University of Technology
الجامعة التكنولوجية
Computer Science Department
قسم علوم الحاسبات

Information Technology
تكنولوجيا المعلومات

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Chapter One
Information Technology (IT)

Learning Objectives:

1. **Information Technology (IT)**
2. **The differences between data, information and knowledge**
3. **Computer operations that process data into information**
4. **Information System (IS)**
5. **The basic components of information systems.**
6. **Computer-Based Information Systems (CBIS)**

1. Information Technology (IT)

When computer and communications technologies are combined to create, process, store, retrieve and exchange all types of data and information, the result is information technology.

1.1. What is a computer?

A computer is a programmable electronic device that accepts data (raw facts) as input and processes it with a set of instructions (a program) to produce the output as information or other data.

- Examples of computer systems
  - Desktop
  - Laptop
  - Smartphone (Mobile)
  - iPad

1.2. Communication or Telecommunications system.

Communication system is a system which describes the information exchange between two points. The process of transmission and reception of information is called communication.

- **The major three elements of communication are:**
  A. The Transmitter of information (Sender).
  B. The Channel or medium of communication.
  C. The Receiver of information (Receiver).
- **Examples of communication networks**
  A. Internet and Intranet networks.

B. Telephone and Mobile networks.

C. Radio and Broadcast Television (TV).

2. The differences between data, information and knowledge:

2.1. **Data:** are raw facts or elementary descriptions of things, events, activities, and transactions that are captured, recorded, stored, and classified but not organized to convey any specific meaning. It can be in the form of numbers, text, images, or any other type of input.

2.2. **Information:** It is a collection of raw facts (data) that has been processed, analyzed and organized in a meaningful way to become useful. for example, if we include the student's name with his or her grades, customer names with bank balances, and employees' wages with hours worked, we would have useful information.

2.3. **Knowledge:** is the use of human experience with data and information for the purpose of deriving a set of rules that helps to make decisions. In fact, we cannot store knowledge because it depends on human theoretical and practical experience to the subject.

Note: Information that is not of high quality may lead to wrong decisions and cost the organization a great deal of money. Therefore, for information to be useful to managers and the organization, the information must contain characteristics such as being accurate, complete, reliable and flexible.

3. Computer operations that process data into information

A computer goes through four operations when it processes data into information.

3.1. **Input operation:** data (raw, unsorted facts) is entered or captured electronically and converted to a form that can be processed by the computer. Input devices (such as a keyboard or scanner) are used to enter or capture data.

3.2. **Processing operation:** the data is processed to turn it into information, for example numbers can be added or subtracted.

3.3. **Output operation:** the information which has been processed from the data is produced in form usable by people. For example, it displayed on a computer screen, printed on a printer or played as sound on computer speakers.

3.4. **Secondary storage operation:** Information and programs are stored in a computer-process able form.

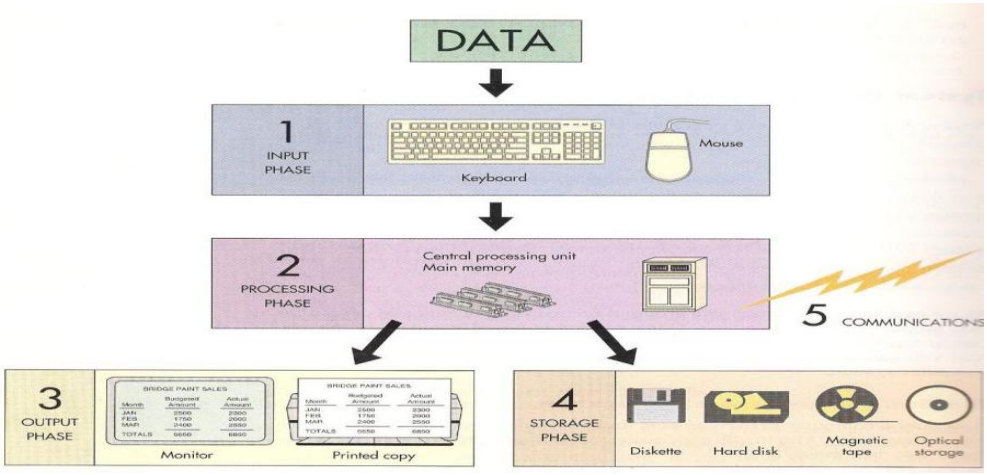


Figure 1: Computer operations

4. Information System (IS).

An information system (IS) can be defined technically as a set of interrelated components that collect, process, store, and distribute information to support decision making and control in an organization.

5. The basic components of information systems

An information system can consist of six main components. The first four components are technological (hardware, software, database and network), while the last two are based on human experience (procedures and people).

5.1. **Hardware:** A set of devices such as a keyboard, monitor, processor (CPU), and printer that accepting data as input and then processes it and turns it into information to be displayed to the user.

5.2. **Software:** a set of computer programs that enables the hardware to process data.

5.3. **Database:** an organized collection of related files, records, etc., that stores data and the associations among them.

5.4. **Network (Telecommunications):** a connecting system that permits the sharing of resources among different computers.

5.5. **Procedures:** the policies, methods, rules and strategies for using the information systems.

5.6. **People:** the most important element in IS: include those persons who work with the information system or use its output.

Note: The two terms Information Technology (IT) & Information System (IS) are not precisely synonymous, but are used interchangeably in common practice.

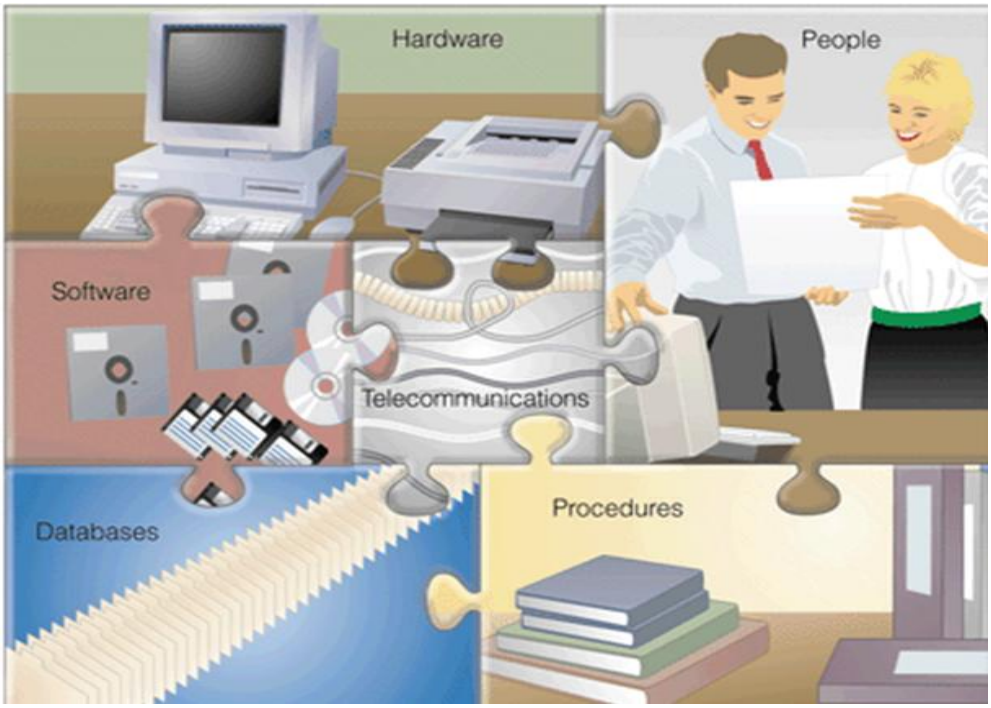


Figure 2: The basic components of information systems

6. Computer-Based Information Systems (CBIS)

The general term CBIS refers to a variety of information systems, such as Management Information Systems (MIS), Management Support Systems (MSS), Geographic Information Systems (GIS), Office Automation Systems (OAS) and Transaction Processing Systems (TPS). As explained earlier, any information system (or CBIS) consists of six major components which are hardware, software, communications, databases, people and procedures. These components are organized to input, process, and output data and information.

Chapter Two
Computer Organization

Introduction to Computer Architecture

Most computers have similar architectures that combine software and hardware.

1- Hardware

The term hardware refers to the physical components of your computer such as the system unit (computer case), mouse, keyboard, monitor, processors, memory and peripheral devices etc...

2- Software

Software is a collection of data and instructions that make a computer work. For instance, when you type in words via the keyboard, the software is responsible for displaying the correct letters, in the correct place on the screen. The software is stored either on the computer's hard disk or in flash memory (or other storage device) and is loaded (copied) into the computer's Random Access Memory (RAM) before executed it. Software includes the operating system which controls the computer hardware and application software, such as word processing, spreadsheets, etc.

Computer Hardware

The basic physical equipment (hardware) of a computer system consists of the following components:

1. System Unit and Mother Board
2. Central Processing Unit (CPU)
3. Main Memory (Primary storage)
4. Secondary Memory (Secondary storage)
5. Input device
6. Output device
7. Computer Ports

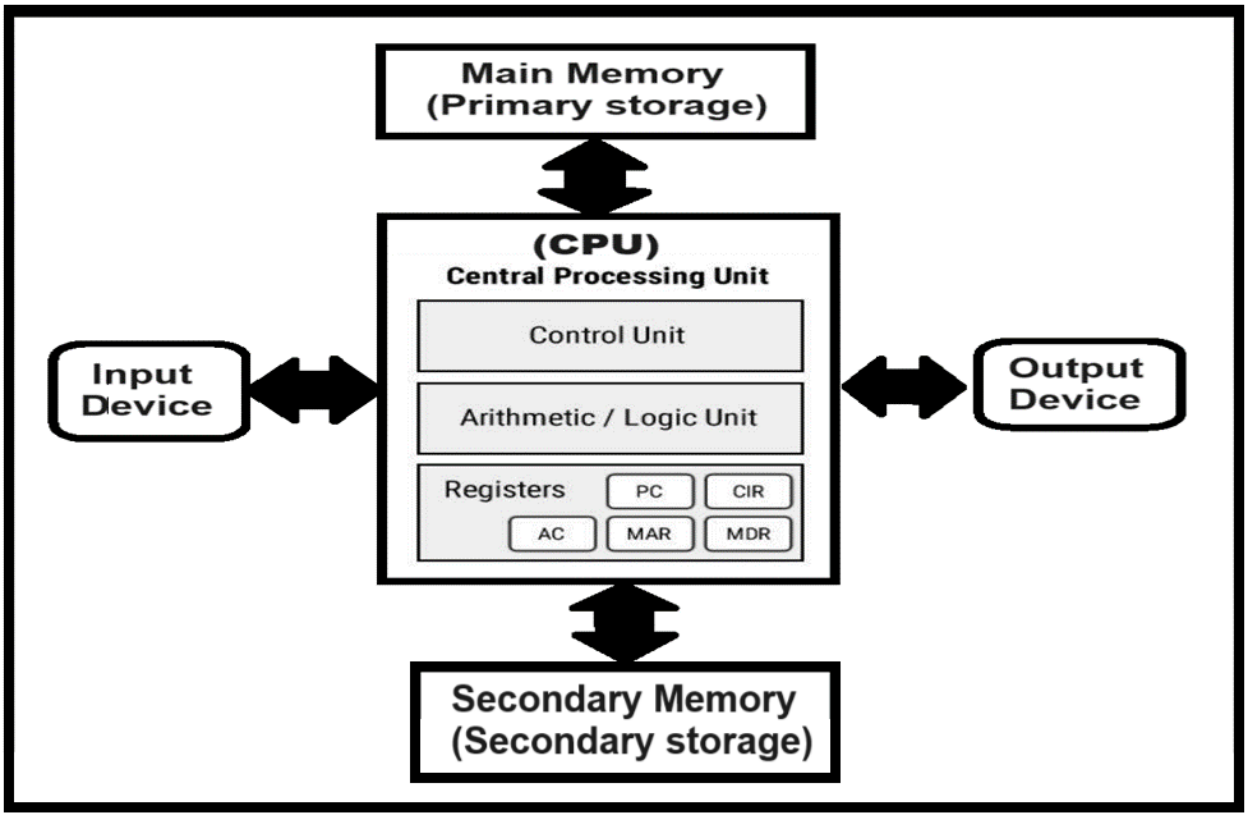


Figure 3: Hardware components of the computer

1.1. System Unit (Computer case)

The "system unit" is the name given to the main PC box which contains the important parts of the computer such as the motherboard, hard disk, Central Processing Unit (CPU), Random Access Memory (RAM) and storage drives. The system unit is basically the core of your computer where all the processing takes place.

Figure 4: System Unit (Computer case)

1.2. System Mother Board

System mother board is contained within your system unit and all the vital computer systems plug directly into the system board. The CPU is normally housed on your system board along with all the other electronic components. Other items such as the hard disk are attached to the system board, either directly or via cables. These boards are getting smaller and smaller as the components become more integrated.

Central processing unit (CPU).

The CPU supervises and controls all other computer units, transfers data to and from these units, and performs the arithmetic and logical operations necessary to transform data into meaningful information. It called "Processor" or "Microprocessor" in personal computer. It is divided into three parts:

1- Arithmetic and Logic unit (ALU).
2- Control unit.
3- Register.

Arithmetic and Logic unit (ALU).

Perform the processing of data including arithmetic operations such as addition, subtraction, multiplication, division and logic operations including comparison (ex. A<B) and sorting.

Control Unit.

The control unit coordinates the operation of the entire computer system automatically, and acts as a central nervous system that sends control signals to other computer units. The operations it performs are:

1- Control of input and output devices.
2- Sending and retrieving information to and from memory (primary and secondary memory).
3- Routing of information between the main memory and the arithmetic and logic unit (ALU).
4- Direct and coordinates all units of the computer to execute program steps.

Registers

Registers are a type of computer memory used to quickly accept, store, and transfer data and instructions that are being used immediately by the CPU. The most important registers are:

1- **Instruction Register (IR)**: It contains the instruction being executed.
2- **Program counter (PC)**: It contains the address of the next instruction to be executed.
3- **Address Register (AR)**: holds the address of memory location.
4- **Data Register (DR):** Holds data that is being transferred to or from memory.
5- **Accumulator (AC):** Where intermediate arithmetic and logic results are stored.

How does the CPU execute program instructions?

1- Fetch the instruction from memory to IR.
2- Change the address of program counter PC to the next instruction.
3- Determine the type of the instruction to be execute.
4- If the instruction uses data in memory, use the address in the AR register to fetch the data.
5- Fetch the data into data register DR register.
6- Execute the instruction.
7- Store the result in the AC register or in a proper place.
8- Go to step 1 to Fetch the next instruction whose address in PC register.

Memory units:

The memory is the part of the computer that holds information (data and Instruction) for processing, the figure represents the classification of computer memory.

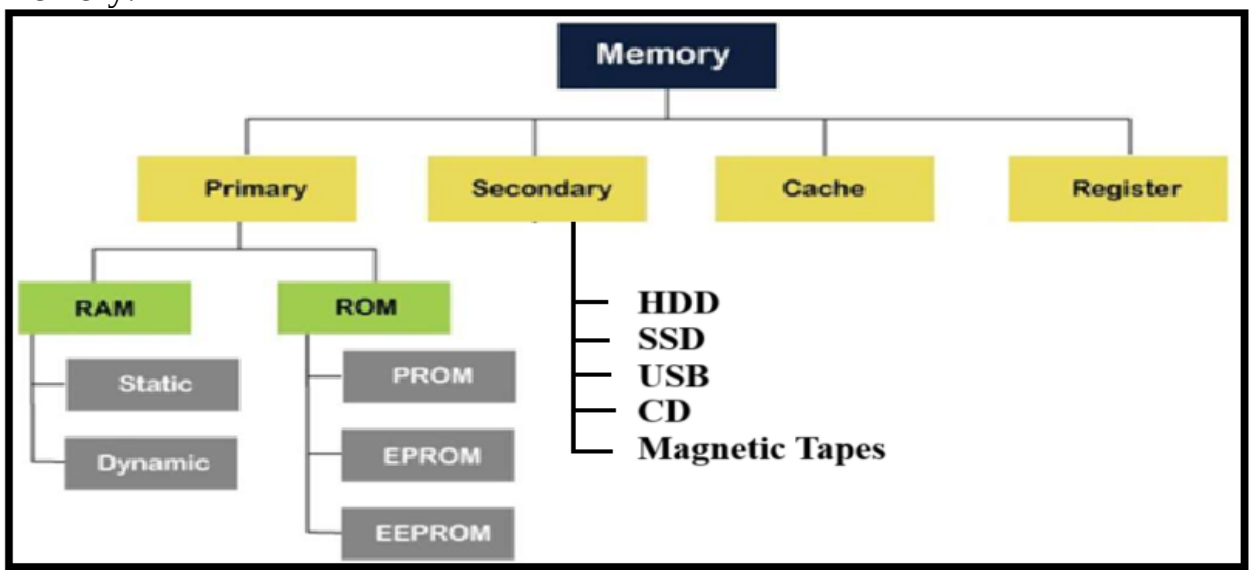


Figure 5: Memory units

2. **Main memory / Primary storage**

Main memory is a component of a computer that can hold (store) small amounts of information (data and instructions) that will be immediately processed (read and write) by CPU. Primary storage is comparatively limited in size, especially when compared with secondary storage. The specific functions of primary storage are to hold:

A- All data to be processed.
B- Intermediate result of processing.
C- Final result of processing.

