

Maintenance of Computer System

Motherboard

A motherboard is the main printed circuit board of a computer. It connects the processor, memory, storage devices, expansion devices and input/output devices.

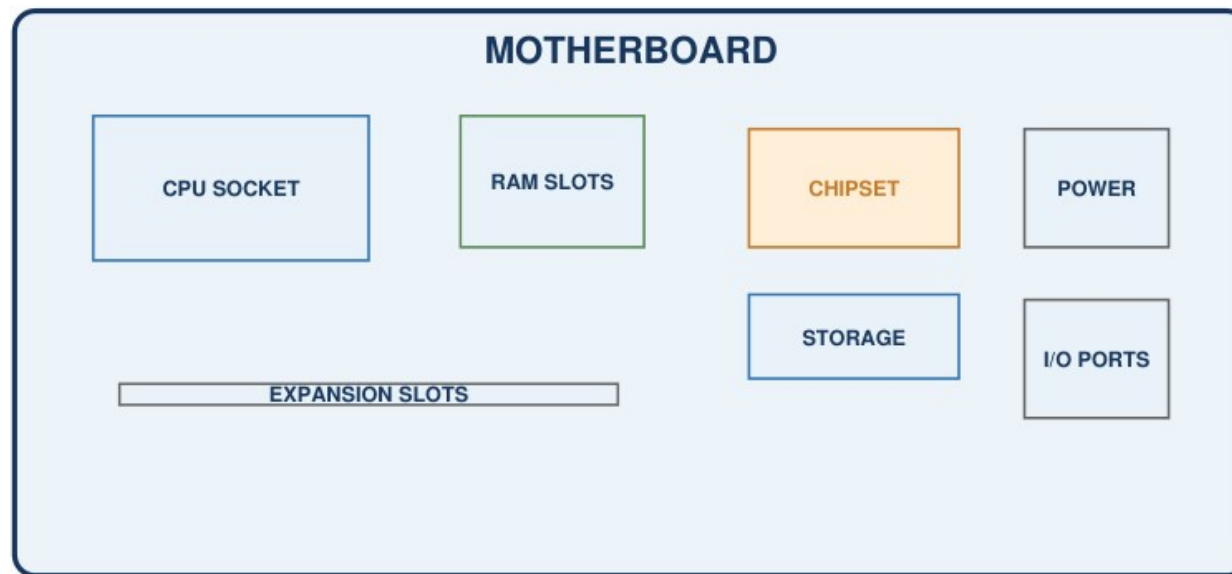


Fig. 1: Main parts of a motherboard.

Main parts

- CPU socket: holds the processor.
- RAM slots: hold memory modules.

- Chipset: manages communication between major components.
- Expansion slots: connect additional cards.
- Storage connectors: connect storage devices.
- Power connectors: supply power.
- I/O ports: connect external devices.

Different Types of Motherboards

Over all there are four types of motherboards :

- **XT Motherboard**

XT stands for Extended Technology.

It is one of the oldest types of PC motherboards.

It was used in early IBM-compatible computers.

It had a CPU socket, RAM slots and ISA expansion slots.

It generally used a 12-pin power connector.

It had very limited ports and expansion facilities.

In simple words: XT motherboard is an old-generation motherboard with basic computer hardware support.

- **AT Motherboard**

AT stands for Advanced Technology.

It was developed as an improvement over the XT motherboard.

It provided a CPU socket and RAM slots.

It supported ISA and later PCI expansion slots.

It commonly used a 20-pin power connector.

AT motherboards were used in older generations of personal computers.

In simple words: AT motherboard is an improved version of the older XT motherboard with better expansion and hardware support.

- **Baby AT Motherboard**

Baby AT is a smaller version of the AT motherboard.

It has a smaller physical size than a standard AT motherboard.

It supports a CPU socket, RAM slots and expansion slots.

It can support ISA, PCI and other expansion interfaces, depending on the design.

It uses AT-style power connections.

It was widely used in older desktop computers.

In simple words: Baby AT is a smaller and more compact version of the AT motherboard.

- **ATX Motherboard**

ATX stands for Advanced Technology Extended.

ATX is a widely used motherboard form factor developed by Intel.

It provides better arrangement of CPU, RAM and expansion slots.

It supports PCI, AGP and other expansion interfaces in older designs.

It uses 20-pin or 24-pin ATX power connectors, depending on the generation.

Modern ATX boards support technologies such as DDR RAM, SATA, USB and PCI Express.

It provides better airflow and easier installation compared with older motherboard designs.

In simple words: ATX is a more modern motherboard design that provides better hardware arrangement, power management and expansion options.

Single Board Based System

A single-board computer is a complete computer system built on one circuit board. Processor, memory and input/output functions are integrated on the board.

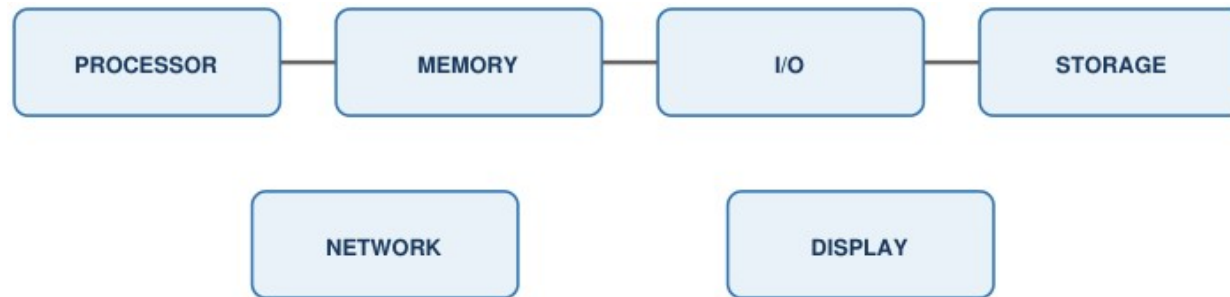


Fig. 2: Single-board based system.

Main sections

- Processor — executes instructions.
- Memory — stores programs and data.
- I/O — connects external devices.
- Storage — stores data and software.
- Network — provides communication.
- Display — provides visual output.

Block Diagram of Motherboard

The motherboard provides connections between the CPU, memory, storage, expansion devices and input/output interfaces.

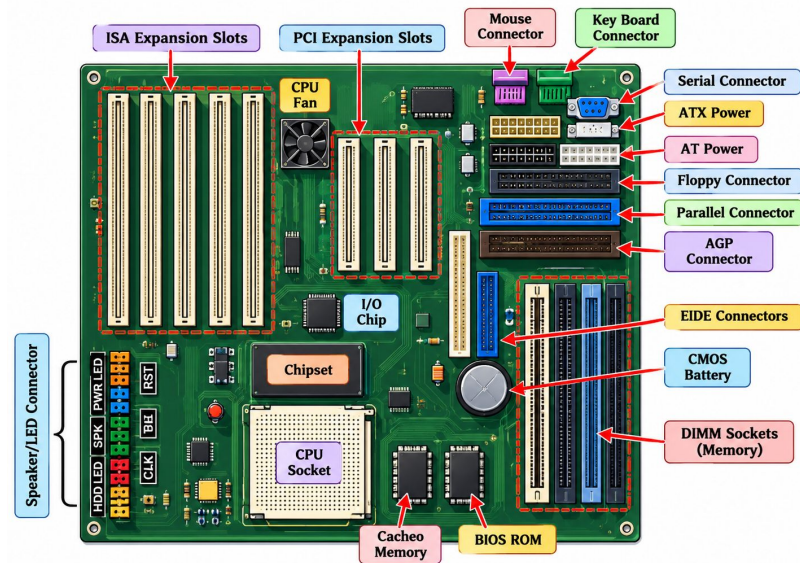


Fig. 3: Block Diagram of Mother Board.

It contains

Processor

CPU slots

Expansion slots such as ISA, PCI.

CMOS battery

ATX, AT Power Connector

various other connectors such as Serial connector, EIDE Connector,

Floppy Connector DIMM Connector etc.

BIOS ROM Chip

I/O Chip

Installation of Computer System

Assembling a desktop computer is a step-by-step process. The aim is to mount every component correctly, connect the cables, and confirm that the system passes POST (Power-On Self-Test) before installing the operating system.

Tools required

- Philips (star) screwdriver, plastic spudger, cable ties.
- Anti-static wrist strap or mat (ESD protection).
- Thermal paste (if the cooler does not have a pre-applied pad).
- All components and the motherboard manual.

Step-by-step procedure

1. Prepare the case. Open the side panel; fit the I/O shield at the back and install the motherboard stand-offs to match the board holes.
2. Install the CPU. Lift the socket lever, align the gold triangle on the CPU with the socket mark, lower it gently (never force), and close the lever.
3. Fit the cooler. Apply a pea-sized amount of thermal paste, mount the heat-sink and fan, and connect the fan cable to the CPU_FAN header.
4. Insert the RAM. Open the clips of the DIMM slots, align the notch and press evenly until both clips click. Use the slots recommended in the manual for dual-channel mode.
5. Mount the motherboard. Lower it onto the stand-offs, align with the I/O shield and fix it with screws.
6. Install the storage. Screw the HDD/SSD into the bay (or M.2 SSD into its slot); connect the SATA data cable to the motherboard and the SATA power cable to the SMPS.
7. Install the SMPS (if not already fitted) and route the 24-pin ATX and 4/8-pin CPU cables to the motherboard.
8. Add expansion cards. Insert the graphics card into the PCIe x16 slot and secure it with a screw; connect the extra PCIe power cable if required.

9. Connect front-panel cables. Power switch, reset, HDD LED, power LED, front USB and audio headers follow the panel diagram in the manual.

10. Cable management and first boot. Tidy the cables, connect monitor, keyboard and mouse, plug in the power, and press the power button. Enter BIOS to check that CPU, RAM and drives are detected.

11. Install the operating system from a bootable USB/DVD, then the chipset, graphics, and network drivers.

Buses

A bus is a communication system that allows different components of a computer to exchange information. It consists of multiple conductors or wires arranged in parallel, which transmit information as electronic signals. A typical communication channel uses these parallel wires to transfer address, data, and control signals.

