

A MASTERY
HAND BOOK OF

DATA COMMUNICATION



NORHIDAYAH KASAH

A MASTERY HANDBOOK OF
**DATA
COMMUNICATION**

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Hakcipta terpelihara. Tiada bahagian daripada terbitan ini boleh diterbitkan semula, disimpan untuk pengeluaran atau ditukarkan ke dalam sebarang bentuk atau dengan sebarang alat, sama ada dengan cara elektronik, gambar dan rakaman serta sebagainya tanpa kebenaran bertulis daripada pemegang hakcipta.

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I would like to thank god , for letting me through all the difficulties.

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Thank you all

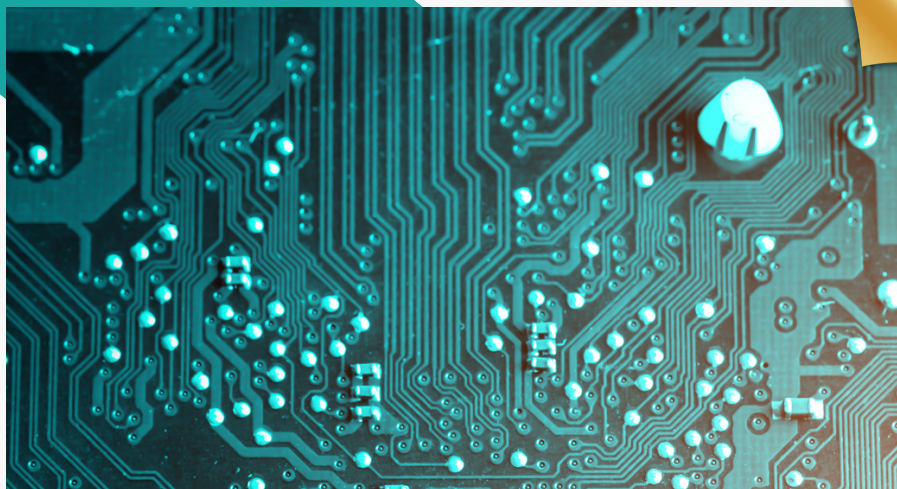
PREFACE

This e-book is designed to provide students with a comprehensive fundamental to data communication. It covers the essential topic that are typically taught in semester 1 for Diploma in Business Information System program.

The e-book is written in clear and concise style, and it include numerous examples and illustration to help students understand the topic. It also include a numbers of exercise to help student test their understanding.

The e-book is intended for students who are studying in semester 1 for the program of Diploma Business Information System in polytechnics. However it can also be used by anyone who is interested in learning about technology of data communication.

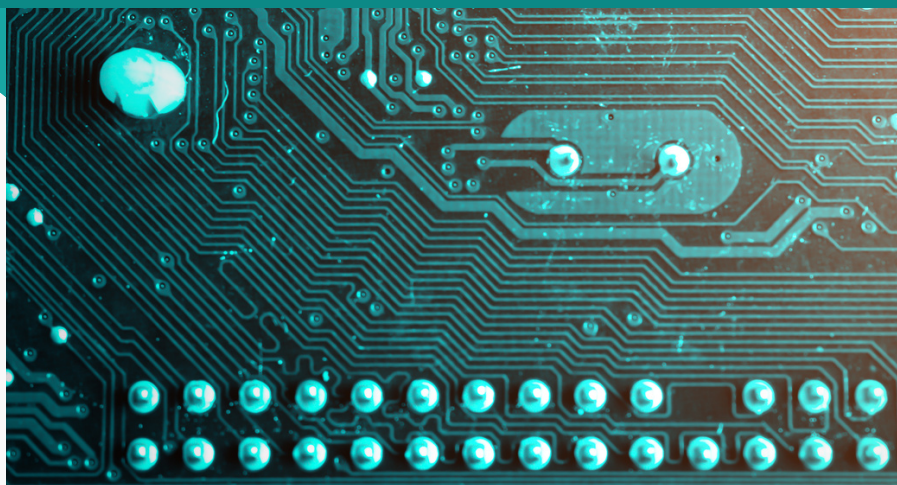
I hope with the existence of the e-book, it will help students to understand and well-prepared for more advance topics that they will learn in later semesters. Last but not least, I hope that this book is helpful. Thank you for the interest



DATA COMMUNICATION

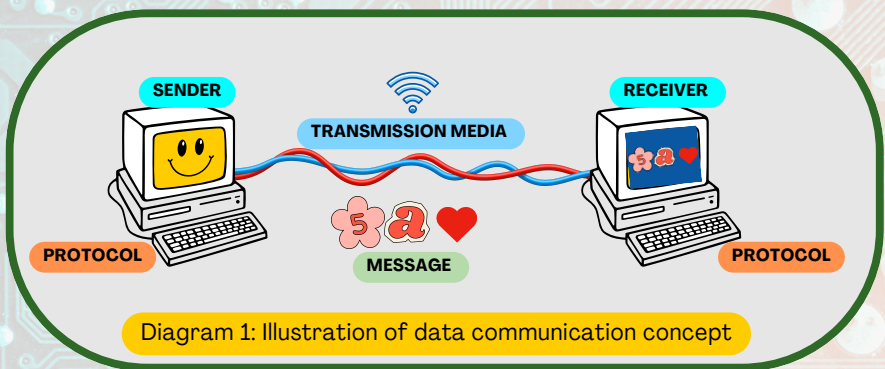


PART - 1

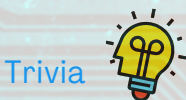


1. DATA COMMUNICATION CONCEPT

Communication is defined as a process in which more than one computer transfers information, instructions to each other and for sharing resources. Or in other words, communication is a process or act in which we can send or receive data.



Data communication is the process of exchanging information between two or more devices through a medium such as wires, cables, or wireless signals. It involves the transmission of data from one point to another with the goal of delivering a message accurately and efficiently



Trivia

In telephone terminology, what is the purpose of a "landline"?

1.1 . DATA COMMUNICATION CHARACTERISTICS

"Characteristics" refers to the distinctive qualities, features, or attributes that define or describe a particular person, thing, or group. These are the inherent traits that set something apart and help identify or differentiate it from others.