2.1. Types of primary storage

There are four types of primary storage:

A- Random Access Memory (RAM)

B- Read Only Memory (ROM)

C- Cache Memory / CPU Cache

D- CPU Registers (تم شرحها سابقا)

A- Random Access Memory (RAM)

RAM (also known as computer memory) is a hardware device (chips) generally located on a computer motherboard. It stores more information than registers but less than secondary storage. It is Read and Write memory, which means the information can be written to it as well as read from it. When the user turn computer on, the CPU loads the Operating System (OS) from the hard disk into RAM. Also, the data (e.g. letters and pictures), applications (word processor or database programs), and program results are initially created and store in RAM and then copied to hard disk when they are saved. RAM is volatile memory i.e. when the user shut down the computer, the RAM loses the data. So, the data remains in the RAM as long as the computer is on and lost when the computer is turned off.

Figure 6: Random Access Memory (RAM)

<u>Type Random Access Memory (RAM)</u>

The RAM can be either dynamic or static.

1- Static RAM (SRAM):

It is a type of RAM used to store static data in the memory. it means the stored data will remain permanent stored as long as the power is supplied without the need for periodically rewriting the data in to memory.

2- Dynamic RAM (DRAM):

It is a type of RAM that is used for the dynamic storage of data in RAM. The stored data will not remain permanently stored even with power is applied unless the data are periodically rewritten in to memory; the later operation is called a refresh operation.

B- Read Only Memory (ROM) / Basic Input Output System (BIOS)

The ROM / BIOS chip is a special chip held on mother board. It contains the instructions required to copy the operating system into random RAM when you turn on the computer (Bootstrap). The (read only) means that these instructions can be read only by the computer and cannot be changed (write) by the user. ROM is non-volatile memory i.e. the memory keeps its contents even when the computer is switched off.

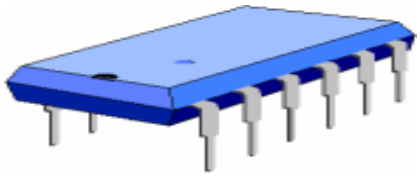


Figure 7: Read Only Memory (ROM)

Type of ROM:

1- Programmable Read Only Memory (PROM):

It is prepared by the maker and can be electrical programmed by the user; it cannot be erased and programmed again this means its content can never be changed.

2- Erasable Programmable Read Only Memory (EPROM):

The maker prepares it and can be electrical programmed by the user, it can be erasing (deleted) by exposure to ultraviolet light and programmed many times.

3- EEPROM (Electrically Erasable Programmable Read Only Memory):

The EEROM is an electrically erasable and programmable read only memory used to erase stored data. It is also a non-volatile memory whose data cannot be erased or lost; even the power is turned off. In EEPROM, the stored data can be erased and reprogrammed up to 10 thousand times.

C- Cache Memory / CPU Cache

CPU cache Used by the CPU to reduce accesses to main memory (RAM). Cache memory is high-speed memory that is smaller and faster than main memory (RAM). Cache memory is located near the processor core, which acts as a buffer between RAM and CPU to store copies of frequently

used data (from RAM to cache) to speed up system performance. The CPU can access it more quickly than RAM. So, it is used to synchronize with high-speed CPU and to improve its performance. Cache memory can only be accessed by CPU. It can be a reserved part of the main memory or a storage device outside the CPU. It holds the data and programs which are frequently used by the CPU. So, it makes sure that the data is instantly available for CPU whenever the CPU needs this data. In other words, if the CPU finds the required data or instructions in the cache memory, it doesn't need to access the primary memory (RAM).

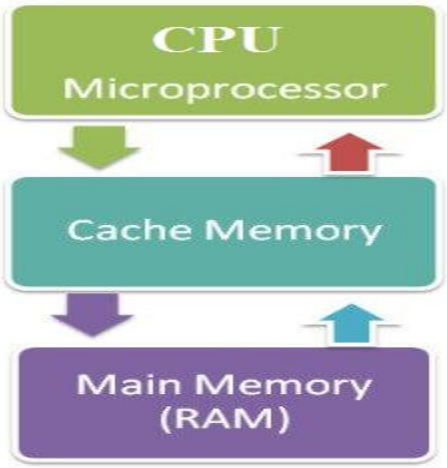


Figure 8: Cache Memory / CPU Cache

- **Memory Capacity**

  Bit: All computers work on a binary numbering system, i.e. they process data in ones or zeros. These 1 or 0 levels of storage is called a bit. Often hardware is specified as a 32-bit computer, which means that the hardware can process 32 bits at a time. Software is also described as 16-bit, 32 bit or 64-bit software. CPU process only 0s and 1s, all data are translated through computer languages into series of these binary digits, or bits. Eight bits are needed to represent a character. This 8-bit string is known as a byte. The storage capacity of a computer is measured in bytes. The hierarchy of byte memory capacity is as follows:

  A- Byte: A byte consists of 8 bits.
  B- Kilobyte: A kilobyte (KB) consists of 1024 bytes.
  C- Megabyte: A megabyte (MB) consists of 1024 kilobytes, (1024*1024) byte or 1,048,576 byte) approximately 1,000,000 bytes.

D- Gigabyte: A gigabyte (GB) consists of 1024 megabytes, (1024*1024*10240 byte) or (1,073,741,824 byte), approximately 1,000,000,000 bytes.

E- Terabyte: A terabyte (TB) consists of approximately 1,000,000,000,000 bytes.

3. Secondary Storage

Secondary storage refers to the storage methods and technologies used for the long-term storage of non-critical data that doesn't need to be accessed as frequently as primary storage. The goal of secondary storage is to retain data until you overwrite or delete it.

The differences between primary and secondary storage are:

A- Secondary storage is designed to store very large amounts of data for long periods of time (i.e.) Secondary storage has a much larger capacity than primary storage.

B- CPU takes much more time to retrieve data from secondary storage than it does from Primary storage.ie. Primary storage is located much closer to the CPU than is secondary storage.

C- Primary storage is faster and more expensive per byte stored than secondary storage.

D- All types of secondary storage are non _volatile.

Types of Secondary Storage

The most commonly used secondary storage units are:

3.1. Hard Disk Drive (HDD)
3.2. Flash memory
3.3. Solid State Drive (SSD)
3.4. Optical disks
3.5. Magnetic tape, Magnetic disc and floppy disc.

3.1. Hard Disk Drive (HDD) / fixed disk

HDD is "non-volatile" magnetic storage device that stores and retrieves data and programs, such as the Operating System (OS), applications, and user files.

3.1.1. How does a hard drive work?

HDD is an electro-mechanical data storage device that has two main components:

A- Platters: are one or more circular disks covered with a magnetic material and spins on a spindle. These disks have Tracks and Sectors to store data.

B- Actuator: is a mechanical arm with magnetic heads that moves across the surfaces of the platter to read and write data.

Data is accessed in a random-access manner, meaning that individual blocks of data can be stored and retrieved in any order.

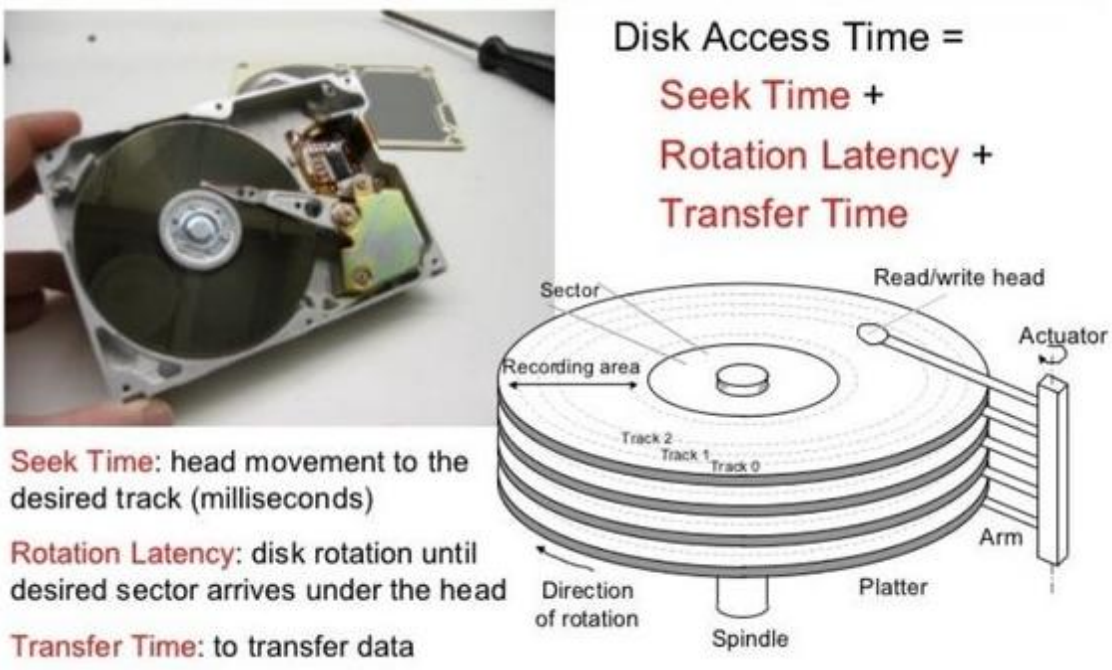


Figure 9: Hard Disk components

3.1.2. How to determine Hard disk performance?

Hard disk performance is determined by averaging the time of several parameters, which are:

A- Seek Time (Seek operation): is the average time of movement the head to the desired **track** (read / write). Typically, hard disk drives have an average seek time of several milliseconds

B- Latency Time (Latency period or Rotation Latency): is the average time takes for the desired **sector** to spin under the head once the head is positioned over the desired track. Latency average time depend on the constant rotational speed of the disk.

C- Transfer Time: is the average time takes to transfer the data.

D- Disk Access Time: is the time of "Seek Time + Rotation Latency + Transfer Time".

3.1.3. The Differences between Internal and External Hard disks

	Internal Hard disks	**External Hard disks**
1	Physically located inside the computer unit or laptop	Physically located outside the computer unit
2	Connected directly to motherboard sockets by Parallel cable using Parallel Advanced Technology Attachment (PATA)	Joined to computer unit by a USB or other type of serial cables using Serial ATA (SATA)
3	Internal hard drives faster than external hard drives	
4	Are internal hard drives more expensive than external hard drives	

3.2. Flash memory

Flash memory is an electronic non-volatile computer memory storage chip developed from EEPROM (Electrically Erasable Programmable Read-Only Memory) which means it can be erased and reprogrammed electrically. It can keep stored data and information even when the power is off. Flash memory has a fast read access time but it is not as fast as static RAM or ROM. A key disadvantage of flash memory is that it can endure only a relatively small number of write cycles in a specific block.

3.2.1. Flash memory types

The two main types of flash memory, NOR flash and NAND flash, are named for the NOR and NAND logic gates.

A- **NAND Flash memory** operates on a serial access approach, this makes NAND are used as high-capacity storage but less efficient for random access tasks. Each NAND flash memory chip consists of an array of blocks (also known as a grid) and within each block, there is an array of memory cells (also known as pages or sectors). The number of bits stored in each cell can vary, and they are typically categorized as 1-, 2- or 3-bit cells. NAND type is used for general storage such as in USB flash drives, memory cards, smart phones and Solid-State Drives (SSDs).

B- **NOR Flash memory** operates on random access approach, this makes NOR are used for executing code. Its architecture allows for individual byte access, facilitating faster read speeds compared to NAND Flash. NOR flash memory is commonly used in smart phones, supporting 1byte random access.
Note: Most smart phones support both types of flash memory, using NOR to boot up the operating system and removable NAND cards to expand the device's storage capacity.

3.3. Solid-State Drive (SSD)

SSD is a semiconductor-based storage device, which typically uses NAND flash memory to save persistent data. SSDs are starting to replace traditional hard disk drives (HDDs) in computers because SSDs are faster than traditional HDDs. HDDs suffer from weaknesses such as latency and access time caused by mechanical delay in the spinning of the platter and movement of the read/write head. Since SSDs have no moving parts, latency and time to access and store data is greatly reduced. With an SSD, the device's operating system will boot up more rapidly, programs will load quicker and files can be saved faster.

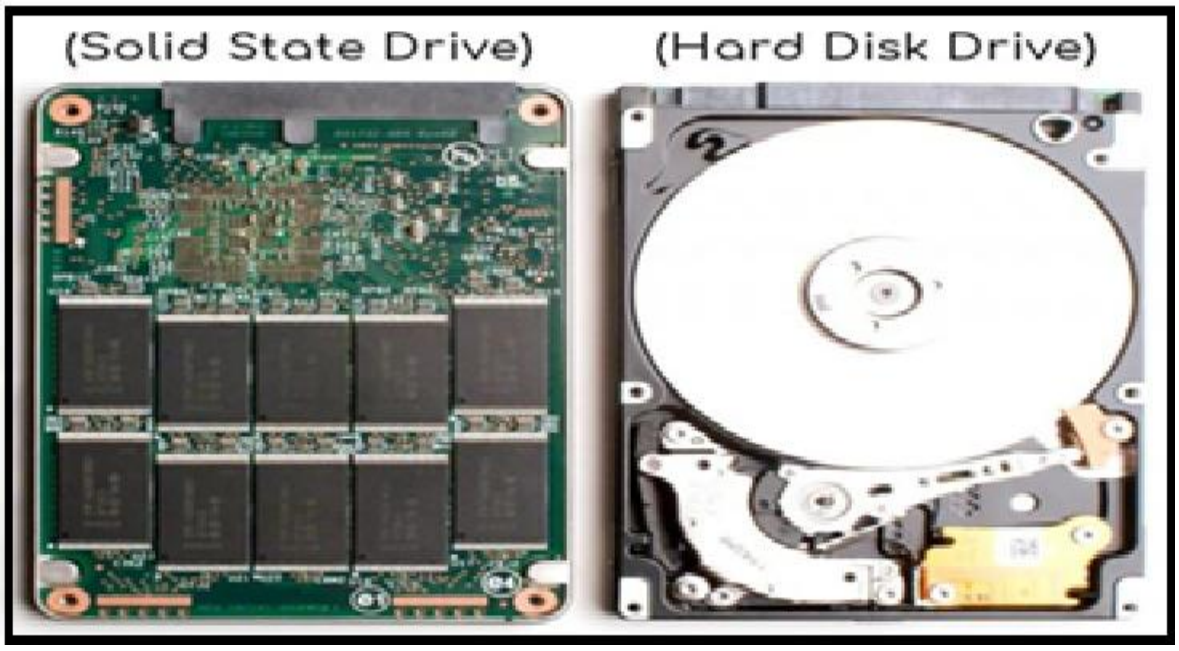
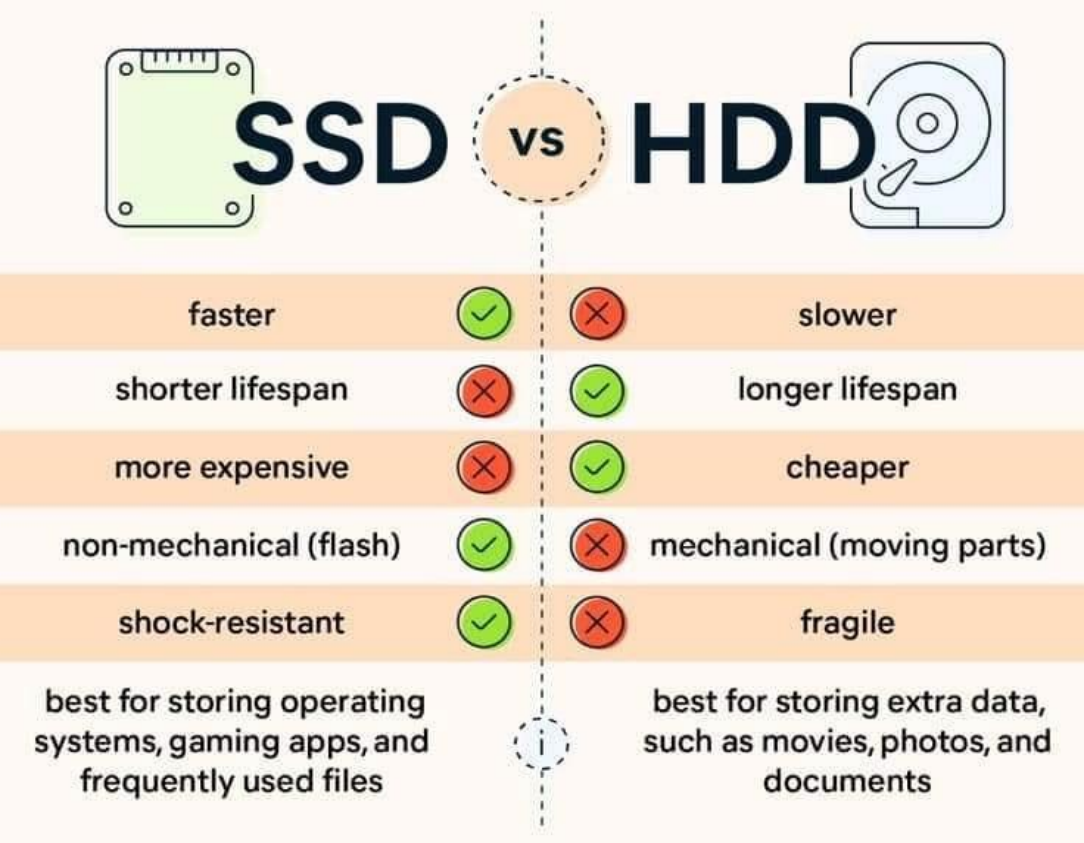


Figure 10: SSD vs HDD

The difference between SSD and HDD



3.4. Optical disks

An optical disk is a random-access storage unit where data is read and write with a laser. Typically, data is written to optical media such as Compact Discs (CDs) and Digital Versatile Discs (DVDs).