Inside the CPU, buses provide communication paths between its internal components. Similarly, a bus connects the CPU with the memory and other computer components. In simple terms, a bus is a collection of wires that carries information from one part of the computer to another.

- **Address Bus**
- **Data Bus**
- **Control Bus**

A bus can transmit information in one direction or in both directions, depending on the system's needs. A bus that links the various components within the CPU is called an internal bus, whereas a bus that connects the CPU to components outside the CPU is known as an external bus.

Address Bus

The address bus, also known as the memory bus, carries the addresses of memory locations that the processor needs to access for reading or writing data. It is a one-way communication bus.

The CPU sends the address of the specific memory location or input/output port that needs to be accessed. This address travels in only one direction, from the CPU to the selected memory location or port. The CPU determines the address of the required data and sends it to perform the desired operation.

The number of address-bus lines determines the maximum number of memory locations that can be accessed. An address bus with n lines can directly address up to 2^n locations.

Data Bus

The data bus is used to transfer data and instructions to and from the processor. Since information can move in both directions, it is called a bidirectional bus.

It provides a communication path for transferring data and instructions between the CPU, memory, and peripheral devices. The width of the data bus is expressed in bits and affects important aspects of computer architecture, such as the word size and the amount of data that can be transferred during each bus cycle.

A microprocessor is generally called an n -bit microprocessor when its data bus has a width of n bits. For example, the original IBM PC with the Intel 8088 processor had an 8-bit data bus, while later Pentium processors featured a 64-bit data bus. A 64-bit data bus is capable of transferring 8 bytes of data in a single bus cycle.

Control Bus

The control bus carries commands and timing signals from the control unit to various hardware components. It is a bidirectional bus because it can also carry response signals back from the connected devices.

The control bus consists of separate lines that transmit control and synchronization signals for managing peripheral devices connected to the CPU. Some commonly used control signals include Memory Read, Memory Write, I/O Read, and I/O Write. The type and number of control signals can vary between microprocessors depending on their design and the devices connected to them.

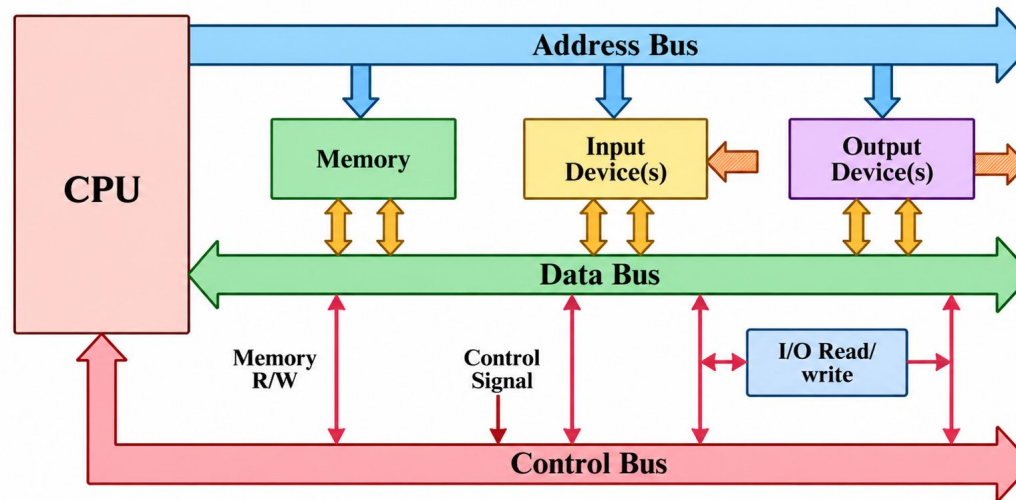


Fig. 4: Data, Address and Control Bus

PCI Bus

PCI stands for Peripheral Component Interconnect. It is a widely used bus standard in computers and was originally developed and introduced by Intel. PCI supports various expansion cards and includes features that were also found in earlier bus standards such as MCA and EISA.

PCI is available in both 32-bit and 64-bit versions. It supports bus-mastering, allowing devices to control the bus when required, and provides automatic configuration of connected devices. The PCI standard also offers different options for increasing the bus width and improving the data transfer speed.

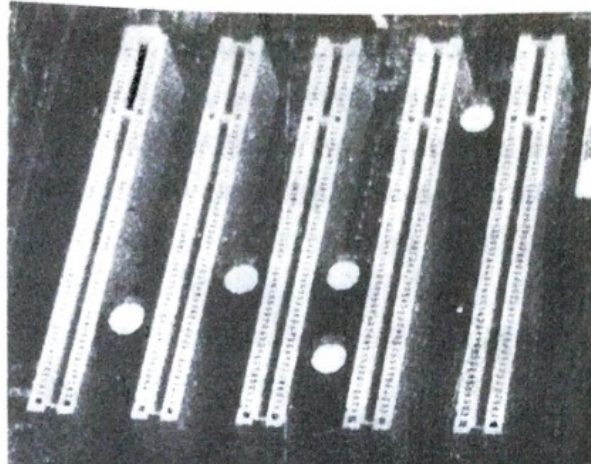


Fig. 5: PCI Bus Slots

PCI buses are available in 32-bit and 64-bit configurations and can operate at speeds of 33 MHz or 66 MHz. PCI slots are provided on the motherboard to allow compatible expansion cards to be connected to the computer.

SCSI

SCSI (Small Computer System Interface) is an expansion bus technology used with personal computers. It is mainly used to connect storage devices, such as hard disk drives and CD-ROM drives. SCSI allows multiple devices to communicate using a shared bus and provides a standard method of communication that is independent of the specific device.

Variations in SCSI

The development of SCSI can be traced back to the Shugart Associates Systems Interface (SASI), which was introduced in 1979. SCSI-1 became an official standard in 1986. It used an 8-bit bus, supported up to eight devices, and provided a data transfer rate of approximately 5

MBps. SCSI-2, introduced later, retained the 8-bit bus while offering improved transfer speeds. SCSI-3 was introduced in 1996 and supported a 16-bit bus. SCSI interfaces continued to be used for connecting various computer peripherals.

SCSI is generally based on a parallel bus architecture, with data widths of 8 or 16 bits. Later developments also included proposals for using serial communication with SCSI-3.

SCSI Devices

SCSI devices can generally be divided into two roles: initiators and targets. The initiator begins communication by sending commands, while the target receives and responds to those commands. Depending on the operation, these roles may change during communication.

Common types of SCSI devices include:

- **Random-access devices** – such as floppy disk drives and hard disk drives.
- **Sequential-access devices** – such as magnetic tape drives.
- **Printers** – devices used for producing printed output.
- **Read-only random-access devices** – devices that allow data to be read but not modified.
- **Processors** – devices capable of processing data.
- **Write Once, Read Many drives** – storage devices that allow data to be written once and read multiple times.

Ports

A port is a connection point on a computer's circuit board that allows external devices, such as keyboards, printers, disk drives, and other peripherals, to be connected. It provides a communication pathway through which signals are exchanged between the processor and input/output devices. Therefore, it is also commonly referred to as an input/output (I/O) port.

Common types of ports include:

- **Keyboard Port** – Used specifically for connecting a keyboard.
- **Mouse Port** – Designed for connecting a mouse to the computer.

- **Serial Port** – An older type of port that typically uses a 9-pin connector.
- **Parallel Port** – Usually equipped with a 25-pin connector and traditionally used to connect printers.
- **Video Port** – A 15-pin connector commonly used to connect a monitor or display.
- **Audio Port** – Used to connect devices such as speakers, headphones, and microphones.
- **USB Port** – A general-purpose connection that supports a wide range of devices and allows devices to be connected or disconnected while the computer is running.

Port Types

Earlier computers primarily relied on serial and parallel ports for connecting external devices. In this unit, computer ports commonly used today are divided into four main categories:

- Serial Port
- Parallel Port
- USB Port
- Special Port

Serial Port

A serial port is an input/output interface that sends and receives data one bit at a time through a single communication line. The RS-232 serial port is a common example of this type of interface.

Serial ports support two-way communication and require fewer signal lines than parallel ports, making the overall cabling simpler. However, traditional serial ports generally do not support hot-swapping, so the computer may need to be turned off before connecting or disconnecting a device.

A serial port converts parallel data into a stream of individual bits, adds the necessary framing information, and transmits the data at the required speed. When receiving data, it accepts the serial bit stream, removes the framing information, converts the data back into parallel form, and performs error or data-block checking. These operations are mainly handled by a Universal Asynchronous Receiver/Transmitter (UART).

Parallel Port

A parallel port is an input/output interface that can handle 8 bits of data simultaneously. Instead of sending data one bit at a time, it transfers one byte at a time using separate data lines. It is an older type of computer port and is also commonly known as a printer port or Centronics port.

A parallel port consists of three main registers: the data register, status register, and control register. The data register is responsible for storing and transferring data. The control register is used to control the operation of the port and determine when the CPU should provide new data. The control and status registers are also used to manage the handshaking signals required for communication between the computer and the connected device.

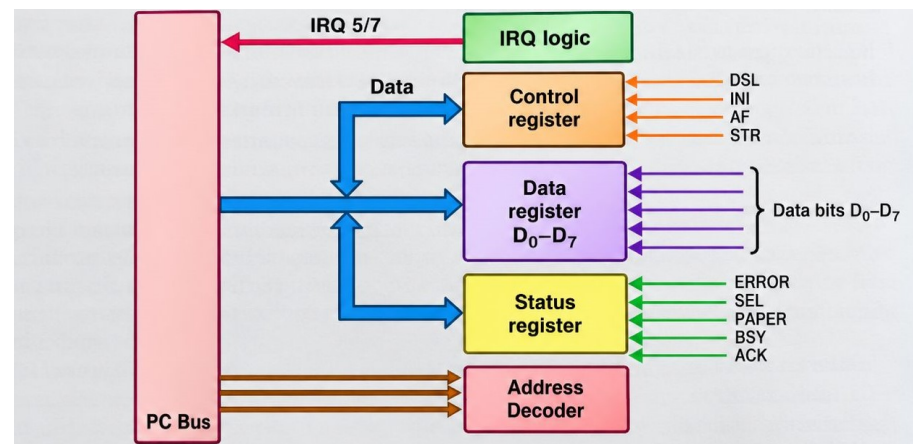


Fig. 6: Block Diagram of Parallel Port

The main signals associated with a parallel port include:

- **D0-D7** – Lines used for transferring data.
- **INI** – Signal used to initialize the device.
- **SEL** – Signal for selecting the device.

