Computer Networks

MID term Syllabus Review: SUMMER 2016

Syllabus:

Chapter 1: Computer Networks and the Internet

Chapter 2: Application Layer

Chapter 4: Network Layer

[Book: Computer Nerworking A Top-Down Approach By Kurose]

Few Most Important Question with Solution:

(a) Visit the site www.traceroute.org and perform trace routes from two different cities in France to the same destination host in the United States. How many links are the same in the two trace routes?

Ans: In these trace routes from two different cities in France to the same destination host in United States; seven links are in common including the transatlantic link.

Or,

Pick a city in the United States, and perform traceroutes to two hosts, each in a different city in China. How many links are common in the two traceroutes? Do the two traceroutes diverge before reaching China?

Ans: Five links are common in the two trace routes. The two trace routes diverge before reaching China.

(b) Skype offers a service that allows you to make a phone call from a PC to an ordinary phone. This means that the voice call must pass through both the Internet and through a telephone network. Discuss how this might be done.

Ans: The circuit-switched telephone networks and the Internet are connected together at "gateways". When a Skype user (connected to the Internet) calls an ordinary telephone, a circuit is established between a gateway and the telephone user over the circuit switched network. The Skype user's voice is sent in packets over the Internet to the gateway. At the gateway, the voice signal is reconstructed and then sent over the circuit. In the other

direction, the voice signal is sent over the circuit switched network to the gateway. The gateway packetizes the voice signal and sends the voice packets to the Skype user.

(c) Why do HTTP, FTP, SMTP, and POP3 run on top of TCP rather than on UDP?

Ans: The applications associated with those protocols require that all application data be received in the correct order and without gaps. TCP provides this service whereas UDP does not.

(d) Consider an HTTP client that wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application-layer protocols besides HTTP are needed in this scenario?

Ans: Application layer protocols: DNS and HTTP
Transport layer protocols: UDP for DNS; TCP for HTTP.

(e) Suppose that your department has a local DNS server for all computers in the department. You are an ordinary user (i.e., not a network/system administrator). Can you determine if an external Web site was likely accessed from a computer in your department a couple of seconds ago? Explain.

Ans: Yes, we can use dig to query that Web site in the local DNS server. For example, "dig cnn.com" will return the query time for finding cnn.com. If cnn.com was just accessed a couple of seconds ago, an entry for cnn.com is cached in the local DNS cache, so the query time is 0 msec. Otherwise, the query time is large.

(f) Install and compile the Python programs TCP Client and UDP Client on one host and TCP Server and UDP Server on another host.

i. Suppose you run TCP Client before you run TCP Server. What happens? Why?
ii. Suppose you run UDP Client before you run UDP Server. What happens? Why?
iii. What happens if you use different port numbers for the client and server sides?

Ans:

i. If you run TCP Client first, then the client will attempt to make a TCP connection with a nonexistent server process. A TCP connection will not be made.
ii. UDP Client doesn't establish a TCP connection with the server. Thus, everything should work fine if you first run UDP Client, then run UDP Server, and then type some input into the keyboard.
iii. If you use different port numbers, then the client will attempt to establish a TCP connection with the wrong process or a non-existent process. Errors will occur.

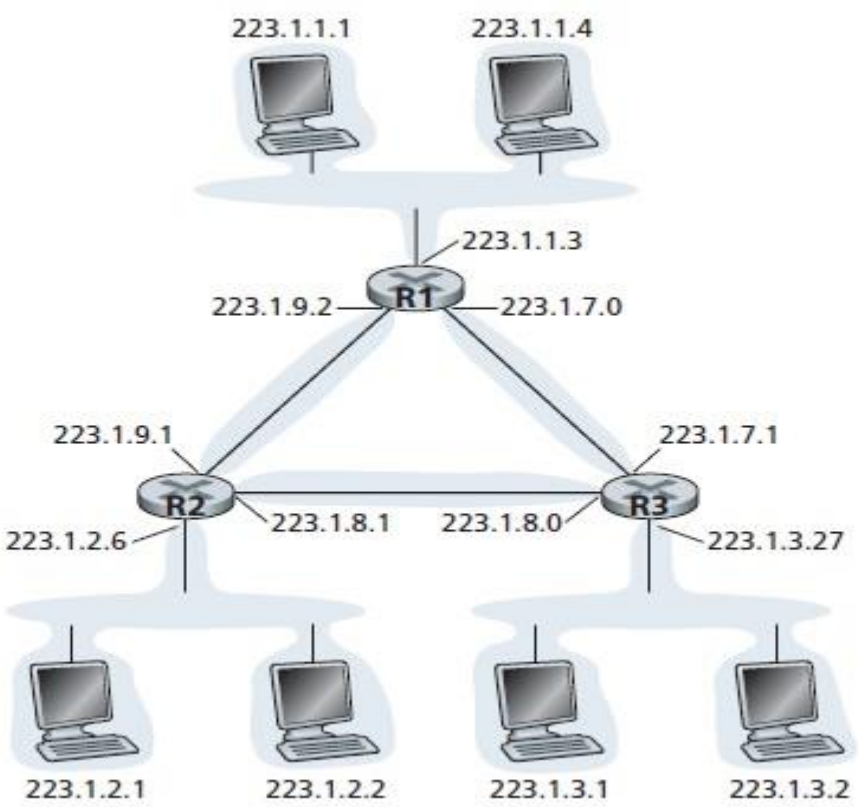
(g) What is the difference between routing and forwarding?

Ans: Forwarding is about moving a packet from a router's input link to the appropriate output link. Routing is about determining the end-to-routes between sources and destinations.

(h) Compare and contrast the IPv4 and the IPv6 header fields. Do they have any fields in common?

Ans: IPv6 has a fixed length header, which does not include most of the options an IPv4 header can include. Even though the IPv6 header contains two 128 bit addresses (source and destination IP address) the whole header has a fixed length of 40 bytes only. Several of the fields are similar in spirit. Traffic class, payload length, next header and hop limit in IPv6 are respectively similar to type of service, datagram length, upper-layer protocol and time to live in IPv4.

(i) Find out the Number of Subnet, Network, Hosts and Default Gateway from this configuration?