3.5. Magnetic tape, Magnetic disc and floppy disc.

Note: These types are old and no longer in use and are mentioned for informational purposes only, so we will leave their explanation

- **Why format a disk?**

  Format disk is erasing the operating system data from the disk and organizing the available space for further use. Formatting a disk will delete your data and provide you with a new and blank disk. Usually, you can format a disk if you want to use a new system or if you need extra space in your drive.

- **Peripheral device**

  A peripheral device is any device which you can attach to your computer such as the Modem, Router or any input / output device.

4. Input devices

Input devices allow you to input information to the computer and include things such as:

4.1. Keyboard.

The keyboard is designed like a typewriter but with additional function keys.

4.2. Mouse.

A mouse is a small hardware input device used by hand. It controls the movement of the cursor on the computer screen and allows users to move and select folders, text, files, and icons on a computer.

4.3. Touch pad

A touch pad is an input device on laptops and some keyboards. It allows the user to move a cursor with their finger. It can be used in place of an external mouse.

4.4. Touch screen

Is a technology that divides the computer screen into different areas. Users simply touch the desired area (often buttons or squares) to trigger an action.

4.5. Light Pen

A light pen is used to allow users to point to areas on a screen and is often used to select menu choices.

4.6. Joysticks

Is used to play video games, they can also used at workstations that can display dynamic graphics.

4.7. Microphones

A microphone is a device that converts sound waves into an electrical signal. It allows you to capture audio and transmit it to various devices, such as computers, amplifiers, or recording equipment.

4.8. Webcam

A webcam is a video camera which is designed to record or stream to a computer or computer network. They are primarily used in video telephony, live streaming and social media, and security.

4.9. Digital camera

A digital camera is a hardware device that captures photographs and stores the images as data on a memory card. Instead of recording the images on film, they are recorded digitally. Once a picture has been taken, it can be downloaded to a computer system, manipulated with a graphics program, and printed.

5. Output devices

Output devices allow you to output information from the computer such as:

5.1. LED monitor

Light-Emitting Diode monitor (LED monitor or LED display) is a flat screen, flat-panel computer monitors or television. It has a very short depth and is light in terms of weight. The actual difference between this and a typical LCD (liquid-crystal display) monitor is the backlighting. The first LCD monitors used CCFL (cold cathode fluorescent lighting) instead of LEDs (light-emitting diodes) to illuminate the screen.

5.2. Image projector (data show)

Image projector is an optical device that projects an image (or moving images) onto a surface, commonly a projection screen. Most projectors create an image by shining a light through a small transparent lens.

5.3. Printer

A printer is an external hardware output device that takes the electronic data stored on a computer or other device and generates a hard copy. Printers are one of the most popular computer peripherals and print text and photos.

- **Types of printers**

There are three types of printer technologies:

A- Impact printers:

Work like typewriters, raised metal character strikes an inked ribbon that makes a printed impression of the character on the paper, these devices cannot produce high-resolution graphics, and they are relatively slow, noisy, and subject to mechanical failure, although inexpensive, they are becoming less popular.

- **Dot matrix printer**

Dot matrix printers are a type of impact printer that prints using a fixed number of pins or wires and typically use a print head that moves back and forth or in an up-and-down motion on the page and prints by impact, striking an ink-soaked cloth ribbon against the paper. They were also known as serial dot matrix printers. Unlike typewriters or line printers that use a similar print mechanism, a dot matrix printer can print arbitrary patterns and not just specific characters.

B- Non-impact printers:

Non-impact printers create pictures, characters, and figures without any uninterrupted contact between the printing device and the paper. Inkjet printers, Laser printers and Thermal printers are some examples of non-impact printers.

- **Inkjet printer**

  Work by shooting fine streams of colored ink onto the paper. These are less expensive than laser printers, but offer less resolution quality.

- **Laser printer**

  A laser printer is a type of printer that uses a laser beam to produce high-quality text and graphics on paper. It works by using a combination of electrostatic ally charged toner and a heated fuser to transfer the toner onto the paper. Laser printers are known for their fast-printing speeds, sharp output, and reliability.

- **Thermal printer**

  A thermal printer is a printer that makes use of heat in order to produce the image on paper.

C- 3D printer

A 3D printer is a type of material design printer that designs and builds 3D models and products of devices and components using an additive manufacturing process. 3D printers design three-dimensional prototypes and create the end product by directly building them using Computer Aided Design (CAD) or software-created 3D design diagrams, figures and patterns. 3D printers may also be called additive manufacturing printers or fabrication printers.

5.4. Plotters

Are printing devices that use computer-directed pens for creating maps and architectural drawings.

5.5. Speaker

A speaker is an output device that produces sound through an oscillating transducer called a driver. The equivalent input device is a microphone.

6. Computer Ports

There are two types of ports:

A- Internal Port: It connects the system's motherboard to internal devices like hard disk, CD drive, internal Bluetooth, etc.

B- External Port: It connects the system's motherboard to external devices like a mouse, printer, USB, etc.

Figure 11: Computer Ports

Types of ports

Some important types of ports are as per follows:

1- Serial Port.

- Used for external modems and older computer mouse
- Two versions – 9 pin, PS/2
- Data travels at 115 Kilobits per second

2- Parallel Port.

- Used for scanners and printers
- 25 pin model

3- Universal Serial Bus (USB).

It can connect all kinds of external USB devices such as mouse, keyboards, printers, scanners, external hard disks, etc. Data travels at 12 Megabits per second.

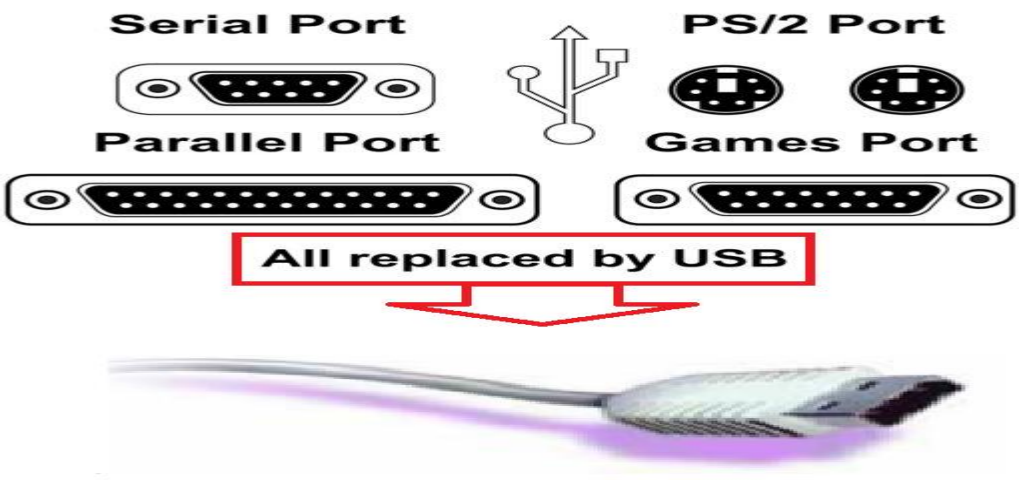


Figure 12: Serial and PS/2 Ports

4- Ethernet Port.

Connects to a network and high-speed Internet.

- Data travels at 10 megabits to 1000 megabits per second depending upon the network bandwidth.

5- Firewire Port.

Firewire is a standard connection type for many electronic devices such as printers and scanners, digital video cameras and external hard drives and other peripherals.

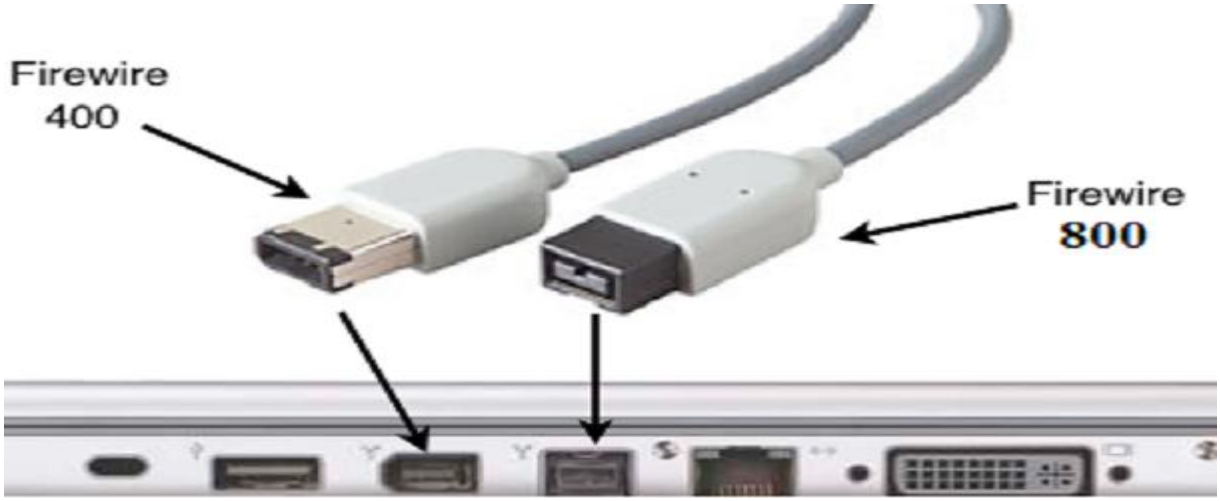


Figure 13: Firewire Port

7. Factors affecting computer performance

There are some factors that affect computer performance, including:

7.1. CPU Clock speed:

The computer clock speed governs how fast the CPU will run. In general, a higher clock speed means a faster CPU. The clock speed measures the number of cycles your CPU executes per second. IBM's original personal computer ran at 4.77 MHz, while modern computers are measured in gigahertz (GHz). A cycle is the basic unit that measures a CPU's speed. During each cycle, thousands of transistors within the processor open and close.

7.2. RAM size:

As a rule, the more memory you have the faster the PC will appear to operate. Windows also uses the hard disk a lot, so logically the faster the hard disk can operate then again, the faster the PC will appear to run.

7.3. Hard Disk Speed and Storage:

Hard disks are also measured by their speed, defined by the disk access time, which is measured in milliseconds. The smaller this access time the faster the hard disk will store or retrieve data. The data storage capacity of hard disks continues to increase as new products are released. The disk storage capacity is measured in Terabyte.

7.4. Free Hard Disk Space:

To get the most out of your Windows based PC, you not only need a fast hard disk but also a large hard disk with plenty of "spare space". This is due to the fact Windows is constantly moving data between the hard disk and RAM. Microsoft Windows will create many so-called "temporary files" which it uses for managing your programs. In fact, if you have very little free hard disk space you may find that Microsoft Windows will not be able to run your programs at all.

7.5. Fragmentation and Defragmentation

Fragmentation occurs on a hard drive, a memory module, or other media when data isn't written closely enough physically on the drive. Those fragmented, individual pieces of data are referred to generally as fragments.

Defragmentation, then, is the process of un-fragmenting or piecing together, those fragmented files so they sit closer, physically, on the drive or other media, potentially speeding up the drive's ability to access the file. De-fragmentation means taking all the broken-up pieces and joining them back together again.

7.6. Multitasking Considerations:

Windows is a multitasking system, which means that it can run more than one program at a time. However, the more programs which are running at the same time, the slower each one will run. To some extent this slowing effect depends on what each program is doing. Editing a large, full cooler picture for instance can take up a lot of CPU time.

8. Computer Hierarchy

The traditional way of comparing classes of computers is by their CPU power. This section presents each class of computers beginning with most powerful and ending with least powerful. We describe the computers and their respective roles in modern organizations.

8.1. Super computers

A supercomputer is a computer with a high level of performance as compared to a general-purpose computer and it run on Linux-based operating systems. The performance of a supercomputer is commonly measured in floating-point operations per second (FLOPS) instead of million instructions per second (MIPS). For comparison, a desktop computer has performance in the range of hundreds of 1011 giga FLOPS to tens of 1013 tera FLOPS. In general, supercomputers run 500 times faster than desktop computers.

8.2. Mainframe Computers (Servers)

- Mainframe computers are often used as servers.
- Are less powerful and generally less expensive than super computers.
- Are used for centralized data processing and maintain large databases.
- Examples of mainframe applications include airline Reservation systems, student's grade calculations and reporting.
- The range of RAM can vary as well, with the average server ranging from 16 GB to 6 TB (that's a lot of RAMS).
- Server HDDs typically range from 1-8TB, with a maximum of 20TB or more. server SSDs can achieve capacities of 50-100TB. Power consumption: Server SSDs require less power compared to server HDDs.

8.3. Minicomputers

- Are called midrange computers
- Are relatively small, inexpensive that perform the same functions as mainframe computers but to a limited extent.
- Are used to accomplish specific tasks, such as process control, scientific research, and engineering applications.

8.4. Workstations (Desktop computer)

A desktop computer can be used as workstation, it is a high-performance computer system that is basically designed for a single user and has advanced graphics capabilities, large storage capacity, and a powerful CPU. A workstation is more capable than normal personal computer (PC) but is less advanced than a server.

8.5. Microcomputers / Personal Computers (PCs)

Microcomputers are smallest and least expensive category of general-purpose computers. They can be subdivided into three classifications based on their size to Desktops, Laptops, iPad and Smartphone (Mobil).

Chapter Three
Computer Software

Learning Objectives:

- **System software**
  1. System control programs
  1.1. Operating System (OS)
  1.2. Operating System Tasks
  1.3. Operating system services
  2. System support programs
  2.1. System utility programs
  2.2. Performance monitors
  2.3. Security monitors
- **Application software**
  1. Microsoft Office (or simply Office)
  2. Multimedia software
  3. Programming languages
  4. The newer programming languages

Software

There are two major types of software:

- **System software**
- **Application software**

<u>System Software</u>

Is a set of instructions that serves primarily as an intermediary between computer hardware and application programs. System software provides important self-regulatory functions for computer system, such as loading itself when the computer is first turned on, managing hardware resources such as secondary storage for all applications, and providing commonly used sets of instructions for all applications to use. System software can be grouped into two major functional categories:

1- **System control programs**
2- **System support programs**.

1. System Control Programs

System control programs control the use of the hardware, software, and data resources of a computer system. The main system control program is the operating system.

1.1. Operating System (OS)

Supervise the overall operation of the computer, including monitoring the computer's status and scheduling operations, which include input and output processes. In addition, the operating system allocates CPU time and main memory to programs running on the computer, and is also provides an interface between the user and the hardware.

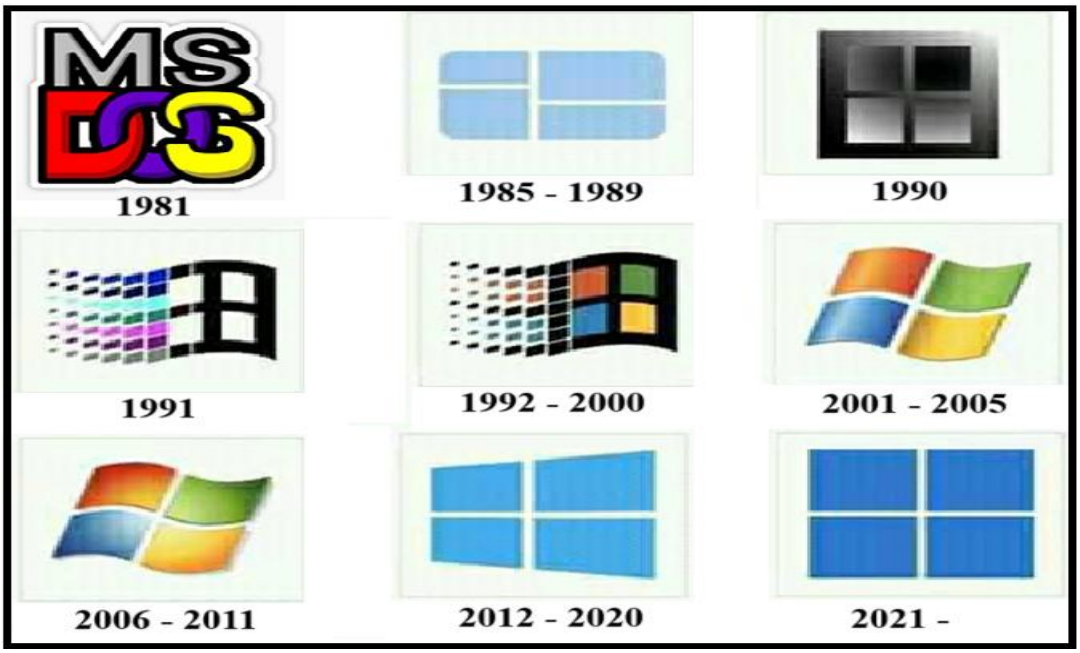


Figure 14: History of Microsoft Operating Systems

1.2. Operating System Tasks

Common tasks of the operating system are

1.2.1. Monitoring performance
1.2.2. Correcting errors
1.2.3. Providing user interface
1.2.4. Starting booting the computer
1.2.5. Reading the program into memory
1.2.6. Managing memory allocation to those programs
1.2.7. Placing files and programs in secondary storage
1.2.8. Creating and maintaining directories.
1.2.9. Formatting diskettes

1.2.10. Controlling the computer monitor
1.2.11. Sending jobs to printers
1.2.12. Minting security and limiting access
1.2.13. Locating files
1.2.14. Detecting viruses
1.2.15. Compressing data

List of Terms Used in Process management

Here is a list of some of the Used in Process management.

- **Task (Job)**

  A task can be defined as a Process or Thread that will be executed in a multitasking environment. A task is a unit of execution or work.

