Introduction to Information Technology

Chapter 1

Computer

- Electronic device for performing arithmetic, and logical operations (decisions are involved)
- The computer is a device or flexible machine to process data and convert it into information

Information Technology

- Information Technology (IT) refers to the management and use of the information using computer-based tools.
- Information technology (IT) is the use of any computers, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data.

Data

- Collection of raw facts and figures
- Stored using the binary number system. Data can be organized into files
- Data means unprocessed facts, statistics, etc., gathered together for reference, storage, or analysis.

Information

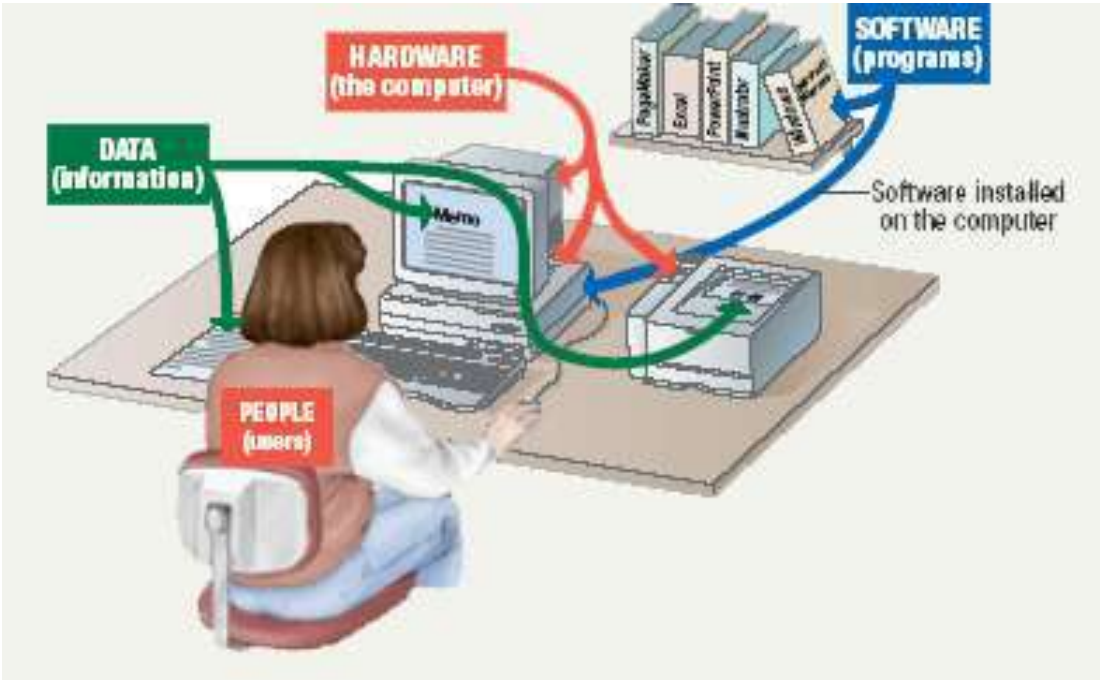
- Information is obtained after data is processed. Useful and meaningful for users.

Program

- Set of instructions that tells the computer what to do.
- A piece is software is called a program

Components / Parts of a Computer

- Computer systems have four parts
    1. Hardware
    2. Software
    3. Data
    4. User



Essential Computer Hardware

- Mechanical devices
- Anything that can be touched (Peripheral Devices)
- Computers use the same basic hardware
- Hardware categorized into four types

Essential Computer Hardware

- Processing devices
  - Brains of the computer
  - Carries out instructions from the program
  - Manipulate the data
  - Most computers have several processors
  - Central Processing Unit (CPU)
  - Secondary processors
  - Processors made of silicon and copper

Essential Computer Hardware

- Memory devices
  - Stores data or programs
  - Random Access Memory (RAM)
    - Volatile
    - Stores current data and programs
    - More RAM results in a faster system
  - Read Only Memory (ROM)
    - Permanent storage of programs
    - Holds the computer boot directions

Essential Computer Hardware

- Input and output devices
  - Allows the user to interact
  - Input devices accept data
    - Keyboard, mouse
  - Output devices deliver data
    - Monitor, printer, speaker
  - Some devices are input and output
    - Touch screens
    - Headsets (Headset consists of Speakers and Microphone).

Essential Computer Hardware

- Storage devices
  - Hold data and programs permanently
  - Different from RAM
  - Magnetic storage
    - Floppy and hard drive
    - Uses a magnet to access data (Disk Drives store data as magnetized charged particles)
  - Optical storage
    - CD and DVD drives
    - Uses a laser to access data (CDs and DVDs store data as dark and light spots)

Software Runs The Machine

- Tells the computer what to do
- Reason people purchase computers
- Two types
  - System software
  - Application software

Application Software

- It is the software which turns the computer into a tool for doing some specific tasks. These are the programs, which cater to various needs of the users. Application software cannot run on itself but is dependent on system software to execute. Application software is written for every type of task, i.e. from word processing to collecting information on the worldwide web(browser).
- Example: Microsoft Word etc.

System Software:

- System software integrates the computer hardware components, and also provides the tools to use the software components in the desired manner and for the day-to-day maintenance tasks like file/directories management , displaying the list of all the directories and files on the disk. One main type of system software is the operating system that is required by the computer to function.
- Example: Windows OS

Computer data

- Fact with no meaning on its own
- Stored using the binary number system
- Data can be organized into files

Computer users

- Role depends on ability
  - Setup the system
  - Install software
  - Running Programs
  - Managing files
  - File Hierarchy
  - File Manager
  - Advantages of File Management
  - Maintaining the System

4 Basic Operations of a Computer

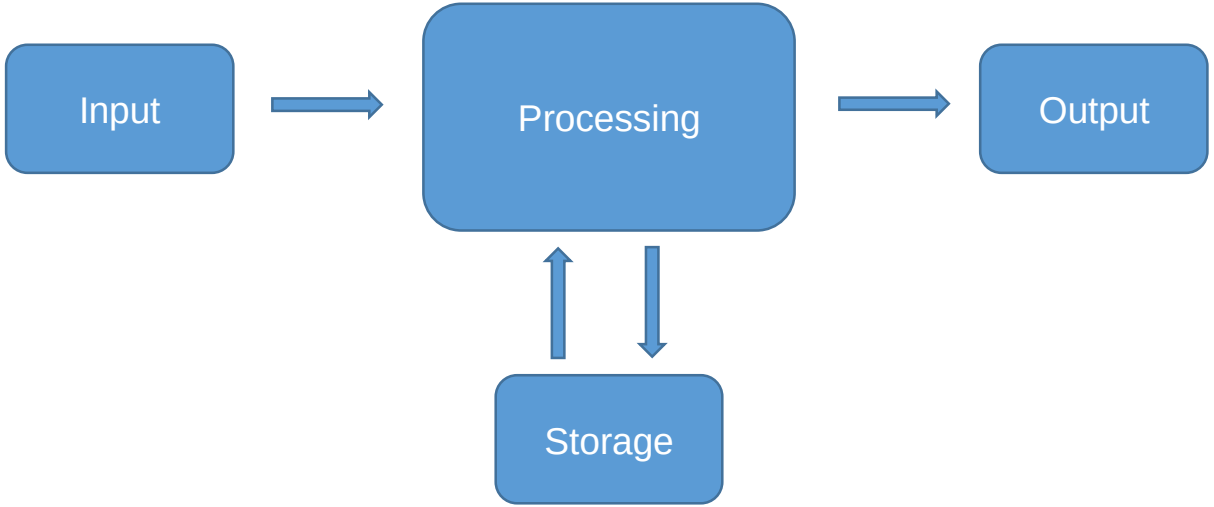
- There are four basic operations which a computer performs, irrespective of the program which is running on it. They are classified as:
  - Input
  - Processing
  - Output and
  - Storage
- Also called IPOS Cycle (“Input Processing Output Storage Cycle”)
- The four steps of the IPOS cycle may not necessarily appear in the same sequence as they are defined.

Input: Computer accepts data from some source, such as a user or a program. This involves inserting or feeding data into the computer by means of an input device, like a keyboard.

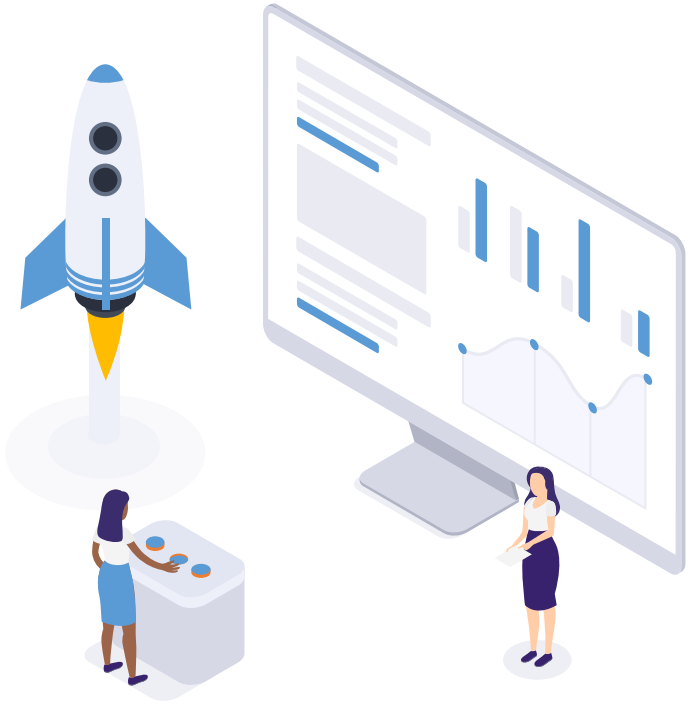
Processing: Some action is performed on the input provided by the user or a program. Some kind of processing is done in the computer to take out or transform data in some way.

Output: Processing result is displayed on any output device. The result can be in the form of text, numbers, images, sound etc. The computer produces an output on a device, such as a printer or a monitor, that shows the result of the processing operations.

Storage: Processing result is stored on a disk. The computer stores the result of processing operations for future use in some storage device, such as a hard disk or a floppy disk.


Input
Processing
Output
Storage

Classification of Computers



Computers For Individual Use

- Desktop computers
  - The most common type of computer
  - Sits on the desk or floor
  - Performs a variety of tasks
- Workstations
  - Specialized computers
  - Specifically Optimized for science or graphics
  - More powerful than a desktop

Computers For Individual Use

- Notebook computers
  - Small portable computers
  - Weighs between 3 and 8 pounds
  - About 8 ½ by 11 inches
  - Typically as powerful as a desktop but high price in comparison
  - Offer desktop-level power in a portable form but tend to be pricier due to their compact design
  - Can include a docking station

Computers For Individual Use

- Tablet computers
  - Newest development in portable computers
  - Input is through a pen OR by gestures.
  - Run specialized versions of office products

Computers For Individual Use

- Handheld computers
  - Very small computers
  - Personal Digital Assistants (PDA)
  - Note taking or contact management
  - Data can synchronize with a desktop
- Smart phones
  - Hybrid of cell phone and PDA
  - Web surfing, e-mail access

Computers For Organizations

- Network servers
  - Centralized computer
  - All other computers connected by cloud
  - Provides access remotely to network resources
  - Multiple servers are called server farms
  - Often simply a powerful desktop

Computers For Organizations

- Mainframes
  - Used in large organizations
  - Handle thousands of users
  - Users access through a terminal

Computers For Organizations

- Minicomputers
  - Called midrange computers
  - Power between mainframe and desktop
  - Handle hundreds of users
  - Used in smaller organizations
  - Users access through a terminal

Computers For Organizations

- Supercomputers
  - The most powerful computers made
  - Handle large and complex calculations
  - Process trillions of operations per second
  - Found in research organizations

Computers In Society

- More impact than any other invention
  - Changed work dynamic and leisure activities making it more convenient
  - Used by all demographic groups
- Computers are important because:
  - Provide information to users
  - Information is critical to our society due to daily advancement
  - Managing information is difficult

Computers In Society

- Computers at home
  - Many homes have multiple computers
  - Most American homes have Internet
  - Computers are used for
    - Business
    - Entertainment
    - Communication
    - Education

Computers In Society

- Computers in education
  - Computer literacy required at all levels
- Computers in small business
  - Makes businesses more profitable
  - Allows owners to manage things in an efficient manner
- Computers in industry
  - Computers are used to design products
  - Assembly lines are automated

Computers In Society

- Computers in government
  - Necessary to track data for population
    - Police officers
    - Tax calculation and collection
  - Governments were the first computer users

Computers In Society

- Computers in health care
  - Revolutionized health care
  - New treatments possible
  - Scheduling of patients has improved
  - Delivery of medicine is safer

Computers In Society

- Computers in Banking
  - Internet Banking
  - Bankers' Automated Clearing Services (BACS)
    - Financial transactions between banks carried out by the BACS through computers
  - Online Banking
    - Internet Banking allows you to connect to your bank using a computer via Internet
  - Automated Teller Machines (ATM)
    - An ATM is defined as a banking terminal used to make transactions without a human teller(interference)

Computers In Society

- Computers in communication
  - Electronic Mail
  - Audio and Video Conferencing
  - News Groups
  - Instant Messaging

Computers In Society

- Computers in Police Department
  - Crime detection
  - Handle vast amount of data and criminal intelligence stored on Police National Computer (PNC)
  - Fingerprinting
  - DNA profiling

Computers In Society

- Computers in Retail
  - Used in supermarkets for receiving, storing, retrieving, manipulating and sending data
    - Cashier, Barcode, Debit/ Credit card, Money transfer
  - Stock control
  - Electronic Funds Transfer Point of Sale (EFTPOS)
  - Internet Shopping

“Userless” Computer

- “Userless” computers
  - Run with no user input
  - Automated systems

Basic Organization of a Computer System

Chapter 2

Bits and Bytes

- A bit is a binary digit, the smallest increment of data on a computer.
- A bit can hold only one of two values: 0 or 1, corresponding to the electrical values of off or on, respectively.
- Because bits are so small, you rarely work with information one bit at a time.
- Bits are usually assembled into a group of eight to form a byte.
- A byte contains enough information to store a single ASCII character, like "h".

Bits and Bytes

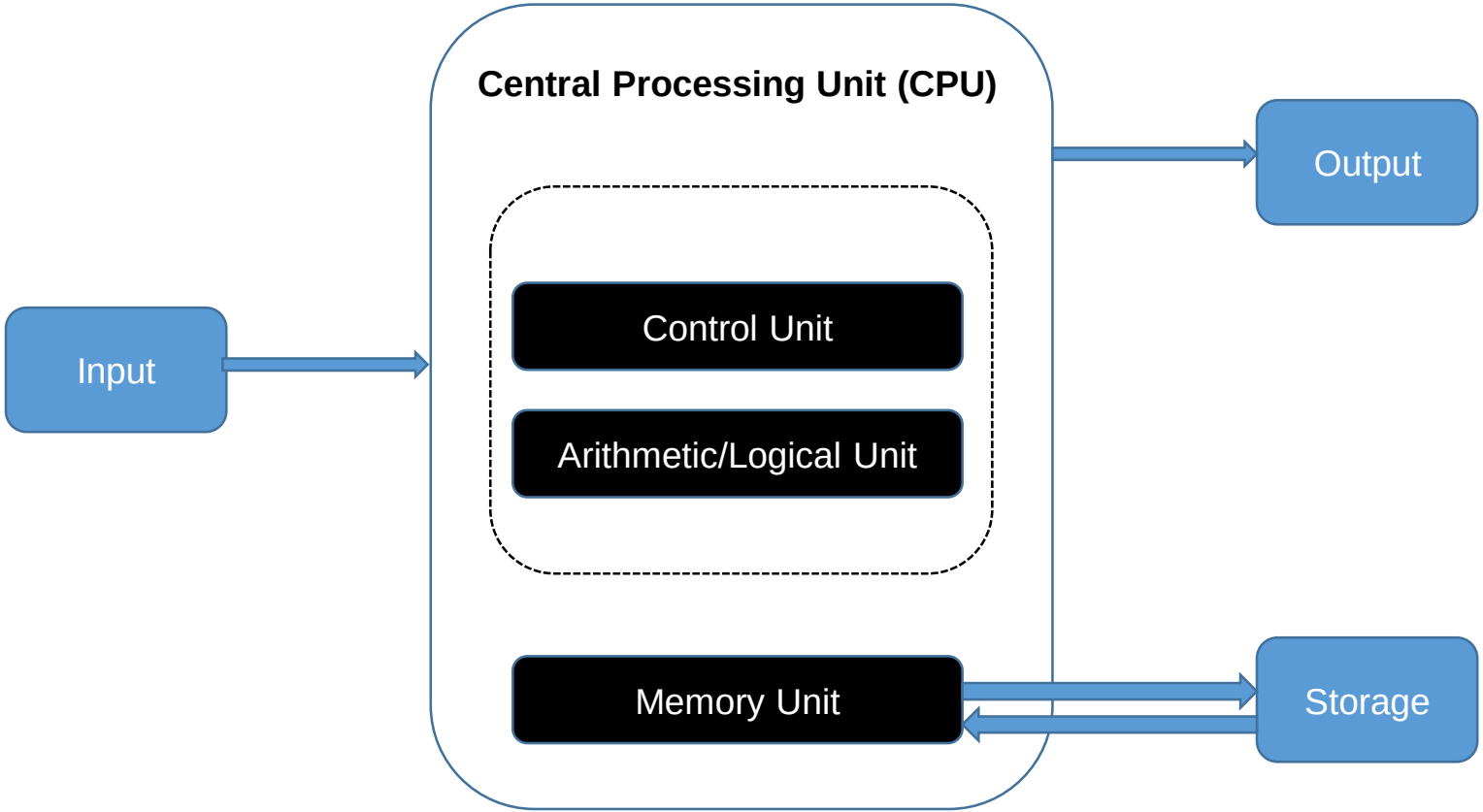
- So in computer jargon, the following units are used:

Unit	Equivalent
1 kilobyte (KB)	1,024 bytes
1 megabyte (MB)	1,048,576 bytes
1 gigabyte (GB)	1,073,741,824 bytes
1 terabyte (TB)	1,099,511,627,776 bytes
1 petabyte (PB)	1,125,899,906,842,624 bytes

Basic Organization of a Computer System

- The basic organization of a computer system is the processing unit, memory unit, and input-output devices. The processing unit controls all the functions of the computer system.
- It is the brain of the computer e.g. CPU.
- The memory unit consists of two units. One is an arithmetic unit and the other is a logic unit.
- Input devices are those devices through which end-users can send messages to computers e.g. keyboard, mouse, etc.
- Output devices are those devices through which end-users get output from computers e.g. monitors.

Remember IPOS Cycle?



Central Processing Unit (CPU)

- A CPU is a brain of a computer. It is responsible for all functions and processes.
- Carries out instructions from the program & Manipulate the data

- The actual processing of the data is carried out in the CPU.
- The CPU stores the data and instructions in the primary memory of the computer, called the Random Access Memory (RAM) and processes them from this location.

Central Processing Unit (CPU)

- The Arithmetic Logic Unit (ALU) and the Control Unit (CU) are the two subcomponents of the CPU.
- The ALU carries out the arithmetic and logical operations while the CU retrieves the information from the storage unit and interprets this information.
- The CPU also consists of circuitry devices called cache and registers.

Arithmetic Logic Unit (ALU)

- Executes all arithmetic and logical operations.
- Arithmetic calculations like as addition, subtraction, multiplication and division.
- Logical operation like compare numbers, letters, or special characters.
- The data and instructions stored in the RAM are transferred to the ALU for processing. The ALU performs the logical and the arithmetic operations on the data and the results are temporarily stored in the RAM. After the processing, the final results are stored in the secondary memory, i.e., the storage unit, and are released through an output device.

Control Unit (CU)

- Controls and co-ordinates computer components.
- Read the code for the next instruction to be executed.
- Increment the program counter so it points to the next instruction.
- Read whatever data the instruction requires from cells in memory.
- Provide the necessary data to an ALU or register.
- If the instruction requires an ALU or specialized hardware to complete, CU instructs the hardware to perform the requested operation.
- It selects, interprets, and ensures the proper execution of the program instructions.

Registers

- To speed up the Computer processor's work by enabling quick access to often-used values, it has a collection of Registers that are incredibly fast but only hold a small quantity of data.
- Computer registers are memory storing units that operate at high speed. It's a component of a computer's processor. It can hold any type of data, including a bit sequence or a single piece of data.
- Eight registers, a memory unit, and a control unit make up a basic computer. These devices must be connected on a regular basis.

Types of Registers

Most common registers in computer:

1. Accumulator (processor register)
2. Program Counter (stores address of instructions)
3. Address Register (stores memory addresses)
4. Data Register (general purpose register used for storing data during calculations)
5. Instruction Register (stores current instructions being executed)
6. Temporary Register (holds the temporary data)

Characteristics of Registers

1. Small, storage locations within the CPU
2. Manipulated directly by the Control Unit
3. Wired for specific function
4. Size in bits or bytes (not MB like memory)
5. Can hold data, an address or an instruction
6. The more registers a CPU has available, the faster it can work

Functions of Registers in Computer Architecture

- **Data Storage:** Registers are used for the temporary storage of data or instructions during the execution of the program. They are mainly used to store information for a small time so that the CPU can access it quickly.
- **Data Processing:** We can perform various logical and arithmetic operations with the help of a register and the data of these instructions is stored in the accumulator register.
- **Addressing:** Registers are used to store memory addresses they can store the address of the instruction or the data that the CPU wants to access either to read from or write to.
- **Data Transfer:** Registers are used to transfer data between CPU and memory. Some of them hold the data that is read from or written to memory.
- **Control:** We can control the order of execution of instructions as some registers temporarily store the current instruction being processed, while others hold the next instruction to be executed.

Microprocessor

- A microprocessor is an integrated circuit (IC) which incorporates core functions of a computer's central processing unit (CPU).
- It is a programmable multipurpose silicon chip, clock driven, register based, accepts binary data as input and provides output after processing it as per the instructions stored in the memory.

Cache:

A cache is a smaller, high-speed volatile memory located between the CPU (Central Processing Unit) and the main memory (RAM) in a computer system. Its primary function is to store copies of frequently accessed or recently used data and instructions temporarily, allowing the CPU to access them quickly when needed.