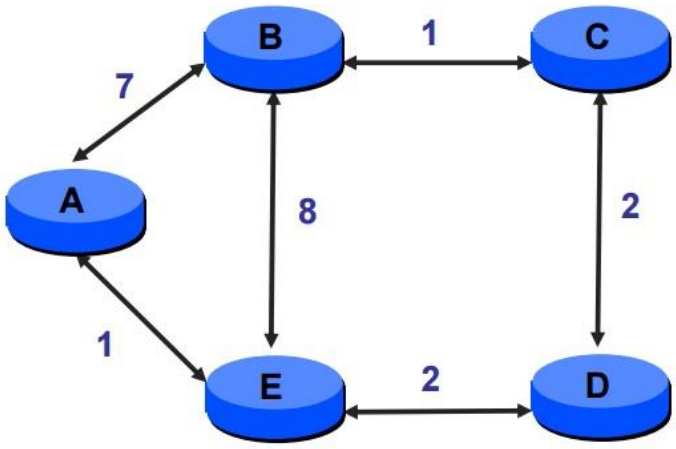


Ans: Subnet: Six Subnets
Network: Six networks.
Hosts: Six Hosts
Default Gateway: Three

(j) Consider a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17/24. Also suppose that Subnet 1 is required to support at least 60 interfaces, Subnet 2 is to support at least 90 interfaces, and Subnet 3 is to support at least 12 interfaces. Provide three network addresses that satisfy these constraints.

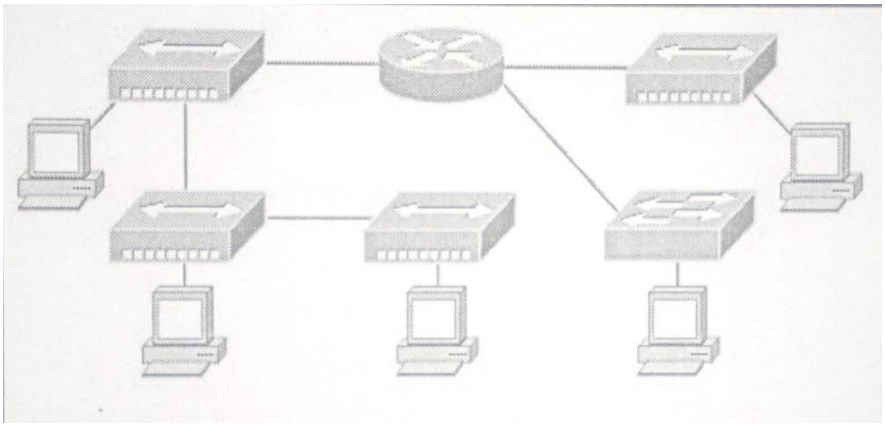
Ans:
Subnet 1: Network Addresse- 223.1.17.0/26 (Allocate size: 64)
Subnet 2: Network Addresse- 223.1.17.64/25 (Allocate size: 128)
Subnet 3: Network Addresse- 223.1.17.192/28 (Allocate size: 16)

(k) Compute the distance tables after the initialization step and after each iteration of a synchronous version of the distance-vector algorithm.



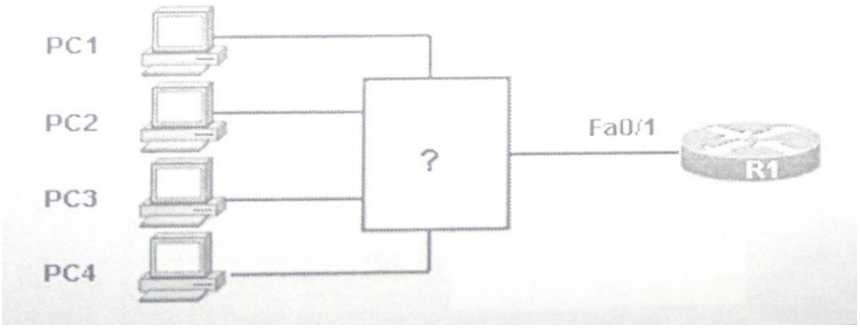
Ans: For Solution this link state with algorithm, **follow this link** or **Click here..**

(l) Consider the below figure, assume all devices are using default configuration. How many subnets are required to address the topology that is shown? What is the reason behind?



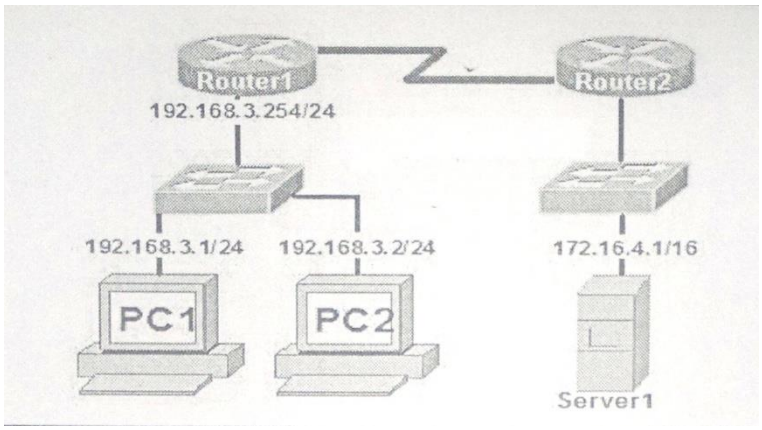
Ans: Three subnets. Because, here one router have three interfaces and we know that each interface determine one subnet.

(m) Consider the Figure, which device should be included in the network topology to provide Layer 2 connectivity for all LAN devices, provide multiple collision domains, and also provide a connection to the rest of the network? What are the major functions of that device?