- **Process (Program)**

  A process is an instance of a program running in a computer. It is close in meaning to task. A process is given its own memory area and can contain a various amount of execution threads.

- **Thread (Function in Program)**

  A thread of execution is the smallest sequence of programmed instructions that can be managed independently by a scheduler. In many cases, a thread is a component of a process. These individual threads can share its memory with other threads, but only if they are contained within that same process. Looking at a gaming program, individual threads are often used to control multiple graphic objects simultaneously. Another example is a web browser, where separate threads are used to load graphic images and respond to a user's input simultaneously.

What is the difference between task and process?

A task is a piece of work that needs to be done. The process is a series of actions that is done for a particular purpose. A task defines the work to be done, whereas process defines the way the work can be done or how the work should be done.

1.3. Operating system services

The operating system provides the following services

- Process management
- File management and security
- Virtual memory
- Fault tolerance, and the user interface.

1.3.1 Process management

Means managing the program's (also called jobs) running on the processor at a given time, in the simplest case (a desktop operating system), the operating system loads a program into main memory and execute it. Some operating system offers more other forms of process management such as:

1- Multi-tasking
   - Time-sharing
2- Multi-threading
3- Hyper-Threading
4- Multi-processing.

1- Multi-tasking (Works on single processor)

A system is known to be a multitasking OS if it is able to run multiple tasks or multiprogramming at the same time on single processor. In other words, Multitasking or multiprogramming is the management if two or more tasks (or programs) running on the computer system at the same time, the first program is executed until an interruption occurs, such as request for input, while the input request is handled, the execution of second program begins because switching among these programs occurs so rapidly. They appear to be executing at the same time, however, because there is only one processor, only one program is actually in execution mode at any one time.

- **Time-sharing**

  Is an extension of multiprogramming (Multitasking). Is the concurrent sharing of a computing resource among many tasks or users by giving each task or user a small slice of CPU time. In this technique, a number of users over the Internet can work on only one CPU (Server CPU) and each user has his own I/O terminal. These users' programs are placed on different segments of the same main memory. The CPU executes these programs alternately between all users, and this happens so quickly that it seems to each user as if he or she is the only one using the computer.

2- Multi-Threading (Works on single processor)

Multithreading is the ability of a single CPU to provide multiple threads of execution. It is a form of multitasking that focuses on running multiple

tasks within single application simultaneously. For example, a word processing application may edit one document while another document is being spell checked.

3- **Hyper-Threading (Works on single processor)**

This is a process where a CPU splits each of its physical cores into **virtual cores**, which are known as threads. Hyper-Threading allows each core to do two things simultaneously. It increases CPU performance by improving the processor's efficiency, thereby allowing you to run multiple demanding apps at the same time or use heavily-threaded apps without the PC lagging.

4- **Multi-processing (Works on multiple processors)**

Occurs when a computer system with two or more processors can run more than one program, or thread, at a given time by assigning them to different processors, multiprocessing uses simultaneous processing with multiple CPUs.

1.3.2. File management and security

The operating system is responsible for file management and security, managing the arrangement of, and access of, files held in secondary storage. The operating system creates and manages a directory structure that allows files to be created and retrieved by name and it also may control access to those files based on permission and access controls. The operating system provides other forms of security as well, for example, it must typically provide protected memory and maintain access control on files in the file system, the operating system also must keep track of users and their authority level, as well as audit changes to security permissions.

1.3.3. Virtual memory

Simulates more main memory than actually exists in the computer system it allows a program to behave as if it had access to the full storage capacity of a computer, rather than just access to the amount of primary storage installed in the computer. Virtual memory divides an application program or module into fixed – length portions called pages. The system executes some pages of instructions while pulling others from secondary storage. In effect, primary storage is extended into a secondary storage device, allowing users to write programs as if primary storage were larger than it actually is. This enlarged capability boosts the speed of the computer and allows it to efficiently run programs with very large numbers of instructions.

1.3.4. Fault tolerance

Is the ability as a system to produce correct results and to continue to operate even in the presence of faults or errors. Fault tolerance can involve error correcting memory, redundant computer components and related software that protects the system from hardware, operating system, or user errors.

2. **System support programs**

The second major category as system software, system support program that support the operations, management and users of a computer system by providing a variety of support services, examples of system support programs are:

- System utility programs
- Performance monitors
- Security monitors

2.3. **System utilities programs**

Are programs that have been written to accomplish common tasks such as sorting records, checking the integrity of diskettes (i.e. amount if storage available and existence of any damage) and creating directories and subdirectories. They also restore accidentally erased files, locate files within the directory structure, manage memory usage, and redirect output.

2.4. **System Performance Monitors**

Are programs that monitor the processing of jobs on a computer system performance and produce reports containing detailed statistics relating to the use of system resources, such as processor time, memory space, input/output devices, and system and application programs, these reports are used to plan and control the efficient use of the computer system resources and to help trouble-shoot the system in case of problems.

2.5. **System Security Monitors**

Are programs that monitor the use of a computer system to protect it and its resources from the unauthorized use, fraud, or destruction such programs provide the computer security needs to allow only authorized users access to the system. Security monitors also control use of the hardware, software, and data resources of a computer system.

Application software

Is a set of computer software that provides more functionality to a user. This type of software consists of many widely used packages such as:

1. **Microsoft Office (or simply Office)**

   It contains a word processor (Word), a spreadsheet program (Excel) and a presentation program (PowerPoint), an email client (Outlook), a Database Management System (Access), and a desktop publishing app (Publisher).

2. **Multimedia software**: multimedia software combines at least two media for input or output of data. These media include audio (sound), voice, animation, video, graphics, and images.

3. **Programming languages**

   Programming languages provide the basic building blocks for all systems and application software. Programming languages allow people to tell computers what to do and are the means by which software systems are developed, we will describe the five generations-levels-of programming languages:

3.1. Machine language

Machine language is a low-level programming language consisting of instructions written in binary bits (0 and 1) and is the only language that a computer understands and can execute with a CPU. Machine language is also known as machine codes or object code.

3.2. Assembly language

Assembly languages are considered second-generation languages; it is more user-friendly because it represents machine language instructions and data locations in primary storage by using mnemonics, which people can more easily use. Compared to machine language, assembly language eases the job of the programmers. Translating an assembly language program into machine language is accomplished by system software program called an assembler.

3.3. Procedural language

- Called third-generation language
- Procedural language is much closer to natural language (the way we talk) and therefore, are easier to write, read. • Procedural language uses common words rather than abbreviated mnemonics.
- There are three examples of procedural languages FORTRAN, COBOL, and C.

3.4. Non-procedural languages

- Called fourth-generation language.
- They can be used by non-technical users to carry out specific functional tasks.
- These languages simplify the programming process as well as reduce the number of coding errors.
- They are common in database applications as query languages, report generators.

3.5. Natural languages

- Are called fifth –generation languages or" intelligent language"
- They are use mnemonics and tables.
- Most of these languages are still experimental because the programs that are translate natural language into machine – readable form are extremely complex and require a large amount of computer resources.

4. The newer programming languages

4.1. Visual programming languages

- Visual basic and visual C++ are examples of visual programming languages.
- Are used within graphical environment
- Are using a mouse, icons, and symbols on screen.

4.2. Hyper Text Markup Language (HTML)

- Is an approach to data management in which data are stored in a network of nodes connected by links (called hyperlinks) • Users can access data through an interactive browsing system.
- The combination of nodes, links, and supporting indexes for any particular topic is a hypertext document
- A hypertext document may contain text, images, and other types of information such as data files, audio, and video.
- World Wide Web (www) uses HTML for creating and recognizing hypertext document.

4.3. Object-Oriented Programming languages (OOP)

- C++ and JAVA are examples of OOP languages.
- OOP languages are based on the idea of taking a small amount of data and instructions about what to do with that data and putting both of them together into what is called an object**.**

Figure 15: History of programming languages

Chapter Four
Managing Organizational Data and information

Learning Objectives

1- Hierarchy of Data in a Database
2- File Access methods
3- Database Management System (DBMS)
4- The problems of traditional data files
5- The difference between a database and traditional data files
6- Centralized and distributed databases
7- Database model
8- Database levels.
9- Data Independence of DBMS
10- Advantages and Disadvantages of Database

1. Hierarchy of Data in a Database

In a database, data is typically organized into a hierarchical structure, with several levels of organization. The main levels of this hierarchy are:

A- Bit: A bit is the smallest unit of data in a computer, representing either 0 or 1.

B- Byte: Each 8 bits represent a byte that can hold one character (letter, number, or symbol).

C- Word: Each 2 bytes represents a word (16 bits), a double word is 4 bytes (32 bits), and a quad word is 8 bytes (64 bits).

D- Field: Each column in a database table is called a field, and each field has its own unique name. The field contains data of the same type (strings, numbers, date, etc.). A field represents a piece of record data, such as a name, address, or phone number.

E- Record (Tuples)**:** Each row in a database table is called a record and has its own index (Identification number ID). A record is a collection of related fields, such as a set of fields that contain information about a specific employee or customer.

F- Table (Database Table/File): A table is a collection of records that have a similar structure, such as a table of customers or a table of orders.

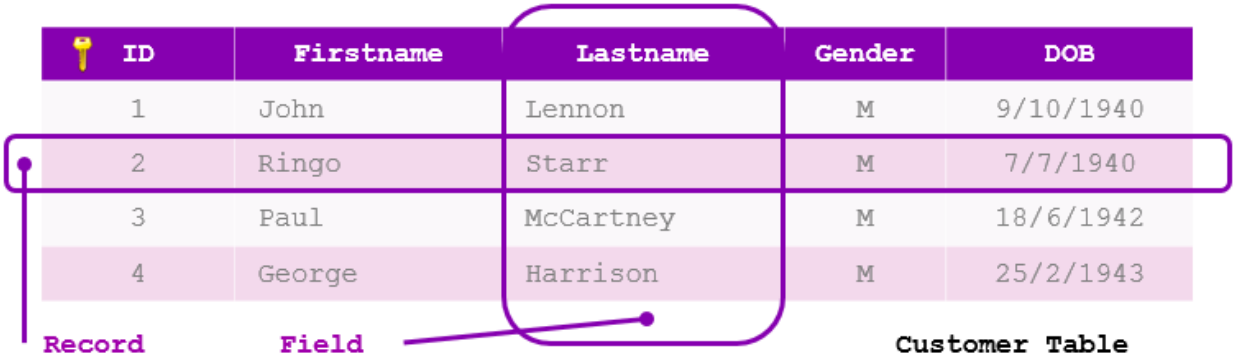


Figure 16: Database Table

G- Database: A database is a collection of tables that are related to each other in some way, such as a database of customer information or a database of sales data.

Primary keys

A primary key is a column (field) or a set of columns in a table that uniquely identifies each row (record) in table, it must be defined when the table is created or altered. For example, in the Customers table there is an index field ID that contains a unique, non-repeated number for each customer record, so this field can be used as a primary key. A primary key cannot have duplicate or null values and the values of the primary key must not change or become null during the time of a relation.

Primary key Benefits

A- A primary key ensures that there are no duplicate records (have same ID value) or missing records (have Null or blank ID) in the table.

B- A primary key can be used for data query operations such as searching, inserting, and updating, restoring and deleting data from the database table.

C- A primary key also enables the creation of foreign keys, which are columns in other tables that refer to the primary key of a related table. Foreign keys allow you to establish relationships and join data across tables.

Secondary keys

A secondary key is a column (field) or set of columns in a table that has the same properties as the primary key and can be used alternatively in place of the primary key, so they are called alternate keys.

Foreign keys

A foreign key is a column (field) in a database table that contains unique, non-duplicate data and refers to another column in another database table that has the same column name and the same non-duplicate data values (often the primary key column in the other table). Foreign keys link together two or more tables in a relational database.

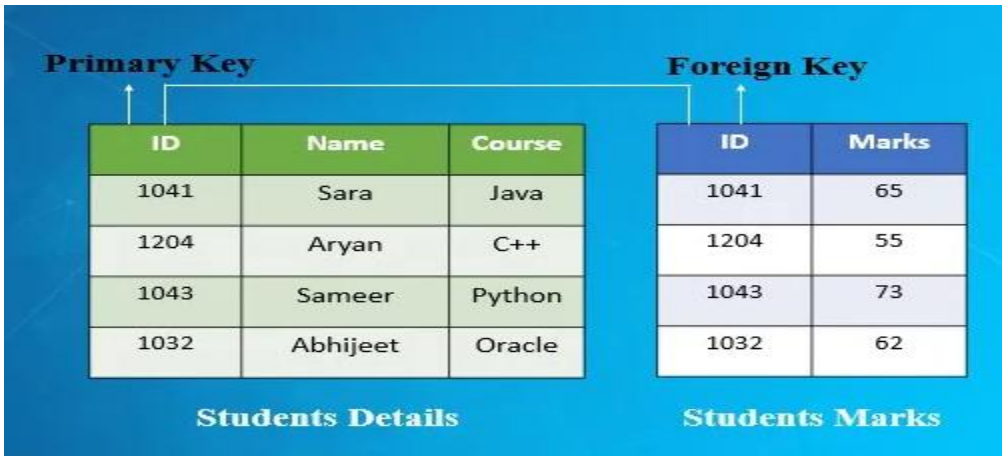


Figure 17: Primary and Foreign keys

What is a Query in a database?

A query is a request for data or information from a database table or combination of tables. In the context of queries in a database, it can be either a select query or an action query. A select query is a data retrieval query, while an action query asks for additional operations on the data, such as insertion, updating or deletion. Most formal queries are written in SQL (Structured Query Language).

A query can either be a request for data results from your database or for action on the data, or for both. A query can give you an answer to a simple question, perform calculations, combine data from different tables, add, change, or delete data from a database.

2. File Access methods

There are three methods to access records to read or write data from their fields:

1- **Sequential File Access**

This method accesses data as one record at a time by starting from the beginning of the file to its end. Moreover, the records are read or written in the order they appear in the file.

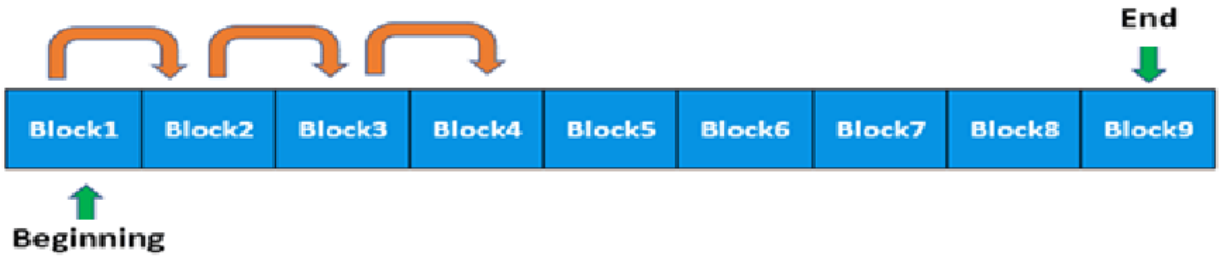


Figure 18: Sequential Access method

2- **Direct File Access (Random access)**

It allows us to access data directly from any location within the file, without the need to read or write all the records that come before it. Furthermore, this method accesses records within the file by using their physical addresses or positions. For example, in a database application, we may need to quickly retrieve customer data based on a specific customer ID (primary key).

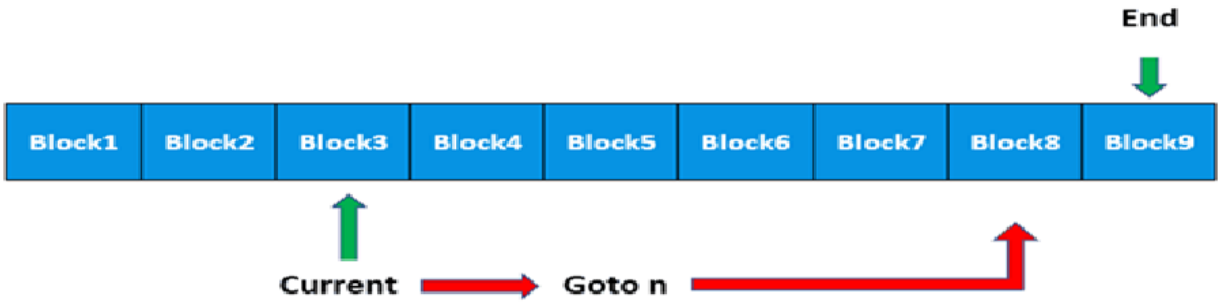


Figure 19: Direct Access method

3- **Indexed File Access**

Indexed file access is a method that incorporates the benefits of both sequential and direct file access. This method involves creating an index file that maps logical keys or data elements to their corresponding physical addresses within the file. Moreover, the system stores the index separately from the data file, enabling quick access to locate the desired data. Indexed file access is best suited for applications that require fast access to particular data elements within a large file. For example, in a file system, we may need to access specific files based on their name or location. The index created for the file system allows quick access to the file's physical location, enabling efficient access.