- **DSL** – Device selection signal.
- **AF** – Controls the automatic paper-feed function.
- **STR** – Strobe signal used to indicate that data is available.
- **ERR** – Indicates an error condition.
- **PAPER** – Indicates that the printer has run out of paper.
- **BSY** – Shows that the connected device is busy.
- **ACK** – Acknowledgement signal confirming that data has been received.



Fig. 7

USB Port

USB stands for Universal Serial Bus. It is an interface designed to connect low- and medium-speed peripheral devices to a computer. USB became popular as an alternative to older serial and parallel ports because it supports hot swapping, which allows devices to be connected or removed without turning off or restarting the computer.

Many devices, including keyboards, mice, digital cameras, printers, and telephones, can use USB connections. USB is a serial communication interface that transfers data one bit at a time. Multiple USB devices can share the available bus bandwidth. In addition to data transfer, a USB cable can also provide electrical power to certain low-power devices.

USB devices generally operate in two roles: Hub and Function. USB follows a tiered-star topology, in which a USB hub provides additional connection points for other USB devices. The USB host controller is responsible for coordinating device drivers, managing data transfer, and controlling the distribution of electrical power.

Common USB host controller interfaces include:

- Universal Host Controller Interface (UHCI)
- Open Host Controller Interface (OHCI)

COM Port

A COM port is the name used in DOS for a serial communication port. Older BIOS versions commonly supported COM1 and COM2, while later versions could support COM1 through COM4. Some computer systems may also provide additional COM ports.

When a new COM port is added, it must be configured with a valid base address and interrupt request (IRQ). Each COM port should have a unique base address; assigning the same address to multiple ports can result in system conflicts. The I/O addresses of COM ports are stored in the BIOS data area of RAM, beginning at 0400h.

LPT Port

In DOS, LPT is the device name used for a parallel communication port. DOS traditionally supports LPT1, LPT2, and LPT3, while some operating systems, such as OS/2, may provide additional network LPT ports. LPT1 and LPT2 were commonly used to connect parallel printers.

LPT1 Port

LPT1 (Line Print Terminal 1) is the logical designation for the first parallel port on a personal computer. It was mainly used to connect printers and was a common printer interface in older computer systems. With the introduction of modern interfaces such as USB, the use of LPT1 has significantly decreased. In Windows, the parallel ports are identified as LPT1, LPT2, and LPT3, with LPT1 representing the first port.

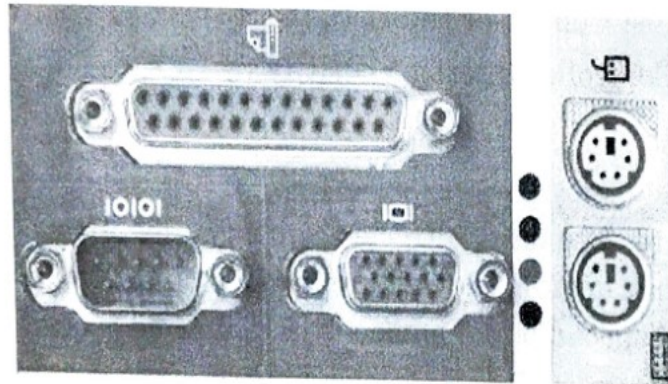


Fig. 8: LPT1 Port

Features of LPT1

1. **Parallel Data Transfer:** LPT1 transfers several bits of data at the same time through multiple data lines.
2. **Common Connector:** It generally uses a 25-pin D-sub connector to connect compatible parallel devices.
3. **Two-Way Communication:** LPT1 can both send and receive data, allowing devices such as printers to send status information back to the computer.
4. **Device Support:** It is mainly used with printers but can also connect to other devices that are designed to communicate through a parallel interface.
5. **Transfer Speed:** Standard LPT ports are relatively slow, with typical transfer rates of around 40–60 KB/s. Enhanced ports using ECP (Enhanced Capabilities Port) can provide considerably higher transfer speeds.
6. **Configuration:** LPT ports are generally simple to set up and configure. However, if the printer is used frequently, it may be useful to install an additional LPT port.

Hard Disk Drive (HDD)

A hard disk drive (HDD) is a non-volatile storage device designed to retain information even after the computer is switched off. It is used for storing the operating system, applications and user files. The reference also discusses the historical Winchester hard disk and explains that HDDs became important because floppy disks were slower and offered much less capacity.

An HDD records information magnetically on coated disk surfaces. It provides high-capacity storage and can hold much larger programs and data collections than traditional floppy media.

Hard Disk Drive Construction

A typical hard disk contains several magnetic platters mounted on a central spindle. The platter assembly is enclosed in a protective housing. The surfaces are prepared with magnetic material so that information can be recorded.

- Platters
- Read/Write Heads
- Head Slider
- Head Actuator
- Spindle Motor
- Logic/Circuit Board
- Bezel
- Air Filter
- Cables and Connectors



Fig.9: Components of hard disk drive

Platters

Platters are circular disks made from a rigid substrate and coated with a magnetic layer. Several platters may be stacked around the central shaft. Both sides of a platter may be used for recording, depending on the drive design.

The reference describes older aluminium platters and later ceramic/glass-based substrates. Modern platter coatings are thin and designed to provide a durable magnetic recording surface.

Read/Write Head

The read/write head is responsible for sensing stored magnetic information and recording new information. A separate head is associated with each usable platter surface in a conventional arrangement.

The head assembly moves over the platter surface without normally touching it during operation. A very small air gap is maintained between the head and the rotating disk surface.

Head Slider

The slider is the small support on which the read/write head is mounted. Airflow produced by the spinning platter helps the slider maintain the required spacing from the disk surface.

Head Actuator

The actuator assembly moves the heads from one track position to another. Modern drives commonly use voice-coil actuation, where magnetic force provides controlled movement.

Spindle Motor

The spindle motor rotates the platter stack at a controlled speed. The motor is connected to the central shaft and provides the continuous rotation required for reading and writing.

The reference also discusses motor speed, spindle placement and power-saving arrangements used in hard disks.

Circuit / Logic Board

The logic board contains the electronic control circuitry of the drive. It manages motor operation, head movement, read/write activity, internal data flow and communication with the computer.

- Controls spindle speed.
- Coordinates read and write operations.

- Manages head positioning.
- Handles internal cache and data transfer.
- Converts information between the electronics and read/write heads.
- Supports error handling and reliability functions.

Bezel

The bezel is part of the physical enclosure of the drive. It helps protect the internal assembly and may also provide access to indicators or mounting features.

Air Filter

A hard disk is not normally operated as a vacuum enclosure. Air-filter and breather arrangements help control particles and pressure changes inside the drive. The filtering system reduces the risk of contamination reaching the disk surface.

Cables and Connectors

Two major connections are required: power and data. The power cable supplies the drive with electrical energy, while the data cable carries commands and information between the controller and the drive.

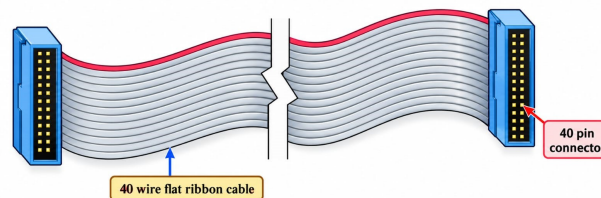


Fig.10 : Hard Drive Cable

Working Principle of Hard Drive

Before storing data, the disk is organized into addressable areas. Partitioning can divide the physical disk into logical volumes, while formatting creates the structures required for data storage and retrieval.

Disk Geometry

Hard-disk geometry describes the organization of platters, surfaces, tracks, cylinders and sectors. These units help the controller identify the exact location of stored information.

- Heads — The number of read/write heads in a hard disk depends on the total number of platter surfaces used for storing data. Since each platter has two usable surfaces, if a hard disk containing six platters provides twelve recording surfaces. Therefore, twelve read/write heads are required, with each surface having one dedicated head. These heads are numbered from Head 0 to Head 11.
- Tracks — concentric circular paths on each surface.
- Cylinders — corresponding tracks at the same radial position across surfaces.
- Sectors — Tracks are split into sectors, allowing specific blocks of data to be located and accessed. The size and number of sectors may differ depending on the type of disk technology used.

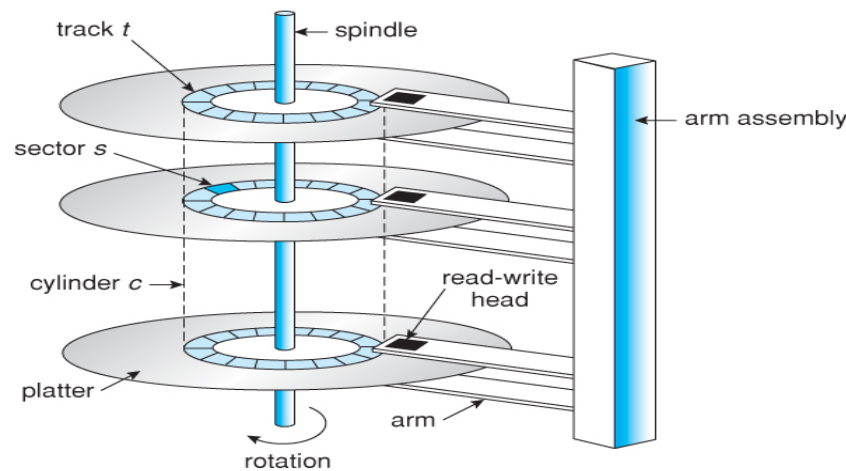


Fig.11: Moving Head Disk Mechanism

Zoned Recording and Sector Sparing

Zoned recording divides the disk surface into different zones, with each zone containing a suitable number of sectors. This technique improves the utilization of the available platter space.

Sector sparing keeps extra sectors available as replacements for sectors that become damaged or unusable. This allows the hard drive to continue functioning even if certain storage areas develop defects.

Operations of a Hard Drive

- **Spin-up** — Rotates the platters until they reach the required operating speed.
- **Seek** — Moves the read/write heads to the track containing the required data.
- **Read/Write** — Reads data from the disk or writes new data to it.