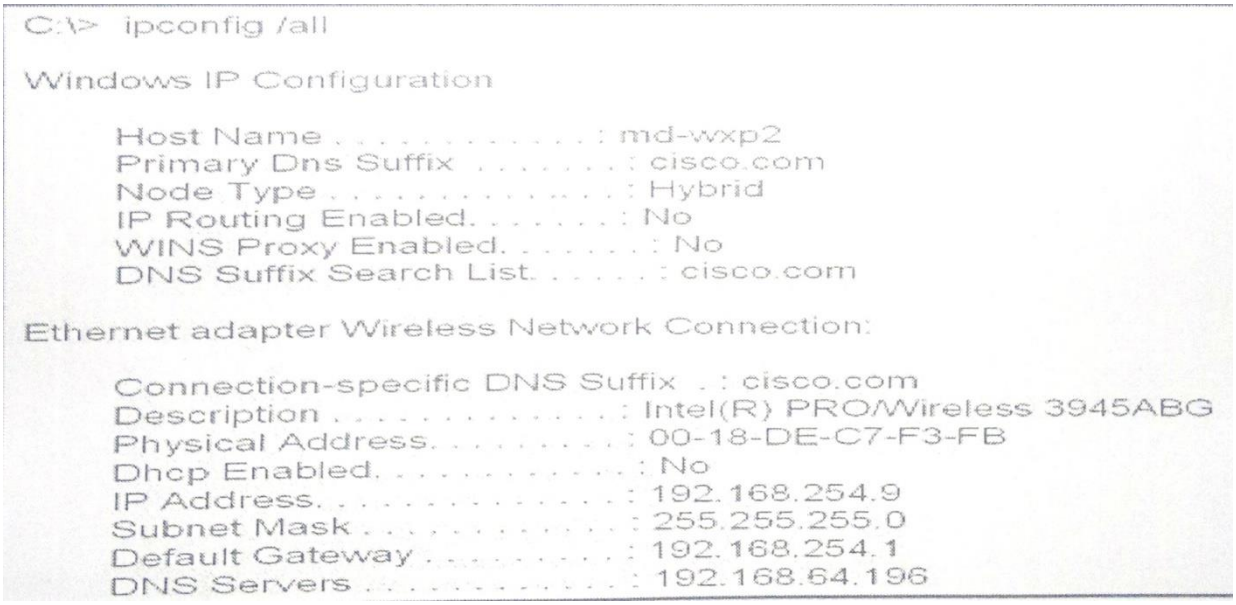
Ans: Switch should be included in the network topology.
Major Function: When a switch receives a packet of data, it determines what computer or device the packet is intended for and sends it to that computer only. It does not broadcast the packet to all computers and makes the network much more efficient.

(n) Refer to the exhibit; A technician has been asked to test connectivity from PC1 to a remote network. Which action will indicate if there is remote connectivity?



Ans: For testing the remote connectivity, technician use this action instruction-
ping 172.16.4.1/16.

(o) Refer to the exhibit; a technician is working on a network problem that requires verification of the router LAN interface. What address should be pinged from this host to confirm that the router interface is operational? Why?



```
C:\> ipconfig /all

Windows IP Configuration

        Host Name . . . . . . . . . . . . : md-wxp2
        Primary Dns Suffix . . . . . . . : cisco.com
        Node Type . . . . . . . . . . . . : Hybrid
        IP Routing Enabled. . . . . . . . : No
        WINS Proxy Enabled. . . . . . . . : No
        DNS Suffix Search List. . . . . . : cisco.com

Ethernet adapter Wireless Network Connection:

        Connection-specific DNS Suffix  . : cisco.com
        Description . . . . . . . . . . . : Intel(R) PRO/Wireless 3945ABG
        Physical Address. . . . . . . . . : 00-18-DE-C7-F3-FB
        Dhcp Enabled. . . . . . . . . . . : No
        IP Address. . . . . . . . . . . . : 192.168.254.9
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 192.168.254.1
        DNS Servers . . . . . . . . . . . : 192.168.64.196
```

Ans: Default Gateway address (192.168.254.1) should be pinged from the host to confirm that the router interface is operational. Because, in a LAN, the default gateway is connected with routers and this address build connection as well as share data among router and LAN.

CHAPTER 1
Introduction

Review Questions

1. Identify the five components of a data communications system?

Ans: The five components of a data communication system are the sender, receiver, transmission medium, message, and protocol.

2. What are the advantages of distributed processing?

Ans: The advantages of distributed processing are security, access to distributed databases, collaborative processing, and faster problem solving.

3. What are the three criteria necessary for an effective and efficient network?

Ans: The three criteria are performance, reliability, and security.

4. What are the advantages of a multipoint connection over a point-to-point connection?

Ans: Advantages of a multipoint over a point-to-point configuration (type of connection) include ease of installation and low cost.

5. What are the two types of line configuration?

Ans: Line configurations (or types of connections) are point-to-point and multipoint.

6. Categorize the four basic topologies in terms of line configuration.

Ans: We can divide line configuration in two broad categories:
a. ***Point-to-point***: mesh, star, and ring.
b. ***Multipoint***: bus

7. What is the difference between half-duplex and full-duplex transmission modes?

Ans: In half-duplex transmission, only one entity can send at a time; in a full-duplex transmission, both entities can send at the same time.

8. Name the four basic network topologies, and cite an advantage of each type.

Ans: We give an advantage for each of four network topologies:
a. ***Mesh***: secure
b. ***Bus***: easy installation
c. ***Star***: robust
d. ***Ring***: easy fault isolation

9. For *n* devices in a network, what is the number of cable links required for a mesh, ring, bus, and star topology?

Ans: The number of cables for each type of network is:
a. ***Mesh***: $n\ (n - 1) / 2$
b. ***Star***: n
c. ***Ring***: $n - 1$

d. ***Bus***: one backbone and n drop lines

10. What are some of the factors that determine whether a communication system is a LAN or WAN?
Ans: The general factors are size, distances (covered by the network), structure, and Ownership

11. What is an internet? What is the Internet?
Ans: An internet is an interconnection of networks. The Internet is the name of a specific worldwide network

12. Why are protocols needed?
Ans: A protocol defines what is communicated, in what way and when. This provides accurate and timely transfer of information between different devices on a network.

13. Why are standards needed?
Ans: Standards are needed to create and maintain an open and competitive market for manufacturers, to coordinate protocol rules, and thus guarantee compatibility of data communication technologies.

Exercises

14. What is the maximum number of characters or symbols that can be represented by Unicode?
Ans: ***Unicode*** uses **32** bits to represent a symbol or a character. We can define $\mathbf{2^{32}}$ different symbols or characters.

