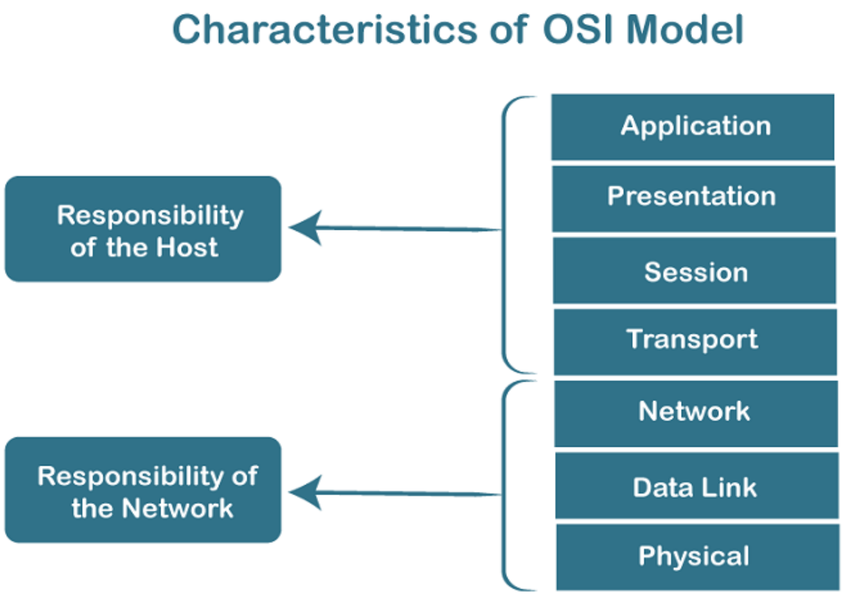
DATA & TELECOMMUNICATION

Introduction

Q-1: Describe any three layers of the OSI model briefly. [FEC_C_01]

Answer: 💡 🌟



Application Layer 📲: The application layer provides network services directly to the end-users, enabling applications to access network resources and communicate with other applications. 📧

Presentation Layer 🖼️: It handles the formatting, encryption, and compression of data for effective presentation to the application layer. 💻

Session Layer 🤝: The session layer establishes, maintains, and terminates sessions between applications, allowing them to communicate and coordinate their interactions. 📝

Transport Layer 📦: It provides reliable and efficient data transport between endpoints, managing flow control, segmentation, and reassembly of data. 🚚

Network Layer 🌍: This layer establishes end-to-end logical paths (routes) for data packets across different networks. It handles addressing, routing, and packet forwarding. 🌐

Data Link Layer 🖇️: It ensures reliable transmission of data frames between directly connected nodes, dealing with error detection and correction. 🚀

Physical Layer 🔌: It represents the actual physical connection and transmission of raw bits over the network, like cables, wires, and electromagnetic signals. 🌐

Q-02:Define data communication. List components needed for data communication. [Pre_3:1_2021]

Answer:

Data communication refers to the transferring of electronic or digital data between two or more devices through a communication medium. It involves the exchange of information in the form of bits, bytes, or packets, enabling effective and efficient communication between devices.

Components needed for data communication include:

Sender/Transmitter: The device or system that initiates and sends the data.

Receiver: The device or system that receives and accepts the data transmitted by the sender.

Medium/Channel: The physical pathway or medium through which the data is transmitted. It can be wired, such as cables (e.g., Ethernet cables) or wireless, such as radio waves or satellite signals.

Protocol: A set of rules and standards that govern the format, encoding, transmission, and decoding of data between devices, ensuring compatibility and reliable communication.

Encoder/Decoder: These components convert the data into a suitable format for transmission and convert received data back into a readable format.

Modem: Short for Modulator-Demodulator, it converts digital signals into analog (modulation) for transmission over analog communication mediums, such as telephone lines, and converts analog signals received back into digital form (demodulation).

Multiplexers/Demultiplexers: These components allow multiple signals/data streams to be combined (multiplexing) and transmitted over a single communication channel, and then separated (demultiplexing) at the receiving end.

Protocols/Standards: These define the rules and specifications for different aspects of data communication, such as addressing, error detection and correction, flow control, and data compression.

Q-03:Define: Jitter, Protocol, Throughput[Pre_3:1_2021]

Answer:

Jitter

Jitter refers to the variation in the delay of packets arriving over a network. Imagine sending data packets like cars on a highway. Ideally, they'd all arrive at the destination at consistent intervals, like a smooth traffic flow. But in reality, some cars might encounter slower traffic, detours, or stop signs, arriving later than others. This inconsistency in arrival times is jitter.

Jitter is measured in milliseconds (ms) and can be caused by various factors, such as:

- Network congestion: When the highway is overloaded, all the cars slow down, causing delays and variations in arrival times.
- Competing traffic: Different types of traffic (heavy trucks, slow-moving vehicles) can cause delays for other cars.
- Routing changes: If the cars have to take a different route due to construction or accidents, their arrival times will change

<u>Protocol</u>

A protocol is a set of rules and procedures that govern how devices communicate with each other. Think of it as a common language or etiquette guide for devices on a network. Protocols define various aspects of communication, including:

- Data format: How information is packaged and structured for transmission.
- Addressing: How devices identify and locate each other on the network.
- Error correction: Techniques for detecting and fixing errors that occur during transmission.
- Flow control: Mechanisms for managing the rate of data exchange to avoid overwhelming the recipient.
- Security: Measures for protecting data from unauthorized access or modification.

Different types of communication have their own specific protocols, for example:

- TCP/IP: The fundamental protocol suite for the internet, defining how data is transmitted across interconnected networks.
- HTTP: The protocol used for web browsing, governing how web pages and servers communicate.
- Bluetooth: The protocol for wireless short-range communication between devices like smartphones and headphones.

<u>Throughput</u>

Throughput refers to the rate at which data is successfully transferred over a network or communication channel.Depends on various factors like:

- Bandwidth: The capacity of the transmission medium to carry data. A wider highway can handle more cars per minute.
- Network congestion: Heavy traffic will slow down the overall throughput.
- Protocol efficiency: Different protocols have different overhead (additional data used for communication) that can impact throughput.
- Hardware limitations: The capabilities of the sending and receiving devices can also affect throughput.

Q-04:Differentiate LAN and WAN./ , MAN, INTERNET [Pre_3:1_2021]

Answer:

🌐 LAN (Local Area Network):

- LAN refers to a network that spans a relatively smaller geographic area, such as a home, office building, or school campus.

- It is designed to connect devices within a limited area, typically using Ethernet cables or Wi-Fi.

- LANs are commonly used for file sharing, printer sharing, and local communication among connected devices.

- Example: 😜 🖥️ 🖨️ 📱 Devices in a single house connected to a router.

🌍 WAN (Wide Area Network):

- WAN refers to a network that covers a larger geographic area, connecting multiple LANs or other networks across different locations.

- It may use various technologies like leased lines, satellites, or internet connections to establish connections between distant sites.

- WANs often involve multiple interconnected routers and are typically provided by service providers.

- Example: 😜 🌐 🏢 🌐 🏛️ 🌐 Multiple branches of a company connected together across different cities.

🏙️ MAN (Metropolitan Area Network):

- MAN refers to a network that spans a larger geographical area than a LAN but smaller than a WAN.

- It typically covers a city or a metropolitan area.

- MANs are usually built using high-speed fiber optic cables and other technologies.

- They are designed to connect multiple LANs and serve as a communication infrastructure for organizations within a specific region.

- Example: 😜 🏢 🌆 A network connecting different buildings of a university across a city.

🌐 Internet:

- The Internet is a global network of networks, connecting millions of devices worldwide.

- It is not limited to a specific geographic area.

- The Internet uses various technologies and protocols, including routers, switches, and the IP (Internet Protocol) suite.- *Example:* 😜 🌍 📱 💻 📟 A network of networks connecting people, Q-05: What are the basic characteristics of an effective data communication system? [Pre_3:1_2020]

Answer:

An effective data communication system possesses the following basic characteristics:

🔌 Reliability: The system should ensure reliable transmission of data, with minimal errors and disruptions. This involves error detection, correction, and handling of any failures in the network infrastructure.

📶 Speed: The system should provide fast and efficient data transfer rates, meeting the requirements of the users and applications. High-speed communication allows for quick transmission and reception of data.

🔒 Security: The system should have mechanisms in place to protect data from unauthorized access, interception, and manipulation. This involves encryption, authentication, and implementation of security protocols to safeguard the confidentiality and integrity of transmitted data.

📊 Scalability: The system should be scalable to accommodate the growing needs of data transmission. As the number of users and data volumes increase, the system should be able to handle the increased traffic without significant degradation in performance.

🌐 Compatibility: The system should be compatible with different types of devices, operating systems, and protocols. Compatibility allows for seamless integration and communication between various systems and ensures interoperability.

🎯 Efficiency: The system should utilize network resources efficiently, minimizing bandwidth wastage and latency. Efficiency can be achieved through techniques such as compression, data packet optimization, and traffic management.

🌐 Connectivity: The system should support connectivity across different locations, enabling data transfer between geographically dispersed entities. This includes support for various networking technologies, such as wired (Ethernet), wireless (Wi-Fi, cellular), and satellite connections.

💾 Storage and retrieval: The system should have mechanisms to store and retrieve data when required. This may involve data storage solutions like databases, cloud storage, or distributed file systems.

By incorporating these characteristics, a data communication system can facilitate the reliable, secure, and efficient exchange of data between different devices and systems.

Q-06: Sketch a general block diagram of a data communication system and explain the functions of each component. [Pre_3:1_2020]

Answer:

Here's a general block diagram of a data communication system:

```
+-----------------------+
|     Data Source       |
+-----------------------+
            |
            | Data Generation
            |
+-----------------------+
|   Data Encoding/      |
| Modulation/Conversion |
+-----------------------+
            |
            | Signal Transmission
            |
+-----------------------+
| Communication Channel |
+-----------------------+
            |
            | Signal Reception
            |
+-----------------------+
| Demodulation/Conversion |
|   /Decoding/Processing  |
+-----------------------+
            |
            | Data Delivery
            |
+-----------------------+
|     Data Receiver     |
+-----------------------+
```

Explanation of each component:

Data Source: This is the origin of the data that needs to be transmitted. It can be a computer, sensor, microphone, or any device generating data.

Data Encoding/Modulation/Conversion: This component takes the raw data and converts it into a suitable format for transmission.

Signal Transmission: This stage involves the actual transmission of the encoded data over a communication channel. The channel can be wired (e.g., Ethernet cables) or wireless (e.g., radio waves or optical signals).

Communication Channel: This is the medium through which the signal is transmitted. It can include various physical media like cables, fiber optics, or airwaves. The channel introduces noise, distortion, and other impairments to the signal.

Signal Reception: The received signal is passed to the receiver component, where it undergoes amplification and filtering to improve its quality.

Demodulation/Conversion/Decoding/Processing: In this stage, the received signal is converted back into the original format.

Data Delivery: The processed data is then delivered to the appropriate destination or recipient, such as a computer, display device, or storage system.

Data Receiver: This is the final component that receives the delivered data and makes it available to the user or application.

Q-07:Define protocol? What are the key elements of a protocol? [Pre_2:2_2021]

A protocol is a set of rules and guidelines that governs the communication or interaction between different entities or systems. It specifies the format, timing, sequencing, and error control mechanisms for transmitting data. Protocols are commonly used in various domains, including computer networks, telecommunications, and internet communication.

The key elements of a protocol typically include:

Syntax: This element defines the structure and format of the data to be exchanged. It specifies the rules for encoding data, such as the use of specific characters, delimiters, or data types.

Semantics: Semantics refers to the meaning or interpretation of the data being exchanged. It establishes the rules and conventions for how data should be understood by the sender and receiver. Semantics define the purpose, context, and intended actions associated with the transmitted data.