Reading Data

When a read request is made, the CPU sends the instruction through the system interface to the disk controller. The controller identifies the required location and moves the actuator so that the read/write head reaches the appropriate track. It then waits for the desired sector to rotate into position beneath the head. The data is detected by the head and transferred through the controller back to the computer.

Writing Data

During a write operation, the controller receives the location where the data needs to be stored along with the data itself. The read/write head is moved to the appropriate track, and the required sector is positioned beneath it. The drive then uses its recording circuitry to modify the magnetic properties of that area and store the new data.

Performance Factors of a Hard Drive

The performance of a hard drive depends on several factors, including:

- **Average seek time** — The typical time required for the read/write head to reach the desired track.
- **Track-to-track and full-stroke seek time** — The time needed to move the head between nearby tracks or across the entire disk surface.
- **Rotational speed and latency** — The platter's rotation speed and the waiting time for the required sector to reach the head.
- **Head-switch and track-switch time** — The time taken to switch between different heads or tracks.
- **Areal density** — The amount of data that can be stored in a given area of the disk.
- **Internal transfer rate** — The speed at which data moves between the disk surface and the drive's internal electronics.
- **External or burst transfer rate** — The speed at which data is transferred between the drive and the computer.

- **Reliability and environmental conditions** — Factors such as durability, temperature, vibration, and operating conditions that can affect drive performance.

Servo Techniques

Servo information is used by the hard drive controller to accurately position and maintain the read/write heads over the correct tracks. There are three main servo arrangements:

- **Wedge servo** — Servo information is stored in specific sections or wedges of the disk.
- **Dedicated servo** — A separate disk surface is reserved exclusively for storing servo information.
- **Embedded servo** — Servo information is placed within the data tracks on the disk surface.

Logical Working of a Hard Drive

A hard drive operates through a combination of hardware and software components. The BIOS and operating system provide the necessary interface that allows users and applications to access, store, and manage data on the storage device.

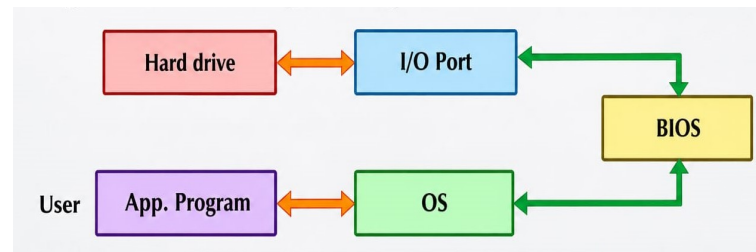


Fig. 12: BIOS and OS interfacing

Common Faults with Hard Disk Drive

Hard disk drive problems can generally be divided into two main categories: hardware-related faults and software-related faults.

Hardware Problems

Common hardware issues include:

- Loose, disconnected, or damaged power and data cables
- Incorrect drive or controller settings
- Damaged or bent connector pins
- Problems with the spindle motor or actuator mechanism
- Defective read/write heads
- Failure of the controller or circuit board
- Problems with the computer's power supply

A basic troubleshooting process involves turning off the computer, checking the cables and connectors, confirming that the controller settings and compatibility are correct, inspecting the power supply, and then testing the hard drive again.

Software Problems

Common software-related issues include:

- Incorrect CMOS or BIOS configuration
- Missing, outdated, or incompatible drivers
- Conflicts between system resources
- The hard drive not being recognized by the system
- Damaged or bad sectors
- Problems with booting or disk formatting
- Viruses or operating-system-related errors

Software problems can be investigated by checking the system configuration and installed drivers, performing appropriate disk and virus scans, and determining whether the issue occurred after a recent software or system change.

Hard Disk Drive Controller

A hard disk controller acts as the communication interface between the computer and the hard drive. It manages the transfer of data and coordinates the mechanical and electronic functions required for storing and retrieving information.

- Connects the computer to the hard drive and enables communication between them.
- Manages data transfer in both directions between the system and the drive.
- Controls head positioning to ensure that the read/write heads move to the required location.
- Detects and handles data errors to help maintain data accuracy and reliability.

Common hard disk interfaces discussed in earlier computer systems include ST-506, ESDI, IDE, EIDE, and SCSI. These interfaces used different controller designs and communication methods depending on the technology available at the time.

Features of Hard Disk Drive

The main HDD characteristics discussed in the reference are related to capacity, physical size, geometry, data arrangement, power management and performance.

Storage Capacity

Storage capacity indicates how much information the drive can hold. Capacity may be expressed in bytes and larger units such as megabytes, gigabytes and terabytes.

Form Factor

Form factor describes the physical size and mounting dimensions of a drive. Common sizes have included 3.5-inch and 2.5-inch formats, with smaller sizes used in portable systems.

Geometry

Drive geometry refers to the organization of tracks, sectors, cylinders and heads used to locate information on the disk.

Interleaving

Interleaving changes the order in which sectors are arranged so that the system has enough time to process one sector before the next required sector reaches the head. The reference describes the interleave factor as a relationship between sector spacing and sector length.

Head Parking

Head parking moves the read/write heads to a safer location when the drive is stopped or when conditions require protection. This reduces the chance of the heads damaging the recording surface.

Write Precomposition

Write precomposition adjusts the recording signal to compensate for changes in magnetic behavior across different tracks. The technique was particularly important in older hard-disk technologies.

Drive Power Modes

- Spin-up mode
- Seek mode
- Read/Write mode
- Idle mode
- Standby mode

Different modes use different amounts of power. Power-management features allow a drive to reduce energy use when full performance is not required.

Servo Techniques

Servo systems provide position feedback so that the head can be accurately aligned with the desired track. Wedge, dedicated and embedded servo methods are described in the reference.

Cylinder Skewing

Cylinder skewing offsets the starting sector of successive tracks. The purpose is to reduce the delay that would otherwise occur when the head moves from one track to the next.

Areal Density

Areal density expresses how much information can be stored in a given surface area of the disk. Higher areal density generally allows greater capacity without proportionally increasing physical size.

Performance Factors

HDD performance is affected by internal factors such as seek time, latency and transfer rate, and external factors such as interface speed and environmental conditions.

Hard Disk Drive Problems Solutions

When an HDD fails to function properly, troubleshooting should start with basic checks before concluding that the drive has suffered permanent hardware damage.

1. Turn off the computer and unplug it from the power source.
2. Make sure the hard drive is compatible with the controller.
3. Examine the power and data cables and check that they are properly connected and working.
4. Inspect the controller card and confirm that all jumpers and settings are configured correctly.
5. Ensure that the hard drive is receiving the required power supply.
6. Check the CMOS/BIOS settings to make sure the drive is detected and configured correctly.
7. If a software-related issue is suspected, perform appropriate virus scans and disk diagnostic tests.
8. If the problem continues, test the hard drive and controller independently and replace the defective component if necessary.

Pen Drive

A pen drive is a compact, portable storage device that uses flash memory and connects to a computer or other device through a USB port. It is mainly used for storing and transferring data conveniently.

- Small, lightweight, and easy to carry.
- Stores data using flash memory without any moving parts.

- Suitable for storing documents, images, presentations, music, videos, and other files.
- Available in different storage capacities depending on the model.
- Data transfer speed varies according to the USB version and the design of the device.
- Can work with various operating systems, provided the necessary drivers and support are available.



Fig.13: Pen Drive

RAM Module

A memory module is a packaged memory component used in a computer system. RAM modules provide temporary working storage so that the processor can access active data and programs quickly.

RAM Module Types

- DIP — Dual Inline Package
- SIPP — Single Inline Pin Package
- SIMM — Single Inline Memory Module
- DIMM — Dual Inline Memory Module
- RIMM — Rambus Inline Memory Module
- SO-DIMM — Small Outline DIMM

Uses of RAM Module

1. Temporary data storage while programs are running.
2. Keeping frequently used data available for quick access.
3. Supporting multitasking.

4. Providing temporary caching/buffering.
5. Improving performance when sufficient memory is available.
6. Helping applications run smoothly by reducing excessive storage swapping.

Features of RAM Module

- Volatile operation — contents are lost when power is removed.
- Fast read/write access.
- Different capacities are available.
- Different DDR generations provide different performance characteristics.
- DIMM and SO-DIMM form factors suit different systems.
- Dual/triple/quad-channel arrangements may increase memory bandwidth.
- ECC memory can provide error detection/correction.
- High-performance modules may use heat spreaders.

RAM (Random Access Memory) is the main working memory of a computer. It temporarily stores data and instructions that are being used by the processor.

Solid State Drive

An SSD is a storage device that uses flash memory instead of spinning magnetic platters. Since it has no moving mechanical parts, it can provide quick access, low latency and good resistance to physical shock.

Uses of SSD

- Operating-system storage for faster boot and application loading.
- Application storage for software requiring quick access.
- Gaming systems where fast loading is useful.
- Data transfer and high-speed file operations.
- Laptops and ultrabooks where size, weight and efficiency matter.
- Enterprise and data-centre storage.
- Portable external storage.

Features of SSD

- High read/write and access performance.
- No spinning platters or mechanical heads.
- Good durability against physical shock.
- Available in formats such as 2.5-inch, M.2 and PCIe/NVMe.
- Lower power use in many portable applications.
- Quiet operation.
- Newer generations continue to improve speed and efficiency.
- Flash memory has a finite number of write/erase cycles.

RS-232C

RS-232C is a serial communication standard that defines electrical and interface characteristics for serial data communication. It was widely used to connect computer equipment with devices such as modems and other serial peripherals.

The reference describes communication between DTE (Data Terminal Equipment), such as a computer, and DCE (Data Communication Equipment), such as a modem.

HDMI

HDMI, or High-Definition Multimedia Interface, is a digital interface designed to carry high-quality video and audio over a single connection.

The reference describes HDMI use with televisions, monitors, computers, gaming systems, Blu-ray players, streaming devices and home-theatre equipment.



Fig. 14: HDMI Cable

Uses of HDMI

Connecting computers, game systems, Blu-ray players and similar sources to displays.
Home-theatre connections between receivers, projectors and screens.
Gaming connections requiring high-quality graphics and audio.
Computer display output to external monitors.
Video conferencing equipment.
Streaming devices and media equipment.