15. A color image uses 16 bits to represent a pixel. What is the maximum number of different colors that can be represented?
Ans: With **16** bits, we can represent up to $\mathbf{2^{16}}$ different colors.

16. Assume six devices are arranged in a mesh topology. How many cables are needed? How many ports are needed for each device?
Ans: a. Cable links: n $(n - 1) / 2 = (6 \times 5) / 2 =$ **15**
b. Number of ports: $(n - 1) =$ **5** ports needed per device

17. For each of the following four networks, discuss the consequences if a connection fails.
a. Five devices arranged in a mesh topology
b. Five devices arranged in a star topology (not counting the hub)
c. Five devices arranged in a bus topology
d. Five devices arranged in a ring topology

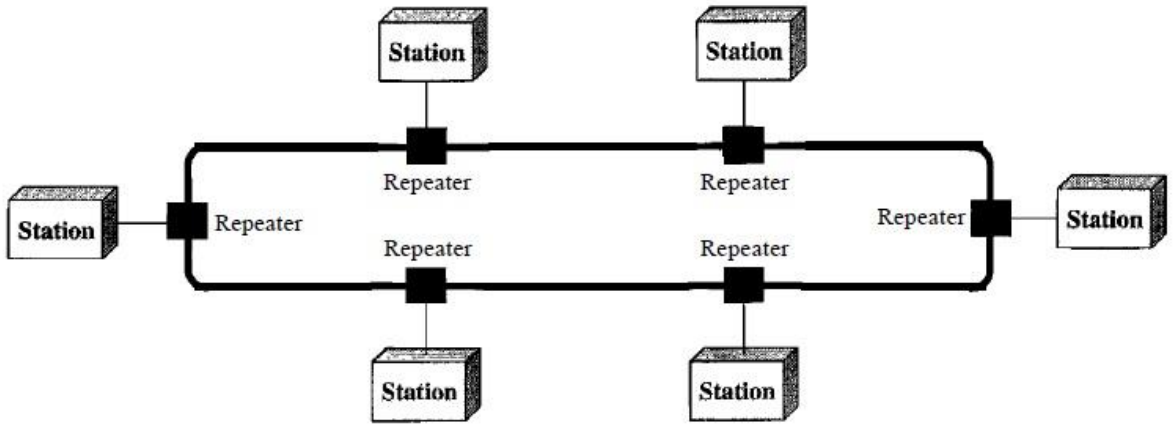
Ans:
a. ***Mesh topology***: If one connection fails, the other connections will still be working.
b. **Star topology**: The other devices will still be able to send data through the hub; there will be no access to the device which has the failed connection to the hub.
c. **Bus Topology**: All transmission stops if the failure is in the bus. If the drop-line fails, only the corresponding device cannot operate.
d. ***Ring Topology***: The failed connection may disable the whole network unless it is a dual ring or there is a by-pass mechanism.

18. You have two computers connected by an Ethernet hub at home. Is this a LAN, a MAN, or a WAN? Explain your reason.

Ans: This is a LAN. The Ethernet hub creates a LAN because of we know that a local area network (LAN) is a computer network that is designed for a limited geographic area such as a building or a campus or an isolated network to connect computers.

19. In the ring topology in Figure 1.8, what happens if one of the stations is unplugged?

Figure 1.8 *A ring topology connecting six stations* **SR KohinooR**

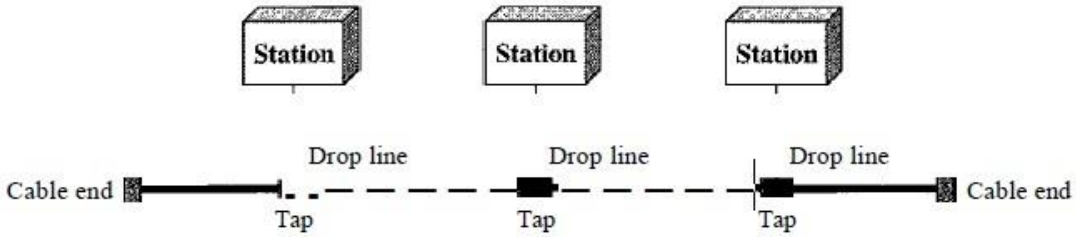


Ans: Theoretically, in a ***ring topology***, unplugging one station, interrupts the ring. However, most ring networks use a mechanism that bypasses the station; the ring can continue its operation.

20. **In** the bus topology in Figure 1.7, what happens if one of the stations is unplugged?