Timing: Timing aspects of a protocol ensure proper synchronization between the sender and receiver. It defines when data transmission can occur, how long to wait for a response, and the order in which data is exchanged.

Error Control: Protocols incorporate mechanisms to detect and correct errors that can occur during data transmission. These mechanisms include error detection codes, acknowledgment signals, retransmission strategies, and error recovery procedures.

Flow Control: Flow control mechanisms regulate the rate of data transmission between the sender and receiver to prevent data overload or congestion. They ensure that data is sent at an appropriate rate based on the capacity and capabilities of the receiving entity.

Session Management: Protocols often include session management elements to establish, maintain, and terminate communication sessions between entities. Session management includes features like session initiation, authentication, session security, and session teardown.

Q-08: For n devices in a network, what is the number of cable links required in a mesh, ring, bus, and star topology? [Pre_2:2_2021]

Here's a breakdown of the number of cable links required for different network topologies, along with visual examples:

Mesh Topology:

- Number of cable links: n(n-1)/2
- Explanation: Every device is directly connected to every other device, creating a web-like structure. This requires a separate cable for each possible pair of devices.

Ring Topology:

- Number of cable links: n
- Explanation: Devices are connected in a circular loop, with each device linked to its two immediate neighbors. Data travels around the ring in a single direction.

Bus Topology:

- Number of cable links: n-1
- Explanation: All devices are connected to a single, shared backbone cable. Data travels along this central cable, and each device can access it as needed.

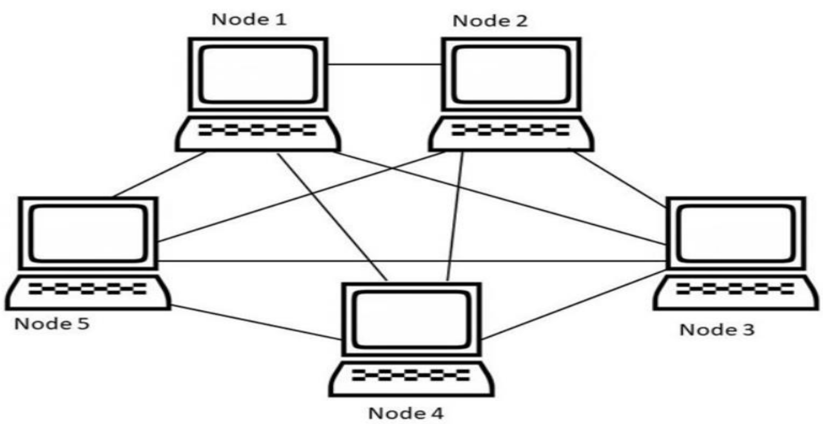
Star Topology:

- Number of cable links: n
- Explanation: All devices are connected to a central hub or switch. Data is transmitted between devices through this central device, which acts as a traffic controller.

Q-08:Explain different network topologies. (Image: Diagrams of mesh, bus, ring, and star topologies) [Pre_3:1_2021]

Mesh Topology:

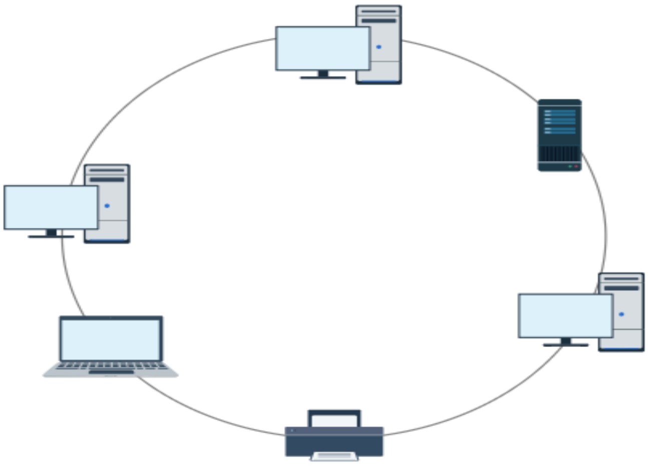
- Description: Every device is directly connected to every other device, creating a web-like structure.
- Diagram: [Link to visual representation of Mesh Topology]



- Advantages:
    - High redundancy: Multiple paths for data transmission, ensuring reliability even if some links fail.
    - Increased fault tolerance: Network can function even with multiple device failures.
- Disadvantages:
    - High cost: Requires a large number of cables and connections.
    - Complex installation and configuration.
    - Potential for increased traffic congestion.

Ring Topology:

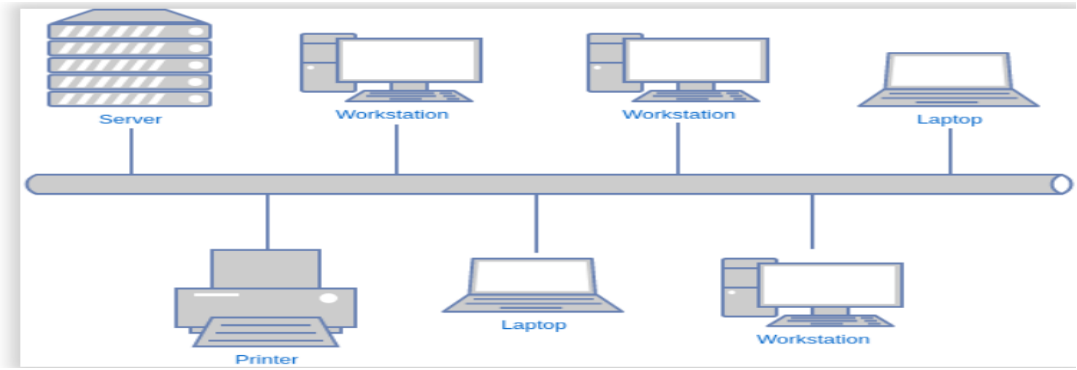
- Description: Devices are connected in a circular loop, with data traveling in one direction.
- Diagram: [Link to visual representation of Ring Topology]



- Advantages:
    - Efficient data transmission: Data flows in a continuous circle.
    - No need for a central device.
- Disadvantages:
    - Vulnerable to single point of failure: A break in the ring can disrupt the entire network.
    - Troubleshooting can be challenging.

Bus Topology:

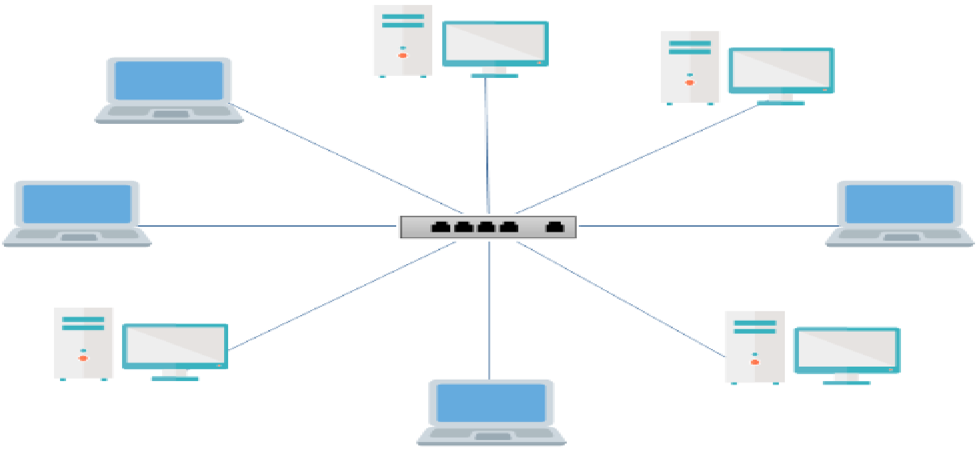
- Description: All devices are connected to a single, shared backbone cable.
- Diagram: [Link to visual representation of Bus Topology]



- Advantages:
    - Simple and inexpensive to implement.
    - Easy to add or remove devices.
- Disadvantages:
    - Vulnerable to cable failures: A single cable break can disrupt the entire network.
    - Prone to congestion and collisions: Only one device can transmit at a time.

Star Topology:

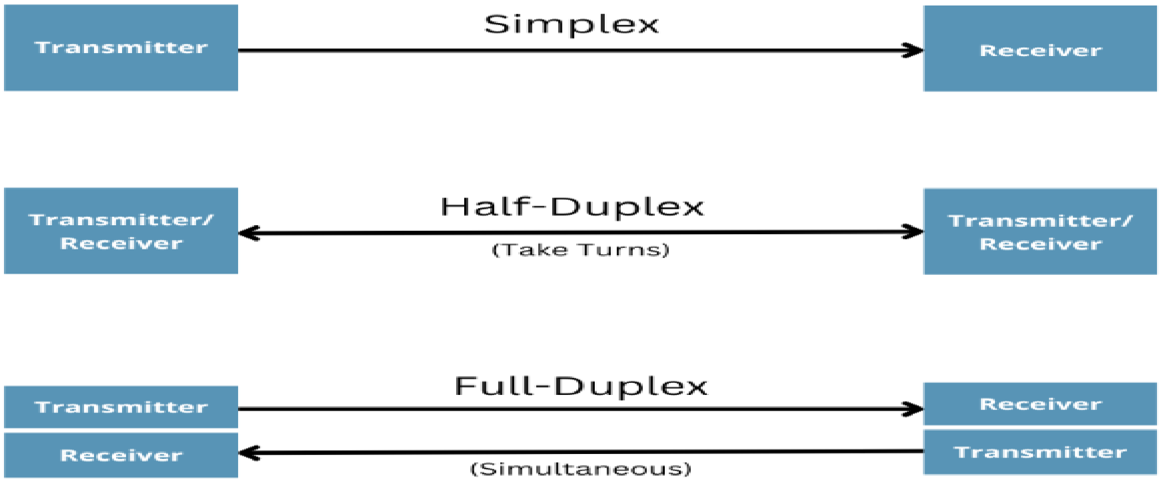
- Description: All devices are connected to a central hub or switch.



- Advantages:
    - Easy to manage and troubleshoot: Central device controls and monitors the network.
    - Scalable: Easy to add or remove devices.
    - Fault isolation: A single device failure doesn't affect the entire network.
- Disadvantages:
    - Dependent on central device: A failure of the hub or switch can bring down the entire network.

Q-09:Differentiate among Simplex, Half-duplex and Full-duplex modes with appropriate figures. [Pre_3:1_2020]

This presentation explores three dominant modes - Simplex, Half-duplex, and Full-duplex - with a focus on their distinct data flow directional characteristics.



1. Simplex Mode:

This single-direction data transmission characterizes the Simplex mode. Information flows seamlessly from a singular sender to one or multiple receivers, fostering broadcast-like scenarios.

- Flow Direction: Unidirectional (Sender → Receiver)
- Application Examples: Radio broadcasting, television transmissions, satellite communication

2. Half-duplex Mode:

Now picture a two-way road, albeit one where traffic must take turns, flowing first in one direction and then the other. This aptly illustrates the Half-duplex mode, where data transmission occurs in both directions, but not simultaneously. Flow Direction: Bi-directional, alternating (Sender → Receiver, then Receiver → Sender)

- Application Examples: Walkie-talkies, early Ethernet networks, mobile phone calls

3. Full-duplex Mode:

Consider a multi-lane highway, where dedicated lanes facilitate traffic flow in both directions concurrently. This represents the Full-duplex mode, allowing for simultaneous bi-directional data transmission. Devices exchange information independently, maximizing efficiency and enabling real-time interactions. Video conferencing and online gaming exemplify situations where seamless data flow in both directions is crucial.