Features of HDMI

High-quality video and multi-channel audio support.
Single-cable transmission for both audio and video.
Digital signalling that preserves signal quality.
Broad compatibility across consumer electronic devices.
HDCP support for content protection.

CEC support for controlling compatible devices.
Ethernet/networking capability on supported HDMI versions.

Benefits of HDMI

High-quality audio and video output.
Convenient single-cable connection.
Wide compatibility with modern displays and multimedia equipment.
Digital transmission with good signal integrity.
Advanced control features such as CEC on compatible equipment.
Support for newer resolutions and audio formats as standards evolve.

Overall, HDMI provides a convenient digital connection for modern audio-visual systems, while the exact capabilities depend on the HDMI version and connected devices.

Input Devices

Input devices are hardware components used to enter data and instructions into a computer for processing. They provide a communication path between the user and the processing unit. Common input devices include keyboards, mice, scanners, touch screens, digitizers, and similar peripherals.

Keyboard

A keyboard is one of the most widely used input devices. It contains a collection of keys used to enter letters, numbers, symbols and commands. Depending on their purpose, the keys may be grouped as alphabet keys, number keys, function keys, space bar, Escape, Delete, Tab, Enter and other special-purpose keys.

The keyboard is connected to the computer through an interface. Traditional keyboards commonly used serial-style interfaces, while modern keyboards may use USB or wireless connections.

Types of Keyboards

The Four most common types of Keyboards

- 83-key keyboard
- 84-key keyboard

- 101-key keyboard
- 104-key keyboard

83-Key Keyboard

The 83-key keyboard was commonly used with early PC systems. It has a separate arrangement of function and control keys. The position and grouping of some keys differ from later keyboard designs. It also includes keys used for numeric entry and cursor movement.



Fig. 15: 83- Key Keyboard

84-Key Keyboard

The 84-key design introduced several improvements over the earlier 83-key arrangement. The Enter key and other control keys were repositioned, making the keyboard more convenient for typing. Cursor-control keys and numeric keys were also arranged for easier access.

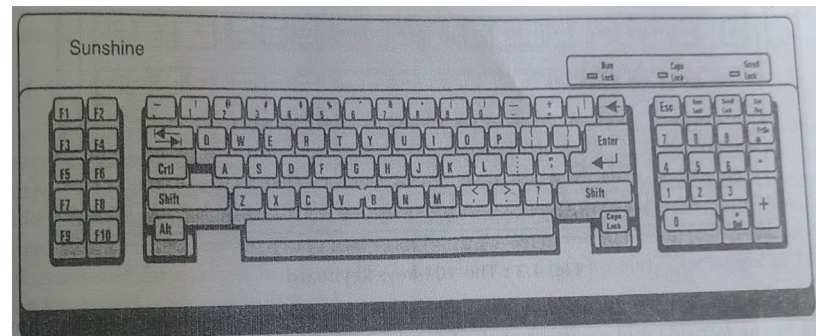


Fig. 16: 84- Key Keyboard

101-Key Keyboard

The 101-key keyboard became a widely accepted standard for personal computers. It provides a larger function-key section, a dedicated cursor-control area and a numeric keypad. Variations may include additional keys for special functions.



Fig. 17: 101- Key Keyboard

104-Key Keyboard

The 104-key keyboard is also known as a Windows keyboard. It adds extra Windows-related keys to the 101-key arrangement. Its electrical connection is generally compatible with the earlier layout, while the additional keys support operating-system and application functions.



Fig. 18: 104- Key Keyboard

Ergonomic Keyboard

An ergonomic keyboard divides the central key area into sections and angles them outward. This arrangement is designed to provide a more natural hand position and greater comfort during long typing sessions.

Laptop Keyboard

Laptop keyboards are integrated into portable computers. They are designed to save space and may combine several functions on a single key. Special function keys can control features such as brightness, sound and display settings.

Common Keyboard Faults

- Keyboard does not operate
- One or more keys are broken or stuck
- Some keys work while others do not
- Loose or damaged cable/connector
- Driver or compatibility problems

Non-Operation of Keyboard

If a keyboard does not work, first check its connection and cable. Make sure the connector is firmly inserted and verify that the keyboard type is compatible with the computer. If the keyboard is still unresponsive, the fault may be in the keyboard hardware or system interface.

Broken or Stuck Keys

A key may stop working because of a damaged switch, dirt or a broken mechanical part. Cleaning the key area and checking the switch can solve minor faults. A damaged switch may need replacement.

Some Keys Working and Others Not

If only certain keys fail, inspect the keyboard for broken tracks, loose contacts or a damaged key matrix. Cleaning and reconnecting the keyboard may help; otherwise the keyboard circuitry may require repair.

Other Problems

Additional problems can include incorrect characters, repeated characters and communication errors. System settings, drivers and keyboard hardware should be checked systematically.

Keyboard Controller

A keyboard controller is an electronic circuit or microcontroller that manages the operation of a keyboard. It receives signals from the keys, identifies which key has been pressed, processes the information from the key matrix and sends the corresponding code to the computer. A keyboard controller generally consists of processing circuitry, memory such as RAM/ROM and input/output registers.

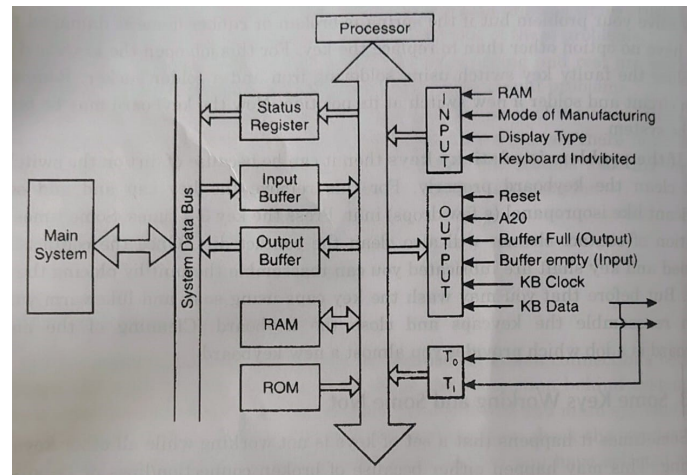


Fig. 19: Block Diagram of Keyboard Controller

Mouse

A mouse is a pointing input device used to control the pointer on a computer screen. It allows the user to select, open and perform different commands easily. It is especially useful for working with graphical user interfaces.



Fig. 20: Mouse

Types of Mouse

- Mechanical mouse
- Optical mouse
- Optomechanical mouse

Mechanical Mouse

A mechanical mouse uses a small ball and rollers to sense movement. When the mouse is moved, the ball rotates the internal rollers. These rollers generate electrical signals, which are processed by the controller to move the pointer on the screen.

Optomechanical Mouse

An optomechanical mouse uses both mechanical and optical methods to detect movement. The ball rotates wheels that contain slots or patterns. Light sensors detect the movement of these wheels and produce signals that indicate the direction and amount of movement.

Optical Mouse

An optical mouse detects movement using a light source and a sensor. It does not contain a tracking ball. The sensor continuously detects changes on the surface and sends movement information to the computer. Since it has fewer moving parts, it generally requires less maintenance.

Connecting a Mouse to a Computer

A mouse can be connected to a computer using different types of connections, such as a mouse port, serial port, bus connection or USB port. The connection allows the mouse to receive power and send movement and control signals to the computer.

Uses of Mouse

A mouse is generally used on a smooth, flat surface or a mouse pad. It is used to perform various operations, such as:

- **Click:** Used to select or activate an item on the screen.
- **Double-click:** Used to open a file, folder or perform a specific action.
- **Drag:** Used to move an object from one location to another by holding the mouse button and moving the pointer.

Common Faults of Mouse

Some common problems found in a mouse are:

- Mouse does not work.
- Pointer moves incorrectly or does not move.
- Computer shows a mouse-not-detected message.
- Problems with drivers or the computer interface.

To solve mouse problems, first check the wired or wireless connection. Clean the mouse sensor and check the driver settings. If the problem continues, examine the mouse hardware and the computer's connection or interface.

Scanners

A scanner is an optical input device used to convert printed text, photographs and other documents into digital information. The captured information can then be stored, processed or edited by a computer.



Fig. 21: Scanner

Types of Scanners

- Hand-held scanner
- Flatbed scanner

Hand-Held Scanner

A hand-held scanner is moved manually across the document surface. It contains a light source and sensing elements that capture the image as the scanner passes over the document.

Flatbed Scanner

In a flatbed scanner, the document is placed on a glass plate. A scanning mechanism moves beneath the glass and captures the document line by line. The resulting digital data represents the scanned image.

Working Principle of Scanner

The scanner illuminates the document and senses the reflected or transmitted light. The sensor converts the optical information into electrical signals. These signals are digitized and transferred to the computer for processing.

Uses of Scanner

- Converts paper documents into digital form.
- Can capture photographs and printed text.
- Useful for document storage and sharing.
- Supports image processing and optical character recognition (OCR).

Digitizer

A digitizer is an input device that converts drawings, handwriting or other physical information into digital data. It is commonly used for graphical work, design and precise pointing applications.



Fig. 22: Digitizer

Working of a Digitizer

The user moves a stylus or pointer over the digitizing surface. The device detects the position and converts it into digital coordinates that the computer can process. Digitizers are useful where accurate drawing or position information is required.

Webcam

A webcam is a small digital camera that works as an input device for capturing pictures and videos. It may be built into a computer or connected externally. Webcams are commonly used for video calls, online classes, virtual meetings, recording videos and live streaming.



Fig. 23: Webcam

Uses of Webcam

- Used for video calls, video conferences and online meetings.
- Helpful for online education, classes and training sessions.
- Used for live streaming and creating digital content.
- Can capture and record photos and videos.
- Helps people communicate from different locations.
- Can be used for security and monitoring purposes.

Benefits of Webcam

- Provides real-time video communication.
- Makes online meetings and virtual classes more convenient.
- Allows users to record, save and share videos.
- Useful for both personal communication and professional activities.

Display Devices

A computer system is commonly described through three major functional units: the input unit, the output unit and the central processing unit (CPU). Input devices send information toward the processor, whereas output devices present the processed result to the user. Interfaces, cables and supporting circuits allow these devices to work with the computer.