Figure 1.7 *A bus topology connecting three stations*

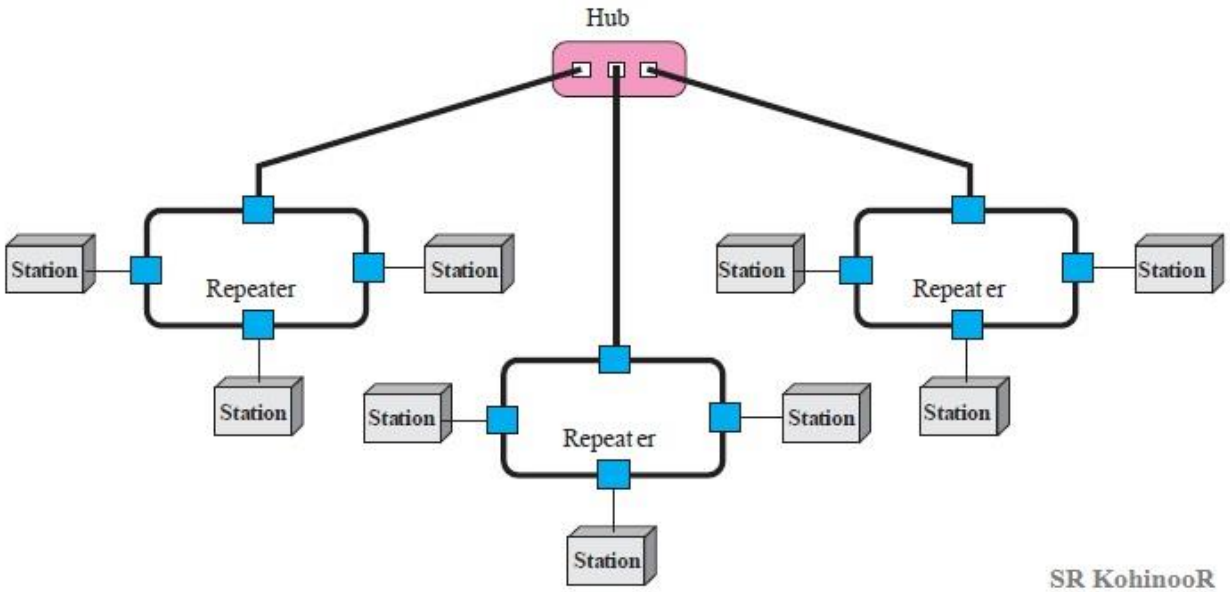
SR KohinooR



Ans: In a bus topology, no station is in the path of the signal. Unplugging a station has no effect on the operation of the rest of the network.

21. Draw a hybrid topology with a star backbone and three ring networks.

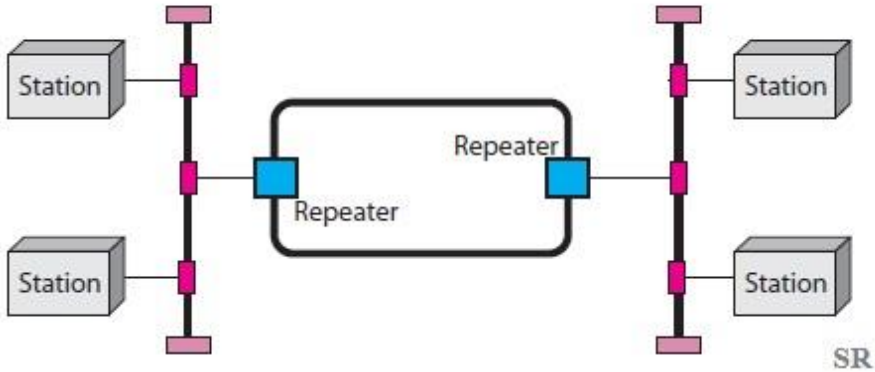
Ans:



SR KohinooR

22. Draw a hybrid topology with a ring backbone and two bus networks.

Ans:



SR KohinooR

23. Performance is inversely related to delay. When you use the Internet, which of the following applications are more sensitive to delay?

a. Sending an e-mail
b. Copying a file
c. Surfing the Internet

Ans: a. E-mail is not an interactive application. Even if it is delivered immediately, it may stay in the mail-box of the receiver for a while. It is not sensitive to delay.
b. We normally do not expect a file to be copied immediately. It is not very sensitive to delay.
c. Surfing the Internet is the an application very sensitive to delay. We except to get access to the site, we are searching.

24. When a party makes a local telephone call to another party, is this a point-to-point or multipoint connection? Explain your answer.

Ans: In this case, the communication is only between a caller and the caller. A dedicated line is established between them. The connection is point-to-point.

25. Compare the telephone network and the Internet. What are the similarities? What are the differences?

Ans: The telephone network was originally designed for voice communication; the Internet was originally designed for data communication. The two networks are similar in the fact that both are made of interconnections of small networks. The telephone network, as we will see in future chapters, is mostly a circuit-switched network; the Internet is mostly a packet-switched network.

CHAPTER 2
Network Models

Review Questions

1. List the layers of the Internet model.

Ans: The layers of TCP or Internet model are:

i. Physical layer
ii. Data link layer
iii. Network layer
iv. Transport layer and
v. Application layer.

2. Which layers in the Internet model are the network support layers?

Ans: Physical, data link, and network layers.

3. Which layer in the Internet model is the user support layer?

Ans: In the Internet Model only Application layer supports the user.

4. What is the difference between network layer delivery and transport layer delivery?

Ans: The transport layer is responsible for process-to-process delivery of the entire message, but the network layer oversees host-to-host delivery of individual packets.

5. What is a peer-to-peer process?

Ans: Peer-to-peer processes are processes on two or more devices communicating at a same layer

6. How does information get passed from one layer to the next in the Internet model?

Ans: Each layer calls upon, the services of the layer just below it using interfaces between each pair of adjacent layers.

7. What are headers and trailers, and how do they get added and removed?

Ans: Headers and trailers are control data added at the beginning and the end of each data unit at each layer of the sender and removed at the corresponding layers of the receiver. They provide source and destination addresses, synchronization points, information for error detection etc.

8. What are the concerns of the physical layer in the Internet model?

Ans: The physical layer is responsible for transmitting bits. Also it is concerned with

a. physical topology
b. representation of bits
c. type of encoding
d. synchronization of bits
e. transmission rate and mode
f. Line Configuration

9. What are the responsibilities of the data link layer in the Internet model?

Ans: The data link layer is responsible for
a. Framing data bits
b. Physical addressing
c. Data rate means flow control
d. Error Control
d. Access Control

10. What are the responsibilities of the network layer in the Internet model?
Ans: The network layer is responsible for transmitting of a packet across multiple networks; therefore its responsibilities include
a. Logical addressing
b. Routing

11. What are the responsibilities of the transport layer in the Internet model?
Ans: The transport layer oversees the process-to-process delivery of the entire message. It is responsible for
a. Segmentation and reassembly
b. Connection Control
c. Flow control
d. Error control

12. What is the difference between a port address, a logical address, and a physical address?
Ans: The physical address is the local address of a node; it is used by the data link layer to deliver data from one node to another within the same network. The logical address defines the sender and receiver at the network layer and is used to deliver messages across multiple networks. The port address (service-point) identifies the application process on the station.

13. Name some services provided by the application layer in the Internet model.
Ans: The application layer services include file transfer, remote access, shared database management, and mail services. Also responsible for dialog control, synchronization, (concern session layer in OSI model) translation, encryption and compression. (concern presentation layer in OSI model)

14. How do the layers of the Internet model correlate to the layers of the OSI model?
Ans: The application, presentation, and session layers of the OSI model are represented by the application layer in the Internet model. The lowest four layers of OSI correspond to the Internet model layers.