In data communications the effectiveness of data communication systems depends on FOUR (4) fundamental characteristics. They are :

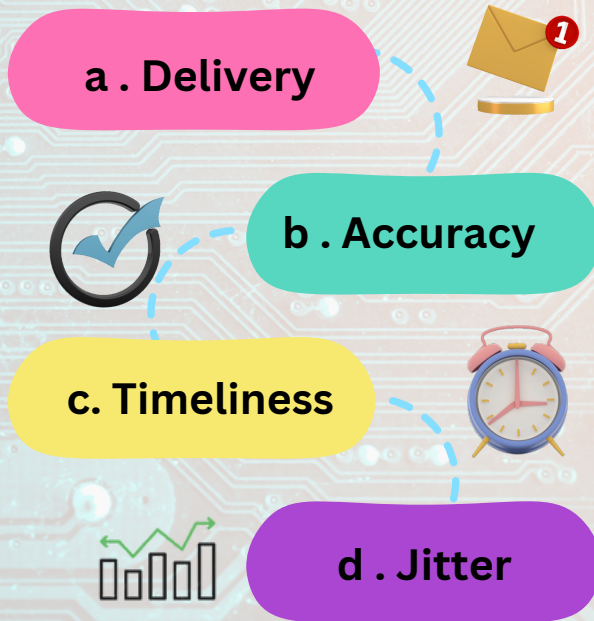


Diagram 2 : Characteristics of Data Communication

a. Delivery

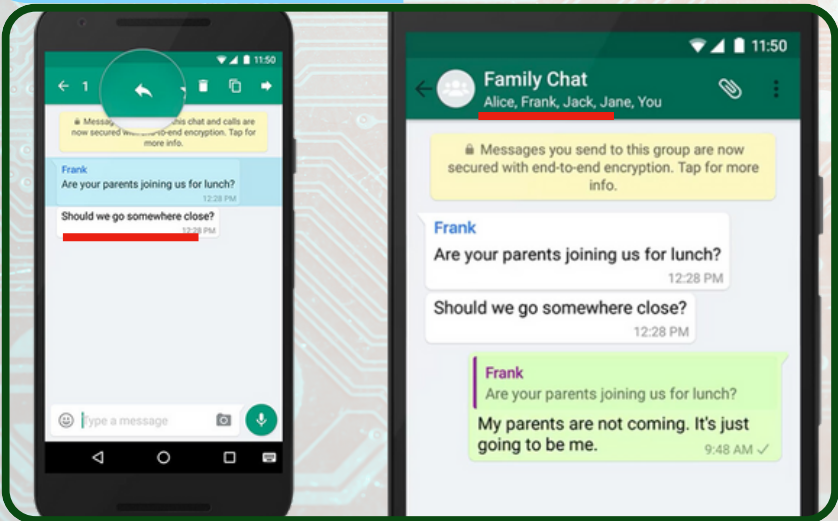


Delivery in communication generally refers to the act of transporting and handing over information from one party to another.

It involves the successful conveyance or transfer of something to its intended destination or recipient.

In Information system, the system must deliver data to the correct destination. Data must be received by the intended device or user.

Example



Sender

Recipients

b . Accuracy

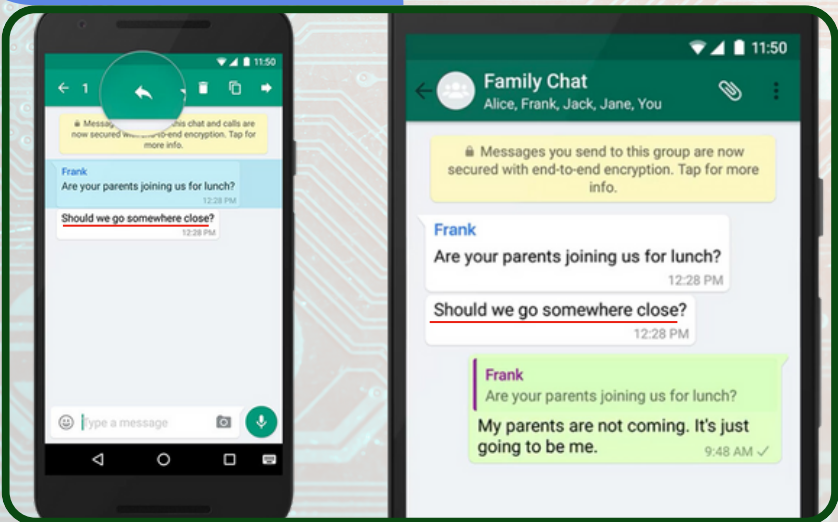


Accuracy is the degree of correctness or precision in the representation of information. It measures how closely a given value aligns with the true or expected value

Achieving high accuracy is a goal in various disciplines to enhance the reliability and trustworthiness of data, measurements, and information.

In Information system, The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.

Example



Sender

Recipients

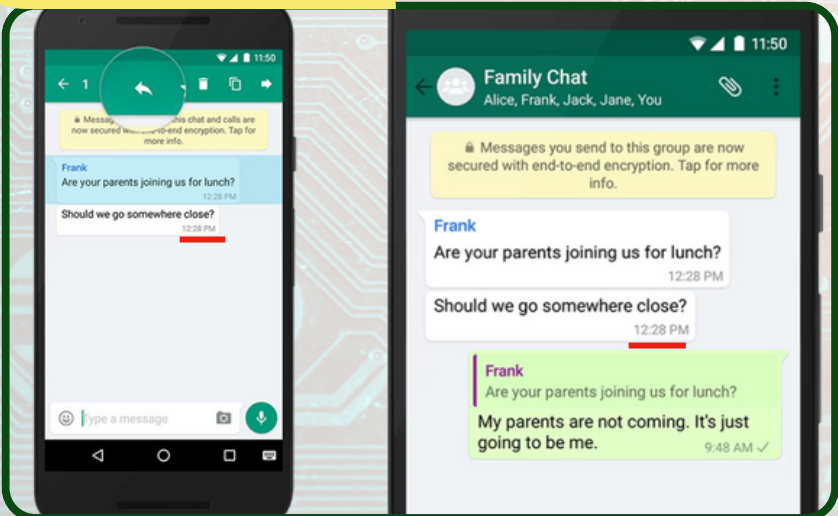
c . Timeliness



Timeliness in communication refers to the quality of being well-timed, prompt, and relevant. It emphasizes the importance of delivering information, messages, or responses in a timely manner, considering the context and the needs of the recipients. The system must deliver data in a timely manner. Data delivered late are useless.

In the case of texting a message through Whats app , timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.

Example



Sender

Recipients

d . Jitter

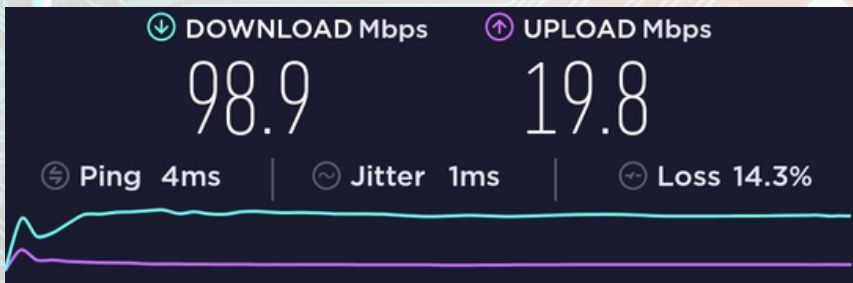


Jitter is the term used to describe delays in data transmission due to compromised internet speed. When jitter occurs, the sound and video quality of sent data is negatively impacted.

It is the uneven delay in the delivery of audio or video packets.

Jitter has an adverse effect on the user experience. The effect of jitter is most severe for real-time applications such as audio/video calls and gaming.