- Flow Direction: Bi-directional, simultaneous (Sender ⇔ Receiver)
- Application Examples: Ethernet networks, fiber optic cables, Wi-Fi, video conferencing, online gaming

Comparative Overview:

Feature	Simplex	Half-duplex	Full-duplex
Data Flow Direction	Unidirectional	Bi-directional, alternating	Bi-directional, simultaneous
Transmission Channels	Single	Single	Dual
Analogy	One-way street	Two-way street with alternating traffic	Highway with dedicated lanes for both directions
Applications	Broadcasting, dissemination	Two-way communication with occasional delays	Interactive applications, real-time data exchange

Q-10:Key elaments of a Protocol, TCP/IP.

Here's a breakdown of the key elements of a protocol, with a focus on TCP/IP, incorporating images for enhanced understanding:

Key Elements of a Protocol:

1. Syntax:
    - How data is structured and formatted for transmission.
    - Defines rules for message length, data types, and field ordering.
    - Example in TCP/IP: IP packet header format, specifying fields like source address, destination address, and protocol version.
2. Semantics:
    - The meaning of the data being exchanged.
    - Defines actions to be taken in response to specific messages or events.

    - Example in TCP/IP: HTTP request methods (GET, POST, PUT, etc.) each conveying different actions to be performed by the server.

3. Timing:
    - The sequence and timing of message exchanges.
    - Coordinates events like when to send or receive data, and how to handle delays or errors.
    - Example in TCP/IP: TCP's three-way handshake for establishing a reliable connection.
4. Error handling:
    - Methods for detecting and handling errors during communication.
    - Includes mechanisms for retransmission of lost or corrupted data, and error correction techniques.
    - Example in TCP/IP: TCP's checksum calculation for data integrity verification.
5. Flow control:
    - Manages the rate of data transmission to prevent overwhelming the receiver.
    - Regulates the amount of data that can be sent at a time.
    - Example in TCP/IP: TCP's sliding window mechanism for adaptive flow control.

<u>TCP/IP (Transmission Control Protocol/Internet Protocol):</u>

- The foundation of internet communication.
- Suite of protocols working together to enable devices to communicate and exchange data over networks.
- Four-layer model:
    - Application layer: Provides services directly to applications (e.g., HTTP, FTP, SMTP).
    - Transport layer: Manages end-to-end communication and reliability (e.g., TCP, UDP).
    - Internet layer: Handles addressing and routing of packets (e.g., IP).
    - Network access layer: Interacts with physical hardware for data transmission (e.g., Ethernet, Wi-Fi).

Physical Layer

Q-01: Write a short note on the causes of transmission impairments.

Or, Discuss on transmission impairments OSI model. [FEC_C_01]

Answer:

Transmission impairments can occur in a communication system and affect the quality and integrity of transmitted data. Several factors can contribute to these impairments. Here are the key causes:

1. Attenuation: Attenuation refers to the loss of signal strength as it travels through a transmission medium, such as copper wire or fiber optic cable. Factors like distance, poor quality cables, and environmental interference can cause attenuation. As the signal weakens, it becomes harder to distinguish the original data, resulting in errors.

2. Distortion: Distortion occurs when the shape or integrity of the transmitted signal is altered during propagation. It can be caused by factors like electromagnetic interference (EMI), noise, or improper impedance matching in transmission equipment. Distortion can lead to signal degradation, making it difficult for the receiver to correctly interpret the transmitted data.

3. Noise: Noise is an unwanted random signal that interferes with the intended communication signal. It can be generated by various sources, including electrical interference from nearby devices, thermal noise, or external factors like atmospheric conditions. Noise adds unwanted fluctuations to the signal, making it harder to extract the original data accurately.

4. Delay: Delay refers to the time it takes for a signal to reach its destination. Excessive delay can occur due to long distances, congested networks, or inefficient routing. Delay can affect real-time applications like voice or video communication by causing issues such as latency and jitter

5. Crosstalk: Crosstalk is the undesired coupling of signals between adjacent communication channels or wires. It occurs when signals from one channel "leak" into another, resulting in interference and potential data corruption. Crosstalk can happen in scenarios like improperly shielded cables or tightly packed wire bundles.

6. Bit errors: Bit errors occur when transmitted data bits are incorrectly received at the receiving end. Bit errors can result from transmission impairments like attenuation, noise, or interference. Bit errors can be detected and corrected using error detection and correction techniques such as checksums or forward error correction (FEC) codes.

It's important to identify and minimize transmission impairments to ensure reliable and high-quality communication. Techniques such as signal amplification, error detection and correction, proper cable installation, and shielding can help mitigate the impact of these impairments.

Q-02: Convert the following data into signals using NRZ-I, Differential Manchester, and MLT-3 encoding techniques. [FEC_C_01]

(i) 10110001 (ii) 01001110

Answer:

Data: (i) 10110001 (ii) 01001110

<u>NRZ-I (Non-Return-to-Zero Inverted):</u>

(i) 10110001:

Signal: + - + - + + + + -

(ii) 01001110:

Signal: - + - - + + + + -

<u>Differential Manchester:</u>

(i) 10110001 (ii) 01001110

Signal: +0 -1 +1 -0 +1 +0 +0 -1

Signal: -1 +0 -0 +1 -0 -1 -1 +0

<u>MLT-3 (Multi-Level Transmit-3):</u>

(i) 10110001 (ii) 01001110:

Signal: +0 -Z +Z -Z +Z +0 +0 -Z

Signal: -Z +0 -Z +Z -Z -Z -Z +0

<u>*NRZ-I:*</u>

- High voltage (+V) represents a 1.
- Low voltage (-V) represents a 0.
- No transition at the start of a 1 bit.

<u>*Differential Manchester:*</u>

- Transition at the beginning of each bit period.
- Additional transition in the middle of the bit period for a 0.
- No transition in the middle of the bit period for a 1.

<u>*MLT-3:*</u>

- Three voltage levels: +V, 0V, -V.
- Each bit is represented by three signal levels, ensuring at least one transition per bit.
- Z represents a zero voltage level.

Q-03: We have a channel with 1MHz bandwidth. The SNR of the channel is 63. What are the appropriate bit rate and signal level? [FEC_C_01]

Answer:

To determine the appropriate bit rate and signal level for a channel with a given bandwidth and signal-to-noise ratio (SNR), we can use the Shannon Capacity formula:

$C = B * \log2(1 + SNR)$,

where C is the channel capacity, B is the bandwidth, and SNR is the signal-to-noise ratio.

Given:

Bandwidth (B) = 1 MHz

Signal-to-Noise Ratio (SNR) = 63

Let's calculate the channel capacity:

$C = 1 \text{ MHz} * \log2(1 + 63)$

$C \approx 1 \text{ MHz} * \log2(64)$

$C \approx 1 \text{ MHz} * 6$

$C \approx 6 \text{ MHz}$

The channel capacity is approximately 6 Mbps (megabits per second).

Now, to determine the appropriate bit rate and signal level, we can consider the channel capacity as the maximum achievable bit rate. However, to ensure reliable communication with minimal errors, we usually use a bit rate lower than the channel capacity.

Assuming we want to use a bit rate that is 70% of the channel capacity:

Bit rate = 0.7 * channel capacity

Bit rate = 0.7 * 6 Mbps

Bit rate ≈ 4.2 Mbps

<u>Therefore, an appropriate bit rate could be approximately 4.2 Mbps.</u>

Q-04: Describe ASK, FSK, FM, PM briefly. [Pre_FEC_C_01]

Answer:

1. ASK (Amplitude Shift Keying): ASK is a digital modulation technique where the amplitude of the carrier signal is switched between two or more levels to represent different digital symbols. A high-level amplitude represents one symbol, while a low-level amplitude represents another symbol.

2. FSK (Frequency Shift Keying): FSK is a digital modulation technique where the carrier signal's frequency is switched between two or more frequencies to represent different digital symbols. Each frequency represents a specific digital symbol, and the receiver detects the frequency changes to decode the symbols.

3. FM (Frequency Modulation): FM is an analog modulation technique where the frequency of the carrier signal varies continuously in proportion to the amplitude of the modulating signal (audio or data signal). The variations in frequency represent the information being transmitted.

4. PM (Phase Modulation): PM is an analog modulation technique where the phase of the carrier signal is modified according to the variations of the modulating signal. The changes in phase represent the encoded information.

Q-05: Describe NRZ-I and NRZ-L schemes of Line Coding. [Pre_FEC_C_01]

Answer:

Here's a description of NRZ-I and NRZ-L schemes of Line Coding:

NRZ (Non-Return-to-Zero) schemes are a group of line coding techniques where the signal does not return to zero voltage between consecutive bits with the same value. This makes them efficient in terms of bandwidth usage but can present some challenges.

<u>NRZ-L (NRZ-Level)</u>

- Signal level determines the bit value:
  - High voltage level (typically +V) represents a binary 1.
  - Low voltage level (typically -V or 0V) represents a binary 0.
- Pros:
  - Simple to implement.
  - Efficient use of bandwidth.
- Cons:
  - Susceptible to DC wander (long sequences of 1s or 0s can cause a DC bias in the signal).
  - Difficult to clock recovery for long sequences of 1s or 0s.

NRZ-I (NRZ-Invert)

- Transitions indicate a binary 1:
  - A transition (change in voltage level) occurs at the beginning of a bit interval if the bit is a 1.
  - No transition occurs if the bit is a 0.
- Pros:
  - Better clock recovery than NRZ-L, as there's at least one transition per two bits.
  - Less susceptible to DC wander.
- Cons:
  - Still can have synchronization issues for long sequences of 0s.

Q-06:Define data rate and signal rate. [Pre_FEC_C_01]

Answer:

Data Rate:

Data rate, also known as bit rate or symbol rate, refers to the rate at which data is transmitted over a communication channel. It measures the number of bits or symbols transmitted per unit of time. The data rate is typically expressed in bits per second (bps), kilobits per second (Kbps), megabits per second (Mbps), or gigabits per second (Gbps). It represents the capacity or throughput of the communication channel and determines how quickly data can be transmitted.

Signal Rate:

Signal rate, also known as baud rate or modulation rate, refers to the rate at which signal elements or symbols are transmitted over a communication channel. In digital communication, these signal elements are used to represent data in the form of voltage or frequency levels. The signal rate is measured in baud, which represents the number of symbol changes per second. It is important to note that the signal rate and data rate may not be the same, especially in the presence of encoding schemes that transmit multiple bits per symbol.

Q-07:An analog signal has a bit rate of 8000 bps and a baud rate of 1000 baud. How many data elements are carried by each signal element? How many signal elements do we need? [Pre_FEC_C_01]

Answer:

In an analog signal with a bit rate of 8000 bps and a baud rate of 1000 baud:

- Data elements carried per signal element: To determine this, we need to find the ratio of bit rate to baud rate. Data elements per signal element = Bit rate / Baud rate Data elements per signal element = 8000 bps / 1000 baud Data elements per signal element = 8
- Signal elements required: Since the baud rate is given as 1000 baud, the number of signal elements needed would be the same as the number of data elements per signal element. Therefore, we would need 8 signal elements.

Q-08: Define: i) Signal Element and Data Element ii) Data Rate and Signal Rate. [Pre_3:1_2020]

Answer:

i) Signal Element: A signal element refers to the smallest unit of a signal used to represent data. In digital communication, it can represent a bit or multiple bits depending on the encoding scheme.

ii) Data Rate: Data rate, also known as bit rate or symbol rate, is the rate at which data is transmitted over a communication channel. It measures the number of bits or symbols transmitted per unit of time.

Signal Rate: Signal rate, also known as baud rate or modulation rate, is the rate at which signal elements or symbols are transmitted over a communication channel. It represents the number of symbol changes per second.