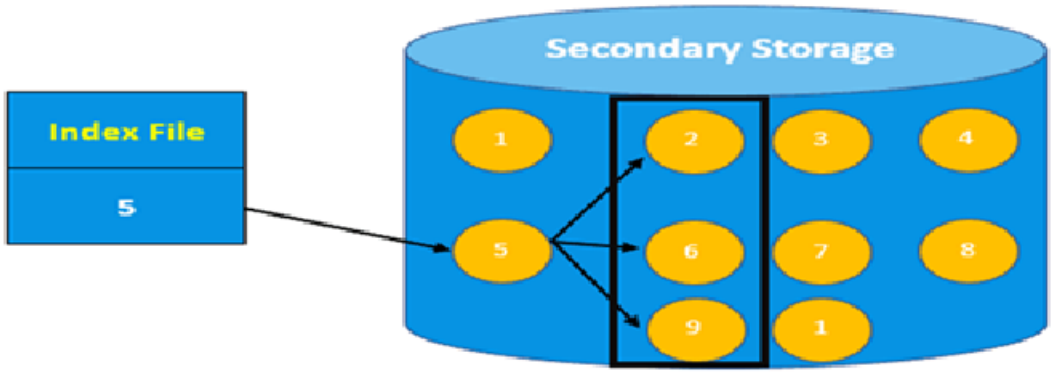


Figure 20: Indexed Access method

Comparison of File Access methods

The following table summarizes the aspects of each method:

Method	Sequential File Access	Direct File Access	Indexed File Access
Access method	Accesses data one record at a time in sequential order from beginning to end	Accesses data directly from any location within the file, using physical addresses or positions	Uses an index that maps logical keys or data elements to their corresponding physical addresses within the file
Suited for	Applications that process data in a linear fashion, such as reading or writing data to a log file or processing data in batch operations	Applications that require quick and efficient access to specific records or data elements within a file	Applications that require fast and efficient access to specific data elements within a large file
Advantages	Simplicity and ease of implementation and use	Speed and efficiency for random access operations	Speed and efficiency for both random and sequential access operations
Disadvantages	Slow and inefficient for random access operations or when working with large files	More complex and difficult to implement and use than sequential file access	Requires additional storage space for the index, which can increase the cost and complexity of the system

3. Database Management System (DBMS)

Database Management Systems (DBMS) are software systems used (Ex. Microsoft Access, Oracle, FoxPro…) to store, retrieve, and run queries on data. A DBMS serves as an interface between an end-user and a database, allowing users to create, read, update, and delete data in the database.

DBMS	Operating system
Microsoft Access	Windows وندو Linux لنكس MacOS ماكنتوش Canonical , FreeBSD and Solaris
Microsoft SQL Server	Windows Linux
Oracle Database	Windows Linux MacOS AIX, BS2000 and HP-UX
Visual FoxPro	Windows Linux

Figure 21: Some types of database management systems

4. The problems of traditional data files

A- Data Redundancy problem

The problem of data duplication occurs when multiple copies of the same information are stored in more than one place at the same time. An example of this is customer information that is duplicated on separate systems of departments (such as finance, marketing, and sales). This problem leads to high storage costs and errors in data analysis.

B- Data Inconsistency problem

The problem of data redundancy leads to the problem of data inconsistency. For example, if a customer changes their address, the address must be changed on all different department applications that require the new address. This leads to different copies of data in different departments.

C- Data isolation problem

When data is isolated and stored in different files that may be in different formats on different systems, it becomes difficult to write new applications to retrieve the required data from these different files.

Data integrity

It is a concept and process that ensures the accuracy, completeness, consistency, and validity of an organization's data. By following the process, organizations not only ensure the integrity of the data but guarantee they have accurate and correct data in their database.

5. The difference between a database and traditional data files

A database which is a logical group of related files, can eliminate many of the problems associated with the traditional data file environment, with the database approach, all the data are typically contained in the same storage location, rather than residing in many different files across the organization, unlike the traditional approach, in which different programs access the different data files, the database is arranged so that one set of software programs the database management system provides access to all data. Therefore, data redundancy, data isolation and data inconsistency are minimized, and data can be shared among all users of the data, an addition, security and data integrity are increased.

6. Centralized and distributed databases

A database is collection of related files, and where those related files are located can greatly affect user accessibility, query response times, data entry, and security and cost in general, database files can be centralized or distributed.

1- Centralized Database

A centralized database is basically a type of database that is stored, located as well as maintained at a single location only. This type of database is modified and managed from that location itself. This location is thus mainly any database system or a centralized computer system. The centralized location is accessed via an internet connection (LAN, WAN, etc). This centralized database is mainly used by institutions or organizations.

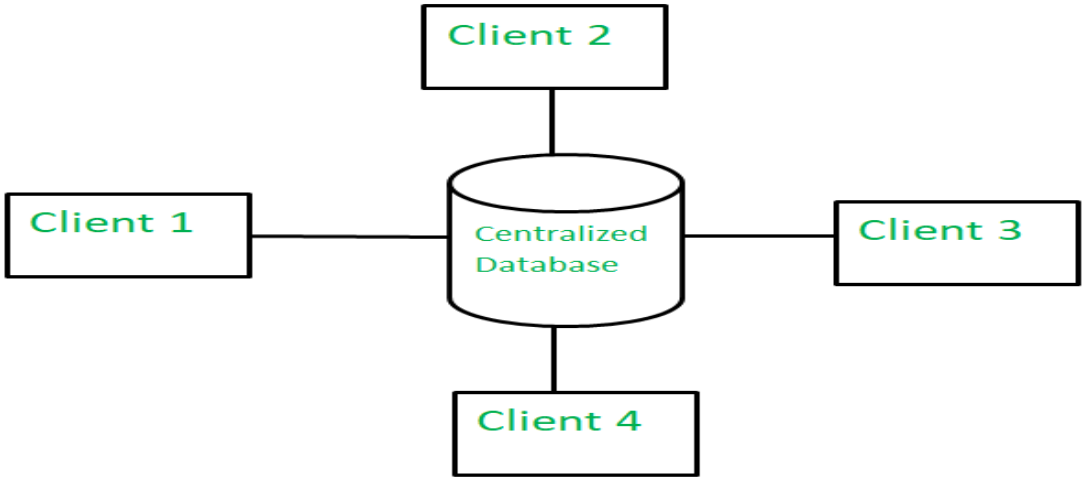


Figure 22: Centralized Database

Advantages:

- Since all data is stored at a single location only thus it is easier to access and coordinate data.
- The centralized database has very minimal data redundancy since all data is stored in a single place.
- It is cheaper in comparison to all other databases available.

Disadvantages:

- The data traffic in the case of a centralized database is more.
- If any kind of system failure occurs in the centralized system, then the entire data will be destroyed.

2- Distributed database

A distributed database is basically a type of database which consists of multiple databases that are connected with each other and are spread across different physical locations. The data that is stored in various physical locations can thus be managed independently of other physical locations. The communication between databases at different physical locations is thus done by a computer network.

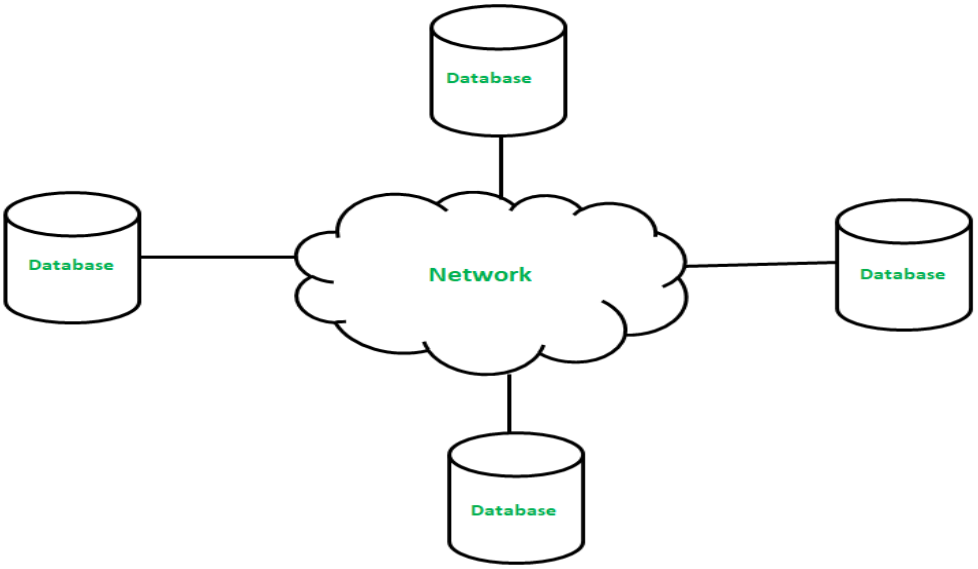


Figure 23: Distributed database

Distributed database types

Distributed database has complete copies of a database or portions of a database in more than one location, which is usually close to the user. there, are two types of distributed databases

A- Replicated database.

Have complete copies of the entire database in many locations. Primarily to alleviate the single point of failure problems of a centralized database as well as to increase user access responsiveness, there is significant overhead, however. In maintaining consistency among replicated databases, as recorded are added, modified, and deleted.

B- Partitioned database

The database is divided into parts so that each site contains a part of the entire database (usually the part that concerns local user needs). This type of database provides speed of response to translated files without the need to repeat all changes in multiple sites. One important advantage of a partitioned database is that data in files can be entered more quickly and maintained more accurately by the users directly responsible for the data.

Advantages:

- This database can be easily expanded as data is already spread across different physical locations.
- The distributed database can easily be accessed from different networks.
- This database is more secure in comparison to a centralized database.

Disadvantages:

- This database is very costly and is difficult to maintain because of its complexity.
- In this database, it is difficult to provide a uniform view to users since it is spread across different physical locations.

DBMS components

There are four main components in a database management system: -

A- Data Definition Language (DDL).

The data definition language defines what types of information are in the database and how they will be structured. (DDL) is a subset of SQL. It is a language for describing data and its relationships in a database. The DDL defines each data element as it appears in the database before that data element is translated into the forms required by the applications the DDL is essentially the link between the logical and physical views of database.

B- Data Manipulation Language (DML).

DML used with third generation, fourth generation, or object-oriented language to query the contents of the database, store or update information in the database, and develop database applications. The DML allows users to retrieve, sort, displays, and delete the contents of the database.

C- Data dictionary

Refers to the definition of data stored within the database and controlled by the DBMS

D- Data model

The data model defines the way data are conceptually structured. Examples include the relational, hierarchical, network, object-oriented, object relational, hypermedia...etc.

7. Database model

A database model shows the logical structure of a database, including the relationships and constraints that determine how data can be stored and accessed. Individual database models are designed based on the rules and concepts of whichever broader data model the designers adopt. Most data models can be represented by an accompanying database diagram.

Types of database models

There are many kinds of data models. Some of the most common ones include:

1- Flat database model

A flat database refers to a simple DB system in which each database has to be represented as a single table (text file), with all records saved as single rows of data separated by tabs or commas. A simple text file is typically used to store and physically display the table.

2- Relational Database (RDB) model

It is a database that contains a group of database tables that are related to each other. RDB has the ability to link different database tables to each other by the primary and foreign keys of the different tables. There are three types of relationships that connect different relational database tables:

- One-to-one
- One-to-many
- Many-to-many

3- Hierarchical database model

A hierarchical database is a data model in which data is stored in the form of records and organized into an inverted tree-like structure, or parent-child structure, in which one parent node (Root node, a key or master field) can have many child nodes connected through links. The advantage of the hierarchical is the speed and efficiency with which it can be searched for the data.

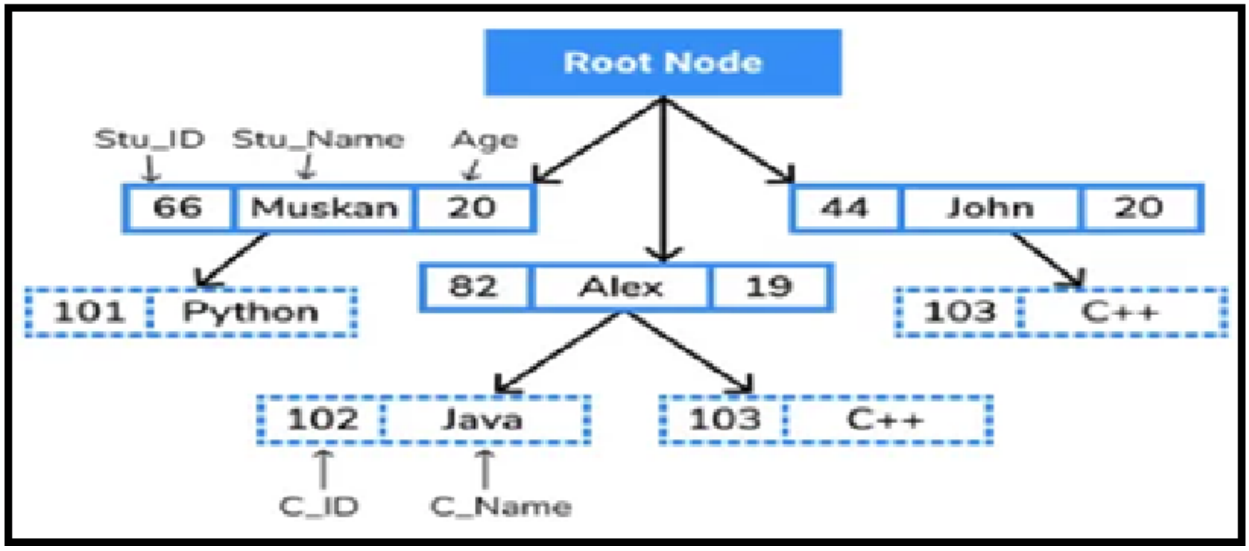


Figure 24: Hierarchical Model

4- Network database model

the network database model creates relationships among data through a linked list structure in which subroutines records (called members, not children) can be linked to more than one data element (called an owner) similar to the hierarchical model, the network model uses explicit links called pointers, to link members and owners. Physically, pointers are storage addresses that contain the location of a related record. With the network approach, a member record can be linked to an owner record and, at same time, can itself be an owner record linked to other sets of members.

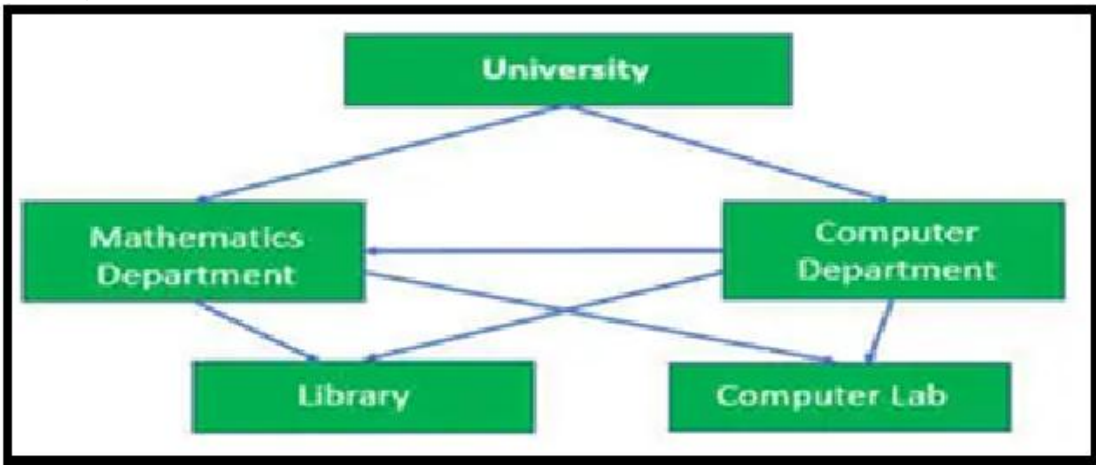
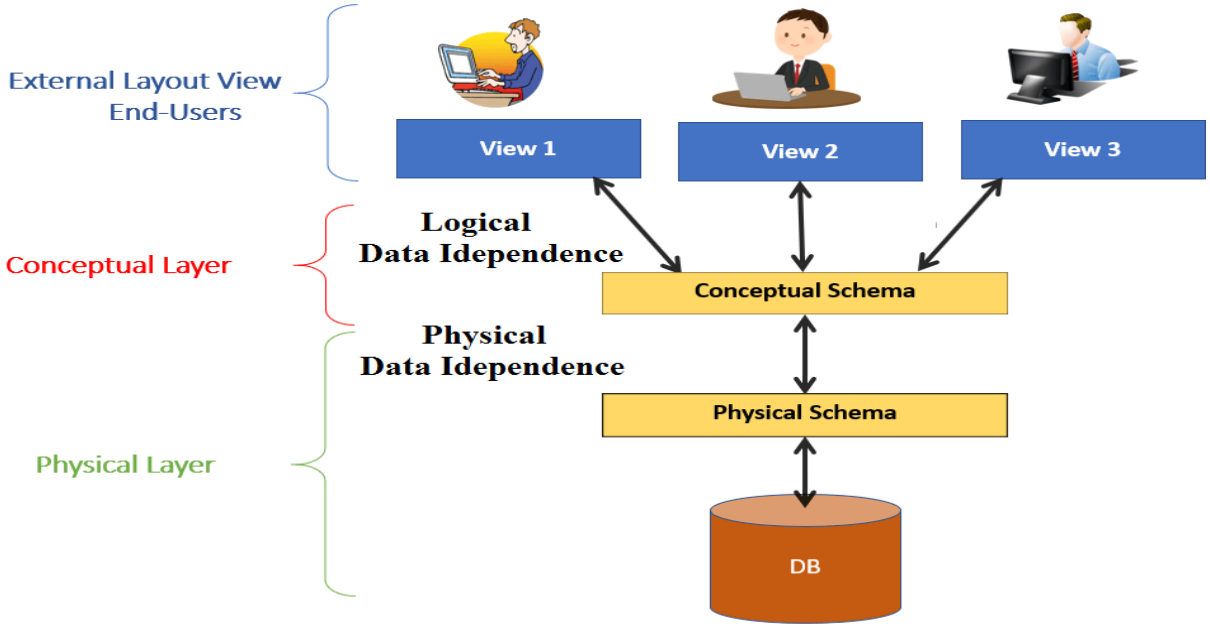


Figure 25: Network database model

Database levels.

