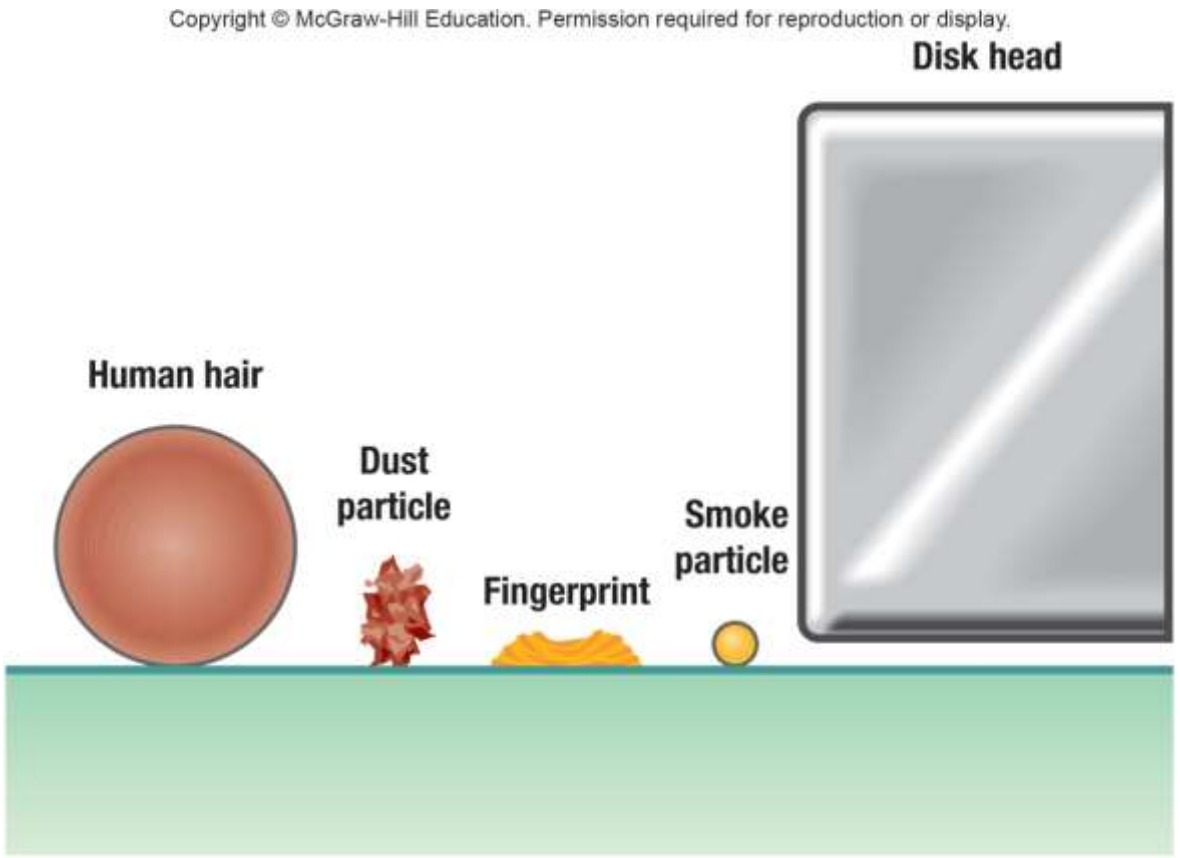


Tracks and Sectors

Head Crash

Occurs when read-write head makes contact with the hard disk's surface or with particles on its surface

- Disastrous



Types of Hard Disks

Internal

- Located inside the system unit
- Used to store programs and data files
- You should perform routine maintenance and periodically backup all important files

External

- Removable
- Used to complement internal hard disk

Courtesy of LaCie

Performance Enhancements

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There are 3 ways to enhance performance.

Technique	Description
Disk caching	Uses cache and anticipates data needs
RAID	Linked, inexpensive hard-disk drives
File compression	Reduces file size
File decompression	Expands compressed files

Courtesy of CalDigit, Inc.

Solid-State Storage

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Solid–state devices (SSDs) have no moving parts

- Solid-state drives
  - Faster and more durable than hard disks
  - Access to slash memory or solid state storage
- Flash memory cards
  - Widely used in laptops, smartphones, GPS navigation systems
- USB Drives (or Flash Drives)
  - Connect to USB port
  - Capacity of 1 GB to 256 GB
  - Portable

Optical Discs

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- Hold over 128 gigabytes (GB) of data
- Use reflected light to represent data
  - Lands represent 1s and 0s on the disc
  - Pits are bumpy areas on the disc that, when light is reflected, determine the 1s and 0s
  - Use tracks and sectors to organize and store files but only use a single track unlike the hard drive

Optical Disc Types

Format	Typical Capacity	Description
CD	700 MB	Once the standard optical disc
DVD	4.7 GB	Current standard
Blu-ray	50 GB	Hi-def format, large capacity