Q-09: Draw the graph of the NRZ-L and Manchester scheme using each of the following data streams: [Pre_3:1_2020] i)11111111

ii) 00000000

iii) 00110011

iv) 01010101

Graphs of NRZ-L and Manchester schemes for the given data streams:

i) 11111111: NRZ-L: Manchester: 

ii) 00000000: NRZ-L: Manchester: 

iii) 00110011: NRZ-L: Manchester: 

iv) 01010101: NRZ-L: Manchester:

Q-10: What are the differences between Periodic and Non-periodic Signals? [Pre_3:1_2020]

Differences between Periodic and Non-periodic Signals:

Answer:

Periodic Signals:

- Periodic signals repeat themselves over time.
- They have a regular, predictable pattern.
- They exhibit periodicity, where a waveform is reproduced identically after a specific time interval called the period.
- Examples include sine waves, square waves, and triangular waves.

Non-periodic Signals:

- Non-periodic signals do not repeat themselves.
- They lack a fixed pattern and do not exhibit periodicity.
- They may represent random events or data.
- Examples include noise signals, speech signals, and transient signals.

Q-11:Explain various types of transmission impairment with appropriate diagrams. [Pre_3:1_2020]

Answer:

Various types of transmission impairment with appropriate diagrams:

1. Attenuation:
   - Attenuation refers to the loss of signal strength as it propagates through a medium.
   - It can be caused by factors such as distance, resistance, or obstacles in the transmission path.
   - The diagram would show a decrease in signal amplitude over distance or time.
2. Distortion:
   - Distortion occurs when a signal undergoes changes in its waveform during transmission.
   - It can be caused by factors such as frequency-dependent attenuation, noise, or improper equipment.
   - The diagram would show a distortion in the shape or amplitude of the signal.
3. Noise:
   - Noise refers to unwanted random variations or disturbances that interfere with the original signal.
   - It can be caused by external sources, such as electromagnetic interference or crosstalk.
   - The diagram would show additional random variations or spikes superimposed on the original signal.

Q-12:What is the relationship between period and frequency? [Pre_3:1_2020]

Answer:

The relationship between period and frequency:

- The period (T) of a signal refers to the time taken for one complete cycle of the waveform.
- Frequency (f) represents the number of cycles per second.
- The relationship between period and frequency is reciprocal: Frequency (f) = 1 / Period (T) Period (T) = 1 / Frequency (f)

Draw the graph of NRZ-L and NRZ-I scheme for the following data stream:

- (i) 1011101011 (ii) 00110011

Graphs of NRZ-L and NRZ-I schemes for the given data streams: (i) 1011101011: NRZ-L: NRZ-I:

(ii) 00110011: NRZ-L: NRZ-I:

Q-13:Define Line Coding, Signal Element, Periodic Signal, and Composite Signal with examples.

- Line Coding: Line coding is the process of converting digital data into a sequence of signals suitable for transmission over a communication channel. It involves mapping the digital bits to specific signal elements. Examples of line coding schemes include Unipolar, Polar, Bipolar, and Manchester encoding.
- Signal Element: Signal element refers to the smallest unit of a signal that carries information. In line coding, each signal element represents a specific bit or group of bits. For example, in binary line coding, a signal element may represent a single bit (0 or 1).
- Periodic Signal: A periodic signal is a signal that repeats itself over time. It forms a pattern that can be represented mathematically by a periodic function. Examples of periodic signals include sine waves, square waves, and triangular waves.
- Composite Signal: A composite signal is a signal that consists of multiple individual signals combined together. These individual signals may have different frequencies, amplitudes, and phases. An example of a composite signal is a music audio signal, which is a combination of various frequencies and amplitudes representing different musical instruments and notes.

Q-14:Define: Manchester, Signal rate, Multilevel 2B1Q. [Pre_3:1_2021]

Answer:

- Manchester: Manchester encoding is a line coding scheme in which each bit is represented by a transition from one voltage level to another in the middle of the bit period. It provides a self-clocking mechanism and improves synchronization between the sender and receiver.

- Signal rate: Signal rate, also known as baud rate, is the number of signal elements transmitted per unit of time. It is measured in baud or symbols per second. In digital communication, the signal rate determines the maximum data transmission rate.
- Multilevel 2B1Q: Multilevel 2B1Q is a line coding scheme used in digital subscriber line (DSL) communication. It allows the transmission of two bits per symbol by encoding two binary bits into a quaternary symbol. It achieves efficient use of bandwidth by representing multiple bits with each symbol.

Q-15:Calculate final signal power after -10dB attenuation of a 5W signal. [Pre_3:1_2021]

Answer:

To calculate the final signal power after a -10dB attenuation of a 5W signal, we can use the formula for decibel power ratio: Final Power = Initial Power × 10^(Attenuation in dB / 10)

Given: Initial Power = 5W Attenuation = -10dB

Plugging in the values: Final Power = 5W × 10^(-10dB / 10) Final Power = 5W × 10^(-1) Final Power = 5W × 0.1 Final Power = 0.5W

Therefore, the final signal power after -10dB attenuation of a 5W signal is 0.5W.

Q-16:Draw the bandwidth of a 3000 Hz composite signal with two sine waves (100 Hz, 30V; and max 10V). [Pre_3:1_2021]

Answer:

To draw the bandwidth of a 3000 Hz composite signal with two sine waves (100 Hz, 30V; and max 10V), you would need to provide more information, such as the frequency range for the composite signal and the specific frequencies and amplitudes of the individual sine waves within that range.

Q-17:Write down the functions of DTE and DCE with examples. [Pre_2:2_2021]

Answer:

- DTE (Data Terminal Equipment): DTE refers to the end-user devices or equipment that generate, process, or receive data. It can be a computer, smartphone, printer, or any device that interacts with a network. The function of DTE is to provide or consume data and communicate with other devices. For example, a personal computer sending data to a printer.
- DCE (Data Circuit-terminating Equipment): DCE is the equipment that provides the interface between DTE and the communication channel or transmission medium. It serves as an interface device that ensures proper transmission of data between DTEs over a communication network. Examples of DCE include modems, routers, bridges, and

switches. For instance, a router connecting a computer network to an internet service provider (ISP).

Q-18:An analog signal carries eight bits in each signal element. If 2500 signal elements are sent per second, find the Baud rate and the Bit rate. [Pre_2:2_2021]

Answer:

Baud rate: 2500 baud Bit rate: 20000 bps

Explanation:

- Baud rate is the number of signal elements transmitted per second. Here, 2500 signal elements are sent per second, resulting in a baud rate of 2500 baud.
- Bit rate is the number of bits transmitted per second. Since each signal element carries 8 bits, the bit rate is 2500 baud * 8 bits/baud = 20000 bps.

Q-19: Describe byte stuffing and unstuffing strategy in Character Oriented Protocols?

Answer:

In Character Oriented Protocols, byte stuffing and unstuffing are strategies used to ensure reliable transmission of data. Here's a description of each strategy:

- Byte stuffing: Byte stuffing is a technique used to ensure data integrity in communication protocols. It involves inserting additional bytes into the data stream to distinguish special characters from the actual data. For example, if a special character needs to be transmitted, it can be preceded or followed by an escape character. The receiver then performs the reverse operation and removes the inserted bytes, reconstructing the original data stream.
- Byte unstuffing: Byte unstuffing is the process of removing the additional bytes inserted during the byte stuffing process. The receiver scans the data stream for the escape characters and eliminates the added bytes, reconstructing the original data.

Byte stuffing and unstuffing strategies help to prevent data misinterpretation or corruption when special characters are part of the data being transmitted.

Q-20: How baseline wandering can be prevented? [Pre_3:1_2020]

Answer:

Baseline wandering is the gradual shift or movement of the baseline (average voltage level) in a communication system. It can occur due to factors such as imperfect synchronization, noise, or interference. Here's how baseline wandering can be prevented:

- Line coding and equalization: The use of suitable line coding techniques and equalizers can help reduce the effects of baseline wandering. Line coding schemes ensure that the signal remains centered around the baseline by encoding the data appropriately. Equalizers help to compensate for distortion and variations in the signal levels, thus mitigating the impact of baseline wandering.
- DC removal: DC removal techniques can be employed to eliminate any low-frequency components, including the DC component, from the signal. This helps in stabilizing the baseline and preventing it from drifting.
- Noise filtering and shielding: Proper noise filtering and shielding techniques can minimize the interference and noise that might contribute to baseline wandering. This includes using quality cables, proper grounding, and employing effective noise filters.

By implementing these measures, baseline wandering can be reduced or eliminated, ensuring reliable data transmission in communication systems.

Q-21:How can a composite signal be decomposed into its individual frequencies? [Pre_3:1_2020]

Answer:

A composite signal can be decomposed into its individual frequencies using a process called Fourier analysis. Fourier analysis allows us to separate a complex signal into its constituent sinusoidal components. Here's how it can be done:

- Apply Fourier Transform: The composite signal is passed through a Fourier Transform algorithm, such as the Fast Fourier Transform (FFT), which analyzes the signal in the frequency domain.
- Frequency Spectrum: The Fourier Transform produces a frequency spectrum that represents the amplitude and phase of each individual frequency component present in the composite signal. The spectrum displays the constituent frequencies and their corresponding magnitudes.
- Identify Individual Frequencies: By analyzing the frequency spectrum, the individual frequencies present in the composite signal can be identified. Each frequency component will have its corresponding magnitude and phase information.
- Filter and Separate: If required, specific frequency components can be filtered or extracted from the composite signal based on their magnitudes or other criteria. This separation allows the reconstruction of the individual signals.

Transmission Medium & Wireless Transmission

Q-01:A nonperiodic signal has a bandwidth of 200 Hz with a middle peak frequency of 145 Hz. Two extreme frequencies have 0 amplitude. Draw the frequency domain of the signal. [Pre_FEC_C_01]

Answer:

To draw the frequency domain of the nonperiodic signal with a bandwidth of 200 Hz and a middle peak frequency of 145 Hz, we can represent it using a frequency spectrum graph. Since the extreme frequencies have 0 amplitude, the frequency spectrum will show a centered peak at 145 Hz with a bandwidth of 200 Hz. Here's a rough representation:

Frequency (Hz)

```
Frequency (Hz)
|
|       X
|     X   X
|    X     X
|   X       X
|  X         X
| X           X
|_X___________X___________
  0   100   145   200   300
```

In the above graph, the peak at 145 Hz represents the middle peak frequency of the signal, while the width of the graph (200 Hz) represents the bandwidth.

Q-02:Explain the process of delta modulation techniques with appropriate figures. [Pre_3:1_2020]

Answer:

Delta modulation is a technique used for analog-to-digital conversion of signals. It involves approximating the slope of the input signal and using the resulting binary value to represent the signal's change in amplitude over time. Here's the process of delta modulation:

1. Quantization: The input signal is compared with a reference voltage. If the input signal is higher than the reference voltage, the output is set to 1 (high), indicating a positive slope. If the input signal is lower than the reference voltage, the output is set to 0 (low), indicating a negative slope.
2. Sampling: The input signal is sampled at regular intervals to determine its amplitude. The sampling rate must be high enough to accurately capture the signal.
3. Encoding: Based on the slope comparison and sampling results, the encoder generates a binary output. A 1-bit binary digit is selected to represent the change in amplitude

between samples. The binary value corresponds to the direction of the slope (positive or negative).

4. Decoding/Reconstruction: At the receiver's end, the binary output is used to reconstruct the approximated signal. The decoder uses the binary values to determine the slope of the signal between samples and reconstructs the signal accordingly.