The different levels of the database are implemented through three layers:



1- External Level (View Level)

It is the level closest to users and is related to the way the data is viewed by individual users (application programs).

Example:

- View 1: student info (id: int, name: string)
- View 2: Course info (cid:int, cname: string)

2- Logical Level (Conceptual Level)

This level of abstraction describes what data is concretely stored in the database. It also describes the relationships that exist between the data. At this level, databases are described logically in terms of simple data structures. Users at this level are not concerned with how these logical data structures will be implemented at the physical level.

Example:

- Students (id: int, name: string, login: string, age: integer)
- Courses (id: int, cname: string, credits: integer)

3- Internal Level (Physical level).

This level is closest to physical storage because it describes how data is physically stored on the storage media.

Example:

- Relations stored as unordered files.
- Index on the first column of Students.

8. Data Independence of DBMS

Data Independence is defined as a property of DBMS that helps you to change the Database schema at one level of a database system without requiring changing the schema at the next higher level. Data independence helps you to keep data separated from all programs that make use of it.

Types of Data Independence

In DBMS there are two types of data independence

1- Logical Data Independence

Logical Data Independence is the ability to change the conceptual scheme without changing

A. External views

B. External API or programs

Logical data independence is difficult to achieve when compared to physical data independence.

Examples:

- Merging two records into one
- Breaking an existing record into two or more records
- Add/Modify/Delete a new attribute, entity or relationship is possible without a rewrite of existing application programs

2- Physical Data Independence

Physical data independence helps you to separate conceptual levels from the internal/physical levels. It allows you to provide a logical description of the database without the need to specify physical structures. Compared to Logical Independence, it is easy to achieve physical data independence.

Examples:

- Using a new storage device like Hard Drive or Magnetic Tapes
- Change of Location of Database from say C drive to D Drive
- Changing the access method.

The Database Concept

- Two primary goals of the database concept are to minimize data redundancy and to achieve data independence.
- The logical integration of records across multiple physical locations is called the **database concept.** It is not dependent on the user's perception of logical location

Advantages of Database

1- Reduces database data redundancy to a great extent
2- The database can control data inconsistency to a great extent
3- The database facilitates sharing of data.
4- Database enforces standards.
5- The database can ensure data security.
6- Integrity can be maintained through databases.

Disadvantages of Database

1- Extra hardware may be required
2- The system is likely to be complex.
3- Security may be compromised without good controls.
4- Integrity may be compromised without good controls.
5- Performance overhead may be significant.

Chapter 4
Telecommunications and Networks

Learning Objectives

- **Describe the components of telecommunication system.**
- **Describe the five basic types of communication media, including their advantages and disadvantages.**
- **Classify the major types of networks**
- **Differentiate among the three types of distributed processing.**
- **Identify seven telecommunication applications.**

The Telecommunications System

A telecommunication system consists of hardware and of software that transmits information from one location to another. These systems can transmit text, data, graphics, voice, document, or full –motion video information. The major components of a telecommunications system include the following:

- **Hardware**

  All types of Computers (e.g. Laptop, Desktop, Smartphones, Server, Mainframe) and communications processes (such as modems)
- **Communications media**

  The physical media through which electronic signals are transmitted, including wireless media (used with satellites and cell phones)
- **Communication networks**

  The links among computers and communications devices.
- **Communication protocols**

  The rules for transmitting information across the system.
- **Data communication**

  Is the process of transferring data from one place to another or between two locations. It allows electronic and digital data to move between two networks
- **Communication software**

  Is used to provide remote access to systems and exchange files and messages in text, audio and/or video formats between different computers or users

- **Communication applications**

  Electronic data interchange teleconferencing, video conferencing, electronic mail, as well as others.

Signals

Telecommunications media carry two basic types of signals, analog and digital.

1- **Analog signals (Continuous signal)**

These signals are continuous in both values and time. All natural or naturally occurring signals are analog signals, so all cameras and microphones capture sound and image as analog signals, then convert them to digital for storage in the digital device, and the process is reversed at the output.

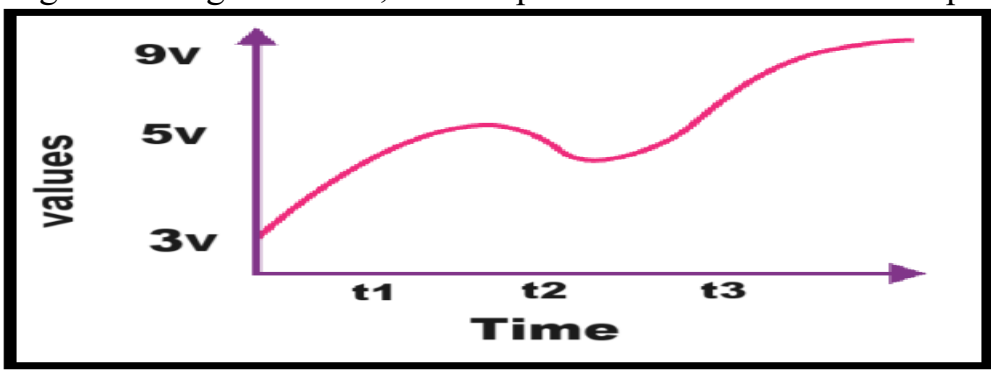


Figure 26: Analog signals

2- **Digital Signals (Discrete signals)**

Unlike analog signals, digital signals are not continuous in value and time(discrete). These signals are represented by binary numbers whose values depend on the values of the analog signal that have been converted.

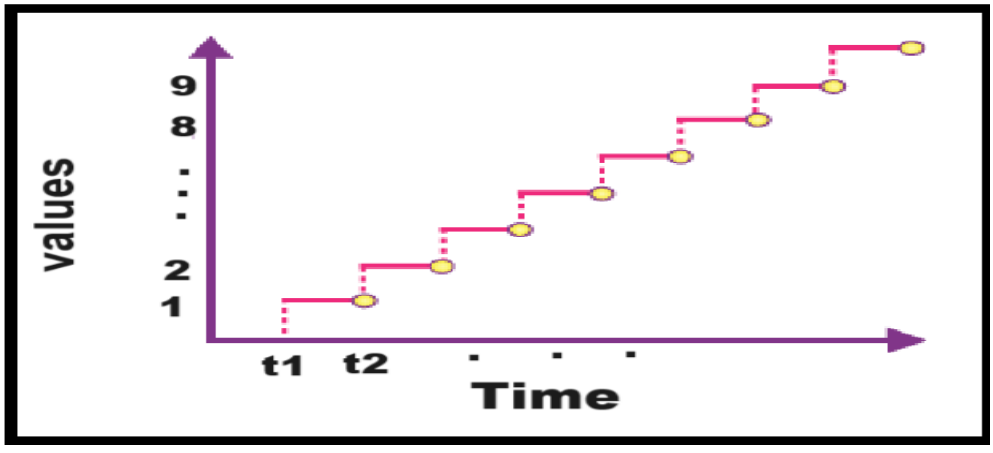


Figure 27: Digital Signals

Binary signal

It is a digital signal that consists of only two logical values, which are 0 and 1. Note that the logical value 0 is 3 volts, the logical value 1 is 5 volts, and the power off value is 0 volts.

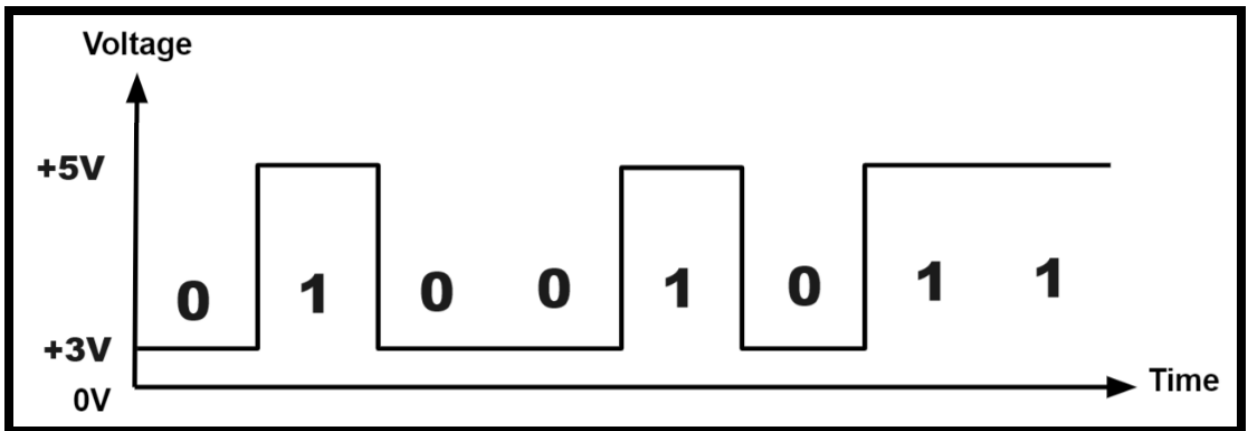


Figure 28: Binary signal

Communications Processors

Communications processors are hardware devices that support data transmission and reception across a telecommunication system. These devices include: **modems, multiplexer, front-end processor, and concentrators.**

Modems

The U.S. public telephone system (called POTS, for "plain old telephone service") was designed as an analog network to carry voice signals or sounds in an analog wave format. In order for this type of circuit to carry digital information, that information must be converted into an analog wave pattern. The conversion from digital to analog is called modulation, and the reverse is demodulation. The device that performs these two processes is called a **modem**. Modems are always used in pairs. The unit at the sending end converts a computer's digital information into analog signals for transmission over analog lines at the receiving end; another modem converts the analog signal back into digital. Signals for the receiving computer like most communication equipment, a modem's transmission's speed is measured in bits per second (bps), typical modem speeds range from 14,400 to 56,600 bps.

Multiplexer

A multiplexer is an electronic device that allows a signal communication channel to carry data transmissions simultaneously from many sources. multiplexers lower communication costs by allowing devices to share communications channels. multiplexing thus make more efficient use of these channels by merging the transmission of several computers (e.g., personal computers) at one end of the channel, while a similar unit separates the individual transmissions at the receiving end (e.g., a mainframe).

Front end processor

With most computers, the central processing unit (CPU) must communicate with several computers at the same time routine communication tasks can absorb a large proportion of the CPU processing time, leading to degraded performance on more important jobs in order not to waste valuable CPU time, many computers' systems have a small secondary computer dedicated solely to communication. Known as front end processor, this specializes computer manages all routing communications with peripheral devices. The functions of a front-end processor include coding and decoding data; detecting errors; and receiving, recording, interpreting, and processing the control information that is transmitted.

Communication media and channels

For data to be communicated from one location to another, some form of pathway or medium must be used. These pathways are called communications channels. And they include cable media and wireless media.

A) Cable media

Cable media use physical wires or cables to transmit data and information. There are three types of cable media:

1) Twisted-pair wire

Is the most prevalent form of communication wiring; it's used for all most all business networks wiring. twisted-pair wire consists of strands of copper wire twisted in pairs. An example of this type is Unshielded-Twisted-Pair (UTP) Cable.

Advantages

1- Its relatively inexpensive to purchase.
2- Widely available and easy to work with.
3- It can be made relatively a hidden by running it inside walls, floors, and ceilings.

Disadvantages

1- Is relatively slow for transmitting data.
2- It emits Electromagnetic interference.
3- Is subject to interference from other electrical sources,
4- Can be easily “tapped" for gaining unauthorized access to data by unintended receivers.

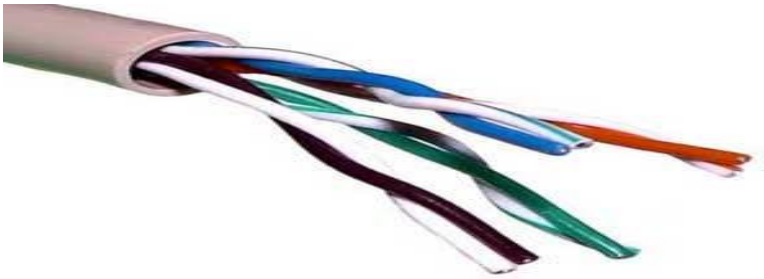


Figure 29: Cat 5 and Cat 6 UTP Patch Cable

2) Coaxial cable

Consists of insulated copper wire .it is much less susceptible to electrical interference than is twisted pair wire and can carry much more data. For these reasons, it is commonly used to carry high –speed data traffic as well as televisions signals. However, coaxial cable is more expensive and more difficult to work with than twisted –pair wire .it is also somewhat inflexible. Data transmission over coaxial cable is divided into two basic types

1- **Base band transmission:**
   Transmission is analog, and each wire carries only one signal at a time
2- **Broad band transmission:**
   Transmission is digital and each wire can carry multiple signals simultaneously.

Figure 30: Coaxial Cable for TV

3) Fiber optical cable

Fiber optics technology combined with the invention of the semiconductor laser provides the means to transmit information through clear glass fibers in the form of light waves, instead of electric current. fiber optic cables consist of thousands of very thin filaments of glass fibers that conducts light pulses generated by lasers at very – high –speed transmission frequencies

Advantages

1- Offer significant size and weight reduction over traditional cable media.
2- Provide increased speed, carrying capacity and greater data.
3- Greater security from interference and taping.

Disadvantages

The high costs and difficulties associated with installing fiber optic cable have slowed its growth.

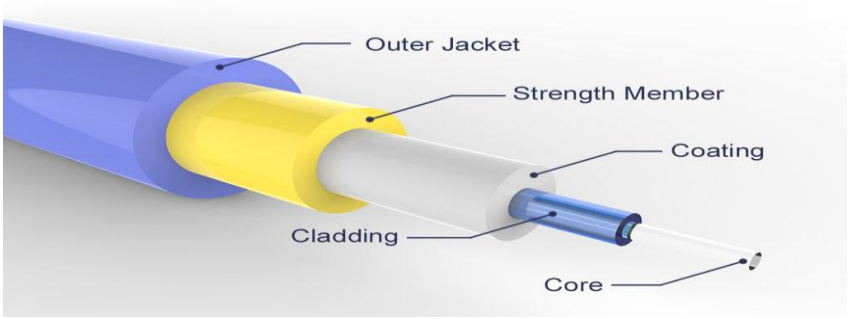


Figure 31: Fiber optical cable

B) Wireless media

Wireless media carry electromagnetic signals at radio and microwave frequencies that represent the binary digits of data communications. As a networking medium, wireless is not restricted to conductors or pathways, as are copper and fiber media. There are several types of wireless waves such as:

- Radio Waves & Microwaves
- Infrared Waves
- Other Waves
  - Visible Light waves
  - Ultraviolet waves
  - X-Rays
  - Gamma Rays

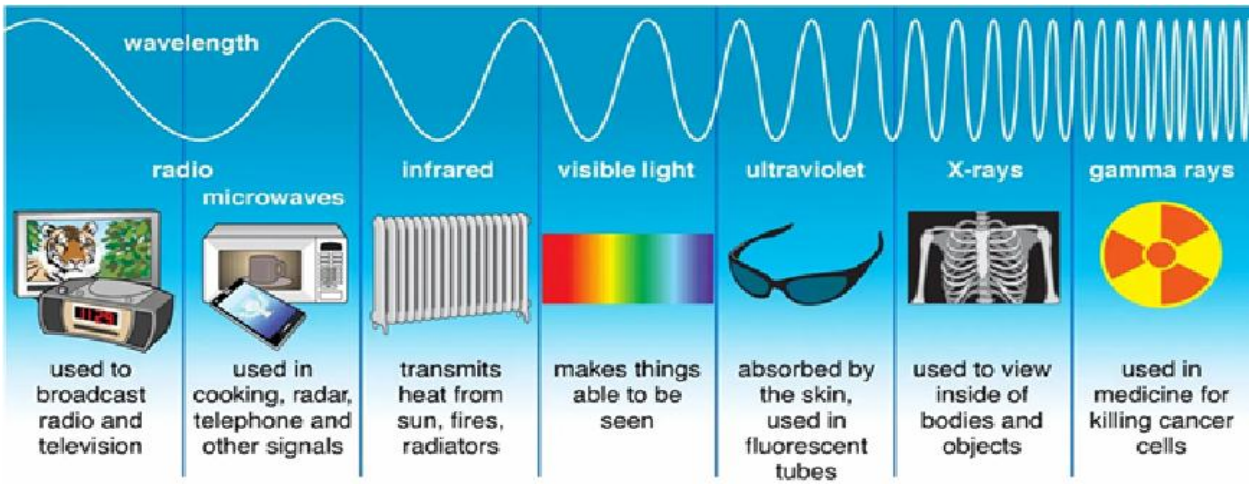


Figure 32: Types of Electromagnetic Radiation

Computer Network

A computer network is a system that connects two or more computing devices for transmitting and sharing information. Computing devices include everything from a mobile phone to a server. These devices are connected using physical wires such as fiber optics, but they can also be wireless.

Types of networks

Networks can be classified according to their area into three types:

1- Local Area Network (LAN)
2- Metropolitan Area Network (MAN)
3- Wide Area Network (WAN)

1- Local Area Network (LAN)

LAN is designed to connect multiple network devices and systems within a limited geographical distance. Computers on local area networks are connected using devices called network interface cards (NICs). The devices are connected using multiple protocols for properly and efficiently exchanging data and services.