Among output devices, monitors and printers are especially common. A monitor produces a soft copy on a display screen, while a printer produces a hard copy on paper. The monitor gives the result immediately in a form that can be viewed directly.

A visual display system can be considered in two broad parts: the monitor and the video adapter. The adapter prepares the display information and the monitor converts that information into a visible image.

- Monitor – the device that presents the image to the user.
- Video adapter – the interface/card that prepares display information for the monitor.

Monitor

A monitor is a major part of a visual display terminal. It receives display information and produces an image on its screen. Older monitors are closely associated with television-style displays, but a computer monitor is designed for computer-generated information and generally provides greater display resolution than a television system.

The source material groups monitors into three principal categories: CRT, LCD and plasma displays. CRT systems use a cathode ray tube, LCD systems use liquid-crystal technology, and plasma systems create light by exciting gas cells.

CRT Monitors

A CRT monitor uses a large vacuum tube made from glass and metal. Its front portion carries the screen, while an electron gun is located toward the rear. The tube is approximately conical in form and the inside of the screen is coated with phosphor. When electrons strike this coating, it emits visible light.

Compared with compact laptop displays, a CRT assembly occupies more space and consumes considerably more power. A portion of this energy is released as heat, so the enclosure requires ventilation. High-voltage insulation is also necessary because CRT circuits can operate at very high voltages.

The monitor enclosure houses the major assemblies needed to operate the CRT.

- Enclosure box

- Cathode-ray tube
- Video/CRT drive board
- Power supply
- Raster drive board

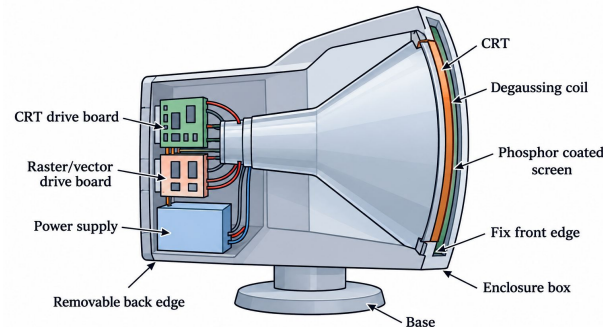


Fig. 24: Block Diagram of a Monitor

Monochrome Monitor

The CRT screen is made from a large number of tiny picture elements called pixels. To form an image, the electron gun produces a controlled beam and directs it toward selected positions on the phosphor-coated screen.

The video drive board receives display requests from the computer through the video adapter. The required display information is kept in video memory. The drive circuitry then controls the electron beam according to that information.

Inside the electron gun, the heater raises the cathode temperature and electrons are emitted. Control and focusing elements guide the electron cloud, while an accelerating grid controls the electron velocity. The beam then passes through a deflection system before reaching the screen.

- Horizontal deflection controls the beam movement from left to right.
- Vertical deflection controls movement from top to bottom.
- Deflection may be produced by electrostatic plates or by external magnetic coils/yokes.
- The final beam position determines which phosphor region is illuminated.

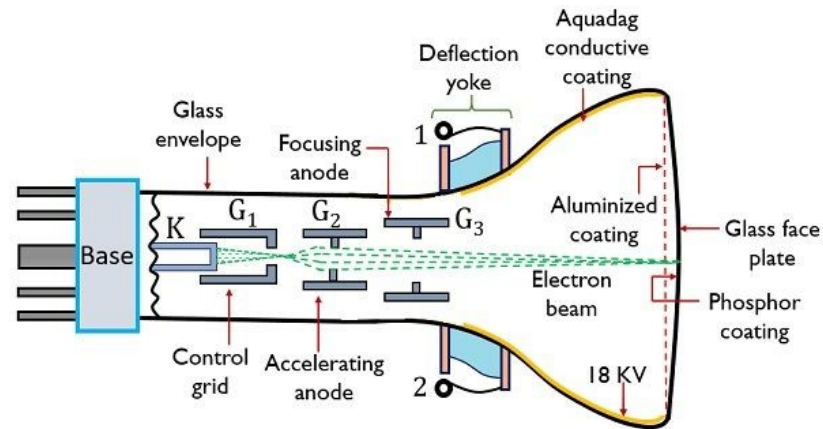


Fig. 25: Monochrome CRT

Colour Monitor

The colour CRT follows the same general principle as a monochrome CRT but uses three electron guns for the three primary display colours: red, green and blue. The screen contains corresponding phosphor regions. A shadow mask helps each beam reach the intended phosphor area. Proper beam alignment is important for colour purity, and convergence adjustments keep the three beams correctly aligned.

After an image is formed, its brightness gradually decreases. The screen therefore has to be refreshed repeatedly. The time between successive refresh operations is related to the refresh process used by the display system.

Display resolution is described in horizontal and vertical directions. Horizontal resolution indicates the number of display columns, while vertical resolution indicates the number of displayed lines. The source material also relates resolution to horizontal and vertical scan frequencies.

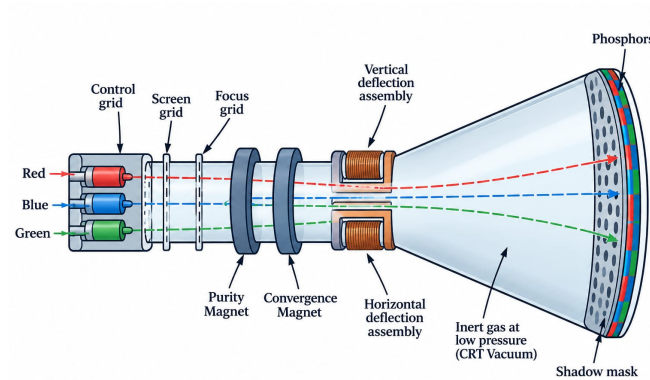


Fig. 26: Colour Monitor

LCD Monitors

LCD monitors differ from CRT monitors because an LCD panel contains a fixed arrangement of pixels. The panel works with liquid-crystal elements, transistors and a backlight. The source material describes LCDs as thin, light and convenient to transport, which is why they became common in portable computers.

An LCD display combines three important functional parts: the display panel, the backlight and the control electronics. The control electronics manages the operation of the pixels, while the backlight provides the illumination needed for viewing.

LCD panels are available in different sizes and quality levels. Their image quality depends on the panel and the selected resolution. The source also notes that LCDs are digital display devices, although manufacturers may provide an analogue interface for compatibility.

A monitor can operate in text mode or graphics mode depending on the video adapter being used.

Plasma Display Monitors

A plasma display produces an image by controlling tiny fluorescent light-emitting cells. Each pixel is formed from red, green and blue components, and different light intensities are combined to produce different colours.

A typical plasma panel uses two glass plates with a gas-filled region between them. Horizontal and vertical electrodes are arranged on the panels, while a central structure divides the gas region into closely spaced cells. When the appropriate voltage is applied, the gas becomes conductive and emits light.

The source material explains that the plasma can be initiated using a relatively high voltage and then maintained with a lower sustaining level. To turn a cell off, the sustaining condition is removed or reduced. A major advantage described is the ability to construct a wide display using relatively thin material.

Video Display Adapters

The video adapter provides the communication path between the computer and the monitor. It is normally implemented as a card installed in an expansion slot. The adapter receives display-related information from the processor and converts it into the signals required by the monitor.

The source material treats the video adapter as a small computer-like subsystem because it contains processing, memory and interface circuitry. Its main blocks include video ROM/BIOS, video RAM, a video processor or ASIC, and connectors or switches.

- Video ROM / BIOS – stores display-related firmware.
- Video RAM – stores image information and display data.
- Video processor – performs display processing and conversion tasks.
- Connectors and switches – provide monitor and configuration interfaces.

Video Adapter Types

MDA

The Monochrome Display Adapter (MDA) was one of the first display adapters developed by IBM for the original IBM PC in 1981. It was mainly designed to display text clearly rather than colorful graphics.

CGA

The Color Graphics Adapter (CGA) allowed a computer to show both text and colored pictures on the screen. CGA was one of the first display adapters to provide color graphics on personal computers.

HGA

The Hercules Graphics Adapter (HGA) was developed by Hercules Computer Technology in 1982. It was created to provide clear text along with better monochrome graphics than the standard MDA.

EGA

EGA stands for Enhanced Graphics Adapter. The source places its introduction in 1984 and describes it as an important step toward higher-resolution colour display. It supports several graphics and text configurations and provides more colour capability than the earlier MDA and CGA standards.

PGA

PGA means Professional Graphics Adapter. It was intended for demanding graphics applications such as computer-aided design. The source highlights its ability to provide three-dimensional rotation and animation-oriented performance. A resolution of 640×480 is associated with the PGA in the supplied material.

The development from MDA and CGA through EGA and PGA reflects a general move toward higher resolution, greater colour depth and more advanced graphics processing.

VGA

VGA stands for Video Graphics Array. The source describes VGA as a major video standard introduced in the late 1980s. It uses analogue colour signals rather than the older TTL-style colour signalling and supports a wide range of text and graphics modes.

VGA also introduced the familiar 15-pin analogue connector arrangement used by the standard.

SVGA

SVGA means Super Video Graphics Array. The source states that early SVGA implementations supported 800×600 resolution with 16 colours, while later cards supported higher resolutions such as 1024×768 with 256 colours. SVGA boards were designed to retain compatibility with conventional VGA while adding additional display modes.

XGA

XGA means Extended Graphics Array. The supplied material places its introduction in 1990. XGA provides enhanced display capabilities and supports multiple operating modes, including a standard VGA mode, an enhanced 132-column text mode and an XGA mode. The source also describes backward compatibility with earlier display standards and support for interlaced display.

Video Adapter Characteristics

The quality of the displayed picture depends strongly on the capabilities of the video adapter. The source identifies three important characteristics: screen resolution, colour depth and memory calculation.

Screen resolution represents the number of pixels used horizontally and vertically. For example, 800×600 means 800 pixels across and 600 pixels vertically. The ratio between image width and height is the aspect ratio; 4:3 is given as a common example.

Colour depth indicates how many colours can be represented by each pixel. With 4-bit colour depth, 16 colour values are possible. With 8-bit colour depth, 256 values are possible. A 24-bit representation can provide 16,777,216 possible colours. The source also distinguishes 8-bit 256-colour mode, 16-bit high-colour mode and 24-bit true-colour mode.