Figure representation:

```
^
   |\
   | \
   |  \
   |   \
   |----\
   |     \
   |      \
   |_______\_______
   Time   Sampled
```

Q-03: List three different techniques in serial transmission and explain the differences. [Pre_3:1_2020]

Answer:

Three different techniques in serial transmission are:

1. Asynchronous Serial Transmission: In asynchronous serial transmission, data is sent one byte at a time without any predefined clock signal. Start and stop bits frame each byte to synchronize the receiver. While being simple and flexible, it involves the overhead of start and stop bits and is slower compared to synchronous transmission.
2. Synchronous Serial Transmission: In synchronous serial transmission, data is transmitted in a continuous stream without start and stop bits. A clock signal is used to synchronize the transmitter and receiver. It provides a higher data rate compared to asynchronous transmission, as there are no start and stop bits overhead. However, it requires a more precise timing between the devices.
3. Isochronous Serial Transmission: In isochronous serial transmission, data is sent with a constant and fixed timing, providing real-time communication. It is commonly used for audio and video streaming applications. Isochronous transmission ensures a continuous data stream, but it may introduce delays or interruptions if data cannot be sent or received in the fixed timeframe.

Q-04:What are the advantage and disadvantage of parallel transmission? [Pre_3:1_2020]

Answer:

Advantages of parallel transmission:

- Higher data transfer rate: Parallel transmission allows multiple bits to be transmitted simultaneously over separate channels, resulting in a higher data transfer rate compared to serial transmission.
- Simplicity: Parallel transmission does not require complex encoding or decoding schemes, as data bits are transmitted concurrently over distinct channels.

Disadvantages of parallel transmission:

- Cost and complexity: Parallel transmission requires multiple channels or wires for data transmission, increasing the cost and complexity of the communication system.
- Synchronization issues: Each parallel channel must be precisely synchronized to ensure proper data alignment and prevent errors, which can be challenging to achieve.

Q-05:Compare the two methods of serial transmission. Discuss the advantages and disadvantages of each.

Answer:

Serial transmission methods can be divided into two categories: asynchronous and synchronous transmission.

Asynchronous transmission: Advantages:

- Flexibility: Asynchronous transmission does not require a predefined clock signal, allowing for variable-length data packets and accommodating devices with different transmission speeds.
- Simple implementation: Asynchronous transmission involves minimal hardware requirements and is relatively easy to implement.

Disadvantages:

- Slower data rate: The presence of start and stop bits in each byte transmission reduces the effective data rate compared to synchronous transmission.
- Overhead: The additional start and stop bits result in increased overhead, requiring more bandwidth for transmission.

Synchronous transmission: Advantages:

- Higher data rate: Synchronous transmission does not require start and stop bits, resulting in a higher effective data rate.

- Efficient use of bandwidth: Without the overhead of start and stop bits, synchronous transmission utilizes the available bandwidth more efficiently.

Disadvantages:

- Requires precise synchronization: Synchronous transmission relies on a predefined clock signal, which necessitates accurate synchronization between the transmitter and receiver.
- Complexity: Synchronous transmission typically requires more complex encoding and decoding schemes to recover the clock signal and maintain synchronization.

The choice between asynchronous and synchronous transmission depends on factors such as required data rate, synchronization capabilities, and the complexity of the communication system.

Comparison of serial transmission methods:

Feature	Asynchronous	Synchronous
Clocking	No shared clock	Shared clock
Framing	Start/stop bits	Blocks or frames
Efficiency	Less efficient (overhead)	More efficient
Complexity	Simpler to implement	More complex
Applications	Low-speed, simple links	High-speed, bulk data

Q-06:What are the differences between Microwave and Radio waves?

Answer:

Microwave and radio waves are both forms of electromagnetic radiation, but they differ in their frequencies and applications.

Differences between Microwave and Radio waves:

Frequency Range:

- Radio waves have lower frequencies, typically ranging from kilohertz (kHz) to hundreds of megahertz (MHz).

- Microwaves have higher frequencies, typically ranging from hundreds of megahertz (MHz) to tens of gigahertz (GHz).

Applications:

- Radio waves are commonly used for broadcasting radio and TV signals, cell phone communication, and AM/FM radio transmission.
- Microwaves are extensively used in microwave ovens, Wi-Fi networks, satellite communications, radar systems, and point-to-point communication links.

Penetration of Obstacles:

- Radio waves can easily penetrate obstacles such as buildings and walls, allowing for wider coverage.
- Microwaves have a shorter wavelength and are absorbed or reflected by obstacles, making them more prone to interference and requiring clear line-of-sight transmission paths.

Directivity:

- Radio waves typically have omnidirectional propagation, meaning they radiate in all directions from the source.
- Microwaves have a more directional nature, allowing for point-to-point communication and focusing the signal in a specific direction.

Q-07: Write down the disadvantages of Optical Fiber Cable.

Answer:

Disadvantages of Optical Fiber Cable:

Installation cost: The initial cost of installing optical fiber cables can be relatively high compared to other transmission mediums, such as copper cables. The specialized tools and expertise required for installation contribute to the higher cost.

Fragility: Optical fiber cables are more delicate and susceptible to damage compared to other types of cables, such as copper cables. They need careful handling, and any physical stress or bending beyond their specified limits can lead to signal loss or breakage.

Limited flexibility: Optical fiber cables are less flexible compared to copper cables, making them less suitable for applications requiring frequent changes in cable routing or physical movements. The rigidity of optical fibers can restrict some installation scenarios.

Susceptibility to temperature extremes: Extreme temperatures, both hot and cold, can affect the performance of optical fibers. Thermal expansion and contraction may cause signal degradation or fiber damage, requiring additional protective measures in harsh environments.

Q-08:Write a short note on FHSS.

Answer:

Frequency Hopping Spread Spectrum (FHSS) is a technique used in wireless communication to improve security and minimize interference. It involves rapidly switching the carrier frequency of a transmitted signal within a predetermined frequency band. Here's a short note on FHSS:

FHSS operates as follows:

1. Frequency Hopping: FHSS divides the available frequency band into multiple sub-channels. The transmitter and receiver synchronize their hopping sequences using a predetermined pattern or algorithm. The hopping pattern specifies the sequence and duration of transmission on each sub-channel.
2. Carrier Frequency Synchronization: The transmitter and receiver maintain synchronization regarding the frequency hopping pattern. This allows the receiver to correctly identify and capture the correct frequency of the transmitted signal.
3. Improved Security: FHSS provides improved security by rapidly shifting the carrier frequency. This makes it difficult for eavesdroppers or jamming devices to intercept or interfere with the communication. Since the frequency changes rapidly, it becomes challenging for unauthorized parties to track the signal and decode the information being transmitted.
4. Interference Mitigation: FHSS helps mitigate interference from other wireless devices operating in the same frequency band. By rapidly switching frequencies, FHSS can avoid or reduce the impact of narrowband interference, frequency-selective fading, and electromagnetic noise.

FHSS finds applications in various systems, including wireless networks, Bluetooth, and military communication systems.

Digital Transmission

Q-01: The loss of the cable is usually defined in dB/km. If the signal at the beginning of a cable with -0.3 dB/km has a power of 2mw, what is the power of the signal at 5 km? [Pre_FEC_C_01]

Answer:

To calculate the power of the signal at a distance of 5 km, we can use the formula: Power at Distance = Initial Power x (10^(-loss per km x distance in km/10)) Given: Initial Power = 2 mW Loss per km = -0.3 dB/km

Converting the loss per km to a linear scale: Loss per km = 10^(-0.3/10) = 0.501

Calculating the power at 5 km: Power at 5 km = 2 mW x (0.501^(5/1)) = 1.608 mW

Therefore, the power of the signal at a distance of 5 km is approximately 1.608 mW. 😊

Q-02: Define Line Coding, Signal Element, Periodic Signal, and Composite Signal with examples.

Answer:

- Line Coding: Line coding is the process of converting digital data into a sequence of signals that can be transmitted over a communication channel. It involves mapping each bit of the data to a specific pattern or signal element. Examples of line coding schemes include Manchester encoding, Differential Manchester encoding, and NRZ (Non-Return-to-Zero) encoding.
- Signal Element: A signal element is the smallest unit of a signal that carries information. It can represent a single bit or a group of bits depending on the line coding scheme used. For example, in NRZ encoding, a signal element corresponds to a single bit, while in Manchester encoding, a signal element represents two bits.
- Periodic Signal: A periodic signal is a signal that repeats itself over time. It exhibits a regular pattern or waveform. The period of a periodic signal is the time it takes for one complete cycle to occur. Examples of periodic signals include sine waves, square waves, and triangle waves.
- Composite Signal: A composite signal is formed by combining multiple individual signals. It can be composed of different frequencies, amplitudes, and phases. An example of a composite signal is a modulated signal, where a carrier signal is modified by a modulating signal to encode information.

Q-03: Distinguish signal elements from data elements.

Answer:

- Signal elements: Signal elements refer to the smallest units or components of a signal. They are the building blocks of a signal and can represent individual bits or groups of bits depending on the line coding scheme used. Signal elements carry the information that is transmitted over a communication channel.
- Data elements: Data elements, on the other hand, refer to the meaningful units of data being transmitted. They can be characters, numbers, or any other data format depending on the context. Data elements are higher-level entities compared to signal elements and are usually composed of multiple signal elements.

In summary, signal elements are the elementary units that transmit data, while data elements represent the meaningful units of data being transmitted.

Q-04: Calculate bit interval for a 400-bps digital signal. [Pre_3:1_2021]

Answer:

To calculate the bit interval (T) for a 400-bps (bits per second) digital signal, we can use the formula: T = 1 / Data Rate

Given: Data Rate = 400 bps

Calculating the bit interval: T = 1 / 400 = 0.0025 seconds

Therefore, the bit interval for a 400-bps digital signal is 0.0025 seconds. 😄

Q-05: Describe byte stuffing and unstuffing strategy in Character Oriented Protocols?

Answer:

Byte stuffing and unstuffing are strategies used in Character Oriented Protocols to ensure the reliable and error-free transmission of data. These strategies are used when special control characters are part of the data being transmitted.

- Byte Stuffing: In byte stuffing, a special control character is used to indicate the start and end of a frame or packet. If the data itself contains the control character, it needs to be "stuffed" or escaped to prevent confusion with the control character. For example, if the control character is "A", and the data contains the sequence "AAB", then the stuffed version would be "AA*BA".
- Byte Unstuffing: Byte unstuffing is the process of reversing the byte stuffing operation at the receiver's end. The receiver examines the incoming data stream and removes the stuffing characters, restoring the original data. For example, if the received data is "AA*BA", the unstuffing operation would convert it back to "AAB".

These strategies ensure that the control characters within the data are preserved correctly during transmission and are not mistaken as control signals by the receiver. 📩

Q-07: Explain two version of Polar Non-Return-to-Zero (NRZ) encoding schemes with examples. [Pre_3:1_2021]

Answer:

Two versions of the Polar Non-Return-to-Zero (NRZ) encoding schemes are NRZ-L (Level) and NRZ-I (Inverted).

- NRZ-L (Level): In NRZ-L encoding, the signal level remains constant at either a high or low level for the entire duration of a bit interval. The signal level represents the bit value, where a high level may indicate a logical "1" and a low level may indicate a logical "0". The absence of a transition in the middle of a bit interval can lead to the problem of DC (direct current) component and baseline wander. Here's an example pulse diagram for the sequence "01001101" using NRZ-L encoding:

0 1 0 0 1 1 0 1

NRZ-L: 

- NRZ-I (Inverted): In NRZ-I encoding, the signal level changes or inverts whenever there is a logical "1" in the bit sequence, and remains at the same level for a logical "0". This ensures frequent signal level transitions to maintain synchronization between the transmitter and receiver. Here's an example pulse diagram for the sequence "01001101" using NRZ-I encoding:

0 1 0 0 1 1 0 1

NRZ-I: 

In both NRZ-L and NRZ-I encoding schemes, the signal levels or transitions represent the binary information being transmitted.