Example



Sender

Recipients

Jitter in Gaming:



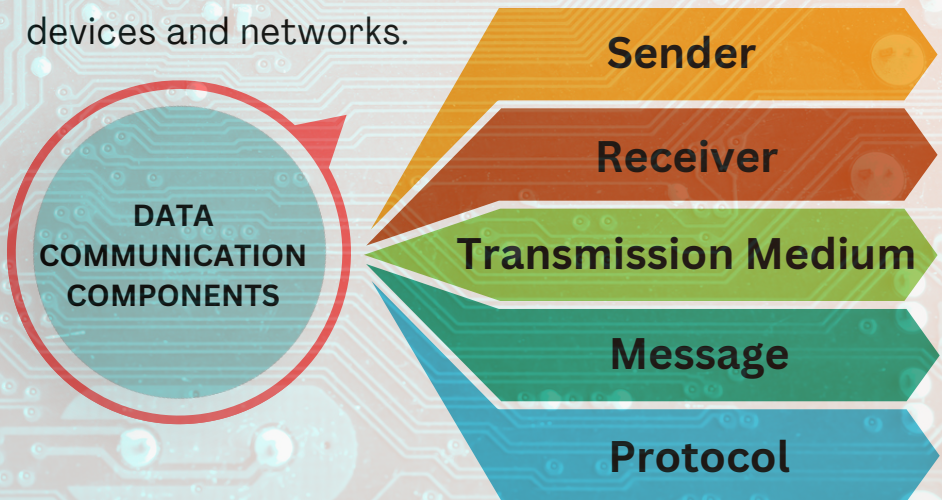
In online gaming, jitter can lead to lag and affect the responsiveness of gameplay, making it a concern for gamers who require real-time interactions.

1.2 . DATA COMMUNICATION COMPONENTS

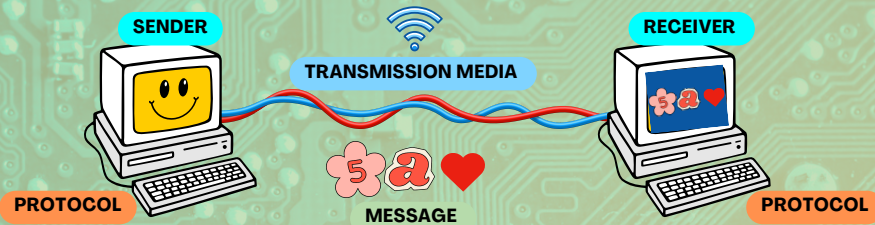
Data communication involves the transmission of data from one point to another, and it encompasses various components to facilitate this process.

Understanding these components is essential for designing, implementing, and managing effective data communication systems.

Each component plays a crucial role in ensuring the accurate and timely transfer of data between devices and networks.



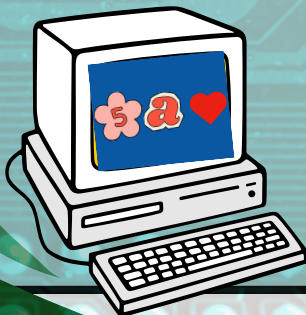
Take a look to data communication concept , from the illustration, we can conclude that, data communication components are: sender, receiver, transmission medium, message and protocol



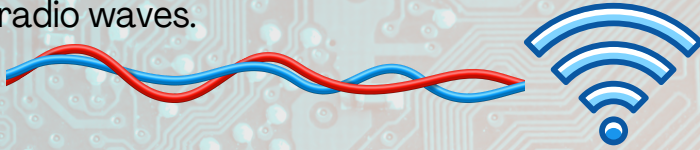
The **SENDER** is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.



The **RECEIVER** is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.



The **TRANSMISSION MEDIUM** is the physical path (cable) by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.



The **MESSAGE** is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.



A **PROTOCOL** is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking Tamil cannot be understood by a person who speaks only Japanese. Example **TCP/IP, FTP, HTTP** and others.

TUTORIAL EXERCISE

SECTION 1.1

True False Question



- 1.The primary objective of data communication is to maximize data transmission delays. (T / F)
- 2.Accuracy in data communication refers to the speed of data transmission. (T / F)
- 3.Timeliness is essential in data communication, especially for real-time applications. (T / F)
- 4.Jitter is a measure of the consistency in the timing of signal arrival at the destination. (T / F)
- 5.One of the objectives of data communication is to ensure that the transmitted data reaches the destination without loss or corruption. (T / F)
- 6.Achieving high accuracy in data communication means allowing for distortions and alterations during transmission. (T / F)
- 7.Security is not a significant objective in data communication systems. (T / F)
- 8.Scalability is a key objective, ensuring that a communication system can handle an increasing number of users or devices. (T / F)
- 9.Interoperability is the ability of different data communication systems or networks to work together. (T / F)
- 1.The objective of minimising jitter is crucial in applications where a consistent and predictable data flow is not essential. (T / F)

TUTORIAL EXERCISE

SECTION 1.2



Fill in the blanks with an appropriate answer

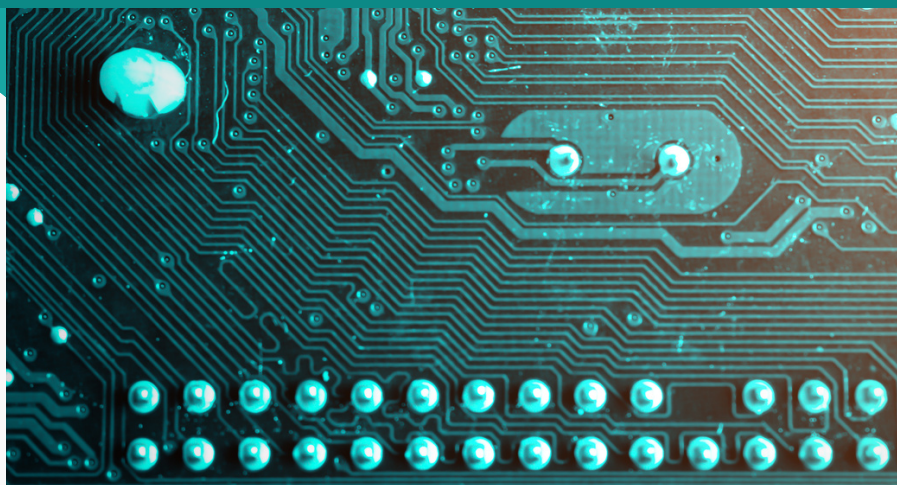
1. _____ Initiates the communication process and is responsible for encoding the message.
2. _____ The intended destination of the message; decodes and interprets the received message.
3. _____ The communication channel through which the message is transmitted from the sender to the receiver.
4. _____ A set of rules and conventions that govern the format and timing of data exchange between sender and receive.
5. _____ The information or data that is being transmitted from the sender to the receiver.