Optical Disc Formats

Type	Access	Description
CD-ROM	Compact disc – read only mode	Cannot be written to or erased
CD-R	Compact disc – recordable	Can be written to
CD-RW	Compact disc – rewritable	Can be written to and erasable

Cloud Storage

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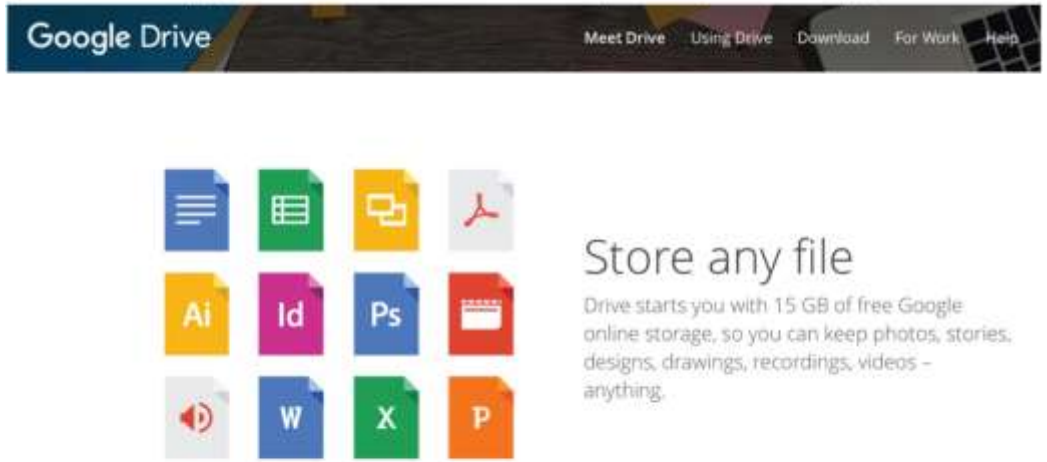
The Internet acts as a "cloud" of servers

- Applications provided as a service rather than a product
- Supplied by servers that provide cloud storage or online storage



Cloud Storage Services

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Benefits / Advantages

- Maintenance
- Hardware upgrades
- File sharing and collaboration

Disadvantages

- Access speed
- File Security

Cloud Storage Service Companies

Company	Location
Dropbox	www.dropbox.com
Google	drive.google.com
Microsoft	www.skydrive.com
Amazon	amazon.com/cloud
Apple	www.icloud.com

Making IT Work for You ~ Cloud Storage

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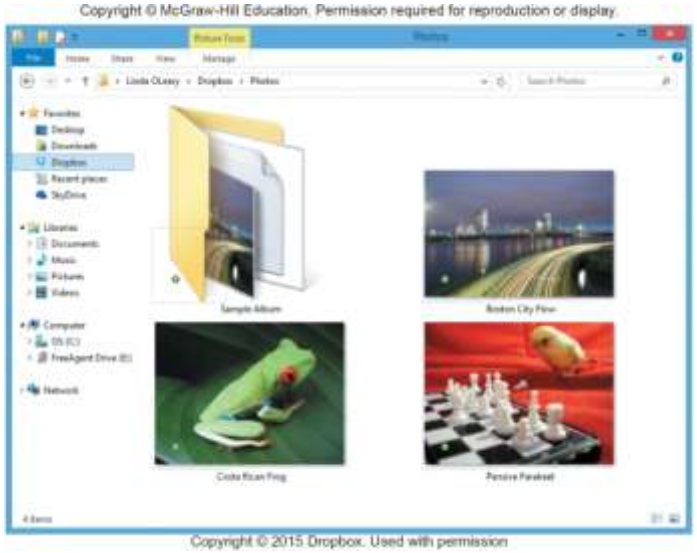
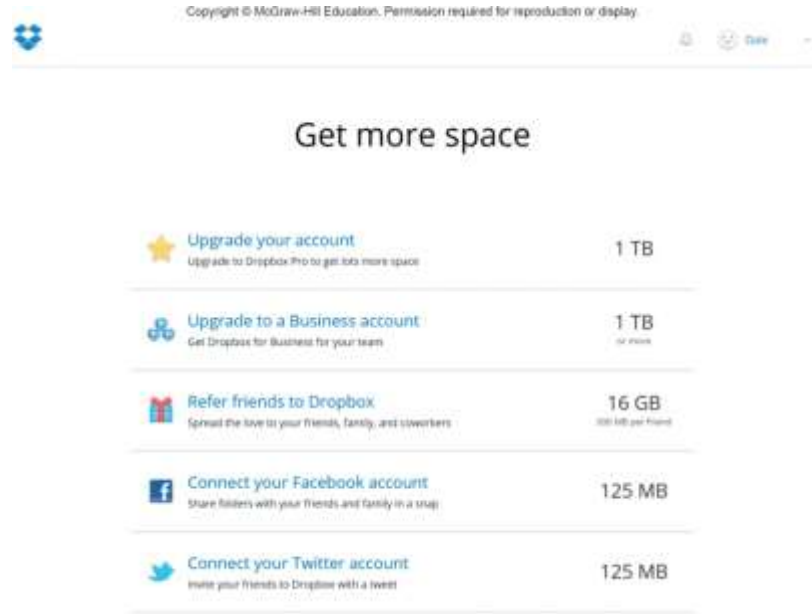
Using a cloud storage service makes it easy to upload and share files with anyone.