Q-08:An analog signal carries 4 bits per signal element. If 2500 signal elements are sent per second, find the bit rate. [Pre_2:2_2021]

Answer:

To find the bit rate, we can use the formula: Bit Rate = Signal Elements per Second x Bits per Signal Element

Given: Signal Elements per Second = 2500 Bits per Signal Element = 4

Calculating the bit rate: Bit Rate = 2500 x 4 = 10,000 bps

Therefore, the bit rate is 10,000 bits per second. 😊

Q-09: Draw pulse diagrams for sequence 01001101 using NRZ-L, NRZ-1, Manchester, Differential Manchester, AMI, Pseudoternary, and 2B1Q schemes. (Images: Pulse diagrams for each scheme) [Pre_3:1_2021]

Answer:

Sequence: 01001101

- NRZ-L (Non-Return-to-Zero Level):

0 1 0 0 1 1 0 1

NRZ-L: 

- NRZ-1 (Non-Return-to-Zero 1):

0 1 0 0 1 1 0 1

NRZ-1: 

- Manchester:

0 1 0 0 1 1 0 1

Manch: 

- Differential Manchester:

0 1 0 0 1 1 0 1

DiffM: 

- AMI (Alternate Mark Inversion):

0 1 0 0 1 1 0 1

AMI : 

- Pseudoternary:

0 1 0 0 1 1 0 1

Pseudo: 

- 2B1Q (Two Binary, One Quarternary): Unfortunately, without more information or a specific encoding scheme defined, I am unable to provide the pulse diagram for 2B1Q.

Analog Transmission

Q-1: Define frequency, period, amplitude, time, wavelength, and phase [Pre_3:1_2020]

Answer:

1. Frequency: Frequency refers to the number of complete cycles or oscillations of a periodic waveform that occur in one second. It is measured in Hertz (Hz). The frequency determines the pitch of a sound wave or the number of cycles of a signal per unit of time.
2. Period: Period is the time it takes for a waveform to complete one full cycle. It is the reciprocal of frequency and is denoted as "T". The period is measured in seconds (s).
3. Amplitude: Amplitude represents the maximum displacement or extent of a waveform from its resting position or the zero level. It is a measure of the intensity or strength of a signal. Amplitude is usually measured from the baseline or zero level to the highest point of the waveform.
4. Time: Time is a fundamental concept used to measure the duration or occurrence of events. In the context of signals and waveforms, time refers to the independent variable along the horizontal axis of a graph or plot.
5. Wavelength: Wavelength is the spatial length of one complete cycle of a periodic waveform. It is inversely related to frequency and is denoted by the Greek letter lambda (λ). Wavelength is commonly used to describe characteristics of electromagnetic waves, such as light or radio waves.
6. Phase: Phase refers to the position of a waveform within its cycle at a specific point in time. It represents the fraction of a complete cycle that has elapsed at a given instant. Phase can be measured in degrees or radians and is used to describe the relationship between different waveforms or components of a signal.

Q-2: f = 6, T =? Draw the signal time domain plot. [Pre_FEC_C_01]

Answer:

To draw the signal time domain plot, we need to know the relationship between the frequency (f) and the period (T). The formula to convert between frequency and period is:

$T = 1/f$

Given that f = 6, we can calculate the period as follows:

$T = 1/6$

Therefore, the period (T) is approximately 0.1667 seconds.

Since we only know the period, we cannot draw the exact time domain plot without additional information or waveform characteristics. However, the time domain plot typically shows the waveform as a function of time on the horizontal axis, and the amplitude on the vertical axis

Q-03;Write short notes on AM, FM, and PM in Analog-to-Analog modulation. [Pre_2:2_2021]

Answer:

Here are short notes on three popular modulation techniques:

1. AM (Amplitude Modulation): In Amplitude Modulation, the amplitude of a high-frequency carrier wave is varied in proportion to the instantaneous amplitude of the low-frequency modulating signal. The modulating signal contains the information to be transmitted, and it is impressed onto the carrier wave. The modulated carrier wave is then transmitted. At the receiver, the original modulating signal can be extracted by demodulation.

2. FM (Frequency Modulation): Frequency Modulation involves varying the frequency of the carrier wave according to the instantaneous amplitude of the modulating signal. As the modulating signal changes, the frequency of the carrier wave shifts up and down. This modulation technique allows for the transmission of audio and other types of signals over radio waves with good noise immunity.

3. PM (Phase Modulation): Phase Modulation is similar to Frequency Modulation but instead varies the phase of the carrier wave in proportion to the modulating signal. Changes in the modulating signal cause a corresponding change in the phase of the carrier wave. PM is closely related to FM and is often used in conjunction with it. It is widely utilized in various communication systems and plays a crucial role in digital modulation techniques.

Each modulation technique has its advantages and applications depending on the specific requirements of a communication system.

Q-04:Explain, with diagrams: i) Amplitude Modulation, ii) Frequency Modulation, iii) Delta Modulation. (Images: AM, FM, and DM waveforms) [Pre_3:1_2021]

Q-05: Explain the pules code Modulation technique with appropriate diagram. [Pre_3:1_2020]

Pulse Code Modulation (PCM) is a digital modulation technique that converts analog signals into digital form for transmission or storage. It involves three main steps: sampling, quantization, and encoding.

1. Sampling: The analog signal is sampled at regular intervals to capture its amplitude values. These samples are taken at a predefined rate determined by the Nyquist theorem, which states that the sampling rate should be at least twice the highest frequency component in the signal.
2. Quantization: In this step, each sample's amplitude is rounded to the nearest value within a predefined range of discrete levels. The continuous analog signal is approximated by a series of discrete levels, which determines the precision or resolution of the digital representation.
3. Encoding: The quantized samples are then encoded into digital binary code. Each discrete level is assigned a binary code word to represent its corresponding amplitude value. The number of bits used for encoding determines the dynamic range and fidelity of the resulting digital signal.

Here's a diagram illustrating the PCM process:

```
Analog Signal ───────┬───────── Sampling ───────┬──────── Quantization
────────┬──────── Encoding ────────
│                    │                         │                              │
▼                         ▼                              ▼
Digital Signal
│      │     │   │     │        │     │   │     │        │     │   │     │
▼     ▼   ▼     ▼        ▼     ▼   ▼     ▼        ▼     ▼   ▼
▼
Digital Signal: 010010011100101110011010 1...
```

The resulting digital signal contains a sequence of binary numbers that represent the encoded analog signal in a discrete format. This digital representation allows for efficient transmission, storage, and processing of the original analog information

Q-06:Explain Pulse Code Modulation (PCM) with figures. (Images: PCM waveforms and quantization levels) [Pre_3:1_2021]

Q-07:Define carrier signal and its role in analog transmission. [Pre_3:1_2020]

Answer:

Carrier Signal: A high-frequency sinusoidal wave that is used to carry information signals during transmission. It serves as a "vehicle" for the information.

Role in Analog Transmission:

- Modulation: The information signal is superimposed onto the carrier wave by altering one or more of its properties (amplitude, frequency, or phase). This creates a modulated signal that can be transmitted over the communication channel.
- Improved Transmission: Carrier signals have higher frequencies than typical information signals, allowing for:
  - Efficient transmission through antennas.
  - Reduced attenuation over long distances.
  - Easier separation of multiple signals using frequency division multiplexing (FDM).

Q-08:Explain Frequency Shift Keying techniques for digital to analog conversion. [Pre_3:1_2020]

Answer:

Frequency Shift Keying (FSK) is a digital modulation technique used for converting digital signals into analog waveforms. It involves varying the frequency of the carrier signal between two distinct frequencies according to the input digital data.

In FSK, a binary "0" is represented by one carrier frequency, and a binary "1" is represented by another carrier frequency. The carrier frequency is shifted instantaneously whenever there is a change in the input symbol.

The FSK process typically includes the following steps:

1. Mapping: Each input symbol (binary "0" or "1") is mapped onto its corresponding carrier frequency.
2. Modulation: The carrier frequency is modulated based on the input symbol. For example, a binary "0" may be associated with a lower frequency, while a binary "1" may correspond to a higher frequency.
3. Transmission: The modulated signal, which consists of carrier frequency shifts, is transmitted over the communication channel.

At the receiver end, the carrier frequency shifts are detected and decoded to recover the original digital signal.

Q-09:Why QAM techniques is used for digital to analog conversion? [Pre_3:1_2020]

Quadrature Amplitude Modulation (QAM) techniques are used for digital-to-analog conversion due to their ability to transmit a higher amount of information in a given bandwidth. QAM is widely used in various communication systems, including digital television, Wi-Fi, and cellular networks. Here are a few reasons why QAM is preferred:

1. Spectral Efficiency: QAM allows for denser packing of information in the frequency spectrum, enabling higher data rates. By varying both the amplitude and phase of the carrier signal, multiple bits can be transmitted simultaneously.
2. Robustness to Noise: QAM offers better noise immunity compared to other modulation techniques. By using a higher number of constellation points (amplitude and phase combinations), QAM can encode redundancy in the signal, enhancing error detection and correction capabilities.
3. Compatibility with Existing Systems: QAM can be easily implemented in existing analog systems by making use of linear amplifiers. This makes it a cost-effective solution for upgrading analog systems to support digital transmission.
4. Flexible Adaptation: QAM allows for adaptive modulation, meaning the modulation scheme can be adjusted dynamically based on channel conditions.

Q-10:Describe the process of Amplitude Modulation(AM). [Pre_3:1_2020]

Answer:

Amplitude Modulation (AM) is a technique for modulating an analog signal onto a carrier waveform. Here's a description of the AM process:

1. Carrier Signal Generation: A high-frequency sinusoidal waveform called the carrier signal is generated. The carrier signal's frequency is typically much higher than the frequencies present in the modulating signal.
2. Modulating Signal: An analog signal, which contains the information to be transmitted, is generated. This modulating signal can be a voice signal, music, or any other analog signal.
3. Modulation: In AM, the amplitude of the carrier signal is varied in proportion to the instantaneous amplitude of the modulating signal. The modulation is achieved by multiplying the carrier signal by the modulating signal. The result is a waveform that consists of the carrier wave with varying amplitude corresponding to the modulating signal.
4. Frequency Translation: Optionally, the modulated signal may be frequency-shifted to a higher frequency for efficient transmission and reception. This process is called upconversion.
5. Transmission: The modulated signal is transmitted over the communication channel, such as a radio frequency band or a wired medium.
6. Reception: At the receiver end, the modulated signal is received and demodulated to recover the original modulating signal. This process involves filtering and amplifying the received signal, followed by demodulation to extract the original modulating signal.

By modulating the carrier signal with the information-bearing modulating signal, AM allows for the transmission and reception of analog signals over long distances with reasonable fidelity.

Q-11: Conversion/Encoding: Analog to Digital [PAM, PCM], Digital to Analog [ASK, FSK, PSK, QAM].

Answer:

Conversion/Encoding refers to the process of converting signals from one format to another. Here's a summary of the conversion techniques for Analog to Digital (ADC) and Digital to Analog (DAC) conversions:

Analog to Digital Conversion (ADC):

1. Pulse Amplitude Modulation (PAM): PAM is a technique where the amplitude of regularly spaced pulses is proportional to the instantaneous value of the analog signal.
2. Pulse Code Modulation (PCM): PCM involves sampling the analog signal, quantizing the samples, and encoding them into binary code words.

Digital to Analog Conversion (DAC):

1. Amplitude Shift Keying (ASK): ASK is a modulation technique in which the amplitude of the carrier signal is varied according to the digital input signal.
2. Frequency Shift Keying (FSK): FSK changes the frequency of the carrier waveform depending on the digital input.
3. Phase Shift Keying (PSK): PSK modulates the phase of the carrier wave to represent different digital input symbols.
4. Quadrature Amplitude Modulation (QAM): QAM combines amplitude and phase modulation to transmit multiple bits simultaneously, allowing for higher data rates.

Digital to Digital:

- Unipolar: Uses only positive voltage levels.
- Polar: Uses both positive and negative voltage levels.
- Bipolar: Uses three voltage levels (positive, negative, and zero).