Exercises

15. How are OSI and ISO related to each other?
Ans: The International Standards Organization, or the International Organization of Standards, (ISO) is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model.

16. Match the following to one or more layers of the OSI model:
    a. Route determination
    b. Flow control
    c. Interface to transmission media
    d. Provides access for the end use

Ans:

a. Route determination: network layer
b. Flow control: data link and transport layers
c. Interface to transmission media: physical layer
d. Access for the end user: application layer

17. Match the following to one or more layers of the OSI model:
    a. Reliable process-to-process message delivery
    b. Route selection
    c. Defines frames
    d. Provides user services such as email and file transfer
    e. Transmission of bit stream across physical medium

Ans:

a. Reliable process-to-process delivery: transport layer
b. Route selection: network layer
c. Defining frames: data link layer
d. Providing user services: application layer
e. Transmission of bits across the medium: physical layer.

18. Match the following to one or more layers of the OSl model:
    a. Communicates directly with user's application program
    b. Error correction and retransmission
    c. Mechanical, electrical, and functional interface
    d. Responsibility for carrying frames between adjacent nodes

Ans:

a. Communication with user's application program: application layer
b. Error correction and retransmission: data link and transport layers
c. Mechanical, electrical, and functional interface: physical layer
d. Responsibility for carrying frames between adjacent nodes: data link layer

19. Match the following to one or more layers of the OSI model:
    a. Format and code conversion services
    b. Establishes, manages, and terminates sessions
    c. Ensures reliable transmission of data
    d. Log-in and log-out procedures
    e. Provides independence from differences in data representation

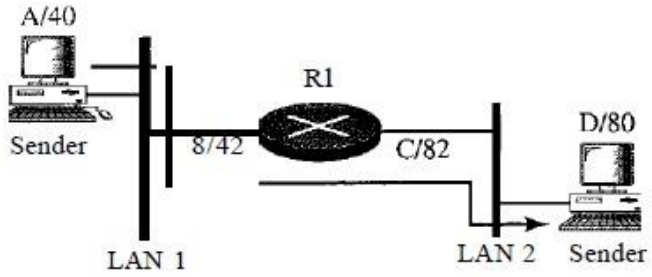
Ans:

a. Format and code conversion services: presentation layer
b. Establishing, managing, and terminating sessions: session layer
c. Ensuring reliable transmission of data: data link and transport layers

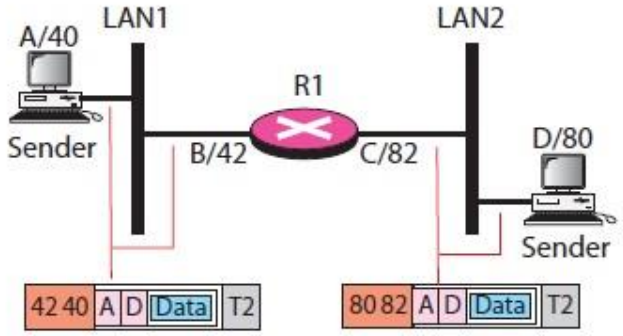
d. Log-in and log-out procedures: session layer
e. Providing independence from different data representation: presentation layer.

20. In Figure 2.22, computer A sends a message to computer D via LANl, router Rl, and LAN2. Show the contents of the packets and frames at the network and data link layer for each hop interface.

Figure 2.22 *Exercise 20* ,**21**

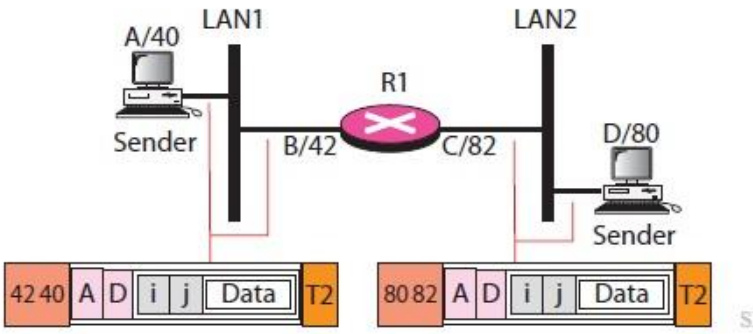


Ans:



21. In Figure 2.22,(given avobe) assume that the communication is between a process running at computer A with port address i and a process running at computer D with port address j. Show the contents of packets and frames at the network, data link, and transport layer for each hop.

Ans:



22. Suppose a computer sends a frame to another computer on a bus topology LAN. The physical destination address of the frame is corrupted during the transmission. What happens to the frame? How can the sender be informed about the situation?

Ans: If the corrupted destination address does not match any station address in the network, the packet is lost. If the corrupted destination address matches one of the stations, the frame is delivered to the wrong station. In this case, however, the error detection mechanism, available in most data link protocols, will find the error and discard the frame.

23. Suppose a computer sends a packet at the network layer to another computer somewhere in the Internet. The logical destination address of the packet is corrupted. What happens to the packet? How can the source computer be informed of the situation?

Ans: Before using the destination address in an intermediate or the destination node, the packet goes through error checking that may help the node find the corruption (with a high probability) and discard the packet. Normally the upper layer protocol will inform the source to resend the packet.

24. Suppose a computer sends a packet at the transport layer to another computer somewhere in the Internet. There is no process with the destination port address running at the destination computer. What will happen?

Ans: Most protocols issue a special error message that is sent back to the source in this case.

25. If the data link layer can detect errors between hops, why do you think we need another checking mechanism at the transport layer?

Ans: The errors *between* the nodes can be detected by the data link layer control, but the error *at* the node (between input port and output port) of the node cannot be detected by the data link layer.

CHAPTER 4
Digital Transmission

Review Questions

1. List three techniques of digital-to-digital conversion.

Ans: The three different techniques are line coding, block coding, and scrambling.

2. Distinguish between a signal element and a data element.

Ans:

Signal element	Data element
1. A signal element is the shortest unit of a digital signal.	1. A data element is the smallest entity that can represent a piece of information (a bit).
2. Signal elements are what we can send.	2. Data elements are what we need to send.
3. Signal elements are the carriers.	3. Data elements are being carried.