DATA TRANSMISSION



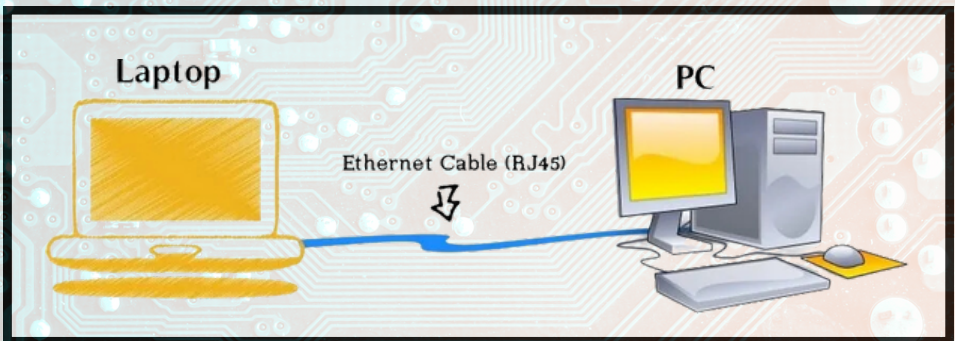
PART - 2



2 . DATA TRANSMISSION CONCEPT

Data transmission refers to the movement digital or analogue data in form of bits between two or more digital devices.

This transfer of data takes place via some form of transmission media (for example, coaxial cable, fiber optics etc.)



Data transmission works when a device aims to transmit a data object or file to one or multiple recipient devices.

Latest example of data transmission

5G Wireless Networks

The deployment of fifth-generation (5G) wireless networks enables high-speed data transmission over mobile networks, offering faster and more reliable connectivity for smartphones and other devices.

Wi-Fi 6

Wi-Fi 6 is the latest standard in wireless networking, providing improved data transmission speeds and efficiency, especially in environments with numerous connected devices.

2.1 . TYPE OF DATA TRANSMISSION MEDIUM

A transmission medium is a physical path between the transmitter and the receiver. It is the channel through which data is sent from one place to another.

Transmission Media is broadly classified into the following types:

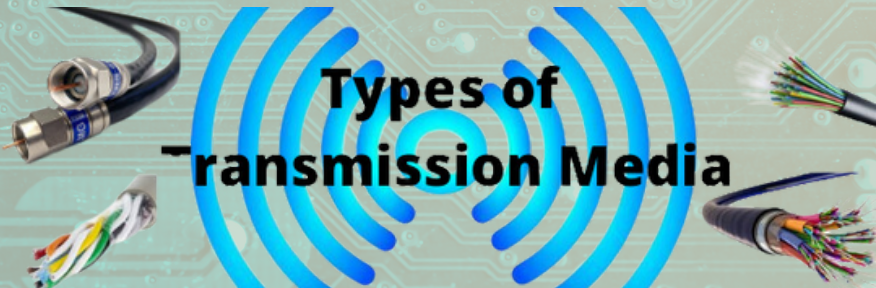
Guided

- Twisted Pair Cable
- Coaxial cable
- Optical Fiber Cable

Unguided

- Radio waves
- Microwaves
- Infrared

Types of Transmission Media



I. GUIDED MEDIA

- It is also referred to as Wired or Bounded transmission media.
- Signals being transmitted are directed and confined in a narrow pathway by using physical links.
- **Features**
 - High Speed
 - Secure
 - Used for comparatively shorter distances

Types of guided media

- a. Twisted Pair Cable
- b. Coaxial cable
- c. Optical Fiber Cable

a . Twisted Pair Cable

- It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath.
- They are the most widely used Transmission Media.
- Twisted Pair is of two types:
 - Unshielded Twisted Pair (UTP)
 - Shielded Twisted Pair (STP)

i. Unshielded Twisted Pair Cable (UTP)

UTP consists of two insulated copper wires twisted around one another.

- Cable has the ability to block interference and does not depend on a physical shield for this purpose.
- It is used for telephonic applications.

Advantages:

- Least expensive
- Easy to install
- High-speed capacity

Disadvantages:

- Susceptible to external interference
- Lower capacity and performance in comparison to STP
- Short distance transmission due to attenuation

Applications:

Used in telephone connections and LAN networks



ii. Shielded Twisted Pair Cable (STP)

STP consists of a special jacket (a copper braid covering or a foil shield)

- Cable has ability to block external interference.
- It is used in fast-data-rate Ethernet and in voice and data channels of telephone lines.

Advantages:

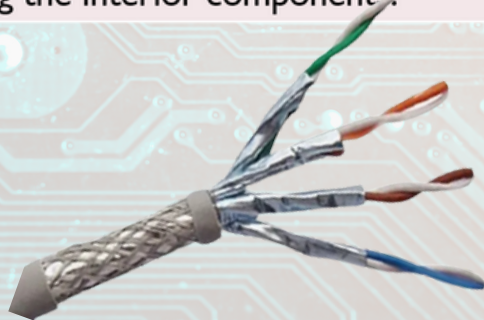
- Better performance at a higher data rate in comparison to UTP
- Eliminates crosstalk
- Comparatively faster

Disadvantages:

- Comparatively difficult to install and manufacture
- More expensive
- Bulky

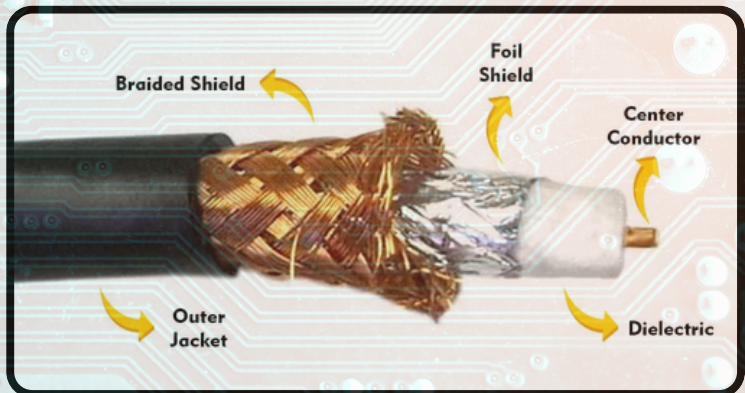
Applications:

Most frequently used in extremely cold climates, where the additional layer of outer covering makes it perfect for withstanding such temperatures or for shielding the interior components.



b. Coaxial cable

- It has an outer plastic covering containing an insulation layer made of PVC or Teflon and 2 parallel conductors each having a separate insulated protection cover.
- The coaxial cable transmits information in two modes:
 - Baseband mode (dedicated cable bandwidth)
 - Broadband mode (cable bandwidth is split into separate ranges).
- Cable TVs and analog television networks widely use Coaxial cables.



Applications coaxial cable

Radio frequency signals are sent over coaxial wire. It can be used for cable television signal distribution, digital audio, computer network connections, and feedlines that connect radio transmitters and receivers to their antennas.