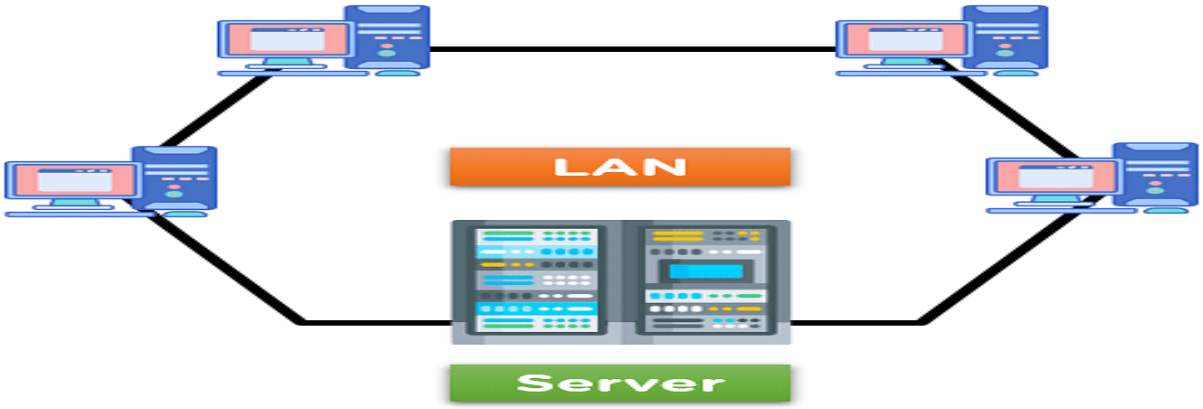


Figure 33: Local Area Network (LAN)

2- Metropolitan Area Network (MAN)

MAN is a network type that covers the network connection of an entire city or connection of a small area. The area covered by the network is connected using a wired network, like data cables.

Figure 34: Metropolitan Area Network (MAN)

3- Wide Area Network (WAN)

The Wide Area Network (WAN) is designed to connect devices over large distances like states or between countries. The connection is wireless in most cases and uses radio towers for communication. The WAN network can be made up of multiple LAN and MAN networks.

Figure 35: Wide Area Network (WAN)

Packets

- For large data transfers, messages need to be broken into smaller pieces so that the message from one computer does not dominate the communications medium
- These smaller entities are called packets
- The most important packet- switching protocol is the one used by the Internet, Transmission Control Protocol/Internet Protocol (TCP/IP)
- TCP/IP handles packetization and also decides how the packets are best routed through the network from source to destination computer

Internet Protocol address (IP address)

- In order to route packets through the network, each computer handling packets of data must have a unique address called the IP address
- IP addresses are made up of a set of four 1-byte numbers, each between 0 to 255, separated by periods
- They are often written in dotted decimal notation, such as: 128.64.32.218
- The left part of this number represents the number of the network the computer is on, while the right part is the host number of that specific computer.

Transmission control protocol (TCP)

The (TCP) is a protocol used by the internet to establish a connection between two remotely hosted applications and deliver a reliable data stream from one to the other.

Open Systems Interconnection (OSI) Model

The OSI model describes seven layers that computer systems use to communicate over a network. The following figure shows the seven layers.

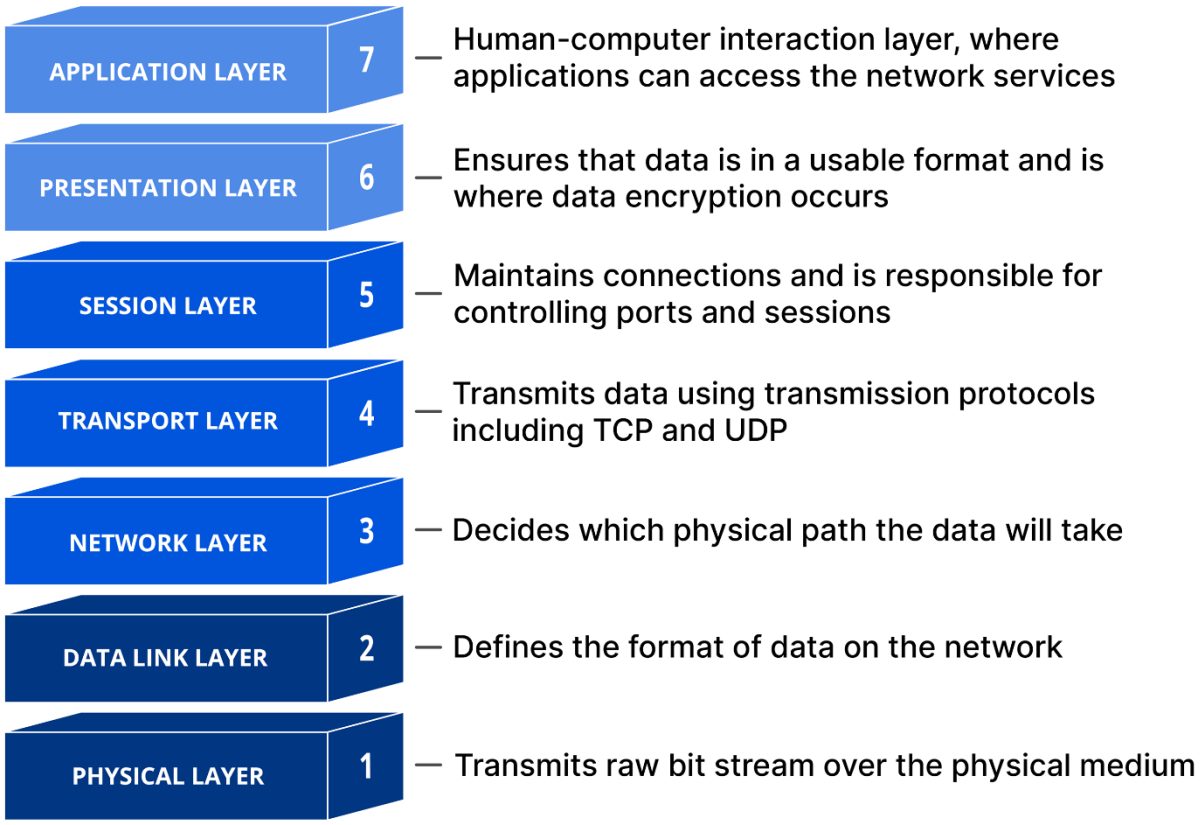


Figure 36: Open Systems Interconnection (OSI) Model

7. Application layer

The application layer is the topmost layer of the OSI model and interacts directly with end-users and applications. It provides network services to user applications, including file transfer, email, web browsing, and remote access. Protocols operating at the application layer include HTTP, FTP, SMTP, POP3, IMAP, DNS, SSH, and Telnet.

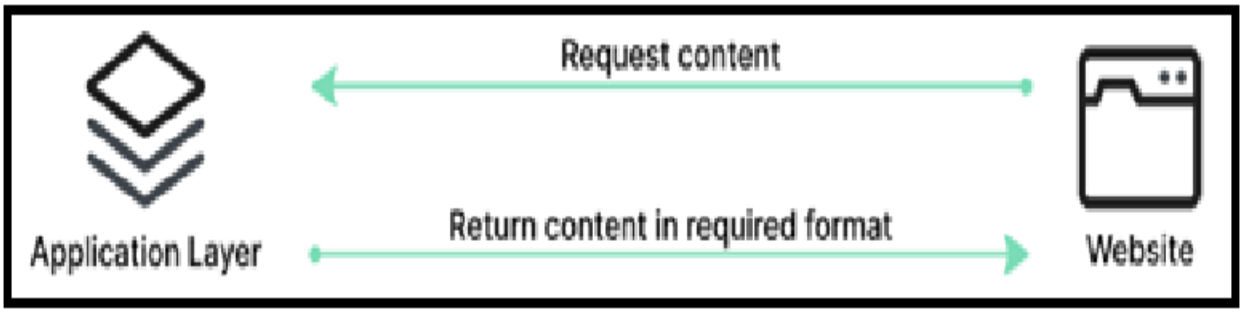


Figure 37: Application layer

6. Presentation layer

The presentation layer is responsible for data translation, encryption, and compression to ensure compatibility between different systems and applications. It handles tasks such as data formatting, character encoding, and encryption/decryption. Common presentation layer standards include ASCII, EBCDIC, MIME (Multipurpose Internet Mail Extensions), and SSL/TLS (Secure Sockets Layer/Transport Layer Security).

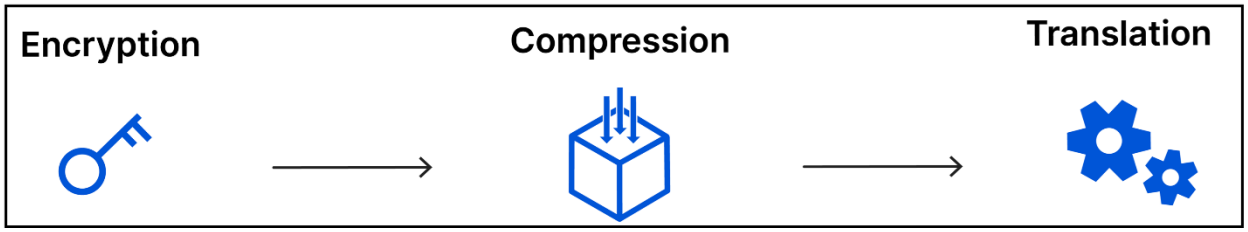


Figure 38: Presentation layer

5. Session Layer

The session layer establishes, manages, and terminates communication sessions between applications running on different hosts. It provides mechanisms for session establishment, maintenance, synchronization, and termination. Session layer protocols include NetBIOS (Network Basic Input/Output System) and Session Control Protocol (SCP).

Figure 39: Session Layer

4. Transport Layer

The transport layer is responsible for end-to-end communication and ensures the reliable and efficient delivery of data between source and destination hosts. It provides services such as segmentation, multiplexing, error detection, and flow control. Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) are the two primary transport layer protocols. TCP provides reliable, connection-oriented communication, while UDP offers faster, connectionless communication.

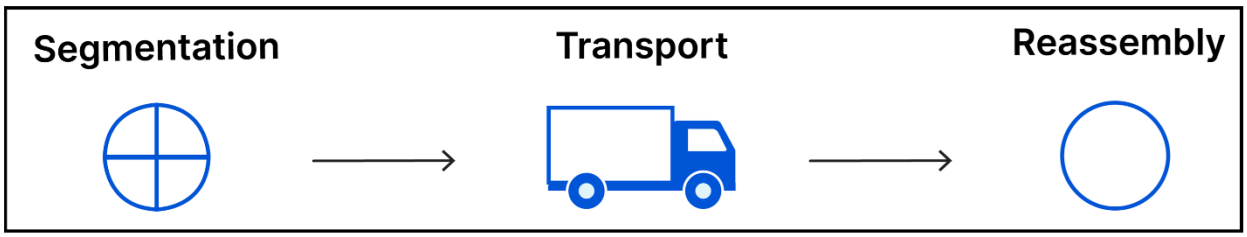


Figure 40: Transport Layer

3. Network Layer

The network layer is responsible for the logical addressing, routing, and forwarding of data packets between different networks. It determines the optimal path for data transmission, based on network topology, addressing, and routing tables. Routers operate at the network layer, performing functions such as packet forwarding and routing. Common network layer protocols include Internet Protocol (IP), Internet Control Message Protocol (ICMP), and Internet Group Management Protocol (IGMP).

Note

In a packet, the source and destination addresses are IP addresses (logical routing).

Figure 41: Packet structure

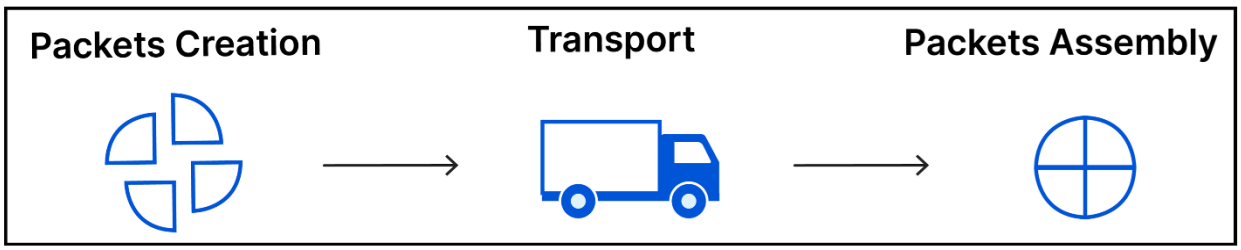


Figure 42: Network Layer

2. Data Link Layer

The data link layer is responsible for providing error-free and reliable data transmission between adjacent network nodes over the physical layer. It performs functions such as framing, addressing, error detection, and flow control. Ethernet switches, wireless access points, and network interface cards operate at the data link layer. Protocols operating at this layer include Ethernet, Wi-Fi (802.11), Point-to-Point Protocol (PPP), and Frame Relay.

Note

In the frame, the source and destination physical addresses (MAC) will be added. At this point, the header will contain the physical and logical addresses.

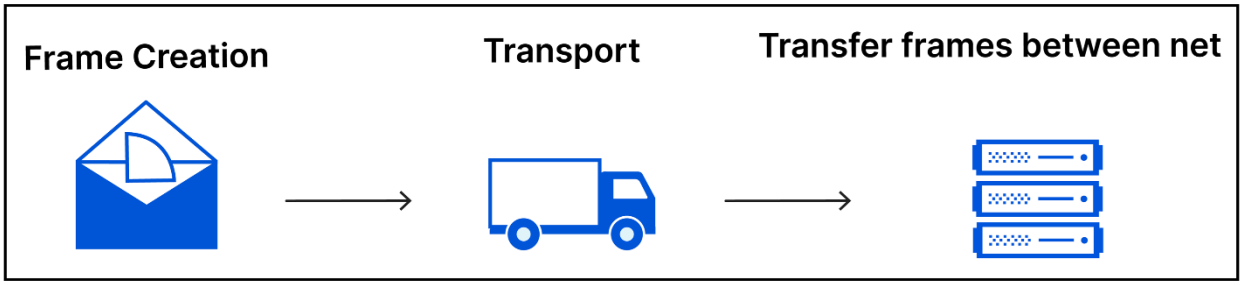
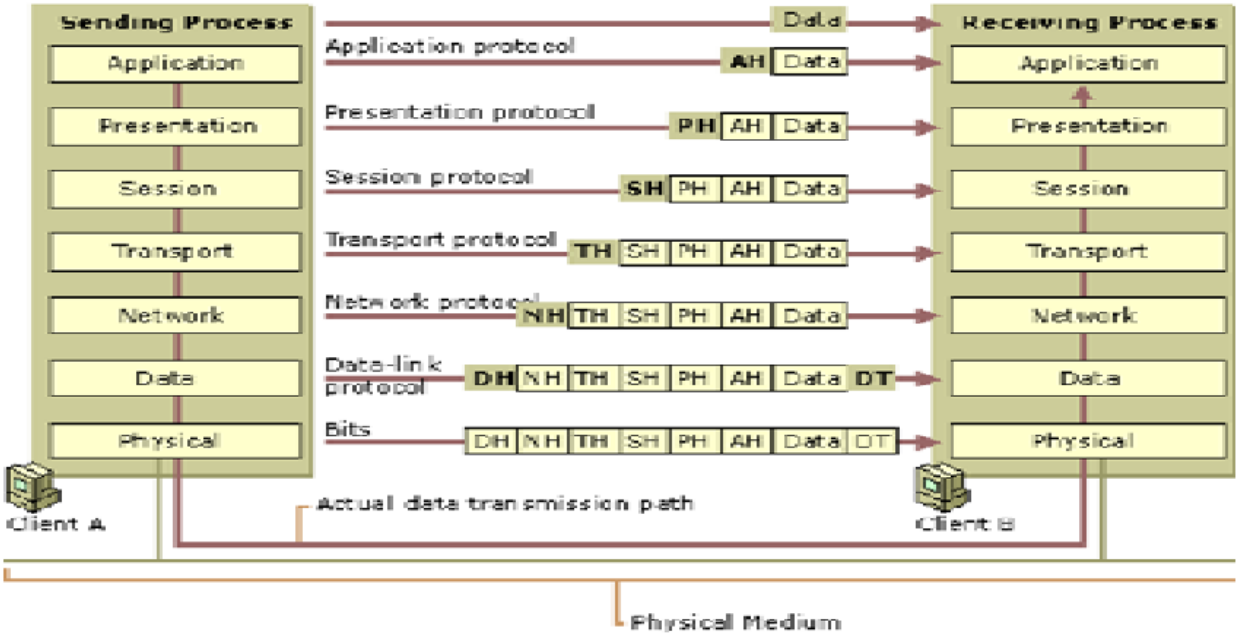


Figure 43: Data link layer

1. Physical Layer

The physical layer is the lowest layer of the OSI model and deals with the physical transmission of data over the network medium. It defines the electrical, mechanical, and procedural aspects of data transmission, including voltage levels, cable types, connectors, and data transmission rates. Examples of physical layer devices include Network Interface Cards (NICs), hubs, repeaters, and cables (e.g., Ethernet cables, fiber-optic cables).

Figure 44: Physical layer



Network Protocols

A network protocol is a set of established rules that specify how to format, send and receive data so that computer network endpoints, including computers, servers, routers and virtual machines, can communicate despite differences in their underlying infrastructures, designs or standards.

To successfully send and receive information, devices on both sides of a communication exchange must accept and follow protocol conventions. In networking, support for protocols can be built into the software, hardware or both.

Without network protocols, computers and other devices would not know how to engage with each other. As a result, except for specialty networks built around a specific architecture, few networks would be able to function, and the internet as we know it wouldn't exist. Virtually all network end users rely on network protocols for connectivity.