Microprocessor

- A microprocessor executes a collection of machine instructions that tell the processor what to do. Based on the instructions, a microprocessor does three basic things:
  - Using its ALU (Arithmetic/Logic Unit), a microprocessor can perform mathematical operations like addition, subtraction, multiplication and division. OR CU for data management
  - A microprocessor can move data from one memory location to another.
  - A microprocessor can make decisions and jump to a new set of instructions based on those decisions.

Bus

- Alternatively known as an **address bus**, **data bus**, **control bus**, or **local bus**, a **bus** is a link between components or devices connected to a computer. This expression covers all related hardware components (wire, optical fiber, RAM sticks slot etc.)
- For example, a bus carries data between a CPU and the system memory via the motherboard.
- You can think of a computer bus like public transportation or a school bus. These types of buses are capable of transporting people from one destination to another destination. Like these buses, a computer bus transmits data from one location or device to another location or device.

Types of Computer Buses

A bus is either a parallel or serial bus, and either an internal bus (local bus) or an external bus (expansion bus).

Internal bus vs. External bus

- An internal bus enables the communication between internal components, such as a video card and memory.
- An external bus can communicate with external peripherals, such as a USB.

Parallel bus vs. Serial bus

- A computer bus can transmit its data using either a parallel or serial method of communication.
- With a parallel bus, data is transmitted several bits at a time. However, with a serial bus, the data is transferred one bit at a time.

Operating Systems and Virtualization

Operating System (OS)

- An Operating System (OS) is an interface (pathway) between a computer user and computer hardware. An operating system is a software which performs all the basic tasks like file management, memory management, error handling, process management, handling input and output, and controlling peripheral devices such as disk drives and printers.

- An operating system is a program that acts as an interface between the user and the computer hardware and controls the execution of all kinds of programs.

Operating System (OS)

- OS is a resource allocator
  - Manages all resources
  - Decides between conflicting requests for efficient and fair resource use so memory doesn't exhausts out.
- OS is a control program
  - Controls execution of programs to prevent errors and improper use of the computer

Different Types of OS

- There are different types of operating systems such as:
- Windows
- MacOS
- ChromeOS
- Linux
- DOS
- iOS
- Android etc.

Windows


Recycle Bin
Most used
Get Started
Maps
People
Calculator
Alarms & Clock
Snipping Tool
Recently added
paint.net
0 – 9
3D Builder
3D Scan
A
Adobe Photoshop Express
Alarms & Clock
American Express
Audible
Autodesk Pixlr
B
Life at a glance
Mail
Find the cat
Where the Ninja Cats are...
5:00 PM - 5:30 PM
Wednesday 20
Store
Photos
Groove Music
Drone manufacturers work to combat growing terro...
Cortana
News
Harriet Tubman replacing Andrew Jackson on $2...
USA TODAY
Microsoft Edge
@Bluefays
Life-size bobblehead anyone?
Twitter
Wed
Thu
Fri
80°
72°
63°
Bellevue
Draft trades illustrate scarcity of talent at...
Sports
Pemex says fire at facility in Coatzacoalcos, Mexico, is no...
Breaking...
Office
Play and explore
Xbox (beta)
Microsoft Solitaire Collection
Minecraft
Movies & TV
SODA
Other cool apps
Wunderlist
Wireless Displ...
PREVIEW
Remote Deskt...
Photoshop Ex...
Give all the feedbacks!
Feedback Hub
Ask me anything
Windows 10 Pro Insider Preview
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MacOS


Finder File Edit View Go Window Help
Fri 9:52 PM
Macintosh HD
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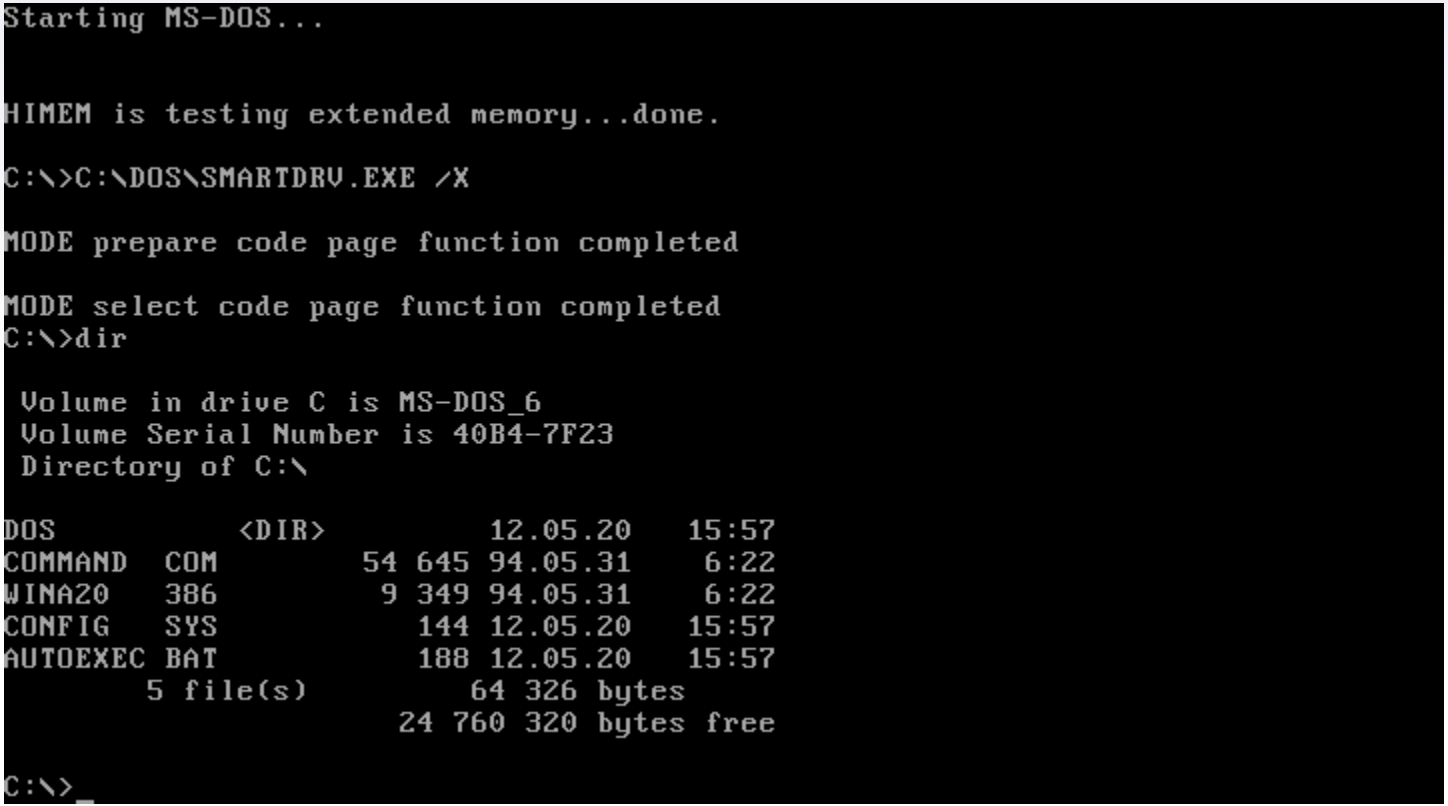
Macintosh HD
iDisk
PLACES
Desktop
Guest
Applications
Documents
SEARCH FOR
Today
Yesterday
Past Week
All Images
All Movies
All Documents
Desktop
Documents
Downloads
Library
Movies
Music
Pictures
Public
Sites
9 items, 15.86 GB available

Linux


Activities
Apr 16 14:23
Type to search...
Terminal
Settings
dconf Editor
Files
Ubuntu Softw...
Software & Up...
Firefox Web B...
System Monitor
Disks
Disk Usage An...
Characters
To Do
Calculator
Thunderbird ...
Transmission
Text Editor
Rhythmbox
Fonts
Image Viewer
LibreOffice Calc
Software Upd...
Calendar
Videos
Startup Disk C...
Frequent
All

DOS


Starting MS-DOS...
HIMEM is testing extended memory...done.
C:\>C:\DOS\SMARTDRV.EXE /X
MODE prepare code page function completed
MODE select code page function completed
C:\>dir
Volume in drive C is MS-DOS_6
Volume Serial Number is 40B4-7F23
Directory of C:\
DOS <DIR> 12.05.20 15:57
COMMAND COM 54 645 94.05.31 6:22
WINA20 386 9 349 94.05.31 6:22
CONFIG SYS 144 12.05.20 15:57
AUTOEXEC BAT 188 12.05.20 15:57
5 file(s) 64 326 bytes
24 760 320 bytes free
C:\>_

iOS

Android


Search
APP SUGGESTIONS
Settings
Maps
Gallery
Apps
WEATHER
London
Mostly Cloudy
13°C
EDIT
Inbox
To: bridget@e.email
(No subject)
Mathieu DUPONT
Demande d'informations
To: bridget@e.email
(No subject)
Jonas Fray
Fairphone 3 teams with /e/OS for a privacy ...

Following are some of important functions of an operating System:

- Memory Management
- Processor Management
- Device Management
- File Management
- Security
- Control over system performance
- Job accounting
- Error detecting aids
- Coordination between other software and users

Memory Management

- Memory management refers to management of Primary Memory or Main Memory. Main memory is a large array of words or bytes where each word or byte has its own address.
- An Operating System does the following activities for memory management –
  - Keeps tracks of primary memory, i.e., what part of it are in use by whom, what part are not in use.
  - In multiprogramming, the OS decides which process will get memory when and how much.
  - Allocates the memory when a process requests it to do so.
  - De-allocates the memory when a process no longer needs it or has been terminated

Processor Management

- In multiprogramming environment, the OS decides which process gets the processor when and for how much time. This function is called **process scheduling**. An Operating System does the following activities for processor management –
  - Keeps tracks of processor and status of process. The program responsible for this task is known as **traffic controller**.
  - Allocates the processor (CPU) to a process.
  - De-allocates processor when a process is no longer required.

Device Management

- An Operating System manages device communication via their respective drivers. It does the following activities for device management –
  - Keeps tracks of all devices. Program responsible for this task is known as the I/O controller.
  - Decides which process gets the device when and for how much time.
  - Allocates and de-allocates the devices in the efficient way.

File Management

- A file system is normally organized into directories for easy navigation and usage. These directories may contain files and other sub-directions.
- An Operating System does the following activities for file management –
  - Keeps track of information, location, uses, status etc. The collective facilities are often known as file system.
  - Decides who gets the resources.
  - Allocates the resources.
  - De-allocates the resources.

- **Security** – By means of password and similar other techniques, it prevents unauthorized access to programs and data.
- **Control over system performance** – Recording delays between request for a service and response from the system.
- **Job accounting** – Keeping track of time and resources used by various jobs and users.
- **Error detecting aids** – Production of dumps, traces, error messages, and other debugging and error detecting aids.
- **Coordination between other software's and users** – Coordination and assignment of compilers, interpreters, assemblers and other software to the various users of the computer systems.

Tasks of the Operating System:

- Accepts inputs from the mouse or keyboard.
- Sends outputs to the monitor or printer.
- Recognizes peripheral devices such as external hard disks, pen drive, web cam etc. and makes sure that software (driver) needed for the hardware to run is installed.
- Manages files and folders in the system (Naming, Creating, Moving, Finding and Deleting folders etc.)
- Allows applications software (word-processing, spreadsheets etc.) to communicate with the system's hardware.

Tasks of the Operating System:

- Shares out system memory efficiently. The operating system will decide how much memory to assign to particular tasks. It also moves data in and out of memory.
- Loads and runs software applications.
- Manages system security. For example - allows passwords to be added / changed.
- Handles system problems and alerts the user. For example if a printer is jammed and cannot printer, the operating system will stop the print job and alert the user with a warning message.
- Manages the moving of data to and from a hard disk.

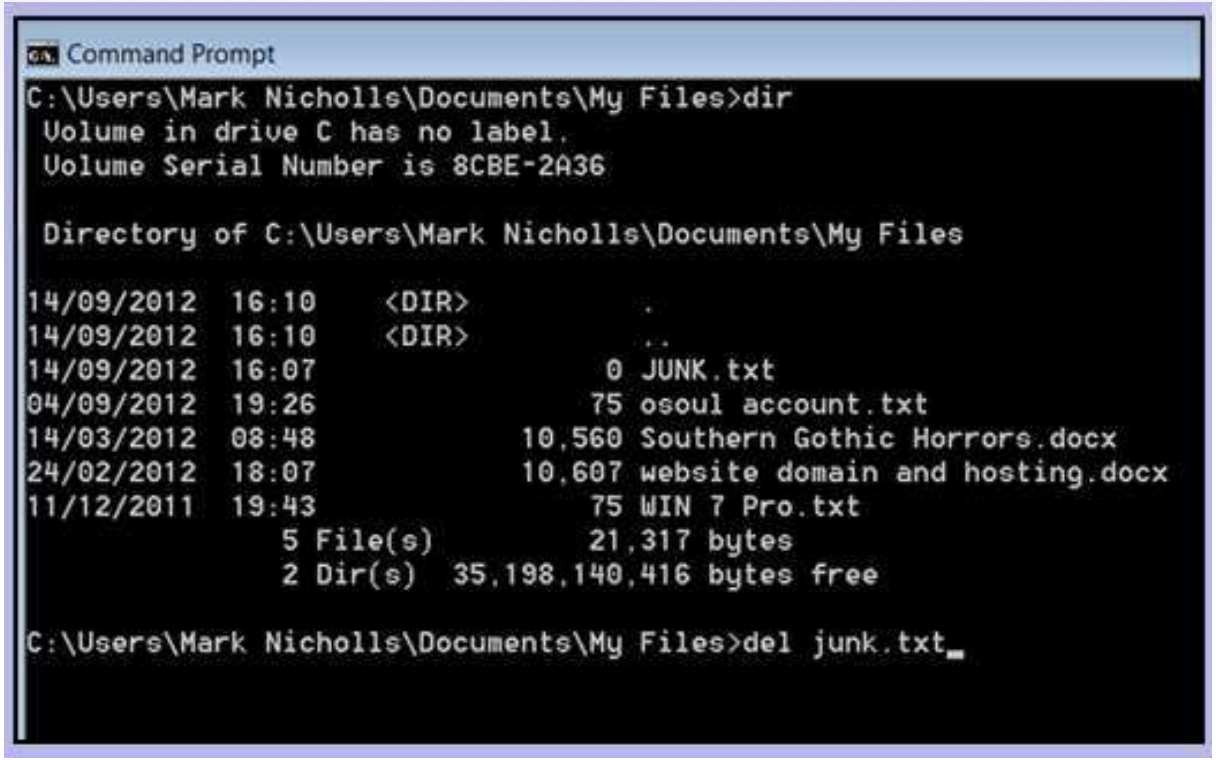
Types of OS Interfaces

- The way (medium through which) in which users communicate with the computer is called an 'interface'. The interface is what we use to give the computer commands. There are three types of operating system interfaces:
  - Command Line Interface (CLI)
  - Graphical User Interface (GUI)
  - Touchscreen Interface

Command Line Interface (CLI)

- A command line interface is an older style operating system where users type in commands using keyboard.
- Command Line Interface's do not make use of images, icons or graphics. All the user is sees is a plain black screen like the one to the right.
- Because they use no graphics they require very little computer power.
- There are over 270 different commands that can be entered at the command prompt. Commands have to be entered precisely without spelling mistakes or else the operating system will return an error.
- Remembering commands and the exact way to enter them can be difficult and so Command Line Interface Operating Systems are considered hard to use.

Command Line Interface (CLI)



Graphical User Interface (GUI)

- GUI's are visual (graphical) interfaces and they are more popular than CLI's because they are very easy to use. The graphics do need more computer power however.
- Instead of typing in commands, the user can use a mouse to point and click objects on the screen. For example: A user can erase a file by right clicking and then selecting delete.
- The main features of a GUI are Windows, Icons, Menus and Pointers.

Graphical User Interface (GUI)

Touchscreen Interfaces

- Portable devices such as mobile phones, PDA's and tablets (e.g. IPad) use interfaces similar to a GUI where icons and menus are used to input commands.
- However, because these devices don't have room for a mouse, the way in which the icons and menus are used is different. (through gestures)
- Touchscreen technology allows people to use their fingers to select icons and options straight from the device's screen.

Virtualization

- Virtualization creates a simulated, or virtual, computing environment as opposed to a physical environment. Virtualization often includes computer-generated versions of hardware, operating systems, storage devices, and more.
- A virtualization software can allow you to create several “virtual computers” (for example 3) within one. Thus, the software will create the “illusion” of generating 3 different computers, each one with its own operating system and its own resources.
- Types: full virtualization, para-virtualization, and OS-level virtualization.
- Use to test network test servers or beta applications on different OS.

Introduction to Software

Software

- Computer software, or simply software is any set of machine-readable instructions that directs a computer's processor to perform specific operations.
- Software tells the computer what to do and how to do

Types of Software

- System Software
- Application Software
- Open Source Software
- Proprietary Software
- Malicious Software

System Software

- A program or set of programs that is especially designed to control different operations of computer system is called system software. It controls the working of different components of the computer.
- Provide a platform for running application software.
- System software can be separated into two different categories, operating systems and utility software.

System Software - Utility Software

- A utility software is a small program that provides an addition to the capabilities provided by the operating system.
- It is intended to analyze, configure, monitor to maintain a computer.
- Typically a utility is smaller than a standard program in size and may be included with an operating system or installed separately.

System Software - Utility Software

- Examples:
  - Antivirus – Microsoft Defender, Norton 360
  - Backup Software – EaseUS Todo, Filefort
  - Compression Utility – WinZip, 7-Zip
  - Debuggers
  - Disk Checkers – Defrag, ScanDisk
  - Encryption Tools – LastPass, VeraCrypt
  - File Manager – eFileCabinet, M-Files
  - Memory Tester – MemTest86, DocMemory
  - Network Monitors – SolarWinds

System Software - Drivers

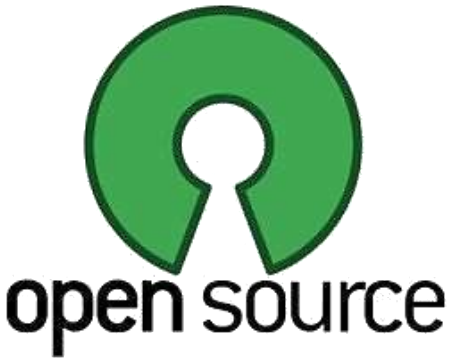
- A device driver (commonly referred to as simply a driver) is a computer program that helps to identify,operates or controls a particular type of device that is attached to a computer.
- Examples Mouse driver, keyboard driver, video card driver, sound card driver

Application Software

- It is a set of one or more programs designed to carry out operations for a specific application.
- Application software cannot run on itself but is dependent on system software to execute.
- Example: Payroll systems, Inventory Control, Word Processor, Spreadsheet and Database Management System etc.

Open Source Software

- Open Source Software (OSS) is software whose source code is available under a license that permits users to use, change, and improve the software, and to redistribute it in modified or unmodified form.
- It is often developed in a public, collaborative manner.
- Well-known products are Linux, Netscape, Apache, etc.



Proprietary Software

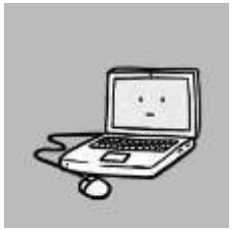
- Software with restrictions on using, copying and modifying as enforced by the proprietor(owner).
- Restrictions on use, modification and copying is achieved by either legal or technical means and sometimes both.
- OR A software related to a particular company/owner and doesn't have open source code that restricts user for modifying it under legal terms.
- Example :
  - MS Office/Windows,
  - CAD,
  - Norton AV etc.

Malicious Software

- Malicious software or Malware – any software used to disrupt computer operation, gather sensitive information, or gain access to private computer systems.
- It contains Viruses, Worms, Trojan horses, Spyware, Adware, Ransomeware and other malicious programs

Virus

- Virus is a program written to sneak into your computer and damage/alter your files/data. A virus might corrupt or delete data on your computer.
- Examples of widespread computer viruses:
  - Morris Worm,
  - MyDoom,
  - ILOVEYOU,
  - Nimda



Worm

- Malicious programs that make copies of themselves again and again on the local drive, network shares, etc.
- Mydoom – fastest spreading email worm in 2004 sending junk emails costing $38 billion

Adware

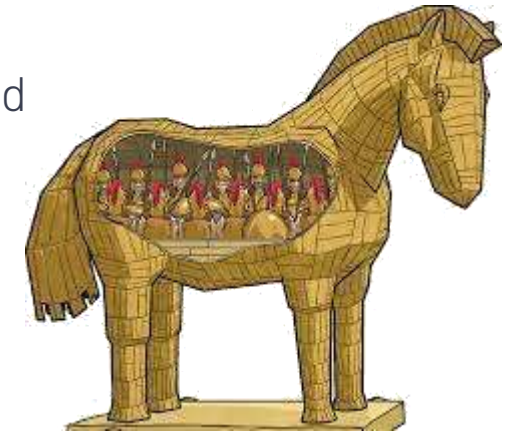
- A software application in which advertising banners are displayed
- Auto download to your system with some program
- Fireball, DollarRevenue

Spyware

- They installed with or without your permission on your PC to collect information about users, their computer or browsing habits
- Tracks each and everything that you do without your knowledge and send it to remote user
- Examples - AgentTesla, Pegasus

Trojan Horse

- The term is derived from the ancient Greek story of the deceptive Trojan Horse that led to the fall of the city of Troy.
- It is a destructive program that looks as a genuine application. Trojans also open a backdoor entry to your computer which gives malicious users/programs access to your system.
- Emotet – considered as one of the most destructive and dangerous Trojans



Software Programming

- Software programming is the act of writing computer code that enables computer software to function. The computer technology field often has overlapping terminology that can be confusing to discern.

Ransomware:

A virus which highly encrypts files/folders and demands money/BTC to retrieve it

E.g. WannaCry, Cerber ...etc.

Some of the famous programming languages are:

- C
- C#
- C++
- Java
- Python
- HTML
- CSS
- PHP
- JavaScript
- Swift
- R etc.