Analog to Analog:

- AM (Amplitude Modulation): Modulates the amplitude of a carrier wave.
- FM (Frequency Modulation): Modulates the frequency of a carrier wave.
- PM (Phase Modulation): Modulates the phase of a carrier wave.

Data Transmission

Q-01: Entire question covers general data communication concepts.

Q-02: Define: Data Rate, Self-synchronization, DC Component, Quantization Error [Pre_3:1_2021]

Data Rate: Data rate refers to the speed at which digital data is transmitted or processed. It is typically measured in bits per second (bps) or symbols per second. A higher data rate allows for the transmission of more information in a given time interval.

Self-synchronization: Self-synchronization is a technique used in data communication to maintain the timing synchronization between the sender and the receiver without the need for external synchronization signals. In self-synchronization, special patterns or sequences are embedded in the transmitted data to enable the receiver to recover and maintain the correct timing for decoding the data.

DC Component: DC component, also known as direct current component, is a term used to refer to the average or constant value of a signal. In the context of data communication, a DC component represents the presence of a constant voltage level or offset in a signal. It can cause issues in communication systems, such as distortion or interference with the signal's original content.

Quantization Error: Quantization error occurs in analog-to-digital conversion when the continuous amplitude of an analog signal is represented by a finite number of discrete levels (quantization levels) in the digital domain. The quantization error is the difference between the actual analog value and the quantized digital approximation. It introduces a certain amount of distortion or error in the reconstructed analog signal when converting it back from digital to analog.

Q-03: List advantages and disadvantages of Asynchronous and Synchronous transmission. [Pre_3:1_2021]

Advantages of Asynchronous Transmission:

1. Flexibility: Asynchronous transmission allows for variable-length gaps between characters, making it adaptable to different data transmission rates and the absence of a fixed time interval.
2. Start/Stop Signals: It uses start and stop bits for character synchronization, providing error detection capabilities and allowing for easy identification of the beginning and end of each character.
3. Simple Implementation: Asynchronous transmission requires less complex hardware and software compared to synchronous transmission, making it more cost-effective and easier to implement in simple systems.
4. Suitable for Short Transmissions: It is suitable for short data transmissions where the overhead associated with synchronizing characters across an entire message may not be necessary.

Disadvantages of Asynchronous Transmission:

1. Lower Data Rate: Asynchronous transmission introduces additional overhead due to the start and stop bits, resulting in a lower effective data rate compared to synchronous transmission.
2. Reduced Efficiency: Asynchronous transmission does not make optimal use of available bandwidth since there is no continuous stream of characters being transmitted.
3. Limited Error Detection: While start and stop bits provide some error detection capabilities, they are not sufficient for detecting errors within the character itself.
4. Clock Drift: Asynchronous transmission can be more prone to clock drift issues because the timing is recovered for each individual character, which may lead to timing misalignment over longer transmissions.

Advantages of Synchronous Transmission:

1. Higher Data Rate: Synchronous transmission eliminates the overhead associated with start and stop bits, allowing for higher effective data rates compared to asynchronous transmission.
2. Better Bandwidth Utilization: Since data is transmitted in a continuous stream without character gaps, synchronous transmission makes better use of available bandwidth.
3. Enhanced Error Detection: Synchronous transmission supports more advanced error detection and correction mechanisms, such as checksums and cyclic redundancy checks (CRC).
4. Clock Synchronization: Synchronous transmission relies on a synchronized clock signal that is shared between the sender and receiver, ensuring accurate timing and reducing clock drift issues.

Disadvantages of Synchronous Transmission:

1. More Complex Implementation: Synchronous transmission requires more sophisticated hardware and software for maintaining clock synchronization and framing techniques, leading to increased implementation complexity and cost.
2. Less Flexibility: Synchronous transmission typically requires fixed-length frames or blocks of data, making it less flexible for variable-length data transmissions.
3. Potential Data Loss: If the clock synchronization is lost for an extended period, it can result in data loss or corruption until synchronization is reestablished.
4. Dependency on Continuous Transmission: Synchronous transmission relies on a continuous flow of data, which may not be suitable for applications that involve intermittent or sporadic data transfers.

Multiplexing

Q- 01: What is Multiplexing? Mention the major techniques of Multiplexing. [Pre_3:1_2021]

Multiplexing refers to the technique of combining multiple independent data streams into a single transmission channel, allowing for simultaneous transmission of the individual streams. The major techniques of multiplexing are as follows:

1. Frequency Division Multiplexing (FDM): In FDM, different signals are assigned different frequency bands within a shared channel. Each signal is modulated onto a separate carrier frequency and combined into a composite signal for transmission. At the receiving end, the individual signals are demodulated by filtering out the corresponding frequency bands.
2. Time Division Multiplexing (TDM): TDM divides the transmission channel into discrete time slots, with each slot assigned to a different signal. The signals take turns transmitting during their designated time slots. At the receiving end, the original signals are reconstructed by demultiplexing the time-interleaved data.
3. Wavelength Division Multiplexing (WDM): WDM is used in optical fiber communication, where signals are transmitted simultaneously using different wavelengths (colors) of light. Each wavelength carries an independent data stream, allowing for high-capacity transmission over a single fiber.

Q-02: Discuss Synchronous and Asynchronous TDM techniques.

Synchronous and asynchronous TDM are two variants of the time division multiplexing technique.

In synchronous TDM, all input sources or channels are coordinated and operate at the same clock rate. Each source transmits data within its designated time slot, maintaining strict synchronization with the clock signal. The time slots are fixed and allocated in a round-robin fashion. Synchronous TDM requires prior knowledge of the characteristics and data rates of all input sources.

In asynchronous TDM, the time slots are not allocated in a fixed, rigid manner. Instead, each source transmits data only when it has data to send, resulting in variable-sized time slots. The slots are dynamically allocated based on the availability of data from the sources. Asynchronous TDM does not require strict synchronization between the sources, making it more flexible and suitable for applications with independent or sporadic data sources.

Q-03: Define interleaving. Describe the goal of multiplexing. [Pre_3:1_2021]

Interleaving is a technique used in multiplexing to combine and transmit data from multiple sources in a more efficient and organized manner. The goal of multiplexing, in general, is to maximize the utilization of the transmission medium and improve overall data transmission efficiency.

Interleaving involves dividing the data from each source into smaller units, such as packets or frames, and interleaving them together for transmission. The interleaved data from different sources are then transmitted sequentially, ensuring fair access to the transmission channel for each source.

The main objectives of multiplexing are as follows:

1. Efficient Utilization: Multiplexing allows multiple data streams to share a common transmission medium, maximizing its utilization and capacity.
2. Cost-Effectiveness: By enabling multiple signals or channels to be transmitted simultaneously, multiplexing reduces the need for additional transmission lines or resources, resulting in cost savings.
3. Improved Efficiency: Multiplexing techniques help optimize the use of available bandwidth and mitigate delays, leading to improved overall data transmission efficiency.
4. Enhanced Flexibility: Multiplexing provides flexibility in supporting different types of data streams with varying data rates, protocols, and services over a single transmission channel.

Q-04: Explain Time Division Multiplexing (TDM) with a diagram. (Image: TDM process diagram) [Pre_3:1_2021]

Q-05: Explain CDMA techniques in spread spectrum. [Pre_2:2_2021]

CDMA stands for Code Division Multiple Access and is a spread spectrum technique used in wireless communication systems. CDMA allows multiple users to transmit and receive data simultaneously over the same frequency by assigning unique codes to each user.

In CDMA, data is spread across a wide frequency band using a unique spreading code that differentiates each user's data. The spreading codes are designed to be orthogonal, meaning they have minimal interference with each other. The spreading process expands the bandwidth of the transmitted signal, which helps in resisting interference and providing increased security and robustness against multipath fading effects.

At the receiver, the receiver's unique spreading code is used to de-spread the received signal and extract the original user's data. The receiver filters out the interference caused by other users' signals by exploiting the orthogonality of the spreading codes.

CDMA offers advantages such as increased capacity, improved call quality, and resilience to interference and fading. It has been widely used in various wireless communication technologies, including 3G, 4G LTE, and some satellite communication systems.

Q-06: Distinguistic between Synchronous and statistical TDM techniques.

Synchronous TDM and statistical TDM are two different approaches to implementing time division multiplexing.

Synchronous TDM:

- Time slots are fixed and allocated in a round-robin manner.
- Requires strict synchronization between all input sources.
- Guarantees equal time allocation to each input source.
- Suitable for applications with fixed and predictable data rates.
- Typically used in scenarios where the data sources are synchronized with a common clock signal.

Statistical TDM:

- Time slots are dynamically allocated based on the availability of data from each source.
- Does not require strict synchronization between input sources.
- Time slots are assigned according to the bandwidth requirements of each input source.
- Provides more flexibility in handling variable data rates and sporadic data sources.
- Requires additional signaling or control mechanisms to manage the allocation of time slots.

Q-07:Multiplexing About: FDM, TDM, WDM.

FDM (Frequency Division Multiplexing):

- FDM is a multiplexing technique that divides the available bandwidth of a transmission medium into multiple non-overlapping frequency bands.
- Each input signal or channel is assigned a different frequency band, and the signals are modulated onto separate carrier frequencies.
- At the receiving end, the signals are demodulated by filtering out the respective frequency bands.
- FDM is commonly used in analog communication systems such as traditional radio and television broadcasting.

TDM (Time Division Multiplexing):

- TDM is a multiplexing technique that divides the transmission channel into discrete time slots.
- Different input sources or channels are assigned exclusive time slots, and the signals are transmitted in a time-interleaved fashion.
- At the receiving end, the original signals are demultiplexed by separating data from the corresponding time slots.

- TDM is widely used in digital communication systems, including telephony and data networking.

WDM (Wavelength Division Multiplexing):

- WDM is a multiplexing technique used in optical fiber communication systems.
- It allows multiple optical signals of different wavelengths (colors) to be transmitted simultaneously over a single fiber.
- Each wavelength carries an independent data stream, enabling high-capacity transmission.
- WDM can be further classified into two types: Dense Wavelength Division Multiplexing (DWDM), which uses closely spaced wavelengths, and Coarse Wavelength Division Multiplexing (CWDM), which uses wider spacing between wavelengths.
- WDM has significantly increased the capacity and efficiency of long-haul fiber optic transmission.

Data Link Layer

Q-01: Define the types of errors that need to be detected in the Data Link layer?

The types of errors that need to be detected in the Data Link layer include:

1. Single Bit Errors: These errors occur when a single bit in a data unit is flipped or changed during transmission due to noise or interference.
2. Burst Errors: Burst errors refer to the consecutive errors that occur within a short interval of time. They are usually caused by line or channel impairments and can affect multiple bits in a data unit.
3. Lost Packets: Lost packets occur when complete data packets are lost during transmission, resulting in missing or incomplete data at the receiver.
4. Delayed Packets: Delayed packets refer to the packets that experience significant delays during transmission, leading to out-of-order delivery or congestion in the network.

Q-02; List four Noisy Channel Protocols for flow and error control in the Data Link Layer.

Four Noisy Channel Protocols for flow and error control in the Data Link Layer are:

1. Stop-and-Wait Protocol: In this protocol, the sender sends one frame at a time and waits for an acknowledgment from the receiver. It ensures that the frames are received error-free before proceeding to the next frame.

2. Go-Back-N Protocol: This protocol allows the sender to transmit multiple frames consecutively without waiting for individual acknowledgments. The receiver discards out-of-order or erroneous frames and requests the sender to retransmit all frames starting from the corrupted or missing frame.
3. Selective Repeat Protocol: Similar to the Go-Back-N protocol, the sender can send multiple frames without waiting for acknowledgments. However, the receiver selectively acknowledges correctly received frames, and the sender retransmits only the corrupted or missing frames.
4. Sliding Window Protocol: Sliding Window protocols use a sliding window of a fixed size at both the sender and receiver sides. They allow a specific number of frames to be in transit simultaneously. The protocol provides efficient flow and error control by acknowledging successful receipt of frames and allowing continuous transmission.