Advantages of coaxial cable

- High Bandwidth
- Better noise Immunity
- Easy to install and expand
- Inexpensive

Disdvantages of coaxial cable

- Single cable failure can disrupt the entire network

c. Fiber optic cable

- Fiber Optic Cable uses the concept of refraction of light through a core made up of glass or plastic.
- The core is surrounded by a less dense glass or plastic covering called the cladding.
- The cable can be unidirectional or bidirectional. The WDM (Wavelength Division Multiplexer) supports two modes:
 - unidirectional
 - bidirectional mode.
- It is used for the transmission of large volumes of data.

Advantages of Fiber optic cable

- Increased capacity and bandwidth
- Lightweight
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials

Disadvantage of Fiber optic cable

- Difficult to install and maintain
- High cost
- Fragile



Applications coaxial cable

- Medical Purpose
 - Used in several types of medical instruments.
- Defense Purpose:
 - Used in transmission of data in aerospace.
- For Communication:
 - This is largely used in formation of internet cables.
- Industrial Purpose:
 - Used for lighting purposes and safety measures in designing the interior and exterior of automobiles.

II. UNGUIDED MEDIA

- Unguided media referred to as Wireless or Unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.
- Features:
 - The signal is broadcasted through air
 - Less Secure
 - Used for larger distances

Types of unguided media

- a. Radio waves
- b. Microwaves
- c. Infrared



a . Radio waves

- These are easy to generate and can penetrate through buildings.
- The sending and receiving antennas need not be aligned.
- Frequency Range: 3KHz – 1GHz.
- AM and FM radios and cordless phones use Radio waves for transmission.

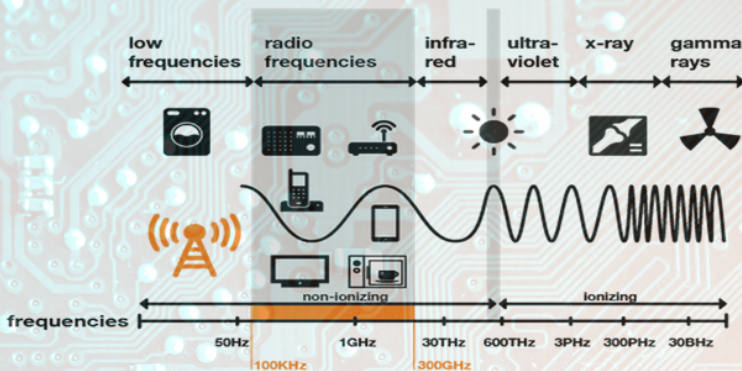
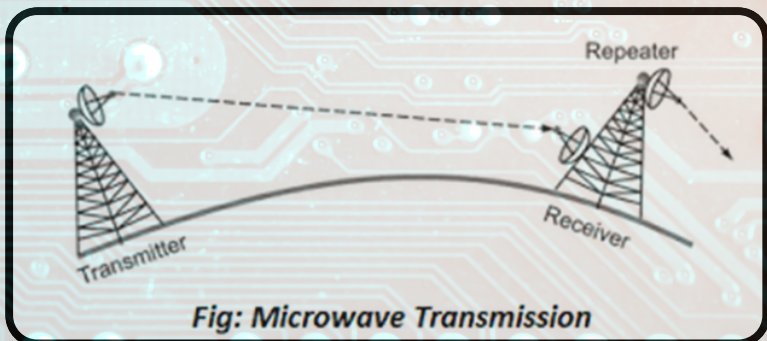


Diagram 3 : Types of transmission using radio Frequency

b . Micro waves

- Microwaves is a line of sight transmission
- Example, the sending and receiving antennas need to be properly aligned with each other.
- The distance covered by the signal is directly proportional to the height of the antenna.
- Frequency for micro waves is Range:1GHz – 300GHz.
- Microwaves transmission are majorly used for mobile phone communication and television distribution.



c . Infrared

- Infrared waves are used for very short distance communication.
 - They cannot penetrate through obstacles.
 - This prevents interference between systems.
- Frequency Range: 300GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc.

Examples the uses of infrared transmission



TUTORIAL EXERCISE



SECTION 2.1 : Transmission Medium in Data Communication

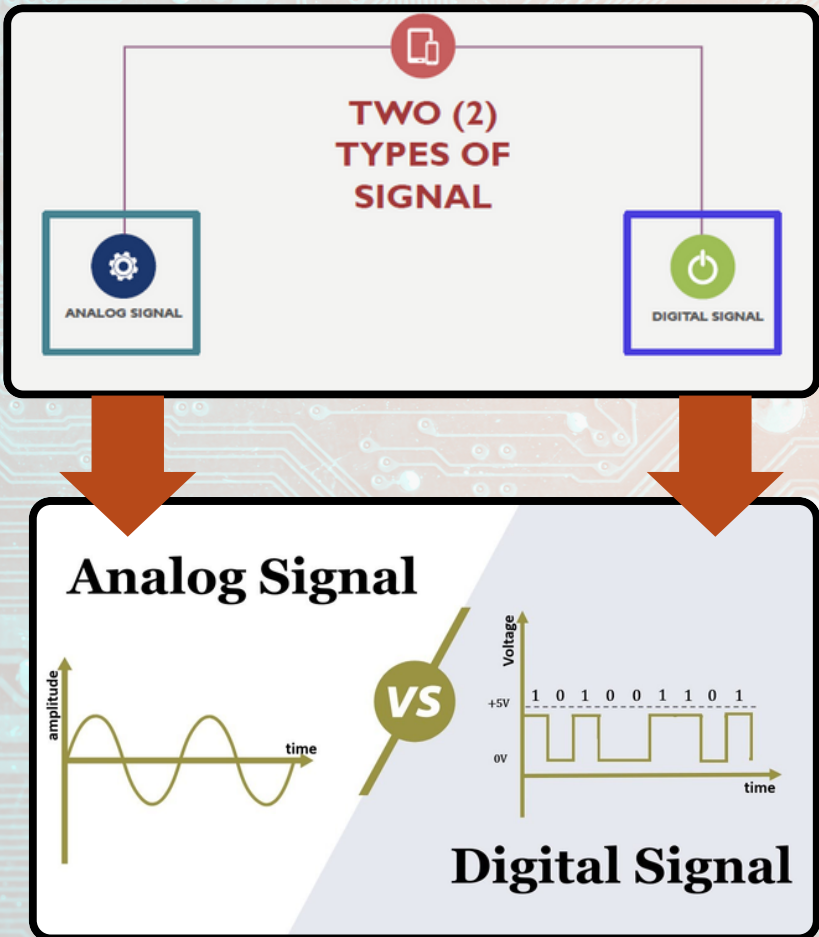
1. Define the concept of a transmission medium in data communication.
2. Briefly explain its role in facilitating the exchange of data between devices.
3. Describe the two main categories of transmission media: guided and unguided.
4. Explore the characteristics and advantages of guided transmission media, such as twisted pair cables, coaxial cables, and fiber-optic cables.
5. Explore the characteristics and advantages of unguided transmission media, such as radio waves, microwaves, and infrared.
6. Discuss the challenges and considerations associated with using unguided transmission media.