3. Distinguish between data rate and signal rate.

Ans:

Data rate	Signal rate
1. The data rate defines the number of data elements (bits) sent in 1s.	1. The signal rate is the number of signal elements sent in 1s.
2. The unit is bits per second (bps).	2. The unit is the baud.

4. Define baseline wandering and its effect on digital transmission.

Ans: The baseline is a running average of the received signal power and a drift in the baseline is called baseline wandering. A long string of 0s or 1s can cause the baseline wandering and make it difficult for the receiver to decoding a digital signal correctly.

5. Define a DC component and its effect on digital transmission.

Ans: When the voltage level in a digital signal is constant for a while, the spectrum creates very low frequencies which called DC components. Its present problems for a system that cannot pass low frequencies.

6. Define the characteristics of a self-synchronizing signal.

Ans: A self-synchronizing digital signal includes timing information in the data being transmitted. This can be happened if there are transitions in the signal that alert the receiver to the beginning, middle or end of the pulse.

7. List five line coding schemes discussed in this book.

Ans: In this book, we introduced unipolar, polar, bipolar, multilevel, and Multitransition coding.
Unipolar- NRZ
Polar- NRZ, RZ and biphrase
Bipolar- AMI and psuedoternery
Multilevel- 2B/1Q, 8B/6T and 4D-PAMS
Multitransition - MLT-3

8. Define block coding and give its purpose.

Ans: Block coding provides an excess to ensure synchronization and to provide inherent error detecting. In general, block coding changes a block of m bits in to a block of n bits, where n is larger than m.

9. Define scrambling and give its purpose.

Ans: Scrambling provides synchronization without increasing the number of bits.
Scrambling is needed in digital to digital convertion, for modifying part of the rules in a line coding scheme to create bit synchronization. Two common scrambling are B8ZS and HDB3

10. Compare and contrast PCM and DM.

Ans: Compare: PCM is the most common technique that converts an analog signal to digital signal. DM iscreated to reduce the complexity of PMC.
Contrast: PCM finds the value of signal amplitude for each sample but DM finds the change from the previous sample.

11. What are the differences between parallel and serial transmission?

Ans: In serial transmission, the data is sent bit-by-bit with serial communication. (More than one cable)
In parallel transmission, the data is moved multi bits at a time. (Need only one cable)

12. List three different techniques in serial transmission and explain the differences.

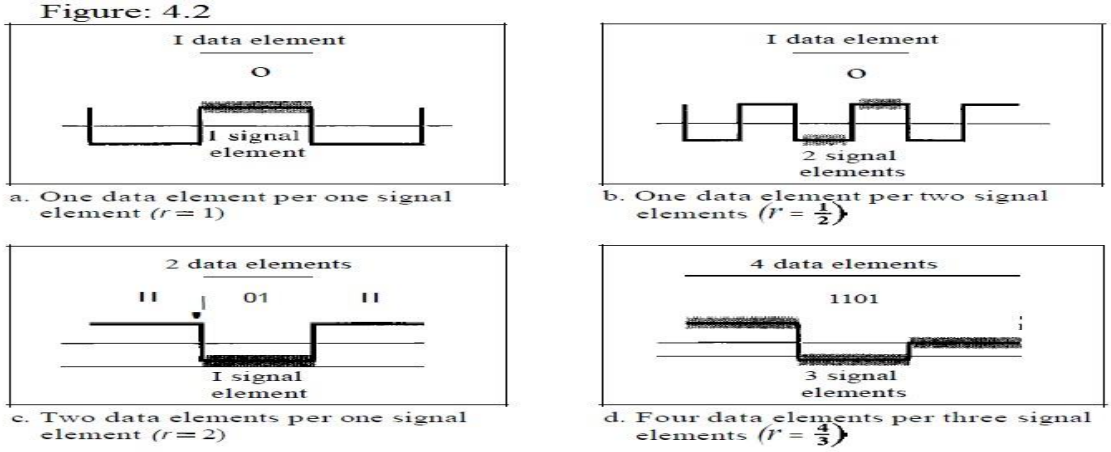
Ans: The three different techniques in serial transmission are: synchronous, asynchronous, and isochronous.

- Asynchronous - send one start bit (zero) at the beginning and one stop bit (one) at the end of each byte. There may be a title between each byte.
- Synchronous - send bit one after another without any start or stop bit and title.
- Isochronous - All bits in the whole stream must be synchronized. It guarantee that the data arrive at the fixed rate.

Exercises

13. Calculate the value of the signal rate for each case in Figure 4.2 if the data rate is 1 Mbps and c = 1/2.

Figure: 4.2



a. One data element per one signal element ($r = 1$)

b. One data element per two signal elements ($r = \frac{1}{2}$)

c. Two data elements per one signal element ($r = 2$)

d. Four data elements per three signal elements ($r = \frac{4}{3}$)

Ans: Given, data rate N = 1 Mbps = 10^6 bps. Case factor c = ½.
∴ We know the relationship between data rate and signal rate is, s = c × N × (1/r). Now,