Classification of Programming Languages

- Machine Language (low level language)
- Assembly Language
- High Level Language

Machine Language

- Machine language is the lowest form of computer language. Programs were only written in binary based machine level language in the first generation computers. The computer understands this language only at its lowest level.
- The set of instructions in a machine level language can be divided into four categories:
  1. Arithmetic- add, subtract, multiply and divide
  2. Controlled- load, store, jump instructions
  3. Input/output- Read and write
  4. Direct use- Halt, start and end
- Example: Binary language (0's and 1's)

Assembly Language

- Assembly language permits the use of symbols or mnemonics, which are two or three letter abbreviations, for the function to be performed by the instruction.
- These are then translated by using a symbolic equivalence table.

Advantages of Assembly Languages:

1. They save time and reduce detail as compared to machine language.
2. Lesser number of errors are made(encountered), and also errors are easier to detect.
3. Assembly programs are easier to modify than machine language programs.

High Level Language

- High level language is a human readable language. A high-level language is any programming language that enables development of a program in a much more user-friendly programming context and is generally independent of the computer's hardware architecture.

Language Translator Programs

- These are programs that translate source code written in other languages into a machine language instructions code, which the computer can interpret and execute.
  - Assembler
  - Compiler
  - Interpreter

Assembler

- Computer understands machine language (0's and 1's). Therefore, the assembly language software translates the specified operation code into its machine language equivalent before the program can be executed.

- Assembly language is converted into machine language using "Assembler".

- Assemblers: An assembler translates the symbolic instruction code of programs written in assembly language into machine code .

Compiler

- A compiler is a special program that translates a programming language's source code into machine code or machine understandable code. Or a compiler is used for converting high level language to a low level language.

- Source code → Compiler(compiler compiles code) → Machine understandable code

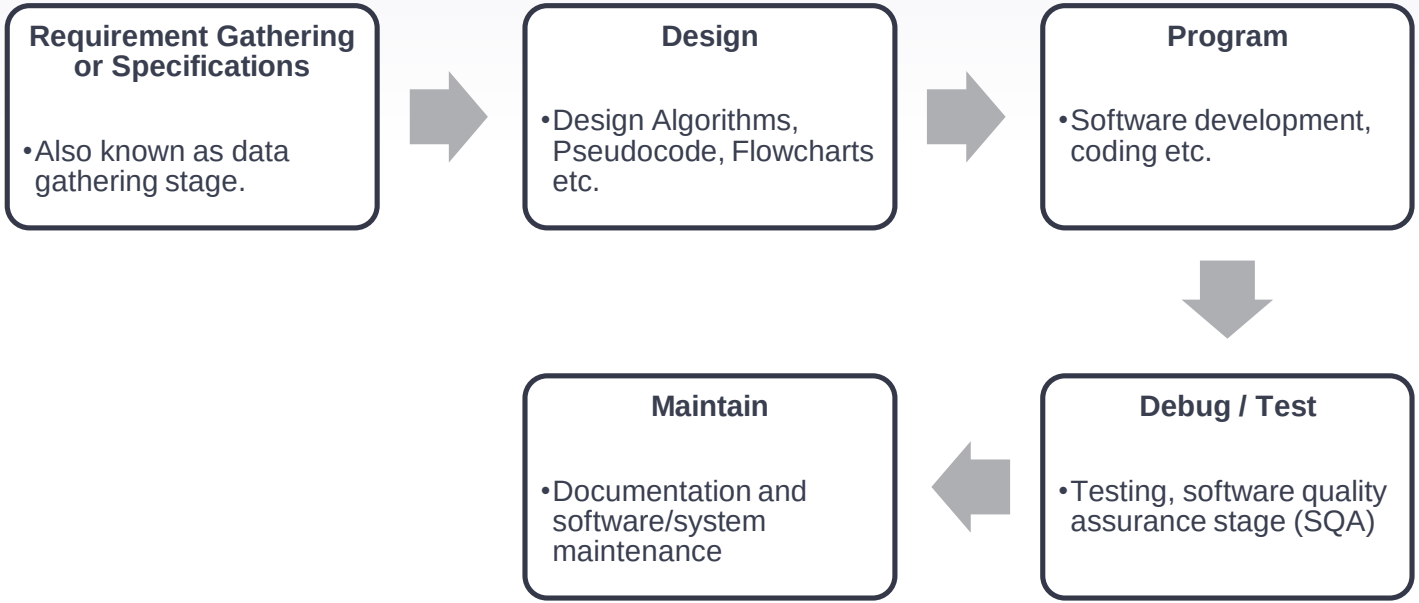
- Compilers: A compiler is a program which produces a machine level program from the specifications of a high level language, by generating one or more than one machine instruction for each high level instruction, i.e. it translates the higher level program into machine code.

Interpreter

- Interpreter: An interpreter translates and executes each program statement, one at a time, instead of producing a complete machine language program, like assemblers and compilers do.
- With an interpreter, the source program is not assembled into an object program.
- The results are computed immediately after an instruction has been translated.
- This process allows very efficient use of computer and programmer time during the debugging of the application.

Systems / Software Development Lifecycle

Programming is a 5 step procedure.



Data Types and Representation

Data

- Refers to the symbols that represent people, events, things, and ideas

- It can be a name, a number, the colors in a photograph, or the notes in a musical composition

Data Types

A data type, in programming, is a classification that specifies which type of value a variable has and what type of mathematical, relational or logical operations can be applied to it without causing an error. A string, for example, is a data type that is used to classify text and an integer is a data type used to classify whole numbers.

Data Type	Used for	Example
String	Alphanumeric characters	hello world, Alice etc.
Integer	Whole numbers	7, 12, 999
Float (floating point)	Number with a decimal point	3.15, 9.06, 00.13
Character	Encoding text numerically	a, b, x etc.
Boolean	Representing logical values	TRUE, FALSE

Data Representation

- Refers to the form in which data is stored, processed, and transmitted

- Devices such as Computers, Smartphones, and iPods store data in digital formats that can be handled by electronic circuitry
- Computers run on electricity – which can be either on or off

- The two-state situation allows computers to use the **binary system** to represent data and programs

Binary System

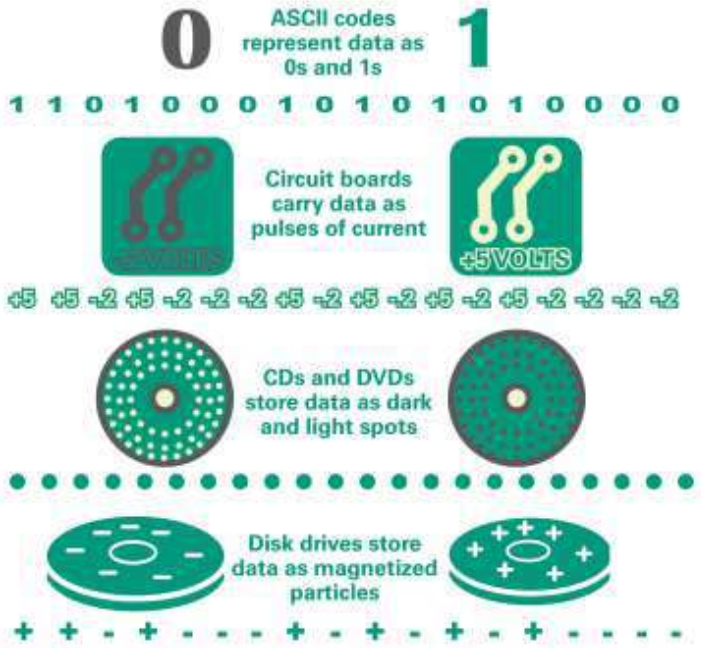
- All data and program instructions that go into the computer are represented in terms of binary numbers

- Binary system has only two digits: **0 and 1**
- Example:
  - When key “G” is pressed on the computer keyboard, the character is automatically converted into the series of electronic impulses that the computer can recognize

Digitization

- The process of converting manual data, such as text, numbers, photo, or music into digital data so that it can be used by electronic devices like computers, smartphones, etc.

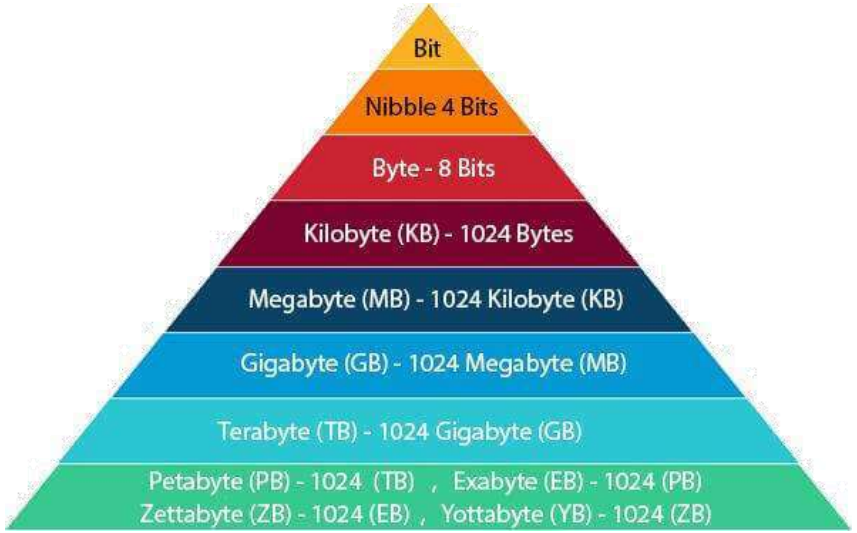
Data Representation



Measuring Capacity

- How many representations of 0s and 1s can be held in a computer or a storage device such as a hard disk?

- Capacity is denoted by **bits** and **bytes** and multiples thereof—kilobytes, megabytes, gigabytes, and so on



Binary Coding Schemes

Binary Coding Schemes

- Letters, numbers, and special characters are represented within a computer system by means of binary coding schemes

- These schemes are different arrangement of **off/on** or **0s and 1s** in such a way that they represent characters, digits, or other values

ASCII

- Stands for **A**merican **S**tandard **C**ode for **I**nformation **I**nterchange
- Pronounced as “ask-ee”
- It is the binary code most widely used on microcomputers in English and Western European languages

Extended ASCII

- ASCII was originally developed for basic computers and uses a 7-bit code
- As more computers began to work with 8-bit groups of data, ASCII was written as 8 bits (Extended ASCII)
- Using eight bits instead of seven bits allows Extended ASCII to provide codes for 256 characters (2^8), where 1 bit is reserved and 255 available.
- Includes such characters as math symbols and Greek letters
- ASCII's 256 characters, however, are not enough to handle such languages as Chinese and Japanese, with their thousands of characters

Character	ASCII	Character	ASCII
A	0100 0001	N	0100 1110
B	0100 0010	O	0100 1111
C	0100 0011	P	0101 0000
D	0100 0100	Q	0101 0001
E	0100 0101	R	0101 0010
F	0100 0110	S	0101 0011
G	0100 0111	T	0101 0100
H	0100 1000	U	0101 0101
I	0100 1001	V	0101 0110
J	0100 1010	W	0101 0111
K	0100 1011	X	0101 1000
L	0100 1100	Y	0101 1001
M	0100 1101	Z	0101 1010
0	0011 0000	5	0011 0101
1	0011 0001	6	0011 0110
2	0011 0010	7	0011 0111
3	0011 0011	8	0011 1000
4	0011 0100	9	0011 1001
!	0010 0001	;	0011 1011

Unicode

- It was developed in the early 1990s
- Unicode uses 2 bytes for each character with default encoding scheme of 16-bits, hence it can handle 65,536 character combinations (2^16).
- Hence it allows almost all the written languages of the world to be represented using a single character set

Other Coding Schemes

- **UTF – 8** (Unicode Transformation Format – 8 bit)

- **EBCDIC** – Extended Binary Coded Decimal Interchange Code)
  - Used with IBM or IBM compatible mainframe computers

Text Document

- Plain, unformatted text is sometimes called ASCII text and is stored in a text file with a name ending in **.txt**.
- In Windows, these files are labeled as "Text Document" while on Apple devices these files are labeled "**Plain Text**."
- ASCII text files contain no formatting
- To create documents with styles and formats, formatting codes have to be embedded in the text

Formatted Text Document

- Microsoft Word produces formatted text and creates documents in **DOCX** format
- Apple Pages produces documents in **PAGES** format
- Adobe Acrobat produces documents in **PDF** format
- HTML markup language used for Web pages produces documents in **HTML** format

Introduction to Number Systems

Non-Positional Number System

- A non-positional number system uses a limited number of symbols in which each symbol has a value.
- However the position a symbol occupies in the number normally bears no relation to its value.
- The value of each symbol is fixed.

Non-Positional Number System

- Roman number system is an example of a non-positional number system.
- This number system has a set of symbols.
- S={I, V, X, L, C, D, M}.
- Values of symbols in the Roman number system.
- **Symbol** I V X L C D M
- **Value** 1 5 10 50 100 500 1000

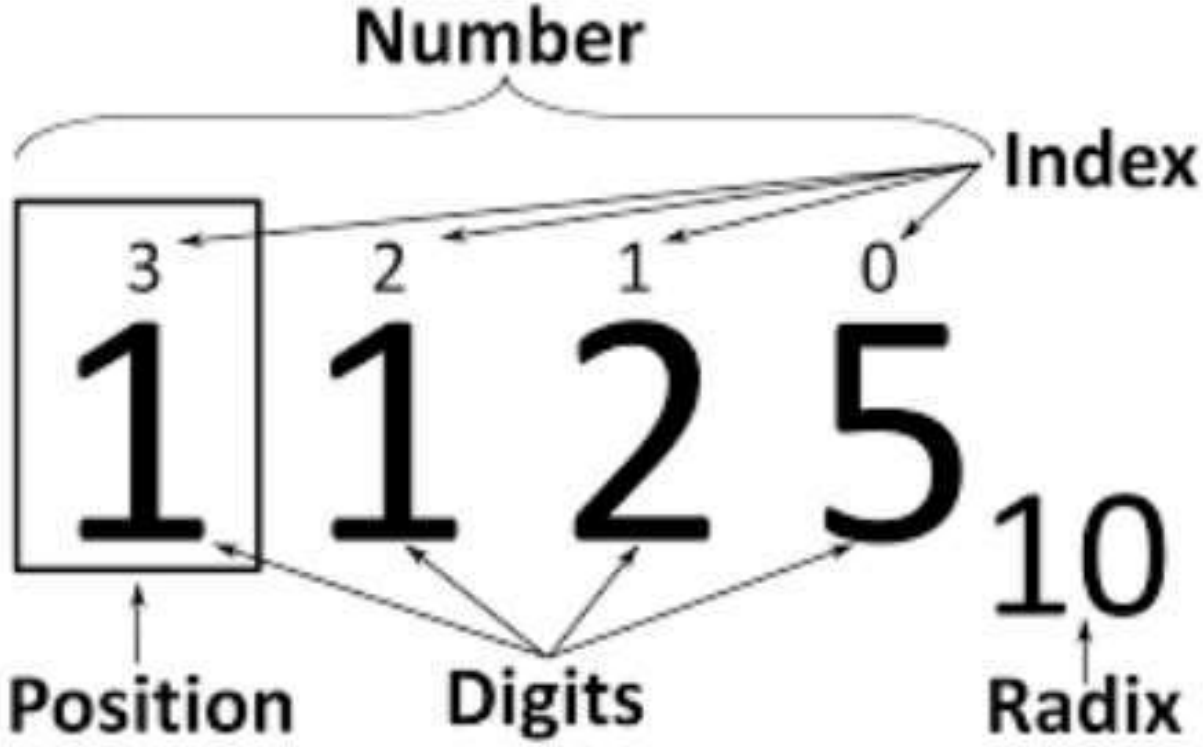
Positional Number System

- A positional (numeral) system is a system for representation of numbers by an ordered set of numerals symbols (called digits) in which the value of a numeral symbol depends on its position.
- For each position a unique symbol or a limited set of symbols is used.

Positional Number System

- Each symbol represents different value depending on the position they occupy in a number.
- The value of a symbol is given by the weight of its position expressed in the bases (or radices) of the system.

Positional Number System – Terminologies



Decimal Number System

- The decimal number system is an example of positional number system because the value of the number depends on the position of the digits.
- For example, the number 12345 has a very different value than the number 54321, although the same digits are used in both numbers.

Decimal Number System

- Ten Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 – Base 10
- Example: 1045_{10}

$$10^{n-1} \cdots 10^4 10^3 10^2 10^1 10^0$$
$$d_{n-1} \cdots d_4\, d_3\, d_2\, d_1\, d_0$$

- Digit d_0 is the least significant digit (LSD)
- Digit d_{n-1} is the most significant digit (MSD)

Binary Number System

- Two Digits: 0, 1 – Base 2
- Example: 1010110_2

$$2^{n-1} \cdots 2^4 2^3 2^2 2^1 2^0$$
$$b_{n-1} \cdots b_4 b_3 b_2 b_1 b_0$$

- Digit b_0 is the least significant bit (LSB)
- Digit b_{n-1} is the most significant bit (MSB)

Base-N Number System

- N Digits: 0, 1, 2, 3, 4, 5, …, N-1 – Base N
- Example: 1045_N

$$N^{n-1} \cdots N^4 N^3 N^2 N^1 N^0$$
$$d_{n-1} \cdots d_4 d_3 d_2 d_1 d_0$$

- Digit d_0 is the least significant digit (LSD)
- Digit d_{n-1} is the most significant digit (MSD)

Number Systems

Four number system

- **Decimal (10)**
- **Binary (2)**
- **Octal (8)**
- **Hexadecimal (16)**
- **.....**

Binary numbers?

- Computers work only on two states
  - On
  - Off
- Basic memory elements hold only two states
  - Zero / One
- Thus a number system with two elements {0,1}
- A binary digit – bit !

Decimal numbers

$$1439 = 1 \times 10^3 + 4 \times 10^2 + 3 \times 10^1 + 9 \times 10^0$$

Thousands Hundreds Tens Ones

- Radix = 10

Binary → Decimal

$$1101 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

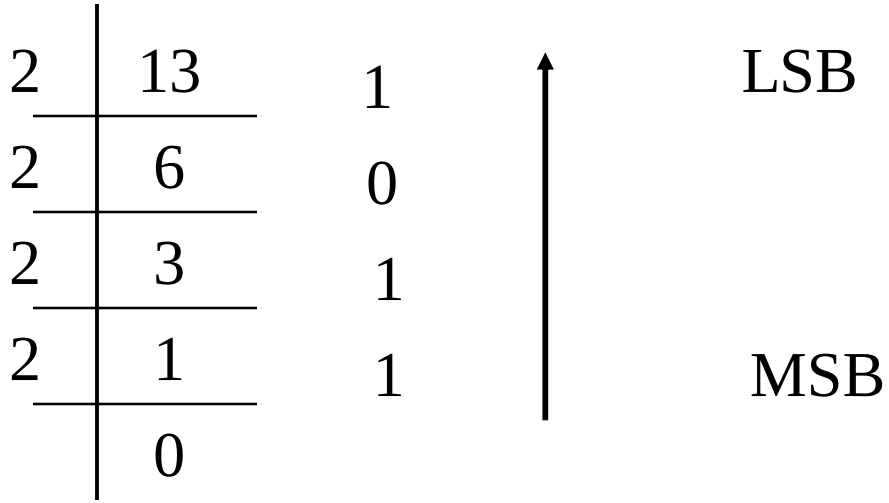
$$= 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1$$

$$= 8 + 4 + 0 + 1$$

$$(1101)_2 = (13)_{10}$$

1, 2, 4, 8, 16, 32, 64, 128, 256, 512, ….

Decimal → Binary



$$(13)_{10} = (1101)_2$$

Octal → Decimal

$137 = 1 \times 8^2 + 3 \times 8^1 + 7 \times 8^0$

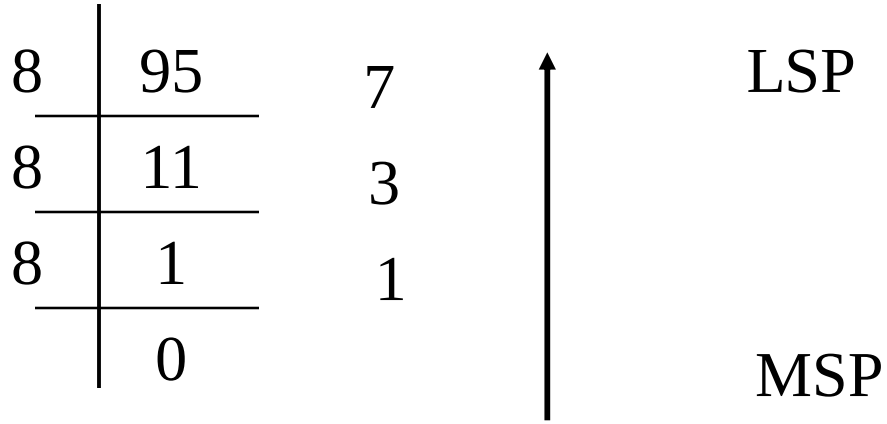
$= 1 \times 64 + 3 \times 8 + 7 \times 1$

$= 64 + 24 + 7$

$(137)_8 = (95)_{10}$

- Digits used in Octal number system – 0 to 7 so 108 will not be part of it as 8 is out of range.