Types of network protocols

There are three types of protocols in networking:

1- **Network communication protocols.**

The efficiency of a network is determined by the communication protocols used. The formats and regulations that govern how data is

exchanged between networks are formally described by these protocols. This applies to both hardware and software and is a requirement for communicating between computing systems and telecommunication systems. In addition to handling syntax, synchronization and semantic requirements that both analog and digital communications must meet to work, communication protocols also handle authentication and error detection. The most common network communication protocols are:

- Hypertext Transfer Protocol (HTTP)
- File Transfer Protocol (FTP)
- User Datagram Protocol (UDP)
- Internet Relay Chat (IRC)
- Transmission Control Protocol (TCP)

2- Network management protocols.

To ensure steady communication and optimal performance throughout the network, network management protocols help specify the policies and processes needed to monitor, administer and maintain a computer network. They also assist in communicating these demands across the network. The most common network management protocols are:

- Simple Network Management Protocol (SNMP)
- Internet Control Message Protocol (ICMP)

3- Network security protocols.

The primary responsibility of network security protocols is to ensure that the data in transit over the network connections are kept safe and secure. These protocols also specify how the network protects data from any unauthorized efforts to inspect or extract it. This ensures that unauthorized users, services or devices don't have access to the network. The most common network security protocols are:

- Secure Sockets Layer (SSL)
- Secure File Transfer Protocol (SFTP)
- HTTP Secure (HTTPS)

Network Operating System (NOS)

A (NOS) is a special type of software that helps computers connect and communicate with each other over a network. It allows different devices, like computers and printers, to share resources and data easily. A NOS is mainly used in businesses or organizations to manage and control network operations, making it simpler to handle tasks like file sharing, security, and user access.

Types of Network Operating System

The important types of network operating systems are:

1- **Peer-to-Peer Network OS**

A Peer-to-Peer Network OS allows all computers in the network to connect and share resources directly without a central server. Each computer can act as both a client and a server, making it simple and cost-effective. This type of network is often used in small setups like homes or small offices where all devices can easily share files or printers.

2- **Client-Server Network OS**

A Client-Server Network OS uses a central computer, called the server, to manage and provide resources like files and security to other computers, known as clients. The server controls everything, while clients request services. This setup is commonly used in larger businesses or organizations for better control and security over the network.

3- **Distributed Network OS**

A Distributed Network OS connects multiple computers to work together as a single system. It spreads tasks across different machines, which helps balance the workload and improves efficiency. This type of network allows computers to share resources and collaborate, making it ideal for larger systems that need to handle a lot of data.

4- **Real-Time Network OS**

A Real-Time Network OS is designed to process data and respond instantly or quickly. It is used in systems where timing is crucial, like air traffic control or medical devices, where delays can have serious consequences. This type of operating system ensures that tasks are completed within strict time limits to maintain safety and efficiency.

5- Multiprocessor Network OS

A Multiprocessor Network OS allows multiple processors (or CPUs) to work together within a single computer to enhance performance. This setup helps handle complex tasks and speeds up data processing, making it ideal for systems that require high computing power. It's commonly used in applications like scientific research, where large amounts of data need to be processed quickly and efficiently.

Chapter Five
The Internet and Intranet

Learning Objectives

- **Describe what the internet is, how it works and how users connect to it. Describe the capabilities that the internet offers to users.**
- **Describe the World Wide Web and differentiate it from the internet Identify and describe the tools that allow users to view and search the web.**
- **Define the term intranet and discuss how intranet is use by businesses.**

Internet

The internet, sometimes simply called the net, is a worldwide system of interconnected computer networks and electronic devices that communicate with each other using an established set of protocols. The internet was conceived by the Advanced Research Projects Agency (ARPA) of the U.S. government in 1969.

World Wide Web (WWW.)

WWW stands for World Wide Web and is commonly known as the Web. WWW is defined as the collection of different websites around the world, containing different information shared via local servers (or computers). Web pages are linked together using hyperlinks which are HTML-formatted and, also referred to as hypertext, these are the fundamental units of the Internet and are accessed through Hypertext Transfer

Components of the Web

There are 3 components of the web:

1- **Hyper Text Markup Language (HTML):**

is the standard markup language for documents designed to be displayed in a web browser. HTML defines the content, structure and organization of a web page.

2- **Hypertext Transfer Protocol (HTTP)**

HTTP specifies communication of browser and server. The HTTP is the foundation of the World Wide Web, and is used to load webpages using hypertext links. HTTP is an application layer protocol designed to transfer

information between networked devices and runs on top of other layers of the network protocol stack. A typical flow over HTTP involves a client machine making a request to a server, which then sends a response message.

3- Uniform Resource Locator (URL)

A URL or Uniform Resource Locator is a Unique identifier that is contained by all the resources available on the internet. It can help to locate a particular resource due to its uniqueness. It is also known as the web address. A URL consists of different parts like protocol, domain name, etc. The users can access the URLs by simply typing them inside the address bar or by clicking any button or link web page.

Example URL:

https://www.geeksforgeeks.org/

Different Parts of a URL

A URL consists of multiple parts that can helps you to visit a particular page on the internet. Every part of a URL has its own importance. Let us discuss about the different parts of a URL.

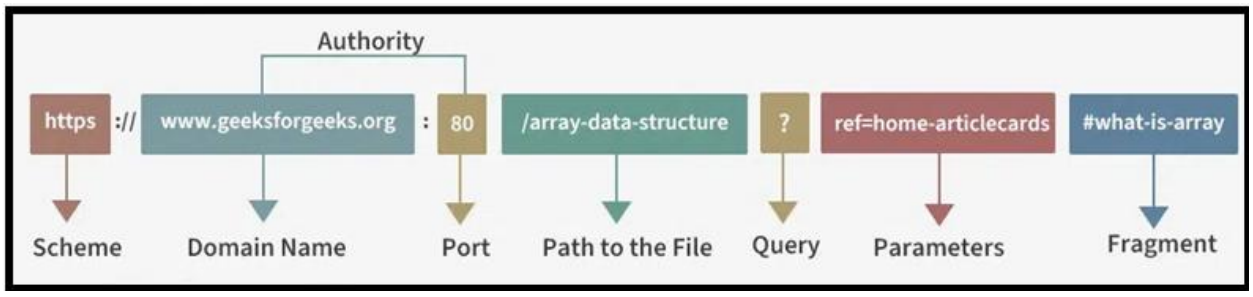


Figure 45: URL stricture

The protocol or scheme:

A URL starts with a protocol that is used to access the resource on the internet. The resource is accessed through the Domain Name System or DNS. There are multiple protocols available to use like HTTP, HTTPS, FTP, mail to, TELNET etc. The protocol used in the above URL is https.

Domain or Host Name:

It is the reference or name of the page that you are going to access on the internet. In this case, the domain name is: www.geeksforgeeks.org.

Figure 46: Domain names

Port Name:

It is defined just after the domain name by using the colons between itself and the domain name. Generally, it is not visible in the URL. The domain name and the port name combinedly can be known as Authority. The default port for web services is port80 (:80).

Path:

It refers to the path or location of a particular file or page stored on the web server to access the content of it. The path used here is: array-data-structure.

Query:

A query mainly found in the dynamic pages. It consists of a question mark(?) followed by the parameters. In above URL query is:?.

Parameters:

These are the pieces of information inside a query string of URL. Multiple parameters can be passed to a URL by using the ampersand (&) symbol to separate them. The query parameter in above URL is: ref=home-article cards.

Fragments:

The fragments appear at the end of a URL starts with a Hashtag (#) symbol. These are the internal page references that refers to a specific section within the page. The fragment in the above URL is: #what-is-array.

Internet protocol suite (TCP/IP Model)

The Internet protocol suite, commonly known as TCP/IP Model, with its four-layer structure, mirrors the practical implementation of the Internet, simplifying the model for real-world network communication. This simplification, however, can come at the cost of some of the comprehensive structure found in the OSI Model, making each model suitable for different networking contexts. The four layers of the TCP/IP model are as follows:

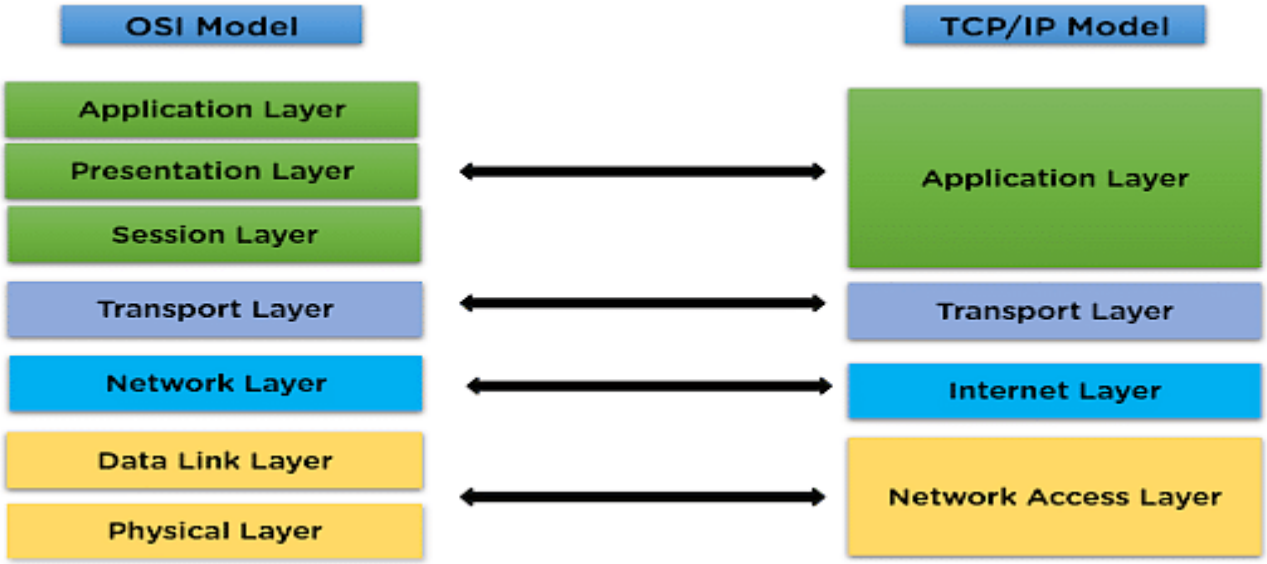


Figure 47: OSI and TCP/IP Models

4- Application Layer

This is the topmost layer which indicates the applications and programs that utilize the TCP/IP model for communicating with the user through applications and various tasks performed by the layer, including data representation for the applications executed by the user and forwards it to the transport layer.

The application layer maintains a smooth connection between the application and user for data exchange and offers various features as remote handling of the system, e-mail services, etc.

Some of the protocols used in this layer are:

- HTTP: Hypertext transfer protocol is used for accessing the information available on the internet.
- SMTP: Simple mail transfer protocol, assigned the task of handling e-mail-related steps and issues.
- FTP: This is the standard protocol that oversees the transfer of files over the network channel.

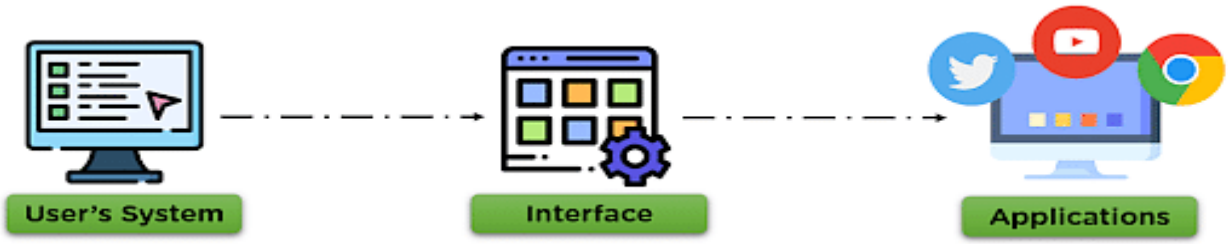


Figure 48: Application Layer

3- Transport Layer

This layer is responsible for establishing the connection between the sender and the receiver device and also performs the task of dividing the data from the application layer into packets, which are then used to create sequences. It also performs the task of maintaining the data, i.e., to be transmitted without error, and controls the data flow rate over the communication channel for smooth transmission of data.

The protocols used in this layer are:

- **TCP:** Transmission Control Protocol is responsible for the proper transmission of segments over the communication channel. It also establishes a network connection between the source and destination system.
- **UDP:** User Datagram Protocol is responsible for identifying errors, and other tasks during the transmission of information. UDP maintains various fields for data transmission such as:
- **Source Port Address:** This port is responsible for designing the application that makes up the message to be transmitted.

- **Destination Port Address:** This port receives the message sent from the sender side.
- **Total Length:** The total number of bytes of the user datagram.
- **Checksum:** Used for error detection of the message at the destination side.

Figure 49: Transport Layer

2- Internet Layer

The Internet layer performs the task of controlling the transmission of the data over the network modes and enacts protocols related to the various steps related to the transmission of data over the channel, which is in the form of packets sent by the previous layer. This layer performs many important functions in the TCP/IP model, some of which are:

A- It is responsible for specifying the path that the data packets will use for transmission.

B- This layer is responsible for providing IP addresses to the system for the identification matters over the network channel.

<u>Some of the protocols applied in this layer are:</u>

- IP: This protocol assigns your device with a unique address; the IP address is also responsible for routing the data over the communication channel.
- ARP: This protocol refers to the Address Resolution Protocol that is responsible for finding the physical address using the IP address.

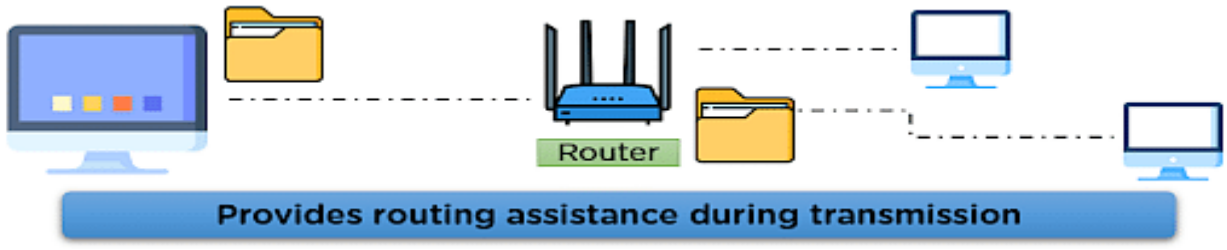


Figure 50: Internet Layer

1- Network Access Layer

This layer is the combination of data-link and physical layer, where it is responsible for maintaining the task of sending and receiving data in raw bits, i.e., in binary format over the physical communication modes in the network channel.

- It uses the physical address of the system for mapping the path of transmission over the network channel.
- Till this point in this tutorial on what is TCP/IP model, you understood the basic idea behind the model and details about its layers, now compare the model with another network model.

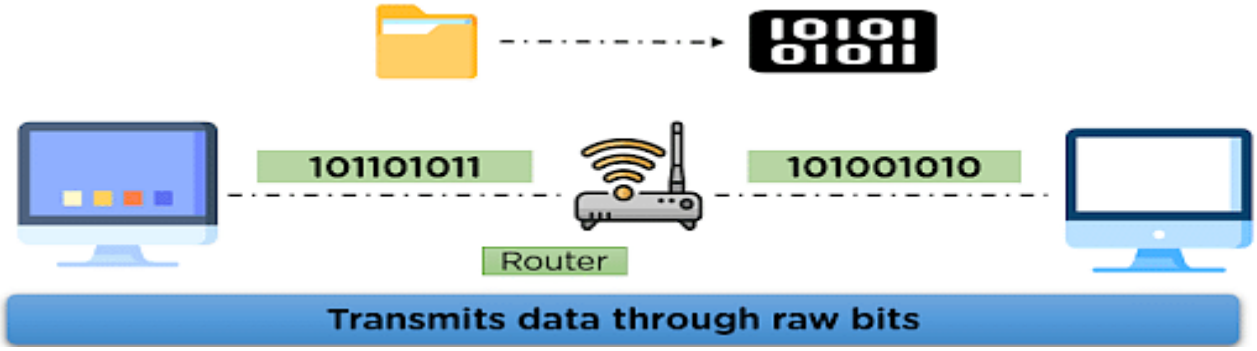


Figure 51: Network Access Layer

Virtual Private Network (VPN)

VPN, is an encrypted connection over the Internet from a device to a network. The encrypted connection helps ensure that sensitive data is safely transmitted. It prevents unauthorized people from eavesdropping on the traffic and allows the user to conduct work remotely. VPN technology is widely used in corporate environments.

Intranet

An intranet is a private network that uses internet software and TCP/IP protocols. In essence, an intranet is a private internet, or group of private segments of the public internet network, reserved for use by people who have been given the authority to use that network. Companies are increasingly using intranets powered by internal web servers to give their employees easy access to corporate information. intranets also are an effective medium for application delivery, although communications traffic is restricted to corporate LANs and WANs, key partners and

suppliers often may be part of an extended intranet as well this outward-facing extension of an intranet is often called extranet.

Security

With this number and variety of applications, intranet security is very important; companies can prevent unwanted intrusion into their intranets in several ways:

- Public key security is used to broker authorization to enter into a private internet it has two parts encryption and certificate authorities.
- Firewall is a device located between a firm's internal network (e.g. intranets) and external networks (e.g. the internet), the firewall regulates access into and out of a company's network.
- Pipelines: for higher security, companies can implement assured pipelines. whereas a firewall examines only the header information of a packet, an assured pipelines examines the entire request for data and then determines whether the request is valid.