Components of a Video Adapter

The supplied material lists several hardware blocks that together make a video adapter function as a display subsystem.

- Bus connector – connects the adapter to the computer system bus.
- Monitor connector – provides the physical signal path to the display.
- Display Power Management System (DPMS) – provides power-management signalling.
- Feature connector – provides additional display-related connections.
- Video BIOS – contains firmware used by the display hardware.
- Video chipset – performs display processing.
- Video memory – stores display data.
- RAMDAC – converts stored digital colour information to analogue display signals.
- Video driver – software layer used to operate the adapter.

The bus connector is especially important because the adapter card communicates with the computer through the system bus. The monitor connector then carries the prepared display signals to the display device.

Printer

A printer is a peripheral output device used to convert computer information into readable hard copy. Printers differ in speed, image quality, noise, colour capability and the method used to place marks on paper.

Types of Printers

Printers can be grouped according to how quickly they produce output, how the printable image is formed and how the print mechanism physically creates the mark on paper.

According to Speed

- Character printer – one character at a time
- Line printer – one complete line at a time
- Page printer – one complete page at a time

According To Character Formation Technology

In character formation, printable characters are stored in the printer hardware. When a character code is received, the printer selects the appropriate stored pattern and prints it. This method is mainly suited to fixed character sets.

In bit-image formation, the printer constructs an image from individual dots. A character can therefore be created by selecting the required dots, and the same technique can be used for graphics.

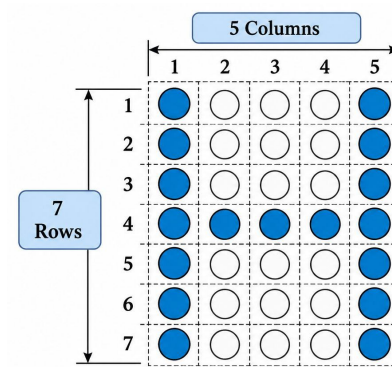


Fig. 27: Formation of Character 'H' using dot matrix of size 7x5

According To Print Mechanism

Impact Printers

Print mechanism describes the physical method used to put the formed image onto paper. Impact printers use mechanical contact, usually through pins or another striking element and an inked ribbon.

Impact printers are divided into groups such as character printers and line printers. Their construction is mechanical and they normally produce more operating noise than non-impact printers.

Non-Impact Printers

Non-impact printers form the image without striking the paper mechanically. Inkjet and laser printers are important examples. They generally operate more quietly and can provide high-quality text and graphics.

Inkjet Printer

An inkjet printer creates output by placing tiny droplets of liquid ink at controlled positions on the paper. The print head travels across the page while the paper is advanced in small steps.

The supplied material describes thermal-bubble and piezoelectric methods. In the thermal method, a resistor heats the ink and creates a bubble that pushes a droplet through a nozzle. In the piezoelectric method, an electrically driven element changes shape and produces the pressure required to eject ink.

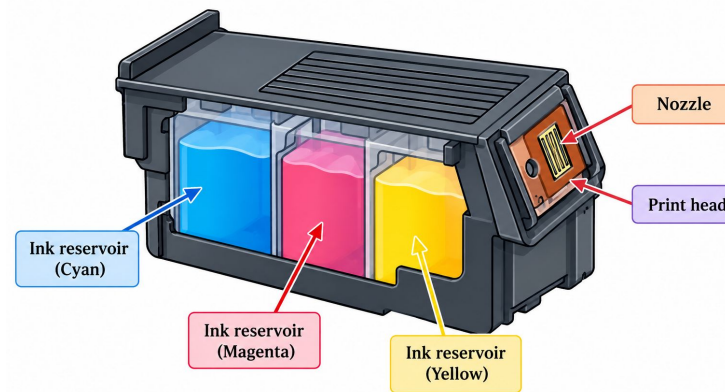


Fig. 28: Ink Cartridge

Working: The cartridge supplies ink to the print head. The head contains many small nozzles, each controlled according to the print data.

Selected nozzles eject droplets at accurate locations and repeated movement builds letters, lines and graphics.

The printing cycle continues until the required area of the page has been covered. Colour inkjet systems use combinations of coloured inks to produce a wide range of visible colours.

Laser Printer

A laser printer is a non-impact page printer designed for fast, clear and relatively quiet printing. The source material notes high resolution, with approximately 300–1800 dots per inch mentioned. Laser printing uses an electrophotographic process. A photosensitive OPC drum is charged, exposed by a laser, developed with toner, transferred to paper and finally fused with heat and pressure.

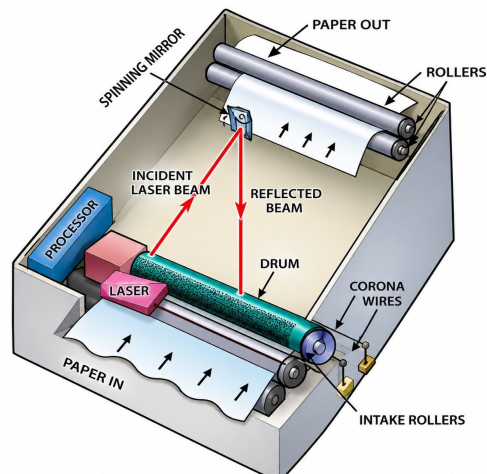


Fig. 29: Laser Printer

Construction : The printer contains electronic, mechanical and electrophoto graphic assemblies. The OPC drum forms the temporary image, while toner provides the powder material that becomes the visible print. The machine-control section coordinates data processing, paper movement and laser operation. The interface receives information from the computer and manages configuration and font-related data. The source lists CPU, EP ROM/ROM, DRAM, NVRAM and ASIC among the control/interface elements.

Working: The source presents the printing cycle as a sequence: cleaning of the drum, conditioning, writing the image, developing the image, feeding paper, transferring the image and fusing the image.

Each stage prepares the material for the next stage. Correct timing of the stages is essential for obtaining a clean printed page.

- Cleaning
- Conditioning
- Writing

- Developing
- Transfer
- Fusing

Cleaning the Drum

Before a new print cycle, remaining toner must be removed from the OPC drum. Physical cleaning uses a rubber cleaning blade or sweeper blade. Electrical methods may also be used as part of the printer's drum-cleaning process.

A clean drum provides a suitable surface for the next charging and image-writing operation.

Conditioning

After cleaning, the drum is given a controlled electrostatic condition. A charging arrangement establishes the required surface potential.

Writing

During writing, a laser beam is directed onto selected regions of the drum. The scanner moves the beam according to the image data, creating an invisible electrostatic or latent image on the drum surface.

Developing the Image on Drum

Toner is brought close to the drum by the developing mechanism. Because of the electrical properties of the toner and drum surface, toner particles are attracted to the appropriate image regions. A visible powder image is thereby created.

The developed image remains on the rotating drum until it reaches the transfer section.

Transfer of Image from Drum to Paper

At the transfer stage, an electrical charge applied through the transfer mechanism attracts toner from the OPC drum onto the paper.

Fusing

The toner is then permanently fixed by the fusing system. Heat softens the toner and pressure bonds it to the paper. The source describes heated and pressure rollers as the main fusing elements.

Laser Printer Faults

Troubleshooting should begin with basic checks such as paper loading, cable connections, cartridge seating, power supply and error indications before replacing hardware.

Thermal Printer

A thermal printer is a non-impact printer in which a print head contains heating elements. Selected elements are heated to create marks on heat-sensitive material or to transfer ink from a ribbon.

Thermal printing has a relatively simple mechanism and can operate quietly. It is useful when compact construction and low-noise printing are desirable.

Some types of thermal color printers that are commonly available

Thermal-wax-Transfer Printer

Thermal -dye-Diffusion Printer

Connecting a Printer to a Computer

A printer communicates with the computer through an interface. The source discusses serial and parallel interfaces and also refers to later interfaces such as USB.

The interface carries print data and control information. The selected interface determines how the data travels and how the two devices coordinate transmission.

- Serial interface
- Parallel interface

Serial Interface

Serial transmission sends information sequentially, normally one bit at a time over a communication path. The source discusses transmit and receive lines and control signals used to coordinate communication.

Serial connections generally use fewer data lines than parallel connections and can be useful for longer communication paths.

Parallel Interface

Parallel communication sends multiple data bits at the same time through separate signal lines. The traditional Centronics printer interface uses a group of data, control and status lines.

The source also mentions EPP (Enhanced Parallel Port) and ECP (Extended Capabilities Port), which were introduced to improve the performance and functionality of parallel communication.

Printer Controller

The printer controller is the control unit responsible for coordinating the printer's internal operations. It accepts data from the host computer, processes commands and manages the printer mechanism.

The controller may contain a processor, ROM, RAM and interface circuits. It controls timing, data storage, communication and mechanical operations.

Interfacing PC with Printer

When a computer communicates with a printer, control, status and data signals travel between the two devices. Modern printer interfaces are generally capable of two-way communication, allowing the printer to report its condition while receiving print data from the computer.

The interface signals can broadly be grouped into two categories:

- Serial interface signals
- Parallel interface signals

Serial Interface Signals

In a serial connection, information is transferred sequentially over the communication link. The computer uses several control and data signals to establish communication and transfer information to the printer or another connected device.

Important signals transmitted from the computer are:

- Data Terminal Ready (DTR)
- Request To Send (RTS)
- Data Carrier Detect (DCD)
- Transmit Data (TXD)

DTR indicates that the computer is active and prepared to communicate with the connected device. RTS is used to request permission to begin transmitting data. DCD indicates whether a valid connection or carrier is detected. TXD is the line through which the computer sends the actual data.

The printer/device can also return status information to the computer through signals such as:

- Data Set Ready (DSR)
- Clear To Send (CTS)
- Ring Indicator (RI)
- Receive Data (RXD)

DSR informs the computer that the connected device is ready for communication. CTS is used as a permission signal indicating that the device is ready to accept data. RI is associated with an incoming call or connection indication, while RXD carries data received by the computer.

Parallel Interface Signals

The Centronics printer interface was originally designed as a one-way (unidirectional) interface. Later versions supported two-way communication, allowing both the computer and printer to exchange information.