Decimal → Octal



$$(95)_{10} = (137)_{8}$$

Hex → Decimal

$$BAD = 11 \times 16^2 + 10 \times 16^1 + 13 \times 16^0$$

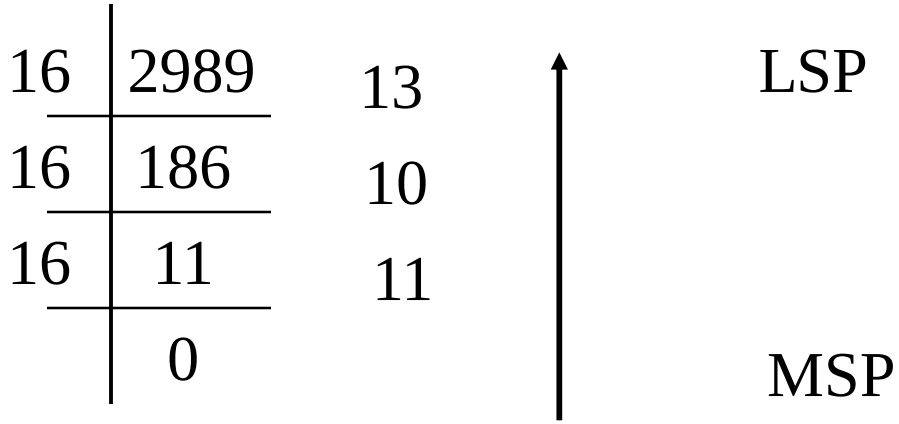
$$= 11 \times 256 + 10 \times 16 + 13 \times 1$$

$$= 2816 + 160 + 13$$

$$(BAD)_{16} = (2989)_{10}$$

A = 10, B = 11, C = 12, D = 13, E = 14, F = 15

Decimal → Hex



$$(2989)_{10} = (BAD)_{16}$$

Why octal or hex?

- Ease of use and conversion
- Three bits make one octal digit

  111 010 110 101

  7 2 6 5 => 7265 in octal

- Four bits make one hexadecimal digit

  1110 1011 0101 → 4 bits = nibble

  E B 5 => EB5 in hex

$0_{hex} = 0_{dec} = 0_{oct}$	0	0	0	0
$1_{hex} = 1_{dec} = 1_{oct}$	0	0	0	1
$2_{hex} = 2_{dec} = 2_{oct}$	0	0	1	0
$3_{hex} = 3_{dec} = 3_{oct}$	0	0	1	1
$4_{hex} = 4_{dec} = 4_{oct}$	0	1	0	0
$5_{hex} = 5_{dec} = 5_{oct}$	0	1	0	1
$6_{hex} = 6_{dec} = 6_{oct}$	0	1	1	0
$7_{hex} = 7_{dec} = 7_{oct}$	0	1	1	1
$8_{hex} = 8_{dec} = 10_{oct}$	1	0	0	0
$9_{hex} = 9_{dec} = 11_{oct}$	1	0	0	1
$A_{hex} = 10_{dec} = 12_{oct}$	1	0	1	0
$B_{hex} = 11_{dec} = 13_{oct}$	1	0	1	1
$C_{hex} = 12_{dec} = 14_{oct}$	1	1	0	0
$D_{hex} = 13_{dec} = 15_{oct}$	1	1	0	1
$E_{hex} = 14_{dec} = 16_{oct}$	1	1	1	0
$F_{hex} = 15_{dec} = 17_{oct}$	1	1	1	1

Negative numbers

Three representations

- Signed magnitude
- 1’s complement
- 2’s complement

Sign magnitude

- Make MSB represent sign
- Positive = 0
- Negative = 1
- E.g. for a 3 bit set
  - “-2”

Sign	Bit	Bit
1	1	0
MSB		LSB

1’s complement

- MSB as in sign magnitude
- Complement all the other bits
- Given a positive number complement all bits to get negative equivalent
- E.g. for a 3 bit set
  - “-2”

Sign	Bit	Bit
1	0	1
0	1	0

2’s complement

- 1’s complement plus one
- E.g. for a 3 bit set
  - “-2”

Sign	Bit	Bit
1	1	0
0	1	0

Decimal number	Signed magnitude	2's complement	1's complement
3	011	011	011
2	010	010	010
1	001	001	001
0	000	000	000
-0	100	---	111
-1	101	111	110
-2	110	110	101
-3	111	101	100
-4		100	

No matter which scheme is used we get an even set of numbers but we need one less (odd: as we have a unique zero)

Binary Arithmetic

- Addition / subtraction
- Unsigned
- Signed
  - Using negative numbers

Unsigned: Addition

Like normal decimal addition

A \ B	+	0	1
	0	0	1
	1	1	10

0101 (5)

\+ 1001 (9)

1110 (14)

The carry out of the MSB is neglected

Unsigned: Subtraction

Like normal decimal subtraction

A \ B	-	0	1
0		0	11
1		1	0

1001 (9)

- 0101 (5)

0100 (4)

A borrow (shown in red) from the MSB implies a negative

Signed arithmetic

- Use a negative number representation scheme
- Reduces subtraction to addition

2’s complement

Negative numbers in 2’s complement

$$\begin{array}{r} 001 \;\; (\;1)_{10} \\ 101 \;\; (-3)_{10} \\ \hline 110 \;\; (-2)_{10} \end{array}$$

The carry out of the MSB is lost

Overflow / Underflow

- Maximum value N bits can hold : $2^n - 1$
- When addition result is bigger than the biggest number of bits can hold.
  - Overflow
- When addition result is smaller than the smallest number the bits can hold.
  - Underflow
- Addition of a positive and a negative number cannot give an overflow or underflow.

Overflow example

$$
\begin{array}{r}
011\ (+3)_{10} \\
011\ (+3)_{10} \\
\hline
110\ \ (+6)_{10} \qquad ????
\end{array}
$$

1’s complement computer interprets it as –1 !!

$(+6)_{10} = (0110)_2$ requires four bits !

Underflow examples

Two's complement addition

$$\begin{array}{lll} & 101 & (-3)_{10} \\ & 101 & (-3)_{10} \\ \hline \text{Carry} \quad 1 & 010 & (-6)_{10} \end{array} \qquad ????$$

The computer sees it as +2.

$(-6)_{10} = (1010)_2$ again requires four bits !

Sample Questions Number Systems

Q: Solve the following number systems

Binary to Decimal	***Octal to Decimal***	***Hexadecimal to Decimal***
1. 11010	1. 25	1. 1F
2. 10101011	2. 377	2. A5
3. 10011001	3. 5432	3. 3C9
4. 1110111	4. 777	4. 7D4
5. 11111	5. 234	5. 2B
6. 10111101	6. 4567	6. F0E
7. 10001011	7. 765	7. 9A
8. 110001	8. 644	8. B3C
9. 10001111	9. 3210	9. 1A0
10. 10010	10. 1001	10. 4D9

Q: Convert the following Decimal Numbers.

1. Convert 200 to octal.
2. Convert 4095 to hexadecimal.
3. Convert 512 to octal.
4. Convert 1023 to hexadecimal.
5. Convert 150 to binary.

Q: Convert the following:

1. Convert the decimal number 42 to binary.
2. Convert the octal number 36 to decimal.
3. Convert the hexadecimal number 1C8 to binary.
4. Convert the hexadecimal number A5 to decimal.
5. Convert the decimal number 156 to octal.
6. Convert the octal number 67 to decimal.
7. Convert the hexadecimal number F3 to binary.
8. Convert the octal number 245 to binary.
9. Determine the octal equivalent of the decimal number 512.
10. Determine the binary equivalent of the hexadecimal number 1F8.
11. Express the binary number 1101101 in octal.
12. Express the decimal number 73 in hexadecimal.
13. Express the binary number 1011010 in octal.
14. Express the binary number 101010 in hexadecimal.
15. Express the binary number 1110011 in octal.
16. Express the octal number 345 in decimal.
17. Find the decimal representation of the hexadecimal number 3D.
18. Find the hexadecimal representation of the decimal number 255.
19. Find the decimal representation of the hexadecimal number 2A.
20. Find the hexadecimal representation of the binary number 11011011.

Introduction to Data Structures

Data Structures

- Data structure is a representation of data and the operations allowed on that data.
- A data structure is a way to **organize** and **store** data in order to facilitate the access and modifications.
- In easy words it is a way in which data is stored on a computer.
- Data structure is the implementation that we provide or specify like set of rules etc. that defines how the data will be accessed, modified, or stored etc.

Data Structures

- Any data structure is designed to organize data to suit a specific purpose so that it can be accessed and worked with in appropriate ways

- In computer programming, a data structure may be selected or designed to store data for the purpose of working on it with various algorithms

Real World Example

Dictionary is an example of how data structure work in real life.

There are more than a thousand words in a dictionary. Suppose you want to search the definition of the word “Work”. You know that first you will look in the “W” section then in the “Wo” so on to find the word “Work”. This process sounds easy because the dictionary is arranged in this particular order. It would be impossible to search for a word in a dictionary without any order. This is exactly how data structures work.

Data structure organizes, and sorts your data as per pre-defined rule or order.

Data Structure Classification

Generally classified into:

1. Primitive Data Structures, and
2. Non – Primitive Data Structures

Primitive Data Structures

- Fundamental data types which are supported by a programming language
- Basic data types such as integer, real, character and Boolean are known as Primitive Data Structures
- These data types consists of characters/single values that cannot be divided and hence they also called simple data types

Non-Primitive Data Structures

- Non-primitive data structures are those data structures which are created using primitive data structures and are not predefined.
- Examples of non-primitive data structures is the processing of complex numbers
- Based on the structure and arrangement of data, further classified into
    1. Linear Data Structure, and
    2. Non – Linear Data Structure

Types of Data Structures

There are two types of data structures:

1. Linear (data is stored in a sequence)
2. Non Linear (data is not stored in a sequence)

Linear Data Structures

1. Stack
2. Queue
3. Linked List

Non-Linear Data Structures

1. Tree
2. Graphs

Linear Data Structure

- A data structure is said to be linear if its elements form a sequence or a linear list.
- There are basically two ways of representing such linear structure in memory.

1. One way is to have the linear relationships between the elements represented by means of sequential memory location.
2. The other way is to have the linear relationship between the elements represented by means of pointers or links. These linear structures are called linked lists.

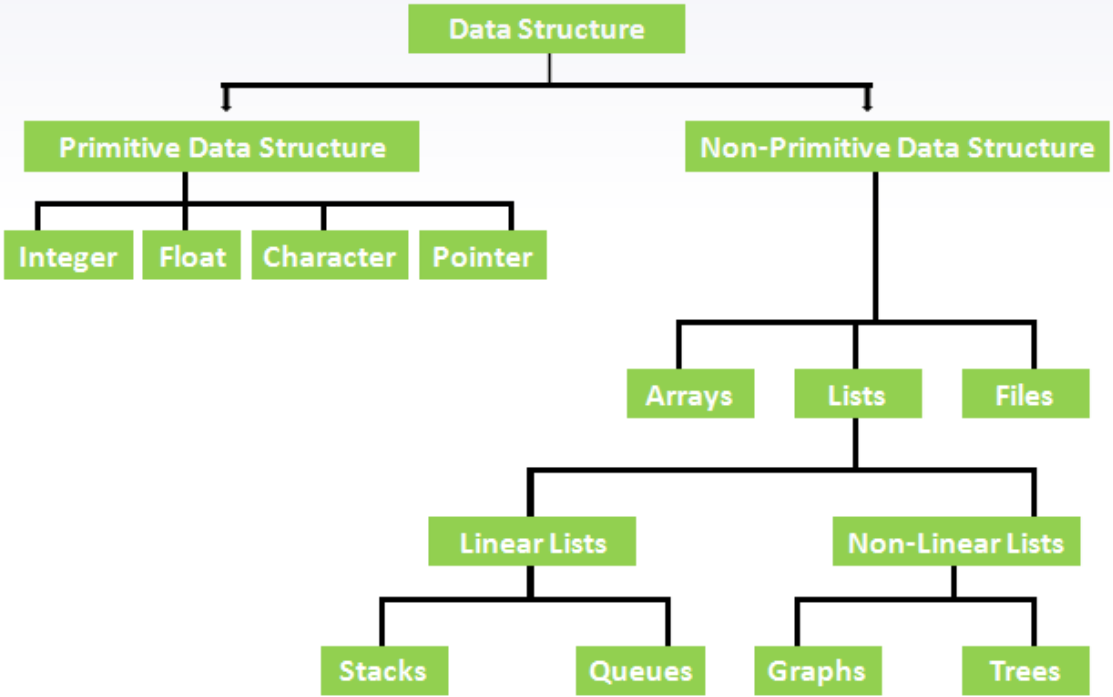
Linear Data Structure

The common examples of linear data structure are **Arrays, Linked Lists , Queues, Stacks**

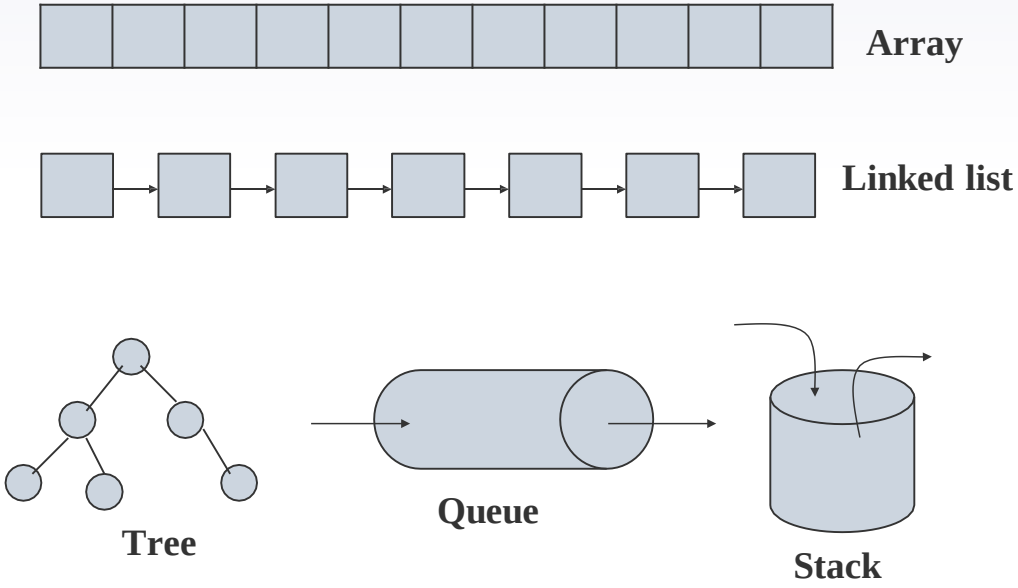
Non Linear Data Structure

- A data structure is said to be non-linear if the data are not arranged in sequence or a linear
- This structure is mainly used to represent data containing a hierarchical relationship between elements.
- Trees and Graphs are the examples of non-linear data structures

Data Structure Classification



Graphical Representation



Selection of Data Structure

The choice of particular data structure depends on two consideration

1. The structure should be simple enough that one can effectively process the data when necessary
2. It must be rich enough in structure to represent the relationship between data elements

Types of Data Structure

- Linear: In Linear data structure, values are arrange in linear fashion
  - **Array**: Fixed-size
  - **Linked-list**: Variable-size
  - **Stack**: Add element in front and remove from front
  - **Queue**: Add element at end/rear and remove from front

Types of Data Structure

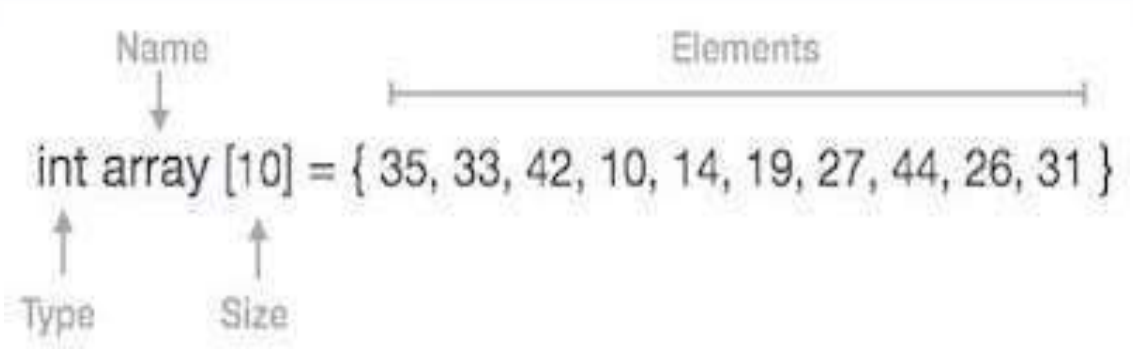
- Non-Linear: The data values in this structure are not arranged in order
  - **Tree**: Data is organized in branches
  - **Graph**: A more general branching structure, with less strict connection conditions than for a tree

Array

- Array is a structure/container which can hold a fix number of items and these items should be of the same data-type
- Most of the data structures make use of arrays to implement their algorithms
- Following are the important terms to understand the concept of Array
  - **Element** - Each item stored in an array is called an element.
  - **Index** - Each location of an element in an array has a numerical index, which is used to identify the element.

Representation of Array

- Arrays can be declared in various ways in different languages.
- For illustration, let's take C array declaration



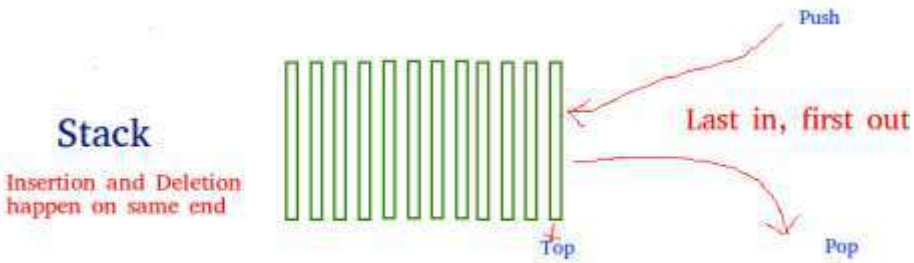
Stack

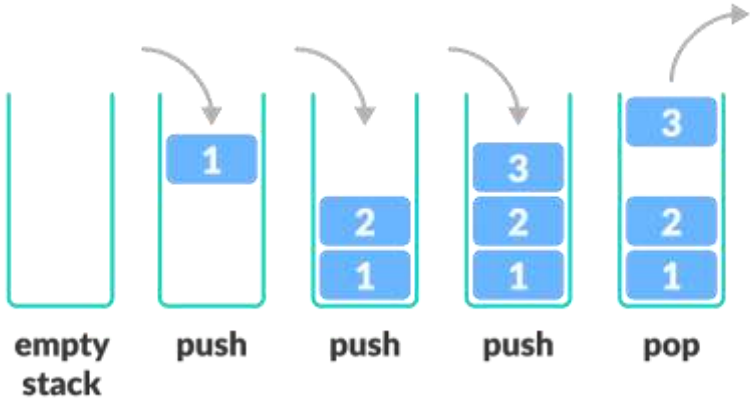
- It is a linear data structure.
- It follows a particular order in which the operations are performed.
- The order may be LIFO(Last In First Out).
- Behaves like a real world stack. Example: Stack of books.

- Consider an example of books stacked over one another. The book which is at the top is the first one to be removed, i.e. the book which has been placed at the bottommost position remains in the stack for the longest period of time. So, it can be simply seen to follow LIFO(Last In First Out) order.

Working of a Stack

- In programming terms, putting an item on top of the stack is called **push** and removing an item is called **pop**.
  - ✓ **Push**: Add an element to the top of a stack
  - ✓ **Pop**: Remove an element from the top of a stack

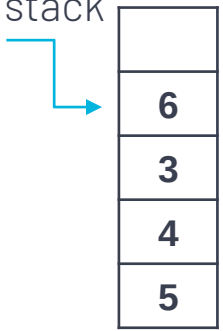




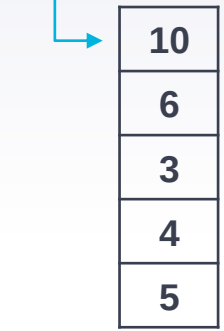
Example

- Suppose the following stack

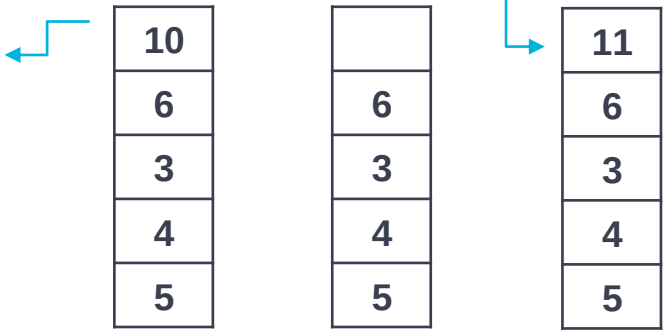
- Push 6 in stack



- Push 10 in stack



- Stack is full. Pop a number and add 11 in stack

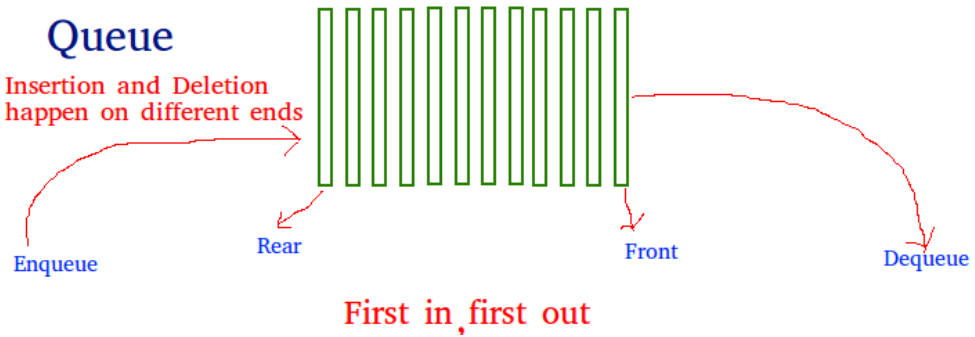


Queue

- It is a linear data structure.
- It follows a particular order in which the operations are performed i.e. FIFO (First In First Out).
- Behaves like a real world Queue.
- It is similar to the ticket queue outside a cinema hall, where the first person entering the queue is the first person who gets the ticket.

Working of a Queue

- Queue follows the First In First Out (FIFO) rule - the item that goes in first is the item that comes out first. In programming terms, putting items in the queue is called **enqueue**, and removing items from the queue is called **dequeue**.



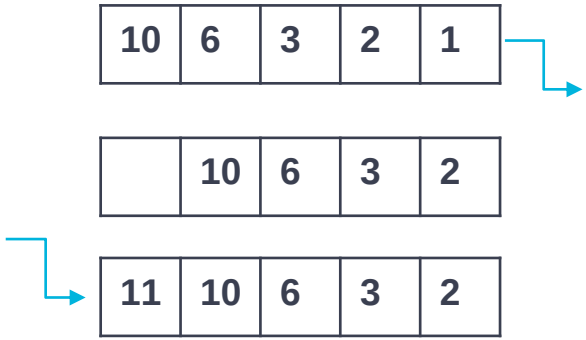
Example

- Suppose the following queue

- Add 6 in queue (enqueue)

- Add 10 in queue (enqueue)

- Queue is full. Remove a number (dequeue) and add 11 in queue.