2.2 . DATA TRANSMISSION SIGNAL

A signal is an electromagnetic or electrical current that carries data from one system or network to another.

When data is sent over physical medium, it needs to convert into electromagnetic signal which is:

- a. Analog signals
- b. Digital signals.



a .Analog Signal

- An analog signal is a continuous waveform that changes smoothly over time.
- As the wave moves from A to B, it passes through and includes an infinite number of values in its path.
- For example, is the human voice. When someone speaks a wave created that continues in the air. This wave can be captured by a microphone and converted into an analog signal.

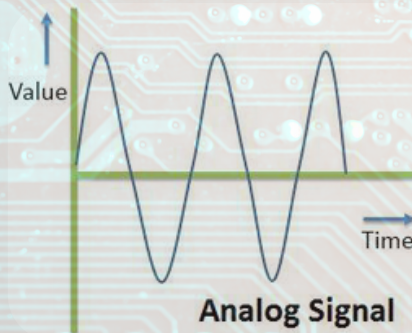
Examples of analog signal



analog clock



Human Voice



Represent by continuous wave form

b . Digital Signal

- A digital signal refers to an electrical signal that is converted into a pattern of bits.
- It must used for computer processing is described as using binary (0s and 1s)
- Data is transmitted through a telephone line, microwave system, and satellite.

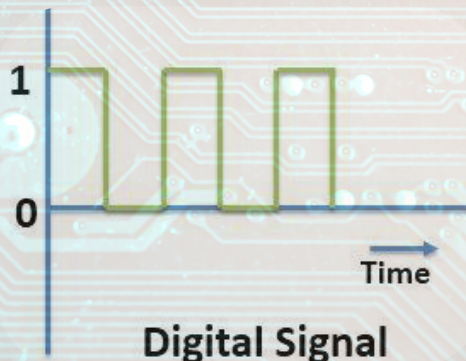
Examples of digital signal



Digital clock



Laptop



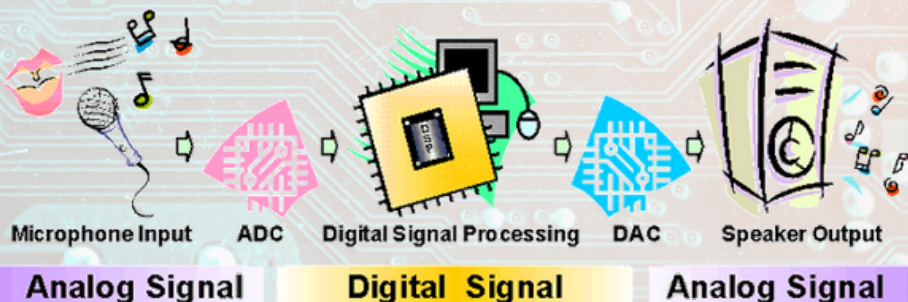
Represent by discrete wave form

Analog signal vs Digital Signal

Analog Signal

Digital Signal

Basic	An analog signal is a continuous wave that changes over a time period.	A digital signal is a discrete wave that carries information in binary form.
Representation	An analog signal is represented by a sine wave.	A digital signal is represented by square waves.
Description	An analog signal is described by the amplitude, period or frequency, and phase.	A digital signal is described by bit rate and bit intervals.
Range	Analog signal has no fixed range.	Digital signal has a finite numbers i.e. 0 and 1.
Distortion	An analog signal is more prone to distortion.	A digital signal is less prone to distortion.
Transmit	An analog signal transmit data in the form of a wave.	A digital signal carries data in the binary form i.e. 0 and 1.
Example	The human voice is the best example of an analog signal.	Signals used for transmission in a computer are the digital signal.



TUTORIAL EXERCISE

SECTION 2.2 : Data Transmission Signal

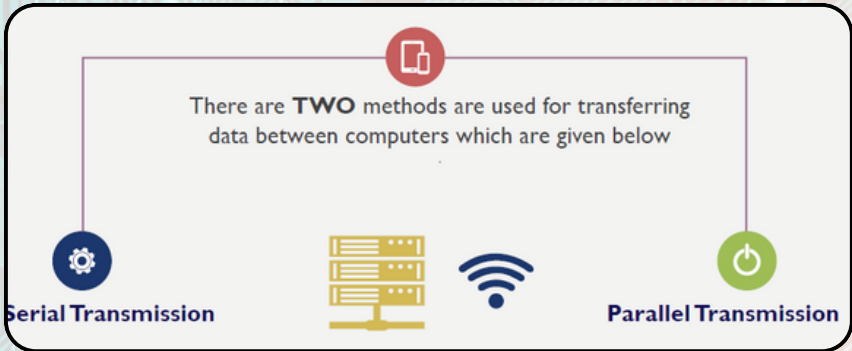


1. Analog signals can take on any continuous value within a given range. (T / F)
2. Digital signals are discrete and can only represent a finite set of values. (T / F)
3. What is the main advantage of digital signals over analog signals in terms of signal quality?
 - A. Higher signal-to-noise ratio
 - B. Greater range
 - C. Simplicity in encoding
 - D. Lower bandwidth requirements
4. Which of the following communication systems is more susceptible to noise and interference?
 - A. Analog
 - B. Digital
 - C. Both equally
5. Describe one application each for analog signals and digital signal are commonly used, and explain why they are preferred in that context.

2.3 . DATA TRANSMISSION TYPE

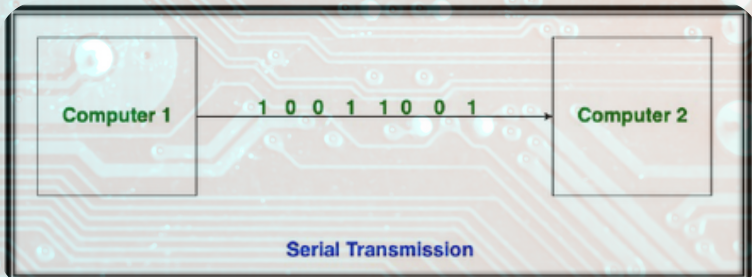
There are two methods used for transferring data between computers which are :

- a. Serial Transmission
- b. Parallel Transmission



a. Serial Transmission

- In Serial Transmission, data-bit flows from one computer to another computer in bi-direction.
- In this transmission, one bit flows at one clock pulse.
- In Serial Transmission, 8 bits are transferred at a time having a start and stop bit.