Starting Dropbox Step 1 Step 2

Dropbox



Sharing Dropbox



Mass Storage Devices

To meet the needs of organizations requiring large amounts of secondary storage requirements

- Enterprise storage system
  - Safe use of data across an organizational network
- Devices include:
  - File servers
  - Networked attached storage (NAS)
  - RAID systems
  - Organizational cloud storage

Storage Area Network (SAN)

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- Architecture to link remote computer storage devices
  - Enterprise storage systems can be connected to
  - Computers to provide local system access
- User's computer provides file system, but SAN provides disk space
- House data in remote locations and still allow efficient and secure access

HARDWARE TRENDS –Part 5

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Current Trend in Computer Hardware

1. AI and Machine Learning Hardware
   - Hardware designed for AI/ ML workload such as GPUs and TPUs, AI chips, NVIDIA Jetson
   - Optimized for parallel processing, large dataset, high computational
2. Edge computing and IoT devices
   - Localized processing to reduce latency in IoT applications.
   - Critical for real-time application such as autonomous vehicles, smart cities
   - Growing demand for energy-efficient and low-latency hardware
   - Edge server, IoT Sensor, IoT gateways, embedded system
3. Multicore Processor
   - allow computers to handle multiple tasks simultaneously, improving parallel processing and overall performance
   - Critical component in smartphones, PCs, servers, and edge devices
   - E.g ARM processor (Apple M1/M2 chips), RISC-V

HARDWARE TRENDS –Part 5

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4. Non-Volatile Memory express (NVMe) storage
   - NVMe SSDs are replacing older storage technologies due to their speed.
   - Faster data access and lower latency compared to traditional SATA SSDs.
   - Critical for data-intensive applications such as gaming, AI, and video editing
5. 5G integration and networking hardware
   - 5G networks drive demand for faster and more reliable data transfer.I
   - innovations in routers, switches, and modems for 5G applications.
   - Enables real-time applications like AR, smart cities, and IoT.

HARDWARE TRENDS –Part 5

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Future Trend in Computer Hardware

1. Quantum Computing
   - leverages the principles of **quantum mechanics**—the fundamental theory in physics that describes the behavior of particles at the smallest scales (atoms and subatomic particles).
   - use **quantum bits** or **qubits** to process information, which can represent both 0 and 1 simultaneously due to the quantum property called **superposition**
   - revolutionize fields like AI, cryptography, optimization and complex simulations
2. Device and Nanotechnology
   - Nanotechnology is the aptitude to perceive, measure, operate, and build materials at the nanometer scale, the size of atoms and molecules.
   - enables the creation of smaller transistors and components, allowing for increased transistor density on integrated circuits
   - enabling the development of smaller, faster, and more efficient components

HARDWARE TRENDS –Part 5

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3. Photonics and Optical computer
   - uses light (photons) instead of electrical signals (electrons) to perform computations. This allows for higher data transfer rates and less heat generation.

4. 3D chips stacking and heterogeneous computing
   - stacking chips vertically to increase performance and reduce power consumption
   - combining different types of processors (CPU, GPU, FPGA) on a single chip to optimize for specific tasks.
5. Neuromorphic computing
   - Hardware that mimics the human brain, potentially leading to more advanced AI and cognitive computing
   - Neuromorphic chips from Intel and IBM are already in development

HARDWARE TRENDS –Part 5

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6. Emerging memories technology
   - Aim to address the limitation of traditional memory type like DRAM and NAND flash storage
   - Improve in speed, density, energy efficiency, durability
   - ReRAM (resistive), MRAM (Magnetoresistive), PRAM (Phase change), FeRAM (Ferroelectric), universal memory

Performance of emerging memories

Table 1. Performance of emerging memories and their comparison with typical memories.

	Memory type	Cell size	Properties	Scalability
Traditional memory devices	Static-RAM	64,000 nm^2	Read/write time < 2 ns	Good
	Dynamic-RAM	2900 nm^2	Read/write time 30–50 ns	Limited
	NAND Flash	784 nm^2	Read/write time 10^3–10^6 ns	Limited
Emerging memory devices	Ferroelectric-RAM	880 nm^2	Read/write time 5–10 ns	Limited
	Resistive-RAM	88 nm^2	Read/write 20–50 ns	Medium
	Phase change-RAM	127.5 nm^2	Read/write 2–100 ns	Limited
	spin-transfer torque-MRAM	1870 nm^2	Read/write 10–20 ns	Good
	Spin–orbit-torque-MRAM	3520 nm^2	Read/write < 10 ns	Good

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