Linked List

- It is a linear data structure.
- Includes a series of connected nodes. Here, each node stores the data and the address of the next node as a null-pointer. For example:

- Real life example: undo button

Linked List

- A Flexible structure, because can grow and shrink on demand
- Elements can be, Accessed, Inserted, and Deleted, at any position
- Only drawback is that direct access to a specific memory location, as done with array indices, is not possible without traversing the list sequentially

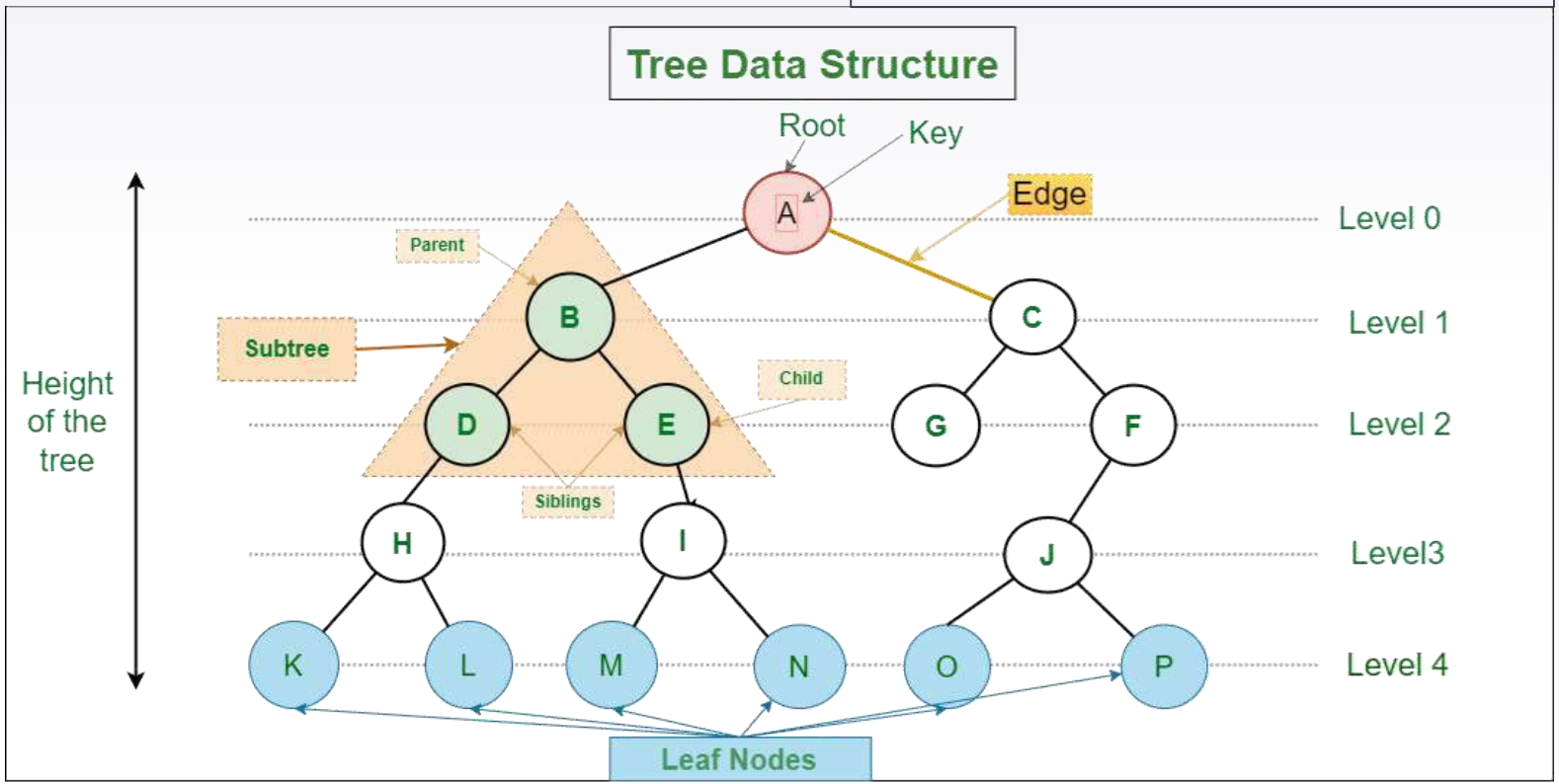
Tree

- A Tree is a collection of elements called nodes

- One of the node is distinguished as a root, along with a relation (“parenthood”) that places a hierarchical structure on the nodes

Tree

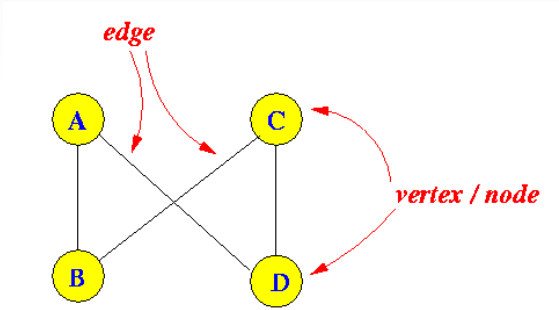
Node with no child further → Leaf Node

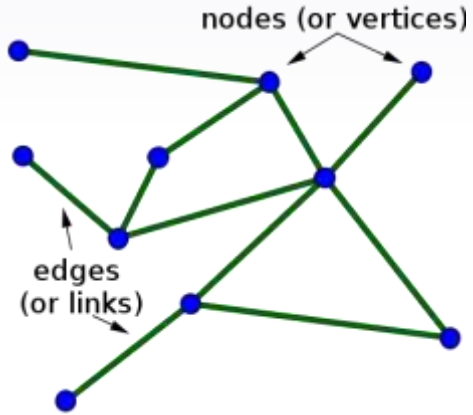


Graph

- A Non-Linear data structure consisting of two things
- Nodes / Vertices – set of elements
- Edges / Links – identified by a pair of nodes

Graph – Nodes and Edges





Types of Graph

In an undirected graph, edges have no direction. They simply represent a connection between two vertices without indicating any flow or one-way relationship.

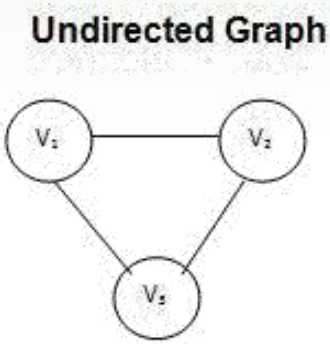


Figure 1: An Undirected Graph

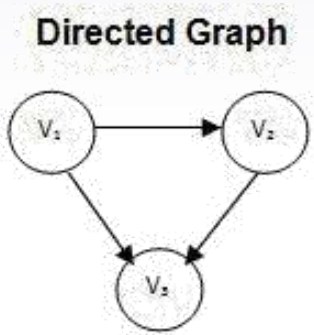
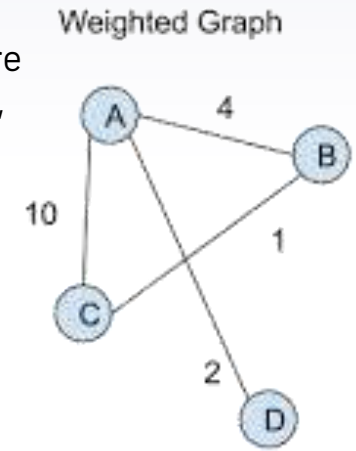


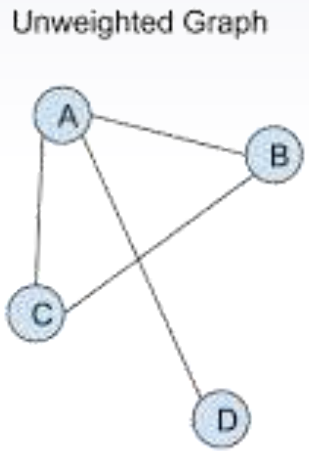
Figure 2: A Directed Graph

In a directed graph, edges have a direction. Each edge is represented by an ordered pair of vertices, indicating a one-way relationship from one vertex to another.

Types of Graph

- In a weighted graph, each edge is assigned a numerical value or weight that represents a certain measure such as distance, cost, time, or any other relevant quantity.
- Weighted graphs are commonly used in applications where the strength or cost of the connections plays a crucial role, such as in network optimization or routing problems.

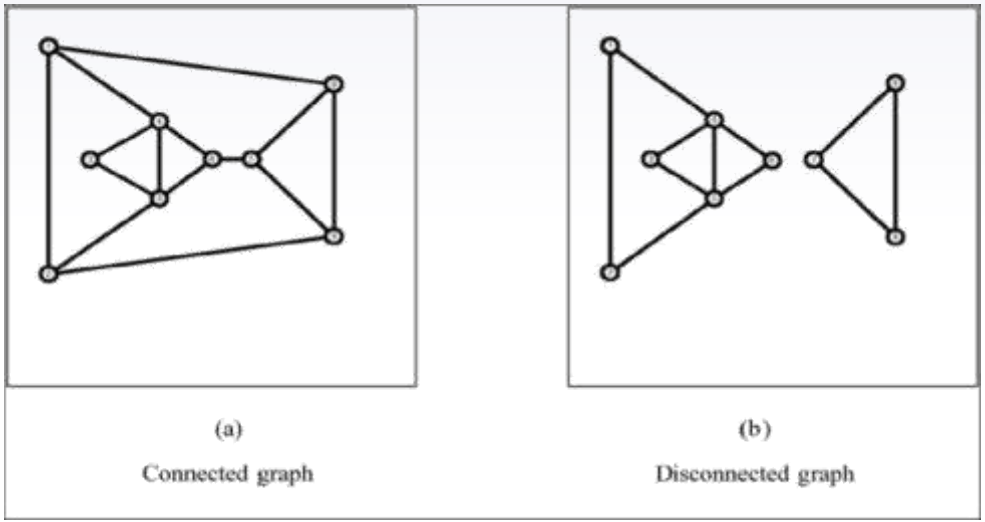




- In an unweighted graph, all edges are considered to have the same value or weight, typically representing a simple connection between vertices.
- Unweighted graphs are often used to model relationships where the strength or cost of the connection between vertices is not relevant.

Types of Graph

- A connected graph is a graph in which there exists a path between every pair of vertices. In other words, every vertex in the graph is reachable from every other vertex through a sequence of edges.
- It is used to model scenarios where all entities or nodes are reachable or communicable with each other.

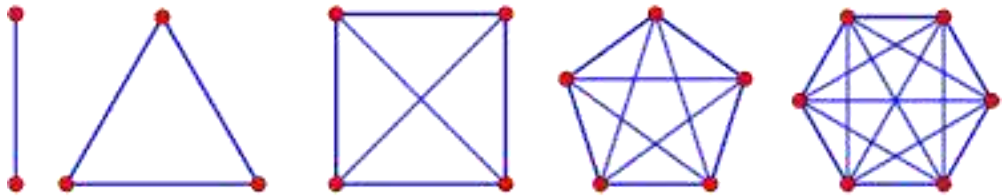


- A disconnected graph is a graph in which there are at least two vertices with no path connecting them. The graph consists of two or more separate connected components.
- It represent scenarios where certain entities or nodes are not reachable from others.

Types of Graph

A complete graph is a type of simple graph in which there is a unique edge connecting every pair of distinct vertices. In other words, in a complete graph, there is an edge between every pair of vertices. If a complete (undirected) graph has n vertices, it will have

(n * (n−1)) / 2 edges.



Complete Graphs

Graph and Tree

A connected acyclic **graph** is called a **tree**

In other words, a connected **graph** with a root node and no cycles(loops) is called a **tree**

Key Operations on Data Structures

Key Operations

- The data appearing in data structures are processed by means of certain operations

- The following four operations play a major role in this context

Traversing

- Accessing each record/node exactly once so that certain items in the record may be processed

- This accessing and processing is sometimes called “visiting” the record

Searching

- Finding the location of the desired node with a given key value, or

- Finding the locations of all such nodes which satisfy one or more conditions

Inserting / Deleting

- Adding a new node/record to the structure
- Removing a node/record from the structure

Introduction to Database

Background

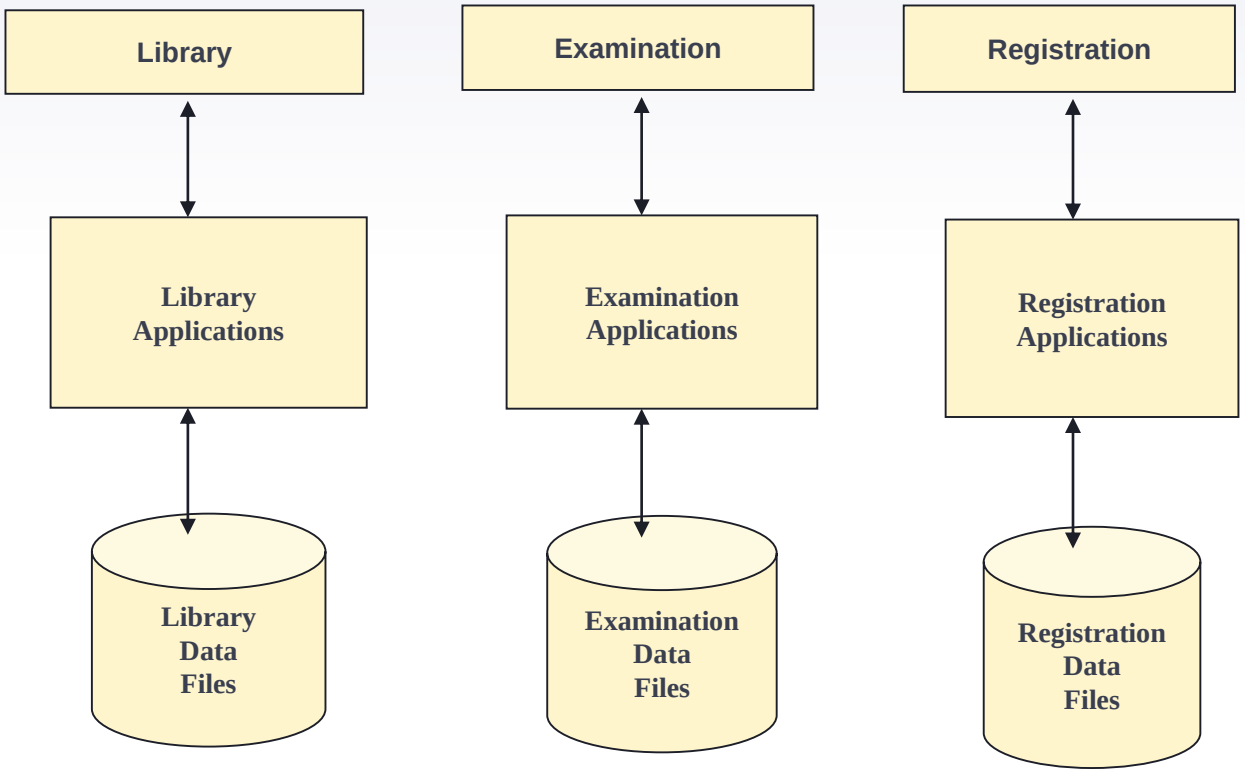
- Computer initially used for computational / engineering purposes
- Commercial applications introduced File Processing System

File Processing System

- A file processing system is a method of managing and organizing data within a computer system using files
- In a file processing system, data is stored in individual files, and programs are designed to read, write, update, and manipulate these files directly

- A collection of application programs that perform services for the end-users such as production of reports
- Each program defines and manages its own data

File Processing System



File Processing System

Library
Reg_Number
Name
Father Name
Books Issued
Fine

Examination
Reg_Number
Name
Address
Class
Semester
Grade

Registration
Reg_Number
Name
Father Name
Phone
Address
Class

Limitations

- **Separation and Isolation of Data**
- Each program maintains its own set of data
- Users of one program may be unaware of potentially useful data held by other programs
- **Duplication of data**
- Decentralized approach taken by each department
- Same data is held by different programs
- Wasted space and potentially different values and/or different formats storage for the same item

Limitations

- **Limited Data Sharing**
- No centralized control of data
- Programs are written in different languages, and so cannot easily access each other's files.
- **Program-Data Dependence**
- File structure is defined in the program code
- All programs maintain metadata for each file they use

Problems with Data Dependency

- Each application programmer must maintain their own data
- Each application program needs to include code for the metadata of each file
- Each application program must have its own processing routines for reading, inserting, updating and deleting data
- Lack of coordination and central control
- Non-standard file formats

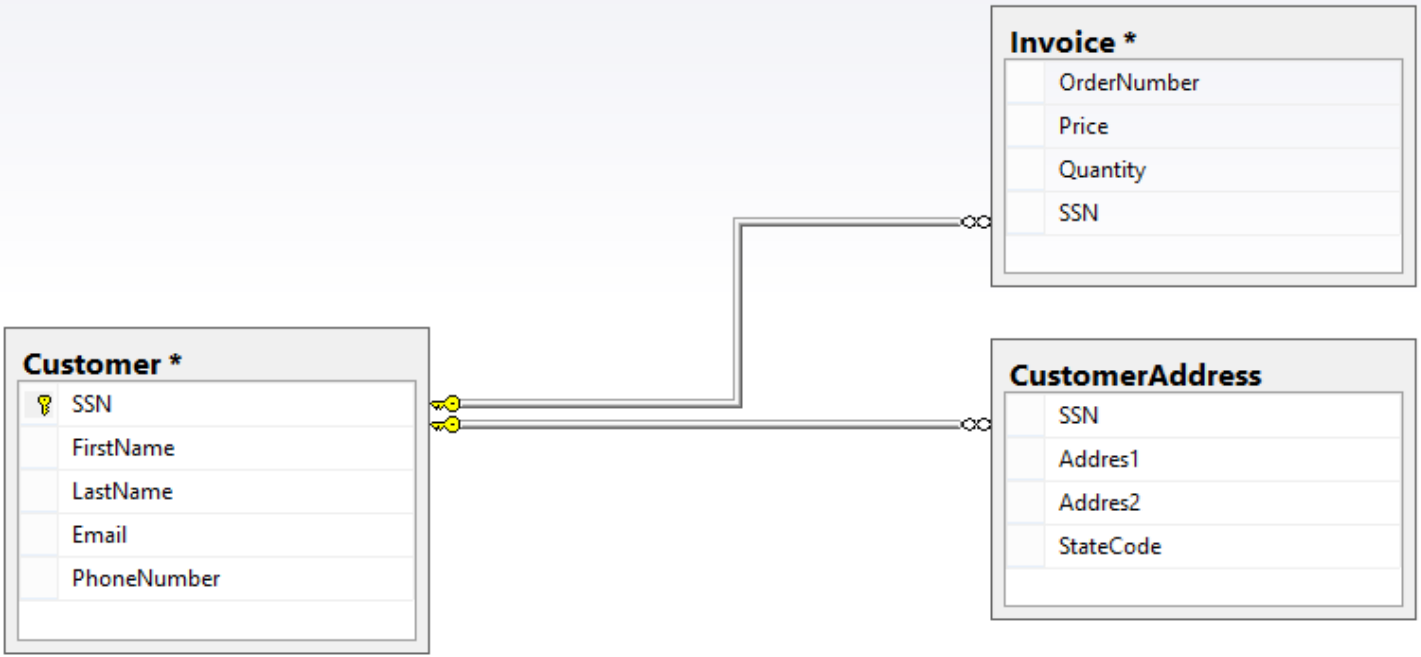
Problems with Data Redundancy

- Waste of space to have duplicate data
- Causes more maintenance headaches
- The biggest problem:
- When data changes in one file, could cause inconsistencies (Vulnerable to Inconsistency and inefficiency)
- Compromises data integrity (data reliability)

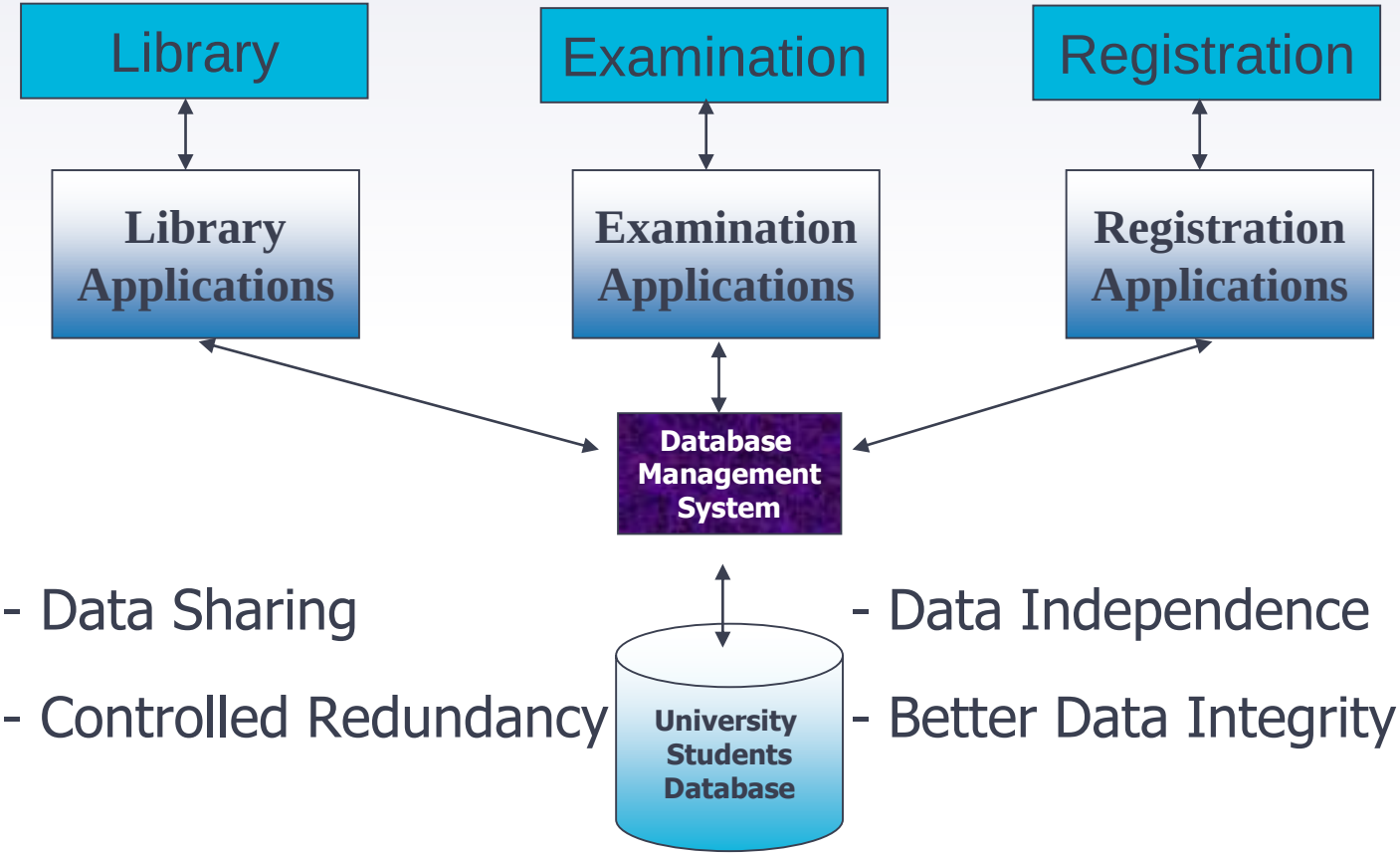
Solution – Database Approach

- Central repository of shared data
- Data is managed by a controlling agent
- Stored in a standardized, convenient form

Database


Invoice *
OrderNumber
Price
Quantity
SSN
Customer *
SSN
FirstName
LastName
Email
PhoneNumber
CustomerAddress
SSN
Addres1
Addres2
StateCode

Advantages of Database Approach



- Data Sharing
- Controlled Redundancy
- Data Independence
- Better Data Integrity

Database Management System – DBMS

- A software system that enables users to define, create, maintain, and control access to the database

Database

- Shared structured collection of **logically related** data, along with **description** of this data, designed to meet the information needs of an organization

- Metadata provides description of data to enable program data independence

SQL

- SQL stands for Structured Query Language. It is used for storing and managing data in a database.
- It enables a user to create, read, update and delete relational databases and tables.
- SQL allows users to query the database in a number of ways, using English-like statements.