Q-03: Describe CRC and Parity Check error detection techniques with examples.

CRC (Cyclic Redundancy Check): CRC is an error detection technique that involves appending a checksum, calculated based on the data, to the transmission message. The receiver recalculates the checksum using the same algorithm and compares it with the received checksum. If they match, it indicates that the data has been received without any errors.

Example: Suppose we want to transmit the data "1011001" using CRC with a generator polynomial of "1101." The sender appends the remainder of the division of the data by the generator polynomial (in this case, "101") as the checksum. The transmitted message becomes "1011001101." At the receiver, the same division is performed, and the received checksum is compared with the calculated checksum to detect any errors.

Parity Check: Parity check is a simple error detection technique that involves adding an additional bit (parity bit) to the transmitted message to make the total number of 1s either even (even parity) or odd (odd parity). The receiver checks the parity of the received message and compares it with the expected parity to detect errors.

Example: Suppose we want to transmit the data "11010" with even parity. The sender calculates the parity bit as 0 (even) since the number of 1s in the data is even. The transmitted message becomes "110100." At the receiver, the received message is checked for even parity. If the number of 1s is also even, no errors are detected.

Q-04: Describe the Go-Back-N Automatic Repeat Request protocol for flow and error control with its pros and cons.

Go-Back-N Automatic Repeat Request (ARQ) Protocol: Go-Back-N ARQ is a flow and error control protocol used in the Data Link layer. It allows the sender to transmit a sequence of frames without waiting for individual acknowledgments. The receiver acknowledges successful receipt of frames but discards out-of-sequence or erroneous frames.

Pros of Go-Back-N ARQ:

1. Efficient utilization of the transmission channel by allowing continuous transmission without waiting for individual acknowledgments.
2. Simplified receiver implementation by discarding out-of-sequence or erroneous frames, easing the complexity of buffer management.

Cons of Go-Back-N ARQ:

1. Potentially inefficient retransmission of frames. Upon detecting an error or missing frame, the sender retransmits all subsequent frames, even if they were received correctly.
2. Increased delay due to discarded frames. Discarded frames cause a gap in the received frame sequence, leading to delays as subsequent frames must wait for retransmission.

Q-05: Error Detection [Redundancy].

Concept: A technique in data communication that involves adding extra bits or information to a message to detect errors that may occur during transmission. It's based on the principle of introducing redundancy to allow the receiver to verify the integrity of the received data.

Key Methods:

1. Parity Checking:
    - Adds a single parity bit (0 or 1) to each data unit to make the total number of 1 bits either even (even parity) or odd (odd parity).
    - The receiver checks if the parity matches; if not, an error is detected.
2. Checksum:
    - A numerical value calculated based on the content of a data block.
    - The receiver recalculates the checksum and compares it to the transmitted value to detect errors.
3. Cyclic Redundancy Check (CRC):
    - A more sophisticated checksum algorithm that uses polynomial division to generate a unique remainder (CRC code).
    - Highly effective in detecting burst errors and commonly used in data transmission protocols.

Q-06: Redundancy Check [VRC, LRC, CRC].

Redundancy Check Techniques: a) Vertical Redundancy Check (VRC): In VRC, a parity bit is added to each data unit. The parity bit is set to 1 or 0, depending on whether the number of 1s in the data is odd or even, respectively. At the receiver, the parity of the received data is checked, and any mismatch indicates an error.

b) Longitudinal Redundancy Check (LRC): LRC involves appending a block of parity bits to the data unit. The parity bits are computed by applying the VRC technique to each column of the data. At the receiver, the parity of each column is checked, and any mismatch indicates an error.

c) Cyclic Redundancy Check (CRC): CRC is a more robust redundancy check technique. It involves generating a checksum based on the data using a generator polynomial. The checksum is appended to the data unit and transmitted. At the receiver, the polynomial division is performed using the received data and generator polynomial to calculate the checksum. Any mismatch indicates an error.

Feature	VRC	LRC	CRC
Parity level	Character/unit	Block of units	Entire frame
Computation	Simple XOR	Multiple XORs	Polynomial division
Error detection	Single-bit errors	Multiple errors	Burst errors, random errors
Complexity	Low	Moderate	High
Overhead	1 bit per unit	1-2 bits per block	Variable
Common uses	Character codes	Data blocks	Networks, storage, protocols

Q-07: Hamming code technique for error correction.

Hamming Code for Error Correction: Hamming code is an error-correcting code that allows the receiver to both detect and correct single-bit errors in the received data. It adds redundant parity bits to the original data bits based on a particular algorithm.

The number of parity bits is determined by the number of control bits required to cover the entire data sequence. These parity bits are inserted at specific bit positions in the data, ensuring that each bit's position has a unique combination of parity bits assigned to it.

During transmission, if a single bit is flipped or corrupted, the receiver can use the Hamming code's parity bits to identify and correct the error. It does this by performing logical operations on the received data and the parity bits to locate the erroneous bit and flip it back to the correct value.

Hamming code provides the ability to detect and correct single-bit errors, making it useful in error-prone communication channels.

Data Link Control

Q-01: Explain Selective Repeat ARQ flow and error control protocol.

[Pre_FEC_C_01]

Selective Repeat Automatic Repeat Request (ARQ) is a flow and error control protocol used in the Data Link layer. It allows the sender to transmit multiple frames without waiting for individual acknowledgments from the receiver. The receiver acknowledges each successfully received frame individually.

The mechanism of Selective Repeat ARQ involves the following steps:

1. Sender's Perspective:
    - The sender divides the data into fixed-size frames and assigns a unique sequence number to each frame.
    - It maintains a sending window that determines the maximum number of unacknowledged frames allowed to be in transit at any given time.
    - The sender starts transmitting frames within the sending window, even if some previous frames are yet to be acknowledged.
2. Receiver's Perspective:
    - The receiver maintains a receiving window that specifies the range of acceptable sequence numbers for incoming frames.
    - It buffers out-of-sequence frames but does not deliver them to the upper layers until the missing frames are received.
    - The receiver sends individual acknowledgments for each correctly received frame, indicating the highest sequentially received frame.
3. Retransmission:
    - If the sender does not receive an acknowledgment for a particular frame within a timeout period, it assumes the frame is lost or corrupted and retransmits it.

    - The receiver discards duplicate frames and sends a cumulative acknowledgment to indicate the highest sequentially received frame.

Selective Repeat ARQ provides better efficiency than the Go-Back-N ARQ protocol by allowing the sender to retransmit only the lost or corrupted frames individually, rather than all subsequent frames.

Q-02: What is Flow Control? What is the mechanism of sliding window flow control?

Flow Control: Flow control is a mechanism used to ensure that the sender does not overwhelm the receiver with an excess of data. It is crucial in situations where the sender is capable of transmitting data faster than the receiver can process it. Flow control helps prevent data loss, buffer overflow, and network congestion.

Sliding Window Flow Control Mechanism: The sliding window flow control mechanism uses a fixed-size window at both the sender and receiver sides to regulate the flow of data.

1. Sender's Perspective:
    - The sender maintains a sending window that determines the number of unacknowledged frames allowed to be transmitted at any given time.
    - The sender keeps track of the acknowledgment status of each frame within the window.
    - New frames can be transmitted as long as they fall within the sending window's range.
2. Receiver's Perspective:
    - The receiver maintains a receiving window that specifies the range of acceptable sequence numbers for incoming frames.
    - The receiver delivers and acknowledges correctly received frames falling within the receiving window range.
    - The receiver discards out-of-sequence or duplicate frames and adjusts the receiving window accordingly.

The sliding window mechanism allows for continuous and efficient data transmission, eliminating the need for the sender to wait for individual acknowledgments after each frame.

Q-03: Explain the mechanism of stop-and-wait ARQ error control.

Stop-and-Wait Automatic Repeat Request (ARQ) is an error control protocol used in the Data Link layer. The mechanism of Stop-and-Wait ARQ involves the following steps:

1. Sender's Perspective:
   - The sender divides the data into frames and transmits one frame at a time.
   - After transmitting a frame, the sender waits for an acknowledgment from the receiver.
   - If an acknowledgment is received within a timeout period, indicating successful receipt of the frame, the sender proceeds to transmit the next frame. Otherwise, it retransmits the same frame.
2. Receiver's Perspective:
   - The receiver receives the frame and checks for errors or corruption.
   - If the frame is error-free, the receiver sends an acknowledgment to the sender indicating successful receipt.
   - If the frame is corrupted, the receiver discards the frame, and no acknowledgment is sent, forcing the sender to retransmit.

The Stop-and-Wait ARQ protocol provides simplicity in implementation but is not optimal for high-speed or long-delay networks due to its inefficient use of network resources. It has a low throughput as the sender has to wait for each acknowledgment before transmitting the next frame.

Q-04: What is HDLC? Draw HDLC frame types and mention how they differ from one another?

HDLC (High-Level Data Link Control) is a protocol used for data encapsulation and synchronization in the Data Link layer. It is widely used in both point-to-point and multipoint communication networks. HDLC frame types differ based on their functionality and control information. The three main frame types are:

1. Information Frames (I-frames):
   - I-frames carry user data between sender and receiver.
   - They ensure reliable data transmission by using sequence numbers, acknowledgments, and error checking.
2. Supervisory Frames (S-frames):
   - S-frames provide flow control and error control functions.
   - They include frames like Receiver Ready (RR), Reject (REJ), Selective Reject (SREJ), and Receiver Not Ready (RNR).
3. Unnumbered Frames (U-frames):
   - U-frames serve various control functions, such as link establishment, disconnection, and error recovery.

- They include frames like Set Asynchronous Balanced Mode (SABM), Unnumbered Acknowledgment (UA), Disconnect (DISC), and Unnumbered Information (UI).

The specific usage and differentiation of HDLC frame types depend on the operating mode and requirements of the communication network.

Q-05: Flow control [Stop-and-Wait, Sliding Window].

Flow Control: Flow control is a mechanism used to regulate the flow of data between the sender and the receiver to ensure that the receiver can handle the data at an appropriate pace. It prevents the sender from overwhelming the receiver and helps maintain efficient and reliable communication.

Stop-and-Wait Flow Control: Stop-and-Wait flow control is a simple method where the sender transmits a single frame and waits for the acknowledgment from the receiver before sending the next frame. This mechanism ensures that the receiver can handle each frame before the sender transmits the next one.

Sliding Window Flow Control: Sliding Window flow control allows the sender to transmit multiple frames without waiting for individual acknowledgments. The receiver maintains a sliding window that determines the range of acceptable sequence numbers for incoming frames. This mechanism enables continuous transmission as long as the sender's frames fall within the receiver's window range.

Q-06: Error control [Stop-and-Wait ARQ, Sliding Window ARQ].

Error Control: Error control is a technique used to detect and recover from errors that occur during data transmission. It ensures data integrity and reliability in communication networks.

Stop-and-Wait ARQ: Stop-and-Wait Automatic Repeat Request (ARQ) is an error control protocol that verifies the successful receipt of each transmitted frame. The sender waits for an acknowledgment from the receiver before transmitting the next frame. If the sender does not receive the acknowledgment within a timeout period, it assumes an error or loss and retransmits the frame.

Sliding Window ARQ: Sliding Window ARQ is an error control protocol that allows the sender to transmit multiple frames before receiving acknowledgments. The receiver maintains a sliding window that verifies the correctness of received frames and sends cumulative acknowledgments. If an error occurs, the sender can retransmit only the damaged or missing frames instead of resending the entire window.

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