Common signals generated by the computer in a parallel interface include:

- Strobe Line Signal (SLS)
- Data Line Signal (DLS)
- Initialize Printer (IP)
- Select Input (SI)
- Auto Feed (XT)

Printer-to-Computer Parallel Signals

- Acknowledge Line Signal (ACK)
- Busy Line Signal (BL)
- Out of Paper Signal (OOP)
- Device Ready Signal (DR)
- Error/Fault Signal (E/F)

Introduction to Networking Devices

A Network Interface Card (NIC) is an expansion or interface unit that allows a computer to connect to a network. It provides the hardware and circuitry required to transmit and receive data over the selected network medium.

A NIC normally includes electronic components, connectors and communication circuitry. Depending on the network technology, a NIC may support different cable types and operating speeds. Before the card is used, its parameters may need to be set, configured and interfaced with the operating system.

Setting

Before connecting a network interface card, certain operating parameters may need to be selected. The source discusses IRQ, I/O address, DMA and shared-memory settings.

An IRQ identifies the interrupt request used by the card. I/O addresses provide locations through which the processor communicates with the device. DMA can allow data to move between the device and memory with reduced processor involvement. Shared memory can provide a memory area used for communication between the device and the system.

Configuring

Configuration involves both hardware and software preparation. Hardware configuration may use jumpers, switches or other selection methods, while software configuration uses the operating system and driver settings.

Interfacing

After the required parameters are configured, the NIC is ready to be interfaced with the computer. Device drivers provide the software link between the network adapter and the operating system.

Need of a Computer Network

The need for networking arises from common requirements such as limited resources, the need to share resources and the demand for fast and dependable communication.

Information can be communicated from one place to another through a network. Programs, data files, storage facilities and peripherals can also be shared. A remote computer may access resources located on another system when the network and its permissions allow it.

Goals of Computer Network

The main goals of computer networking are to make resources available to multiple users, reduce cost, improve system performance and provide an effective communication medium.

Resource sharing allows programs, files and peripherals to be used by more than one computer. Sharing can reduce duplication and save time. Networking can also provide a common communication path for people working in different locations.

- Resource Sharing
- Cost Reduction
- Improve Performance
- Provide Communication Medium

Types of Computer Networks

The source describes three broad types of computer networks: Local Area Network (LAN), Metropolitan Area Network (MAN) and Wide Area Network (WAN).

A LAN covers a comparatively small area such as a building or campus. A MAN covers a larger geographical region, typically across a city. A WAN connects networks over much larger distances.

- LAN – Local Area Network
- MAN – Metropolitan Area Network
- WAN – Wide Area Network

Local Area Network (LAN)

A LAN connects computers and other devices within a relatively small geographical area, such as a building, office or campus. The source describes LANs as providing high-speed communication and using privately owned physical media.

Typical LAN components include computers, workstations, servers, printers, scanners, transmission media and network interface units. Twisted-pair cable, coaxial cable and optical fibre may be used as transmission media.

- Small geographical coverage

- High-speed communication
- Privately owned medium
- Workstations and servers
- Shared peripherals

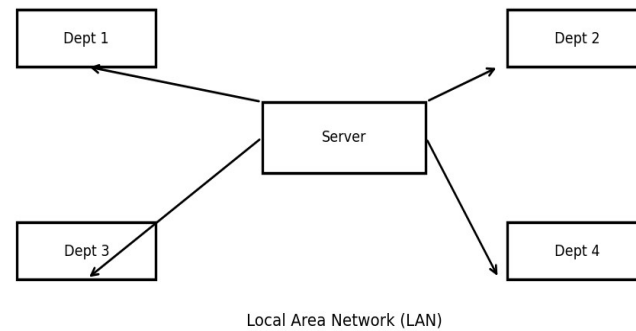


Fig. 30

LAN Characteristics

The source gives several characteristics of a LAN: limited geographical coverage, high data-transfer speed, privately controlled media, simple communication protocols and relatively low cost.

A LAN may use a server to provide shared resources. Server software and workstation software together support resource sharing, data security and communication with other networks.

Wide Area Network (WAN)

A WAN connects computers or networks located over a large geographical area. Compared with a LAN, it normally covers a much greater distance and may use public communication facilities.

The source identifies enterprise WANs and global WANs. WAN hardware can include bridges, routers, gateways and related communication equipment.

- Enterprise WAN
- Global WAN

Bridge is used to connect to more local area network to form a wide area network.



Fig. 31: Wide Area Network

Routers

A router is a networking device that connects different networks and forwards packets toward their destination. It examines network addressing information and selects an appropriate path.

Gateways

A gateway can connect networks that use different communication environments or protocols. The source describes the gateway as a more general connecting device that can provide protocol conversion when required.

Wan Characteristics

WANs can operate over very large distances. The source notes that their links may use leased lines or public systems such as telephone, microwave and satellite facilities. WAN links can be slower and more error-prone than typical LAN connections.

Wi-Fi

Wi-Fi is a wireless LAN technology that allows compatible devices to exchange data using radio waves. A wireless access point can provide connectivity to devices such as computers, phones and tablets.

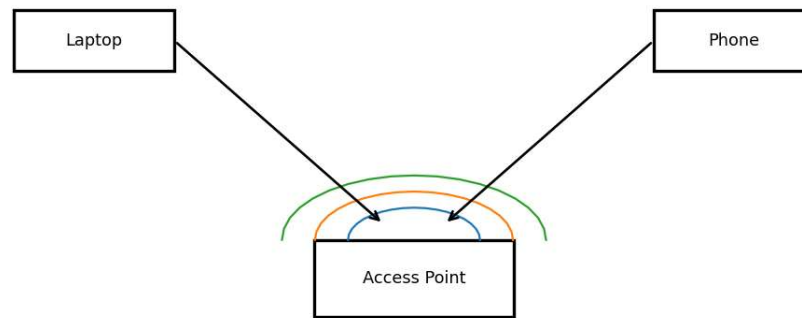


Fig. 32: Wi-Fi Access Point concept.

- Advantages: mobility, easy installation, useful where cables are difficult
- Limitations: range, interference and security concerns

Routers

A router is used to connect two or more networks that are not necessarily similar. It operates at the network layer and forwards packets based on logical network addresses.

Routers can connect LANs to other LANs or WANs. They maintain information about reachable networks and use routing decisions to send packets toward the correct destination.

- Central router
- Local router
- Remote router
- Internal router
- External router
- Peripheral router

A central router works as the main connecting device of a network. It links several LANs and manages communication between them. A local router generally works within the limits of its LAN, whereas a central router can handle communication between multiple LANs. A local router is normally used within a particular LAN. It manages communication between devices or network segments inside the local network and generally does not handle communication beyond its assigned network. A remote router is used to establish communication between networks located at different geographical locations. It allows data to travel between distant networks through suitable communication links. An internal router operates inside a network and manages the transfer of data between different sections or sub-networks. It helps direct packets to their intended destinations within the network. An external router provides connectivity between separate networks. It can connect an organization's internal network to an external network or another network through an appropriate communication path. A peripheral router is positioned near the edge of a network. It provides communication between individual LANs and a central or larger network.

A router can be considered the backbone or traffic-directing device of a network. It connects different networks and determines where data should be sent. The main functions of a router include:

- Connecting two or more networks.
- Examining the destination address of incoming packets.
- Selecting a suitable route for data transmission.
- Forwarding packets toward their destination.
- Maintaining routing information.
- Managing communication between different network segments.

Switch

A switch is a hardware device that receives and forwards packets between network segments. It can provide dedicated connections between devices and can reduce unnecessary traffic by forwarding data toward the appropriate port.

The source explains that switches can monitor traffic and improve network performance. Managed switches may provide additional control and monitoring features.

- Connect multiple devices
- Forward traffic to the required port
- Support VLANs
- Improve network performance
- Provide link aggregation and monitoring

Uses of Switch

Switches are used to connect computers, printers and servers within a LAN. They can improve performance by forwarding data only where it is required.

Switches may also be used for VLAN creation, voice-over-IP support, link aggregation, network expansion and traffic monitoring.

Features of Switch

Important switch features described in the source include smart data forwarding, multiple ports, reduced collisions, learning of device locations, VLAN support and combining connections for higher bandwidth.

These features make switches useful for efficient and organized network construction.

- Smart data forwarding
- Multiple connections
- Reduced collisions
- Learning function
- VLAN support
- Connection combining

Hubs

A hub is a network device used to extend a network by providing additional connection points. It allows several workstations or nodes to share a common communication medium.

The source describes active hubs and passive hubs. Active hubs regenerate or amplify signals and may extend the usable cable distance. Passive hubs mainly provide physical connection without signal amplification.

- Active hub
- Passive hub

Need of Hub

Hubs became useful in star-based networks because a central connection point simplified wiring and allowed several stations to connect to one central location.

A hub can make troubleshooting and maintenance easier in a small network. However, failure of the central hub can affect the complete network, and shared communication can reduce efficiency when many devices transmit at the same time.

Hub Architecture

A hub is generally a box containing several ports into which network nodes are connected. Internal bus connections allow the ports to communicate.

The source also mentions management-module ports and attachment interfaces. Common backbone media discussed include thin Ethernet, thick Ethernet and fibre.



Fig. 33: HUB Archotecture

Types of Hubs

Three hub categories described in the source are passive hubs, active hubs and intelligent or smart hubs.

A passive hub mainly provides a physical connection. An active hub regenerates or strengthens signals so that longer connections can be supported. An intelligent hub includes management features and can provide information about network conditions.

- Passive Hub
- Active Hub
- Smart / Intelligent Hub

Passive

A passive hub is mainly a central connection point and does not amplify the network signal. The source notes that passive hubs are commonly associated with simple star-network wiring.

Active Hubs

An active hub contains signal-repeating circuitry. It strengthens or regenerates the received signal before forwarding it, helping to increase the usable distance between devices. Active hubs may also provide additional ports.

Intelligent Hub

An intelligent hub, also called a smart hub, provides management functions in addition to ordinary hub connectivity. It can monitor network activity, report problems and assist with troubleshooting.

Hub Capacity

Hub capacity refers to the number of connections or ports that can be made through the hub. Different hub models provide different numbers of ports, depending on the network requirement.