What Can SQL do?

- SQL can execute queries against a database
- SQL can retrieve data from a database
- SQL can insert records in a database
- SQL can update records in a database
- SQL can delete records from a database
- SQL can create new databases
- SQL can create new tables in a database
- SQL can create stored procedures in a database
- SQL can create views in a database
- SQL can set permissions on tables, procedures, and views

SQL Commands

- SELECT - extracts data from a database
- UPDATE - updates data in a database
- DELETE - deletes data from a database
- INSERT INTO - inserts new data into a database
- CREATE DATABASE - creates a new database
- ALTER DATABASE - modifies a database
- CREATE TABLE - creates a new table
- ALTER TABLE - modifies a table
- DROP TABLE - deletes a table
- CREATE INDEX - creates an index (search key)
- DROP INDEX - deletes an index

SQL Queries

- Suppose we have a Customer Table.

CustomerID	CustomerName	Address	City
1	Ali	ABC Street	Lahore
2	Ahmed	XYZ Street	Karachi
3	Bisma	GHI Lane	Multan
4	Faraz	RTY Road	Islamabad

SQL Queries- Select

- Write a query to show all entries of the table

SELECT * FROM Customers;

Output:

CustomerID	CustomerName	Address	City
1	Ali	ABC Street	Lahore
2	Ahmed	XYZ Street	Karachi
3	Bisma	GHI Lane	Multan
4	Faraz	RTY Road	Islamabad

SQL Queries - Select

- Write a query to display customer name and city from the table

SELECT CustomerName, City FROM Customers;

Output:

CustomerName	City
Ali	Lahore
Ahmed	Karachi
Bisma	Multan
Faraz	Islamabad

SQL Queries - Select

- Write a query to display all customers from Multan city

SELECT * FROM Customers

WHERE City='Multan';

Output:

CustomerID	CustomerName	Address	City
3	Bisma	GHI Lane	Multan

SQL Queries - Insert

INSERT INTO Customers (CustomerName, Address, City)
VALUES ('Shehzad', 'lane345 street 6', 'Multan');

SQL Queries - Insert

INSERT INTO Customers (CustomerName, Address, City)
VALUES ('Shehzad', 'lane345 street 6', 'Multan'),
VALUES ('Ahsan', 'House no 45 street 9', 'Karachi');

SQL Queries - Delete

DELETE FROM table_name WHERE condition;

Example:

- DELETE FROM Customers WHERE CustomerName= 'Ahsan';
- DELETE FROM Customers; (deletes all rows)
- DROP TABLE Customers; (delete the table completely)

SQL Queries - Update

UPDATE *table_name*
SET *column1* = *value1*, *column2* = *value2*, ...
WHERE *condition*;

- ✓ Basic operations queries in database are known as:

  CRUD (Create, Read, Update, Delete)

Example:

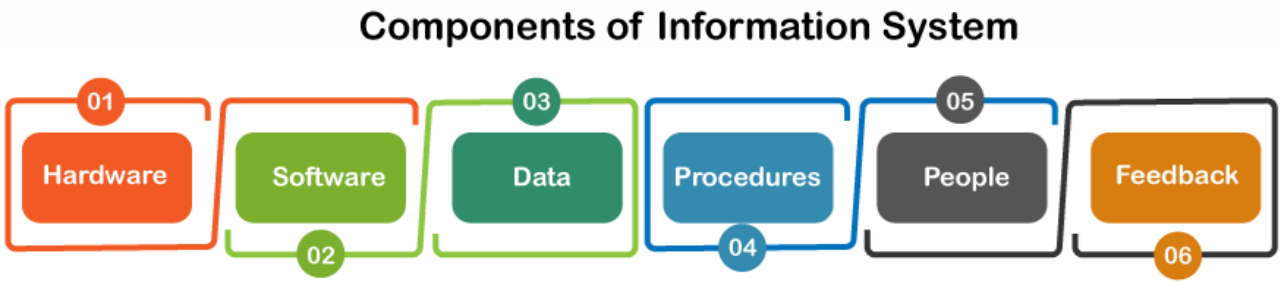
- UPDATE Customers
  SET CustomerName = Ahmed Ali', City= 'Islamabad'
  WHERE CustomerID = 2;

Information System

Information System – Definition

- The Information system can be defined as a collection of **software, hardware**, and **telecommunications network** that **people** develop and use to **gather, create, and distribute useful data**, mainly in organizational settings.

Information System Components



Information System Components

- **Hardware** – includes equipment and machinery and encompasses the computer and all of its supporting equipment

- **Software** – computer programs as well as the manuals which support them

Information System Components

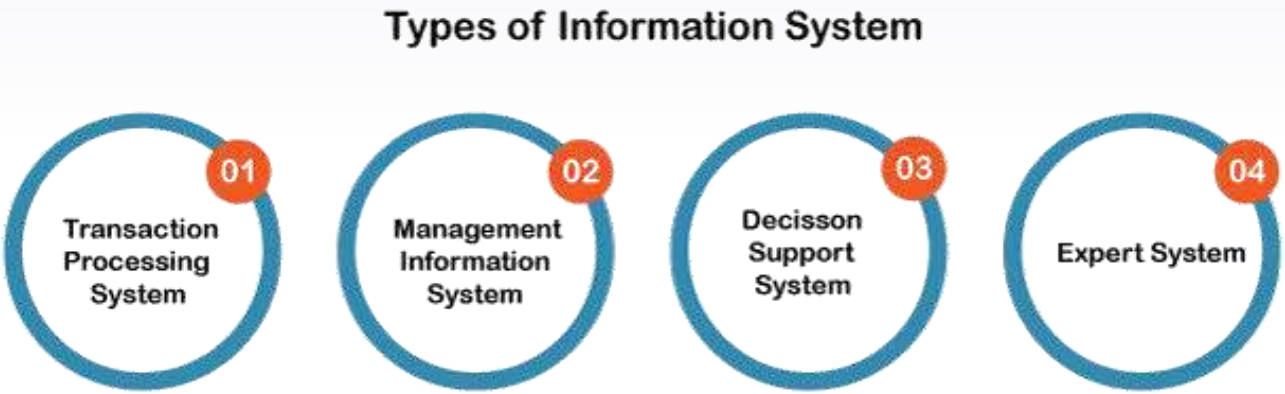
- **Data** – facts that systems use to generate valuable knowledge
- **Procedures** – rules which govern how an operation is performed in information system

Information System Components

- **People** – every system requires individuals if the system is to be beneficial. They have the greatest impact on the success or failure of information systems

- **Feedback** – determines that an information system can be offered with feedback

Types of Information Systems



Transaction Processing System

- Refers to an information system that processes data originating from business transactions
- Designed to process routine transactions efficiently and accurately
- Managers often use these systems to deal with such tasks as payroll, customer billing and payments to suppliers
- Examples are Stock control systems, Payroll systems, Bill systems

Management Information System (MIS)

- Refers to a computer based system that provides managers with the tools to organize, evaluate and efficiently manage departments within an organization

- Purpose is to transform comparatively raw data accessible through using TPS **(Transaction Processing System)** into a summarized and aggregated form for managers, generally in the form of a report

- Examples are Human Resource Management System and Sales Management Systems

MIS – Uses

- Computer Hardware and Software
- Manual Procedures
- Models for analysis, planning, control and decision making, and
- A database
- Store and organize vast amounts of organizational data for easy retrieval
- Support data analysis, trend identification, and forecasting to aid in strategic decision-making
- Automate routine and repetitive tasks, reducing manual workload and minimizing errors
- Improve customer service by providing a comprehensive view of customer interactions and preferences.

Need for MIS

- Manager makes decisions all the time.
- There is an overload of information and not all information is not useful.
- Anything which helps manager improve his decision-making will lead to better result.
- MIS is a system, where data is the input, which is processed to provide output in the form of information reports, summaries, etc. which aid the manager's decision-making process.

Benefits of MIS

- **Improve Planning and Control** - MIS improves the quality of plans by providing relevant information for decision – making. It serves as a link between managerial planning and control

- **Minimize Information Overload** - MIS change the larger amount of data into summarized form and therefore, avoids the confusion which may arise when managers are flooded with detailed facts
- **Encourages Decentralization** – decentralization of authority is possible when there is a system for monitoring operations at lower levels

- **Brings Coordination** – MIS facilitates integration of specialized activities by keeping each department aware of the problem and requirements of other departments. It connects all decision centers in the organization

Decision Support System

- Specifically designed to help management make decisions in situations where there is uncertainty about the possible outcomes of those decisions

- Includes tools and techniques to help gather relevant information and examine other options, and substitutes, fostering a more intricate involvement for end-users in the decision-making process, as opposed to in MIS

- Examples are Bank loan management systems, Financial planning systems

Executive Information System / Expert System

- Designed to help senior management make strategic decisions
- ESS typically involve lots of data analysis and modeling tools to help strategic decision-making
- The principles of artificial intelligence research are used to develop these kinds of information systems.
- Examples include CaDet(Cancer Detection Support Tool), etc.

Introduction to Network & Data Communication

Network

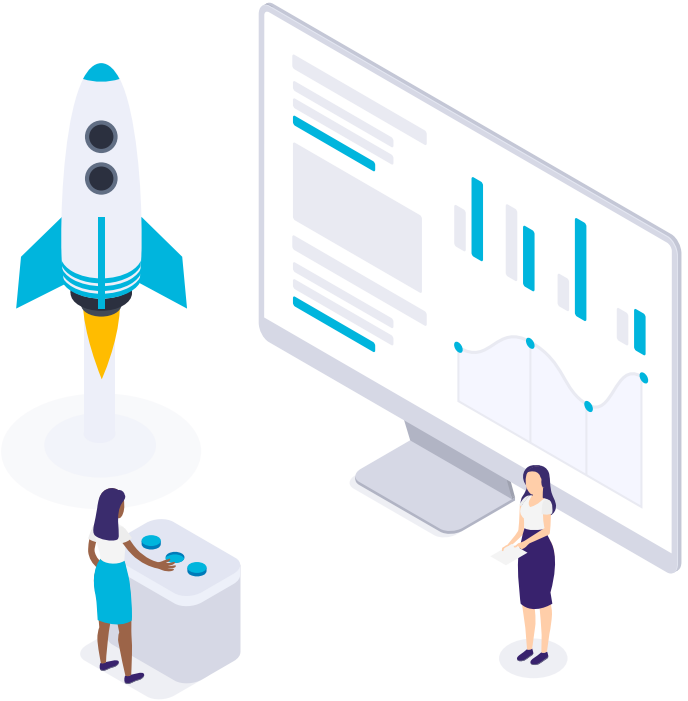
- A network is a collection of computers and devices connected together via communications devices and transmission media.
- A network consist of two or more entities for the purpose of sharing resources and information.

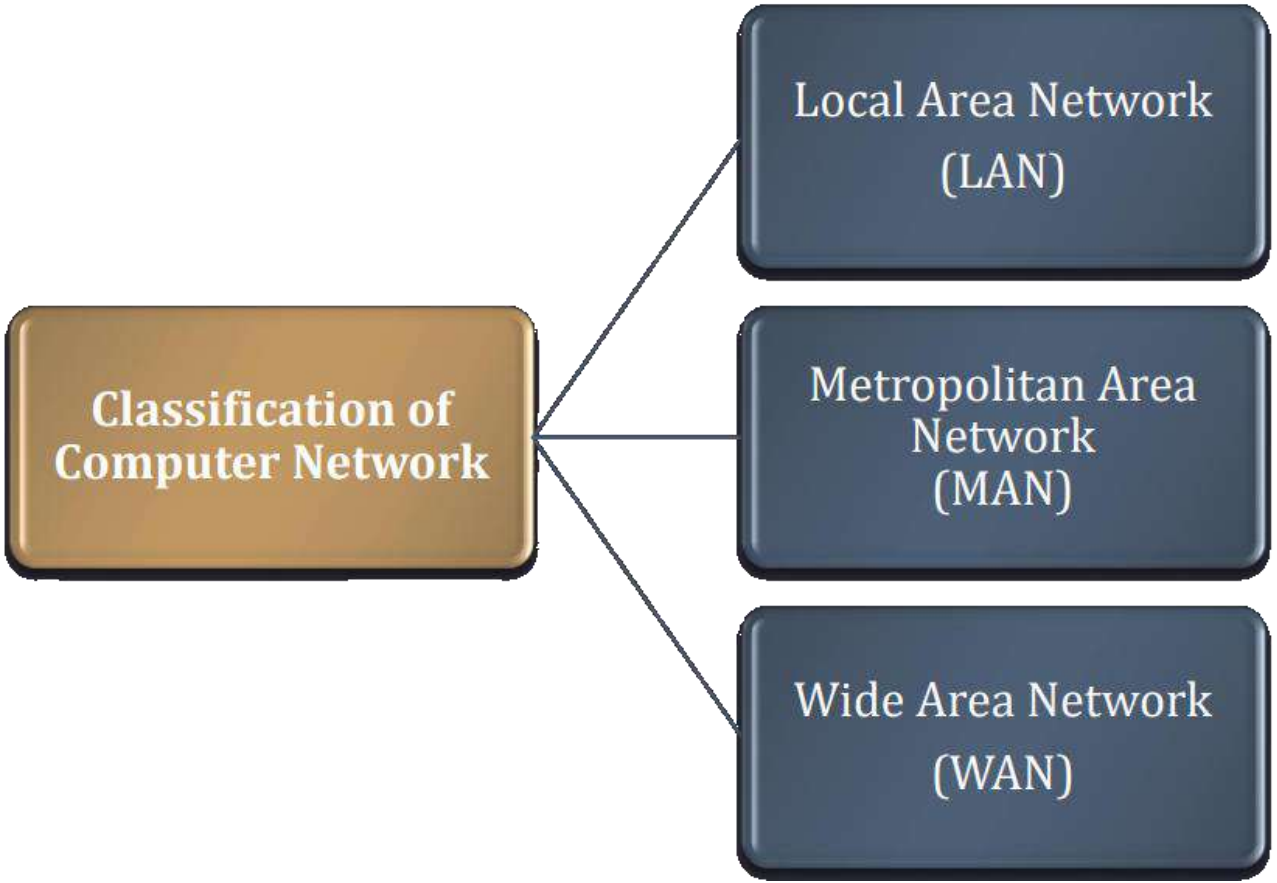
Advantages of using a network include:

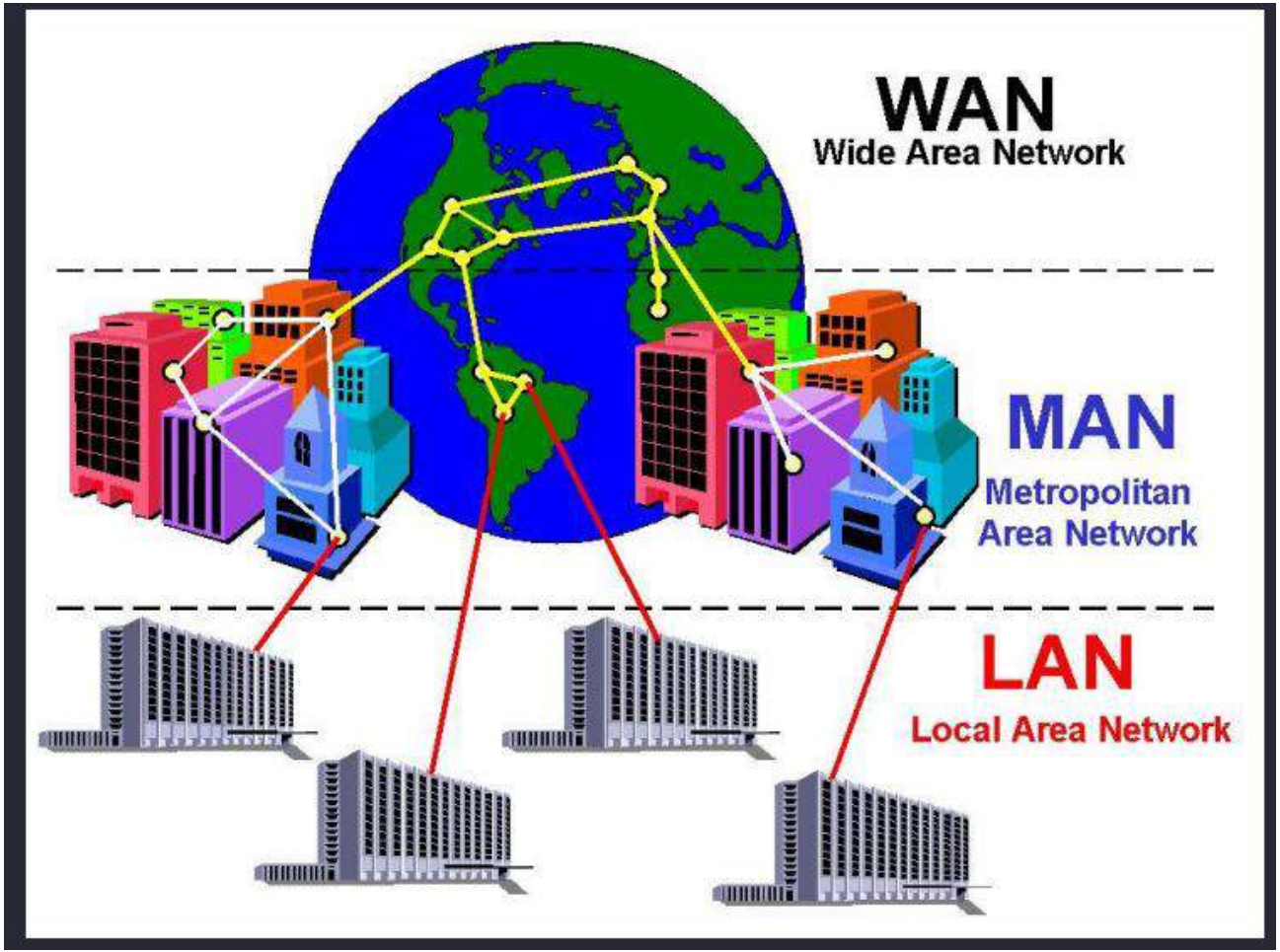
- Facilitating Communications
- Sharing Hardware
- Sharing Data and Information
- Sharing Software
- Transferring Funds etc.

2

Classification of a Computer Network based on Geographical Location




Classification of Computer Network
Local Area Network (LAN)
Metropolitan Area Network (MAN)
Wide Area Network (WAN)


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

LAN (Local Area Network)

- A local area network (LAN) is a network that connects computers and devices in a limited geographical area.
- Example such as a home, school computer laboratory, office building or closely positioned group of buildings.
- The simplest form of LAN is to connect two computers together.
- A network which consists of less than 500 interconnected devices across several buildings, is still recognized as a LAN.

Advantages of a LAN :

- Easy to share devices (printers, scanners, external drives)
- Easy to share data (homework, pictures)
- Cost of LAN Setup is low

Disadvantages of a LAN :

- Power - a good LAN is required to be on all the times
- Security - each computer and device become another point of entry for undesirables
- If all computers running at once, can reduce speed for each
- Area covered is limited

MAN (Metropolitan Area Network)

- A Metropolitan Area Network (MAN) is a high-speed network that connects local area networks in a metropolitan area. Example such as a city or town which handles the bulk of communications activity across that region.
- It is designed to extend over an entire city. It may be a single network such as cable television network available in many cities.
- Range: Within 100 km (a city).
- Campus Area Network (CAN) is a type of MAN

Advantages of a MAN :

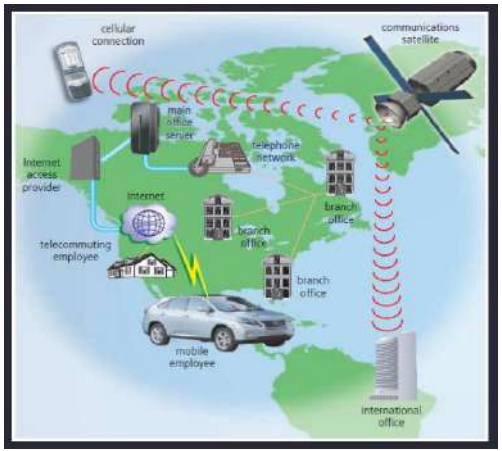
- It provides a good back bone for a large network and provides greater access to WANs.
- The dual bus used in MAN helps the transmission of data in both direction simultaneously.
- A Man usually encompasses several blocks of a city or an entire city.