In Serial Transmission, data-bit flows from one computer to another computer in bi-direction.

b . Parallel Transmission

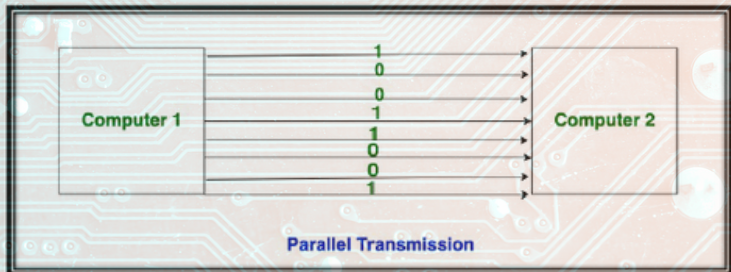
- In Parallel Transmission, many bits are flow together simultaneously from one computer to another computer.
- Parallel Transmission is faster than serial transmission to transmit the bits.
- Parallel transmission is used for short distance.
- Parallel ports can be used to connect a host of popular computer peripherals

Printers

Scanners

CD burners

External hard drives



In Parallel Transmission, many bits are flow together simultaneously from one computer to another computer.

Serial VS Parallel transmission

Serial

- ✓ Single communication link is used to transfer data from one end to another
- ✓ Data(bit) flows in bi-direction
- ✓ Cost-efficient.
- ✓ One bit transferred at one clock pulse.
- ✓ Slow in comparison of Parallel Transmission.
- ✓ Used for long-distance
- ✓ Circuit is simple.
- ✓ Full duplex as sender can send as well as receive the data
- ✓ Converters are required in a to convert the data between internal and parallel form
- ✓ Reliable and straightforward.

Parallel

- ✓ multiple parallels links used to transmit the data
Data(bit) flows in bi-direction
- ✓ Data flows in multiple lines.
- ✓ not cost-efficient.
- ✓ Eight bits transferred at one clock pulse.
- ✓ Fast in comparison of Serial Transmission.
- ✓ Used for short distance.
- ✓ Relatively complex.
- ✓ Half-duplex since the data is either send or receive
- ✓ No converters are required
- ✓ Unreliable and complicated.

TUTORIAL EXERCISE

SECTION 2.3 : Data Transmission Types



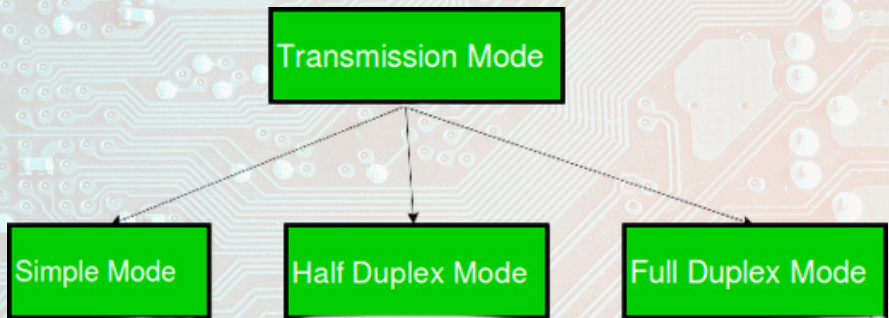
Fill in the blanks with an appropriate answer

1. In _____ data transmission, bits are sent one after another over a single communication channel, reducing the number of required communication lines.
2. In _____ data transmission, multiple bits are sent simultaneously over separate communication lines, allowing for faster data transfer rates.
3. Serial transmission is often preferred in scenarios where _____ is a critical factor, such as long-distance communication or communication over a single wire.
4. Parallel transmission is advantageous in situations where _____ is a priority, as it enables the simultaneous transfer of multiple bits.
5. One common example of _____ data transmission is the use of a single wire or fiber optic cable for transmitting data between devices, often seen in networking and telecommunications.

2.4 .DATA TRANSMISSION MODE

Transmission mode means transferring data between two devices. It is also known as a communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected. Three (3) types of data transmission modes are:

- a. Simplex
- b. Half-duplex
- c. Full-duplex



a. Simplex mode

- In Simplex mode, the communication is unidirectional, as on a one-way street.
- Only one of the two devices on a link can transmit, the other can only receive.
- Simplex channels are not often used because it is not possible to send back error or control signals to the transmit end.
- The simplex mode can use the entire capacity of the channel to send data in one direction.

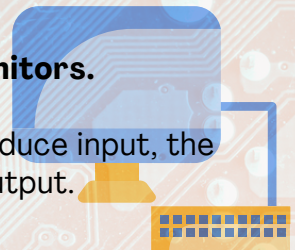


Signal are transmit in only ONE (1) direction

Example simplex mode

Keyboard and traditional monitors.

► The keyboard can only introduce input, the monitor can only give the output.



Advantages

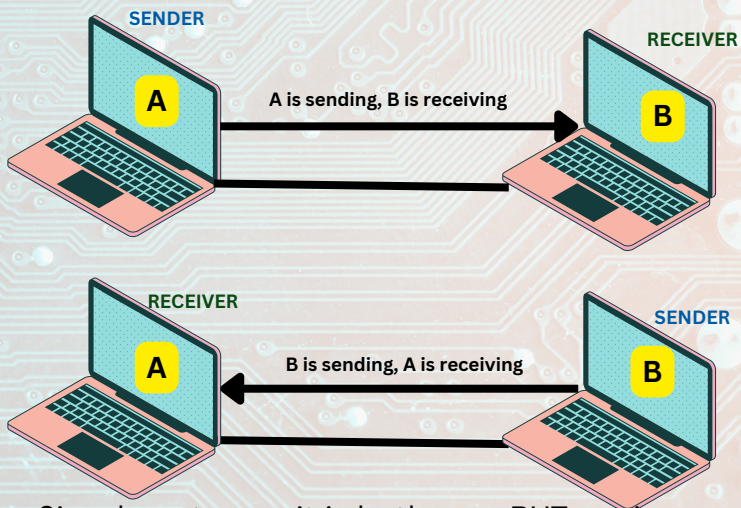
SIMPLEX MODE

Easiest and most reliable mode of communication	Only one-way communication is possible.
Cost-effective mode, only requires one communication channel.	There is no way to verify if the transmitted data has been received correctly.
No need for coordination between the transmitting and receiving devices	Not suitable for applications that require bidirectional communication.
Useful in situations where feedback or response is not required	

Disadvantages

b. Half-duplex mode

- In half-duplex mode, each station can both transmit and receive, but not at the same time.
- When one device is sending, the other can only receive, and vice versa.
- The half-duplex mode is used in cases where there is no need for communication in both directions at the same time.
- The entire capacity of the channel can be utilised for each direction.



Signal are transmit in both way, BUT not in a same time

Example Half-duplex mode

Walkie-talkie

- ▶ Message is sent one at a time and messages are sent in both directions

HALF-DUPLEX MODE

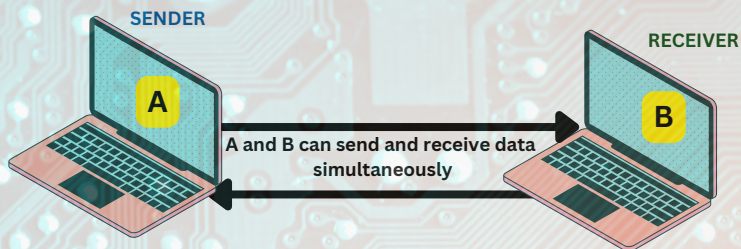
Advantages

Allows for bidirectional communication	Less reliable than Full-Duplex mode, as both devices cannot transmit at the same time.
More efficient mode of communication than simplex mode, as the channel can be used for both transmission and reception	Delay between transmission and reception, which can cause problems in some applications.
Less expensive than full-duplex mode, as it only requires one communication channel.	NEED for coordination between the transmitting and receiving devices, which can complicate the communication process

Disadvantages

c. Full-duplex mode

- In full-duplex mode, both stations can transmit and receive simultaneously.
- In full-duplex mode, signals going in one direction they share the capacity of the link with signals going in another direction.
- Full-duplex mode is used when communication in both directions is required all the time.
- The capacity of the channel, however, must be divided between the two directions.