Disadvantages of a MAN :

- More cable required for a MAN connection from one place to another.
- It is difficult to make the system secure from hackers and industrial espionage (spying) graphical regions.

WAN (Wide Area Network)

- A Wide Area Network (WAN) is a network that covers a large geographic area (such as a city, country, or the world) using a communications channel that combines many types of media such as telephone lines, cables, and radio waves.
- Network that provides long distance transmission of data, voice, image and video information over large geographical areas that may comprise a country, a continent.
- Range: Beyond 100 km.
- The Internet is the world's largest WAN.



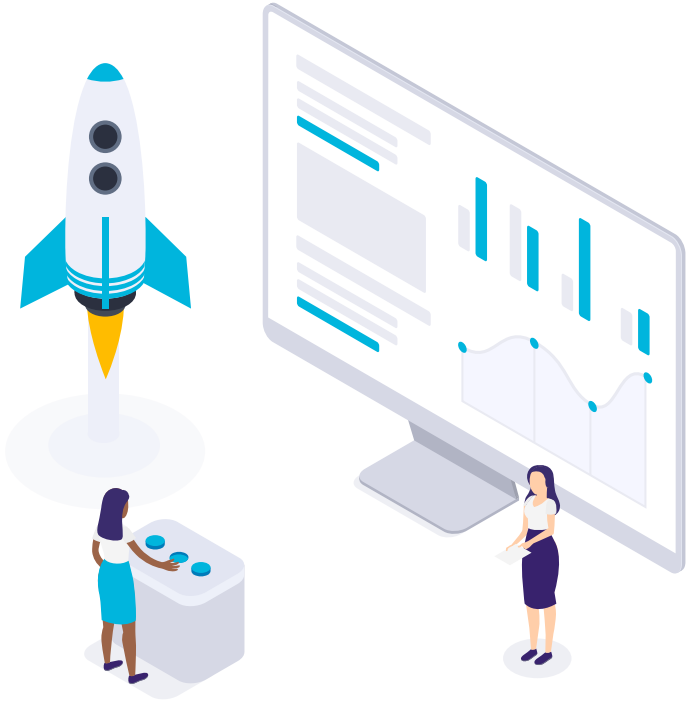
Difference between LAN, WAN and MAN

NIC → Network Interface Card

BASIS	LAN	MAN	WAN
Full Form	**Local Area Network**	**Metropolitan Area Network**	**Wide Area Network**
Range	A communication network linking a number of stations in same local area. **Range is 1 to 10 km**	This network shares the characteristics of packet broadcasting networks. **Range is100 km**	A communication network distinguished from a Local Area Network. **Range is Beyond 100 km**
Media Used	Uses **guided media**	Uses **guided** as well as **unguided media**	Uses **unguided media**
Speed	A high speed i.e. **100kbps to 100mbps**	Optimized for a **large geographical area than LAN.**	**Long distance** communications, which may or may not be provided by public packet network.
Cost	**cheaper**	**costly**	**expensive**
Equipment needed	**NIC, switch and hub**	**Modem and router**	**Microwave and radio**

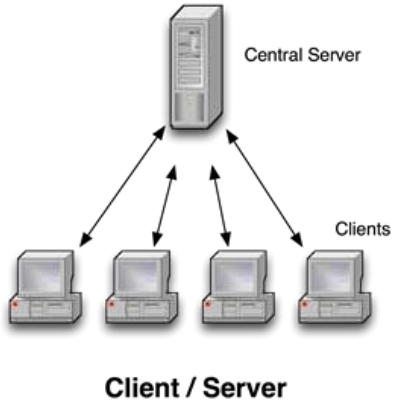
2

Classification of a Computer Network based on Component Roles



Client-Server Network

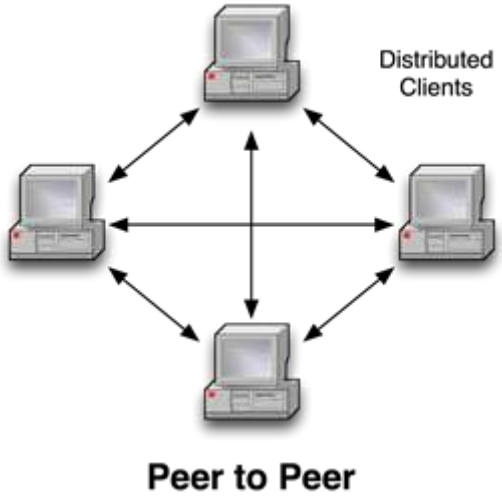
- Large organizations are likely to have more than one server.
- Each server carries out a different role on the network:
  - Manage printing
  - Manage email
  - Manage files
- Once connected to the servers clients will have access to features such as:
  - Dedicated storage
  - Files (if the user has the access rights)
  - Software used within the company
  - Peripheral devices such as printers and scanners (if connected)



Client / Server

Peer-to-Peer(P2P)

- P2P networks require no server.
- Each connected computer performs its own functions but can share files and resources.
- Each computer is considered equal to it's peers.
- These types of networks are usually found in the home or in smaller organizations and are much easier to set up compared to Client-Server networks.



Internet Protocol

- IP is short for the Internet Protocol. IP is the name of a protocol file with small content. It defines and describes the format of IP packets.
- The frequently mentioned IP refers to any content related directly or indirectly to the Internet Protocol, instead of the Internet Protocol itself.

Function	Version
• Provides logical addresses for devices at the network layer. • Is responsible for addressing and forwarding data packets.	• IP Version 4 (IPv4) • IP Version 6 (IPv6)

What Is an IP Address?

- An IP address identifies a node (or an interface on a network device) on a network.
- IP addresses are used to forward IP packets on the network.

What is a Ping ?

- Ping stands for Packet InterNet Groper . Ping is a computer network utility used to test the reachability of a host (typically a computer or server) on an Internet Protocol (IP) network. It also measures the round-trip time it takes for a data packet to travel from the source to the destination and back.

What is DNS ?

- DNS stands for Domain Name System. It is a decentralized naming system that translates human-readable domain names into IP addresses, which are used by computers to identify each other on a network
- Example: - www.example.com instead of numerical IP addresses.

IP Address Notation

- An IPv4 address is 32 bits long.
- It is in dotted decimal notation
- IPv4 address range is 0.0.0.0–255.255.255.255.

Dotted decimal notation

Decimal	**192.**	**168.**	**10.**	**1**	4 bytes
Binary	**11000000**	10101000	00001010	00000001	32 bits

Conversion between decimal and binary systems

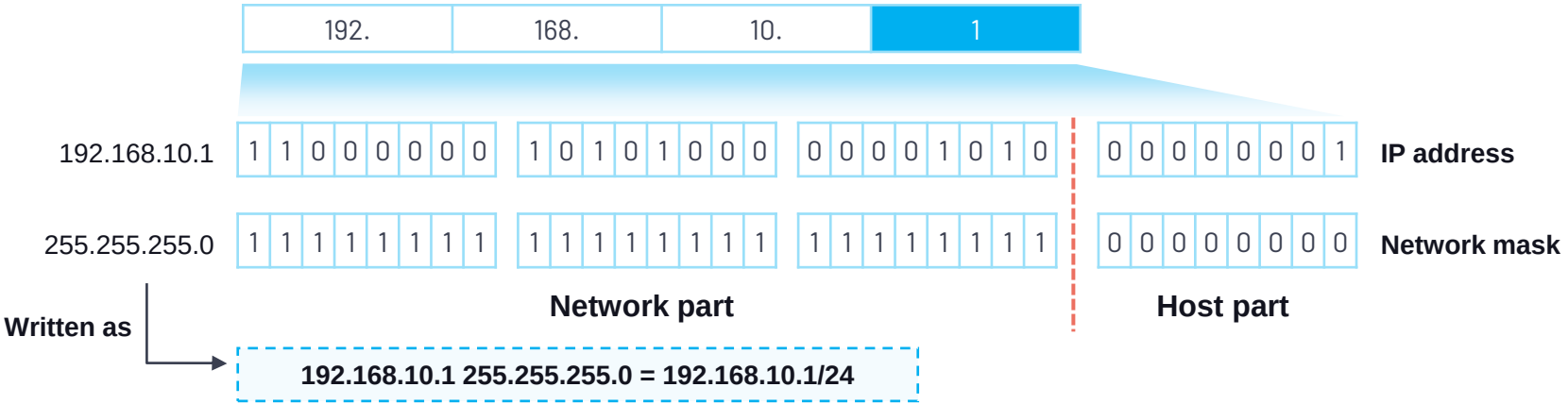
Power	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	128	64	32	16	8	4	2	1
Bit	1	1	0	0	0	0	0	0

= 128 + 64 = 192

IP Address Structure

Network part: identifies a network.
Host part: identifies a host and is used to differentiate hosts on a network.

- **Network mask:** is used to distinguish the network part from the host part in an IP address.



IP Addressing

- **Network part (network ID):** identifies a network.
- **Host part:** identifies a host and is used to differentiate hosts on a network.

MAC Address ?

- A MAC address, or Media Access Control address, is a unique identifier assigned to a network interface controller (NIC) for communication on a network.
- A MAC address is typically a 48-bit (6-byte) identifier, often represented as a series of six pairs of hexadecimal digits separated by colons (e.g., 01:23:45:67:89:ab).
- The first 24 bits of a MAC address represent the OUI, which is assigned to the device manufacturer or organization. The remaining 24 bits are assigned by the manufacturer to uniquely identify the specific device.

IP Address Types

A network range defined by a network ID is called a network segment.
Network address: identifies a network.

Example: 192.168.10.0/24

192.	168.	10.	00000000

- **Broadcast address:** a special address used to send data to all hosts on a network.

Example: 192.168.10.255/24

192.	168.	10.	11111111

- **Available addresses:** IP addresses that can be allocated to device interfaces on a network.

Example: 192.168.10.1/24

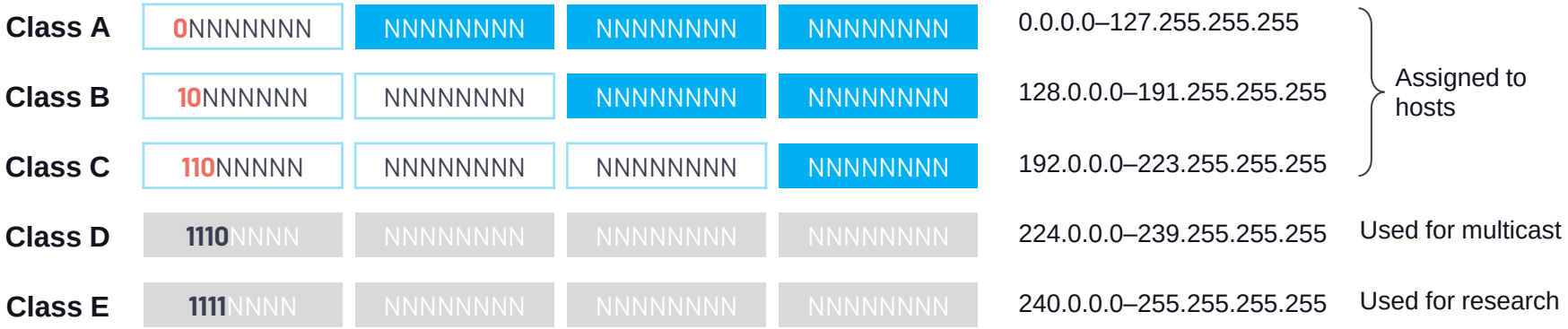
192.	168.	10.	00000001

Note

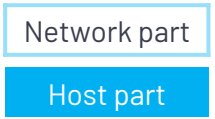
- Network and broadcast addresses cannot be directly used by devices or their interfaces.
- Number of available addresses on a network segment is $2^n - 2$ (n is the number of bits in the host part).

IP Address Classification (Classful Addressing)

To facilitate IP address management and networking, IP addresses are classified into the following classes:

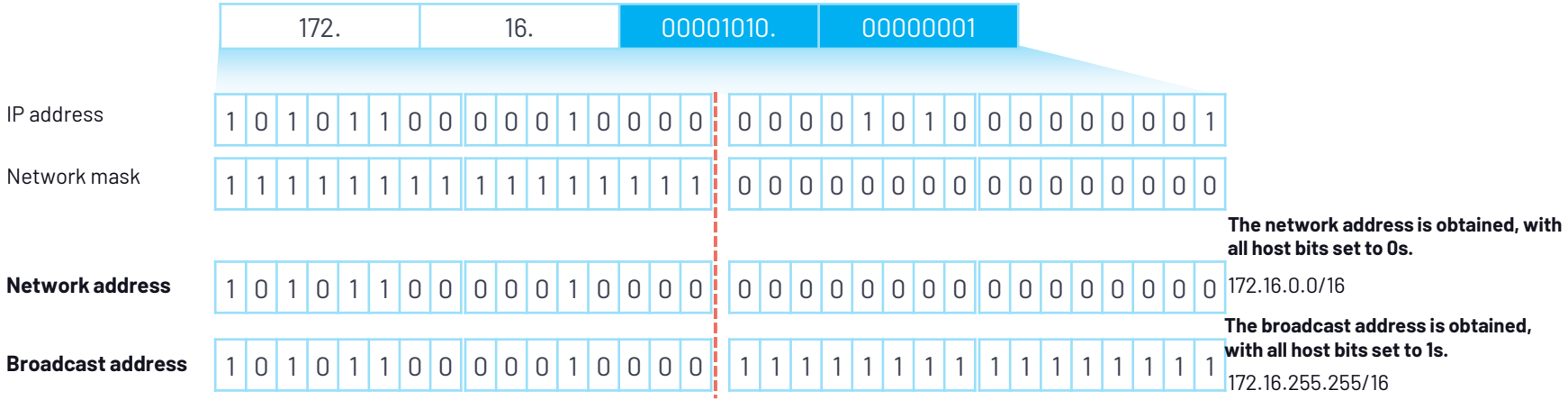


- Default subnet masks of classes A, B, and C
  - Class A: 8 bits, 0.0.0.0–127.255.255.255/8
  - Class B: 16 bits, 128.0.0.0–191.255.255.255/16
  - Class C: 24 bits, 192.0.0.0-223.255.255.255/24



IP Address Calculation

Example: What are the network address, broadcast address, and number of available addresses of class B address 172.16.10.1/16?



The network address is obtained, with all host bits set to 0s.

172.16.0.0/16

The broadcast address is obtained, with all host bits set to 1s.

172.16.255.255/16

Number of IP addresses $2^{16} = 65536$

Number of available addresses $2^{16} - 2 = 65534$

Range of available addresses 172.16.0.1/16–172.16.255.254/16

Quiz

Example: What are the network address, broadcast address, and number of available addresses of class A address 10.128.20.10/8?

Public IP address: An IP address is assigned by the Internet Assigned Numbers Authority (IANA), and this address allocation mode ensures that each IP address is unique on the Internet. Such an IP address is a public IP address.

Private IP address: In practice, some networks do not need to connect to the Internet. For example, on a network of a lab in a college, IP addresses of devices need to avoid conflicting with each other only within the same network. In the IP address space, some IP addresses of class A, B, and C addresses are reserved for the preceding situations. These IP addresses are called private IP addresses.

Class A: 10.0.0.0–10.255.255.255
Class B: 172.16.0.0–172.31.255.255
Class C: 192.168.0.0–192.168.255.255

DHCP: stands for Dynamic Host Configuration Protocol. It is a network protocol used to automatically assign and manage IP addresses and other network configuration information to devices on a TCP/IP network. The primary purpose of DHCP is to simplify the process of configuring devices on a network by automatically providing them with the necessary network settings.

Special IP Addresses

Some IP addresses in the IP address space are of special meanings and functions.

For example:

Special IP Address	Address Scope	Function
Limited broadcast address	255.255.255.255	It can be used as a destination address and traffic destined for it is sent to all hosts on the network segment to which the address belongs. (Its usage is restricted by a gateway).
Any IP address	0.0.0.0	It is an address of any network. Addresses in this block refer to source hosts on "this" network.
Loopback address	127.0.0.0/8	It is used to test the software system of a test device.
Link-local address / APIPA **Automatic Private IP Addressing**	169.254.0.0/24	If a host fails to automatically obtain an IP address, the host can use an IP address in this address block for temporary communication.

IPv4 vs. IPv6

IPv4 addresses managed by the IANA were exhausted in 2011. As the last public IPv4 address was allocated and more and more users and devices access the public network, IPv4 addresses were exhausted. This is the biggest driving force for IPv6 to replace IPv4.

IPv4
▶ Address length: 32 bits
▶ Address types: unicast address, broadcast address, and multicast address
▶ Characteristics:
▶ IPv4 address depletion
▶ Inappropriate packet header design
▶ ARP dependency-induced flooding ...

IPv6
▶ Address length: 128 bits
▶ Address types: unicast address, multicast address, and anycast address
▶ Characteristics:
▶ Unlimited number of addresses
▶ Simplified packet header
▶ Automatic IPv6 address allocation ...

Introduction to Data Communication

Data Communication

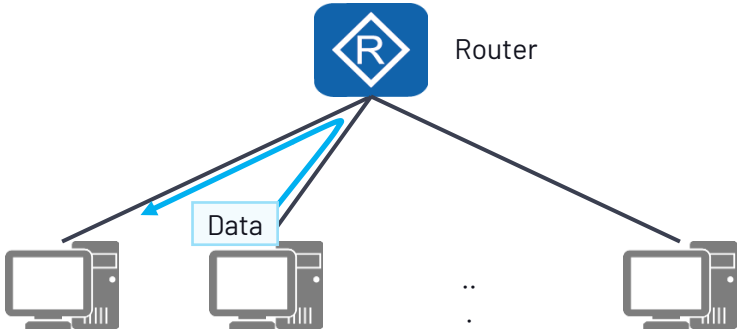
- Communication devices (Telephone, Radio, Phones etc.)
- Communication involves transmission of information from one point to another.
- Information being sent is referred to as data.
- Data can be in form of analog signals or digital bit stream.

Concept of Network Communication

- Communication refers to the information transfer and exchange between people, between people and things, and between things through a certain medium and behavior.
- Network communication refers to communication between terminal devices through a computer network.
- Examples of network communication:

A. Files are transferred between two computers (terminals) through a network cable.

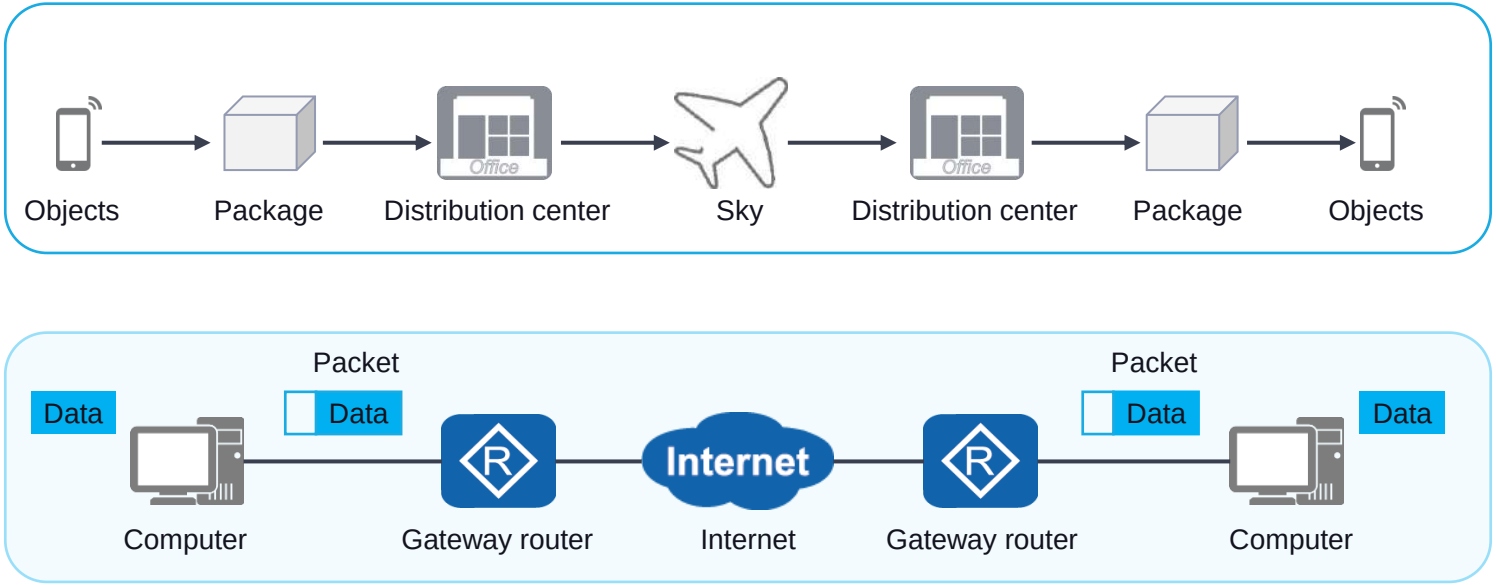
C. A computer (terminal) downloads files through the Internet.



B. Files are transferred among multiple computers (terminals) through a router.

Information Transfer Process

- Virtual information transfer is similar to real object transfer.



Common Terms

Term	Description
Data payload	Information conveyed
Packet	Data unit switched and transmitted on the network
Header	Information segment added before the data payload
Tail	Information segment added after the data payload
Encapsulation	Process of adding a header and a tail to a data payload to form a new packet
Decapsulation	Process of removing the header and tail from a packet to obtain the data payload
Gateway	Network device that provides functions such as protocol conversion, route selection, and data exchange
Router	Network device that selects a forwarding path for packets
Terminal device	End device of a data communication system, used as a sender or receiver of data

Concept of the Data Communication Network

Data communication network:

- Communication network that consists of routers, switches, firewalls, access controllers (ACs), access points (APs), PCs, network printers, and servers.

Switches

Switch: a device closest to end users, used to access the network and switch data frames

- Network access of terminals (such as PCs and servers)

Routers

A network-layer device that forwards data packets on the Internet. Based on the destination address in a received packet, a router selects a path to send the packet to the next router or destination. The last router on the path is responsible for sending the packet to the destination host.

- Implementing communication between networks of the same type or different types
- Isolating broadcast domains
- Maintaining the routing table and running routing protocols
- Implementing WAN access and network address translation

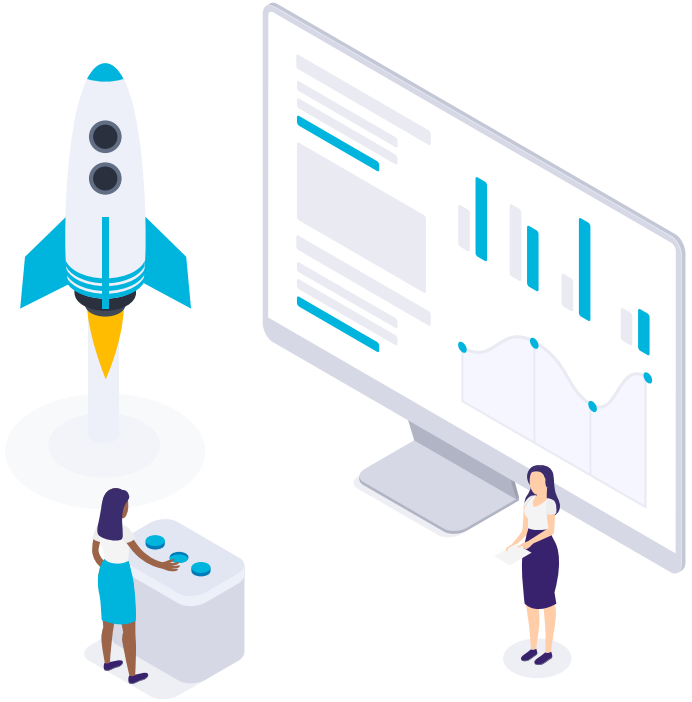
Firewalls

Firewall: a network security device used to ensure secure communication between two networks. It monitors, restricts, and modifies data flows passing through it to shield information, structure, and running status of internal networks from the public network.

- Isolating networks of different security levels
- Implementing access control (using security policies) between networks of different security levels
- Implementing user identity authentication
- Implementing remote access
- Supporting data encryption and VPN services
- Implementing network address translation
- Implementing other security functions

5

Transmission Media



Two types of media

1. **Guided**

   Uses cabling system to guide data signals to a specific path.

2. **Unguided**

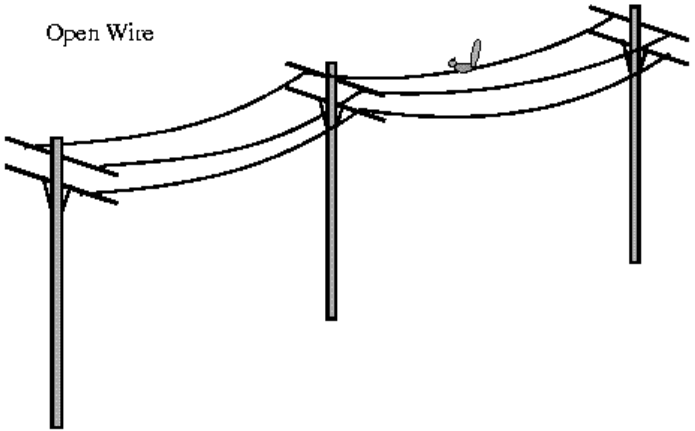
   Data signals travels not to a specific path.

Guided Media

- Types of Guided media
    1. Open wire
    2. Twisted pair
    3. Coaxial cable
    4. Fiber Optic

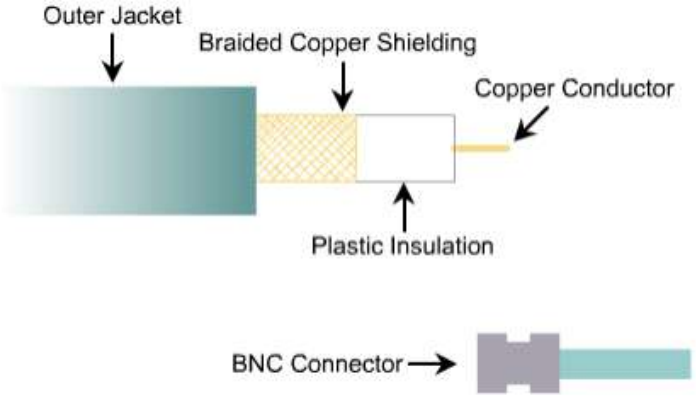
Open wire

- Open electric wires
- No shielding or protection from external noise
- Cannot be used for data transmission but for less distances.



Coaxial cable

- Outer shield protects inner shield from outer electric signals.
- Similarly insulator between two conductors protects them from noise generated by either conductor.
- Cable has 10 – 100 Mbps speed
- Inexpensive
- Maximum cable length 500m.
- Coaxial cable offers several advantages for LAN.
- Run longer distance then other cables.

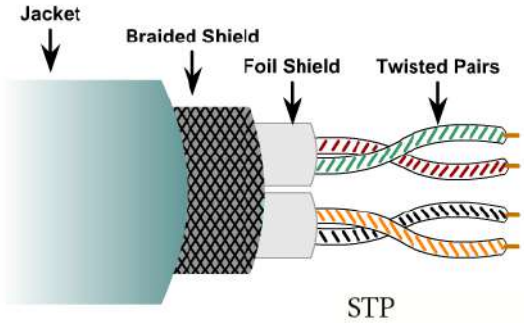


Twisted pair

- Wires are twisted in pairs
- Each pair carries +ve and –ve signals
- Noise appearing on one wire will also occur on other wire of same pair.
- Noise appeared on both wires of pair will cancel its affect.
- Twists of pair cancels the noise affect.
- Increase in the number of turns per foot reduces noise interference.
- Types of twisted pair
    1. Shielded twisted pair
    2. Unshielded twisted pair

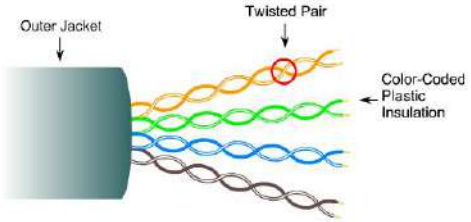
Shielded Twisted pair

- STP cable combine the techniques of cancellation, shielding and twisted wires.
- Each pair wrapped in metallic foil, then two pairs are wrapped in overall metallic foil.



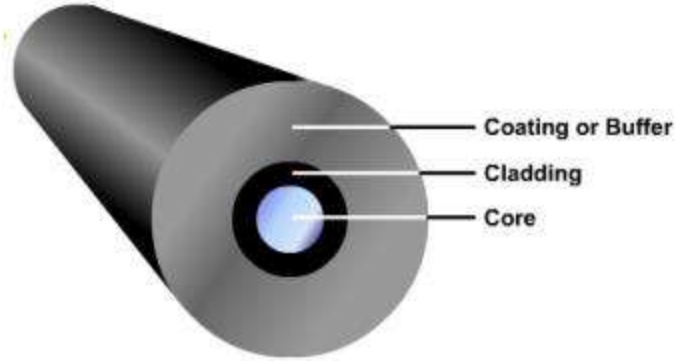
Unshielded Twisted pair

- Eight cables, Four pairs
- Each cable is covered with insulating material
- Each pair is twisted around each other for cancellation effect
- Uses RJ-45 connector



Optical Fiber

- Data or information is transmitted as light pulses.
- Carries more data for longer distances and much more speed as compare to other media.
- Requires more protection.
- Optical fiber is not affected by outer noise.
- No crosstalk.



Unguided media

- Based on electromagnetic waves
- Signals are broadcast
- Electromagnetic spectrum
  - Radio waves & micro waves :3kHz to 300GHz
  - Infrared waves: 300GHz to 400GHz
- Ways in which signals travel from source to destination.
  - Ground propagation (low frequency signals)
  - Sky propagation (higher frequency signals, reflected back to earth)

Modes Of Data Communication:

Simplex, half-duplex, and full-duplex are terms used to describe different communication modes or channels in data communication. These terms refer to the direction in which data can be transmitted between communicating devices.

1. **Simplex:** In simplex communication, data can only be transmitted in one direction. It is a one-way communication channel.

- Radio broadcast, television broadcast.
- Less flexible, as communication is one-way only.

Example: Traditional broadcast radio or television where the transmitter sends signals, and the receiver only receives them. The receiver cannot send signals back to the transmitter.

2. Half-Duplex: Half-duplex communication allows data transmission in both directions, but not simultaneously. The communication can switch between sending and receiving, but not at the same time.

- Two-way communication, but not simultaneously (bidirectional, half at a time).
- Walkie-talkies, traditional push-to-talk systems.
- More flexible than simplex but less efficient than full-duplex due to the need to switch between sending and receiving.

Example: Two-way radios (walkie-talkies) operate in half-duplex mode. One person talks while the other listens, and vice versa. They cannot speak at the same time without interference.

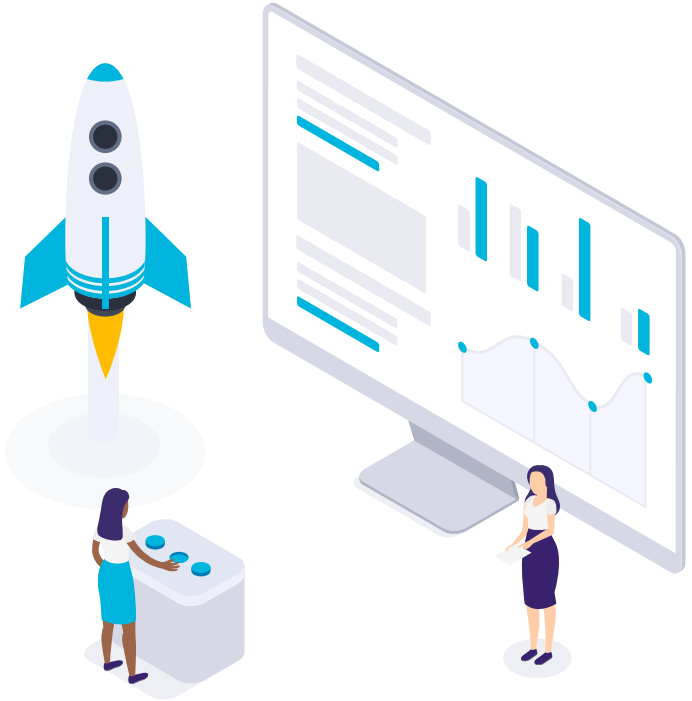
3. Full-Duplex: Full-duplex communication allows simultaneous two-way communication. Data can be transmitted and received at the same time, providing a bidirectional communication channel.

- Simultaneous two-way communication (bidirectional, full at a time).
- Telephone conversations, most modern data communication (e.g., internet communication).
- Most efficient for real-time, interactive communication as both parties can transmit and receive simultaneously.

Example: Telephone conversations over landlines or cellular networks are typically full-duplex. Both parties can talk and listen simultaneously without interrupting each other.

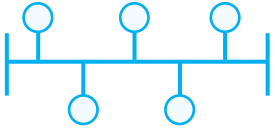
6

Network Topologies

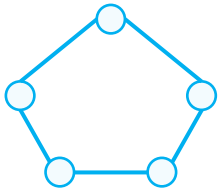


Network Topology Types

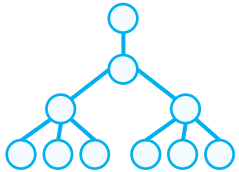
Star network topology



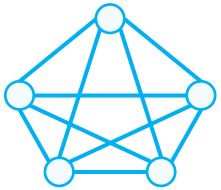
Bus network topology



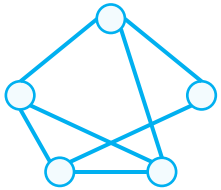
Ring network topology



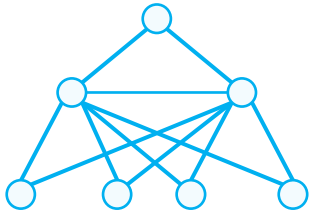
Tree network topology



Full-mesh network topology



Partial-mesh network topology



Combined network topology

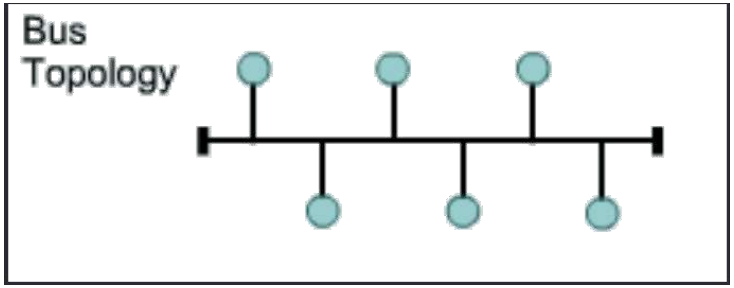
Network topology refers to the arrangement or layout of various interconnected elements (such as nodes, links, or devices) in a computer network. It describes how these components are connected and how data is transmitted between them.

Physical topology

- Bus
- Star
- Ring
- Mesh
- Tree

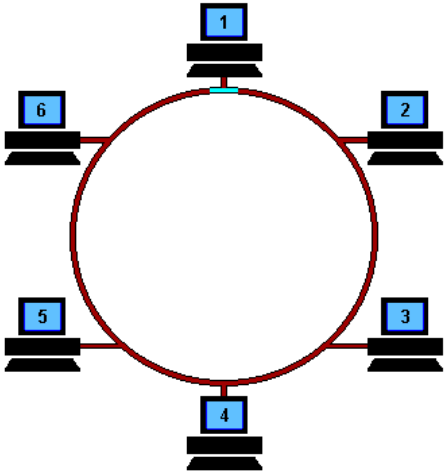
Bus

- Uses single backbone cable, All hosts directly connected to this backbone.
- Inexpensive and easy to install
- All nodes receives data
- Ends terminated with a device terminator.
- Security issues are a common concern in bus topologies due to the shared communication medium



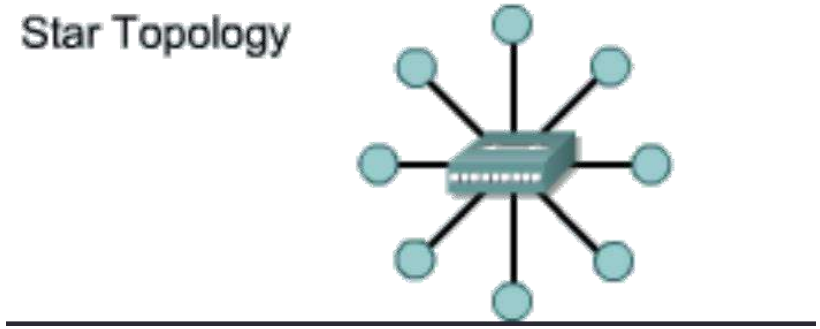
Ring

- All nodes connected to one another in form of closed loop.
- Expensive and difficult to install but offers high bandwidth, not robust.
- Point to point connection with only two devices.
- Signal is passed in one direction only, moves until it reaches to its destination.
- One signal always circulates for fault detection.
- If device don't receives signal for specified time it generates alarm.



Star

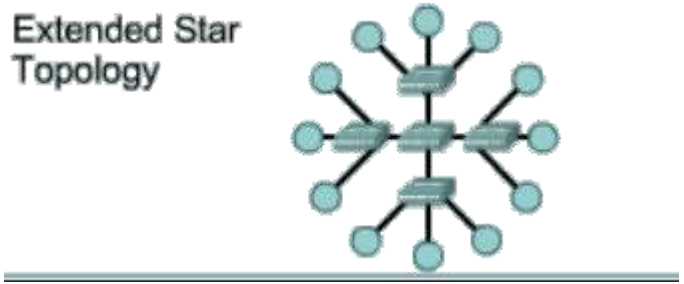
- Connects all devices with central point.
- Central point can be hub.
- Data transmitted reaches to central point, who decides where to send data.
- Bottleneck occur because all data pass from hub.
- Less expensive and easy to install, robust if one link is down still remains active.
- Disadvantage: dependency one central unit.
- Star is used in LANs.



Types of STAR Topology

1. Extended STAR

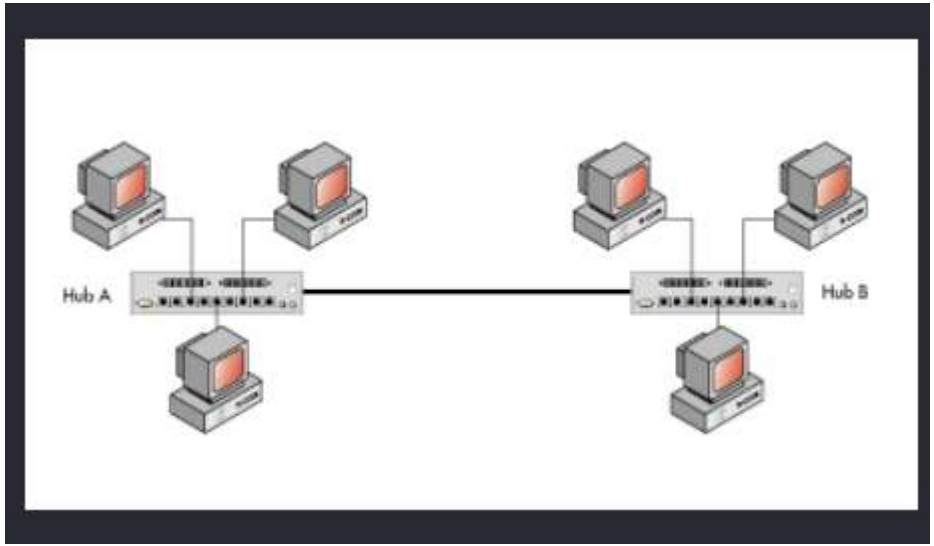
- Has one or more repeaters from central node to extend maximum transmission distance.
- If repeaters in extended star topology is replace with hub or switches then it creates Hybrid topology.
- Or if backbone as star topology and extended with bus then it also creates Hybrid topology.
- Connecting two or more topologies with each other forms hybrid topology.



Types of STAR Topology

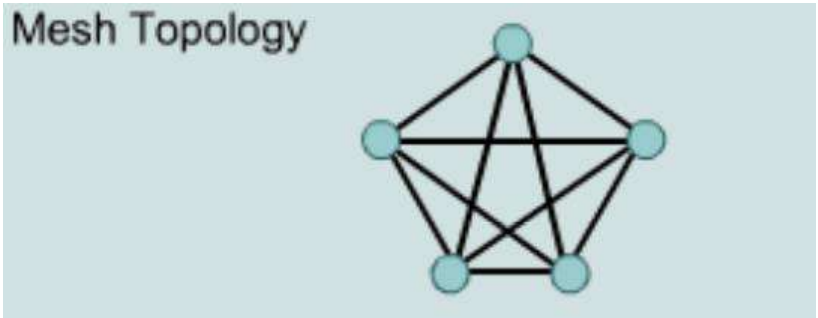
2. Distributed STAR

- Individual networks based on star topology
- These networks do not have central or top level connection points.



Mesh

- Each host has its dedicated point to point link with every other host.
- Link only carries data between two devices only (no other can use that link)
- If link is multi directional or duplex mode then we need n(n-1)/2 links.
- Each device requires n-1 I/O ports to be connected to each device.
- Eliminates traffic problem, Robust, privacy/security of message.
- More cabling required, more I/O ports needed, hard to install, expensive



Tree

- Central node connected to one or more nodes one level lower in hierarchy.
- Combines characteristics of linear bus and star topology.
- Must have three levels of hierarchy.
- If only two levels then it forms star.
- Disadvantage: requires point to point wiring, requires more hardware, dependent on backbone, difficult to configure.

Quiz

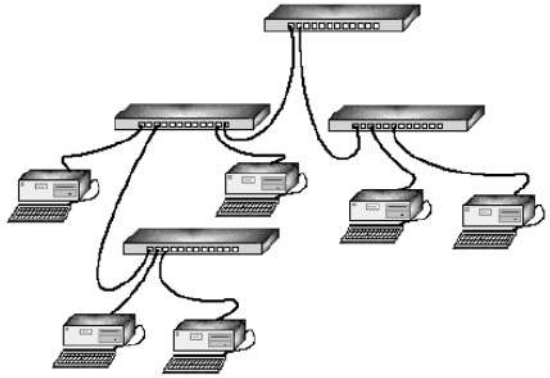
a) Identify the network topology in the following scenario along with reason:
(Assume Computer A, B, C, D, E, F, G, H are connected in network) –

i. Computer A sends a message across a network but it undergoes security issue.

ii. Computer B is the central computer and it failed to send message to other computers. ,

iil. Computer C switches off so entire network is down,

iv, Computer D, E, F, G, H undergoes redundancy of message.



My Answer Of Network Topology:

- **i. Security Issue with Message from Computer A:**
  - **Topology:** Bus Topology
  - **Reason:** In a bus topology, all devices share a single communication line. If there is a security issue with a message from Computer A, it means that other devices on the bus can potentially intercept or access the message, indicating a security vulnerability associated with a shared medium.
- **ii. Central Computer B Failed to Send Message:**
  - **Topology:** Star Topology
  - **Reason:** In a star topology, all devices are connected to a central hub (Computer B). If Computer B fails, it can result in a communication breakdown, as all communication passes through the central point.
- **iii. Computer C Switches Off, Entire Network Down:**
  - **Topology:** Ring Topology
  - **Reason:** In a ring topology, each device is connected to exactly two other devices, forming a closed loop. If Computer C switches off, it breaks the ring, causing the entire network to be down as there is no continuous path for data transmission.
- **iv. Redundancy of Message for Computers D, E, F, G, H:**
  - **Topology:** Mesh Topology or Bus Topology (Maybe)
  - **Reason:** In a mesh topology, every device is connected to every other device. Redundancy of messages (multiple paths) ensures that even if one path fails, alternative paths exist, preventing communication failures.