Signal are transmit in both way at a same time

Example full-duplex mode

Telephone Network

- Communication between two persons by a telephone line, through which both can talk and listen at the same time.

Advantages

FULL-DUPLEX MODE

Allows for simultaneous bidirectional communication, such as video conferencing or online gaming.	Most expensive mode, as it requires two communication channels.
Most efficient mode of communication, as both devices can transmit and receive data simultaneously.	More complex than simplex and half-duplex modes, as it requires two physically separate transmission paths or a division of channel capacity.
Provides a high level of reliability and accuracy, as there is no need for error correction mechanisms	May not be suitable for all applications, as it requires a high level of bandwidth

Disadvantages

TUTORIAL EXERCISE

SECTION 2.4

Question: Data Transmission Mode Structure Questions



1. What is the primary characteristic of simplex mode in data transmission?
2. Give an example of a real-world application that typically uses full-duplex data transmission.
3. What is the advantage of using full-duplex mode over half-duplex mode in certain communication scenarios?
4. Explain a situation where simplex mode might be suitable in data communication.
5. Compare and draw the direction for three (3) modes of data transmission

2.5 . DATA TRANSMISSION IMPAIRMENT

In communication system, analog signals travel through transmission media, which tends to deteriorate the quality of analog signal, which means that the signal at the beginning of the medium is not the same as the signal at the end of the medium.

The imperfection causes signal impairment.

Various factors and conditions can introduce impairments into the transmission process, leading to errors or a reduction in the quality of the transmitted data.

Causes of impairment are:

- a. Attenuation
- b. Distortion
- c. Noise



a. Attenuation

Attenuation: signal strength falls off with DISTANCE. Attenuation Means loss of energy that is the weaker signal. Whenever a signal transmitted through a medium it loses its energy. Amplifiers are used to amplify the signals to compensate for this loss.

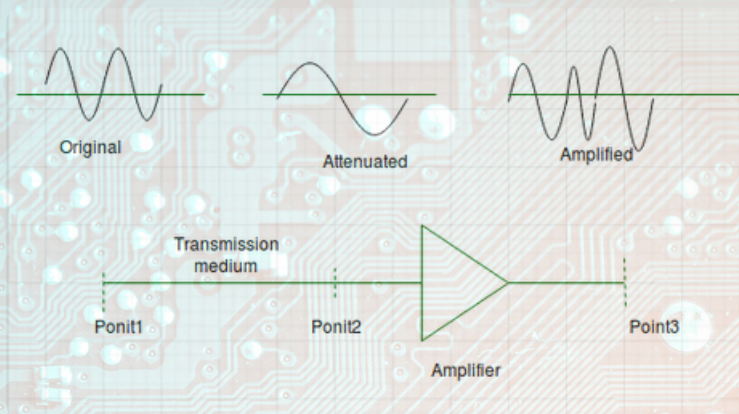


Illustration for attenuation

b. Distortion

Distortion means changes in the form or shape of the signal. This is generally seen in composite signals made up with different frequencies.

Each frequency component has its own propagation speed travelling through a medium. And that's why it delays in arriving at the final destination.

Every component arrives at different times, which leads to distortion. Therefore, they have different phases at the receiver end from what they had at the sender's end.

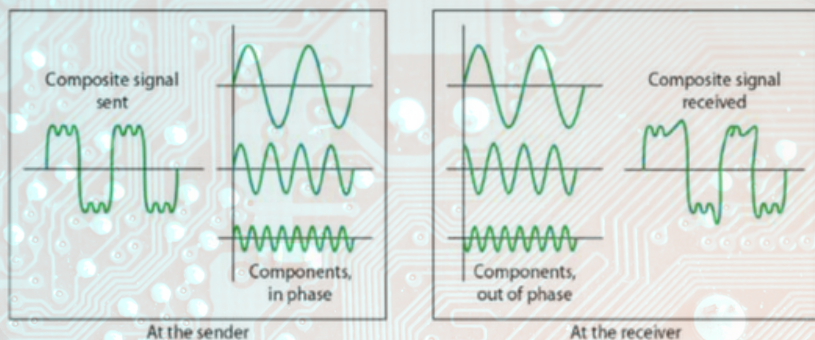


Illustration for distortion

c. Noise

Noise is a random or unwanted signal that mixes up with the original signal is called noise. There are several types of noise that may corrupt the signal such as :

- Induced noise,
- Crosstalk noise,
- Thermal noise and
- Impulse noise

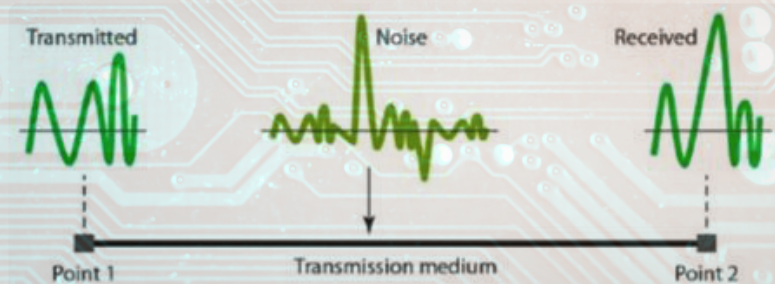


Illustration for Noise



INDUCE NOISE comes from sources such as motors and appliances. These devices act as sending antenna and transmission medium act as receiving antenna.



THERMAL NOISE is movement of electrons in wire which creates an extra signal.



CROSSTALK NOISE is when one wire affects the other wire.



IMPULSE NOISE is a signal with high energy that comes from lightning or power lines

TUTORIAL EXERCISE



SECTION 2.5 Data Transmission Impairment

1. Explain the concept of attenuation in data communication. How does attenuation impact the quality of a transmitted signal, and what are some strategies to address attenuation in a communication system?
2. What role does noise play in data transmission, and how can it be mitigated?
3. Explain the concept of distortion in data transmission and provide an example of a scenario where distortion might occur.
4. Attenuation is the process of increasing signal strength as it travels over a communication medium.
(T / F)
5. Crosstalk occurs when signals from one channel interfere with signals on an adjacent channel, potentially leading to data corruption. (T / F)
6. The use of repeaters or amplifiers is a common strategy to address attenuation and boost signal strength in long-distance data transmission. (T / F)

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