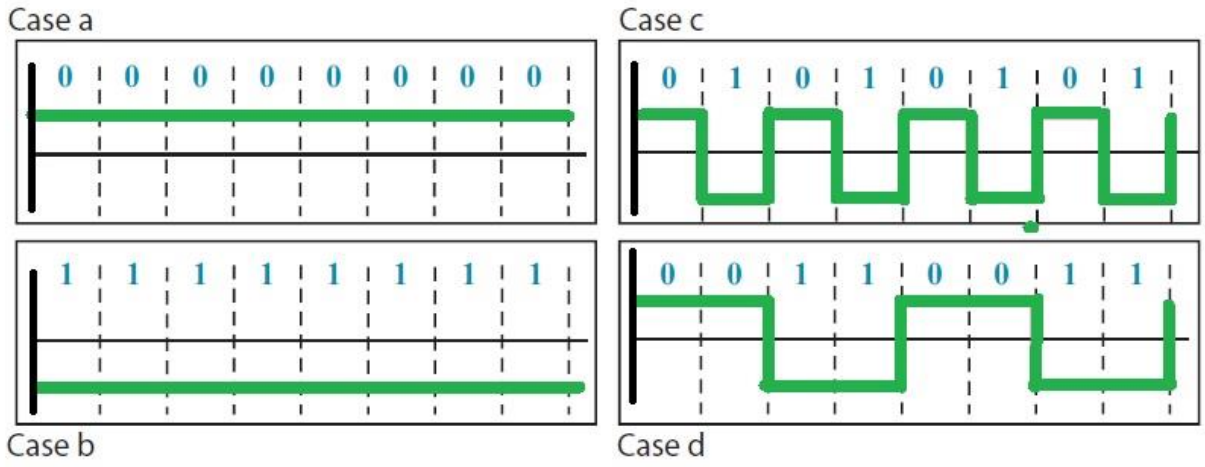
a. Here, r = 1
   ∴ s = ½ × 10^6 × (1/1) = 0.5 Mbaud
b. Here, r = ½ = 0.5
   ∴ s = ½ × 10^6 × (1/0.5) = 1 Mbaud
c. Here, r = 2
   ∴ s = ½ × 10^6 × ½ = 0.25 Mbaud
d. Here, r = 4/3
   ∴ s = ½ × 10^6 × 1/(4/3) = 0.375 Mbaud

14. In a digital transmission, the sender clock is 0.2 percent faster than the receiver clock. How many extra bits per second does the sender send if the data rate is 1 Mbps?

Ans: Given, sender clock faster = 0.2 % = 0.2/100 = 0.002
The data rate = 1 Mbps = 10^6 bps
∴ extra bits = 0.002 × 10^6 = 2000 bits

15. Draw the graph of the NRZ-L scheme using each of the following data streams, assuming that the last signa11evel has been positive. From the graphs, guess the bandwidth for this scheme using the average number of changes in the signal level.
Compare your guess with the corresponding entry in Table 4.1.
a. 00000000
b. 11111111
c. 01010101
d. 00110011

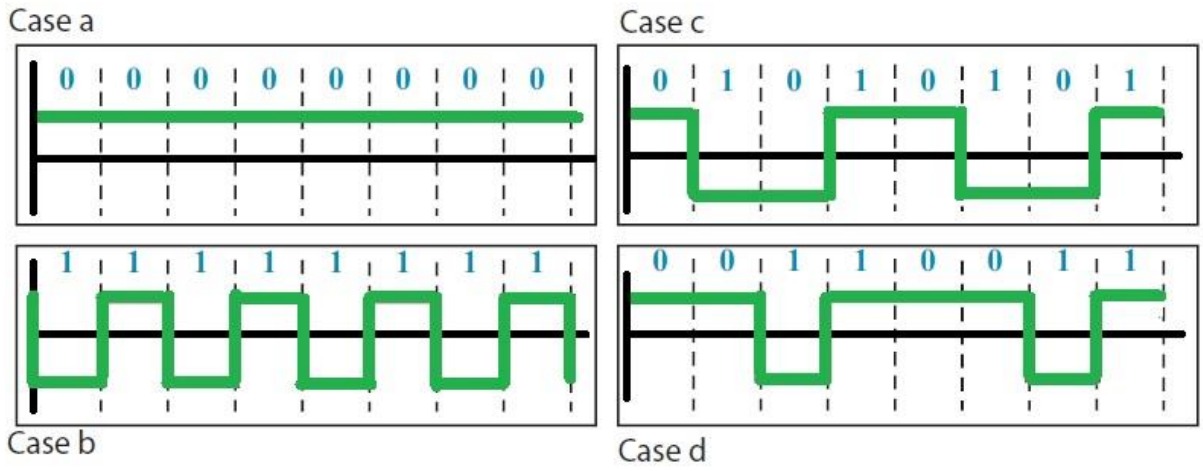
Ans:



Average Number of Changes = (0 + 0 + 8 + 4) / 4 = 3 for N = 8
∴ bandwidth, B → (3 / 8) N

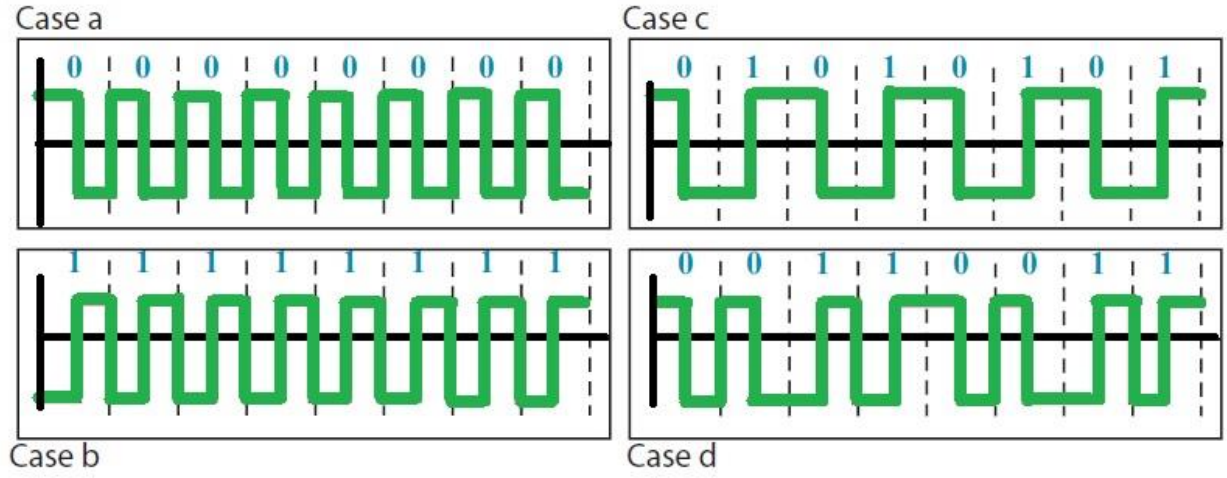
16. Repeat Exercise 15 for the NRZ-I scheme.

Ans:
Average Number of Changes = (0 + 9 + 4 + 4) / 4 = 4.25 for N = 8
∴ bandwidth, B → (4.25 / 8) N



17. Repeat Exercise 15 for the Manchester scheme.

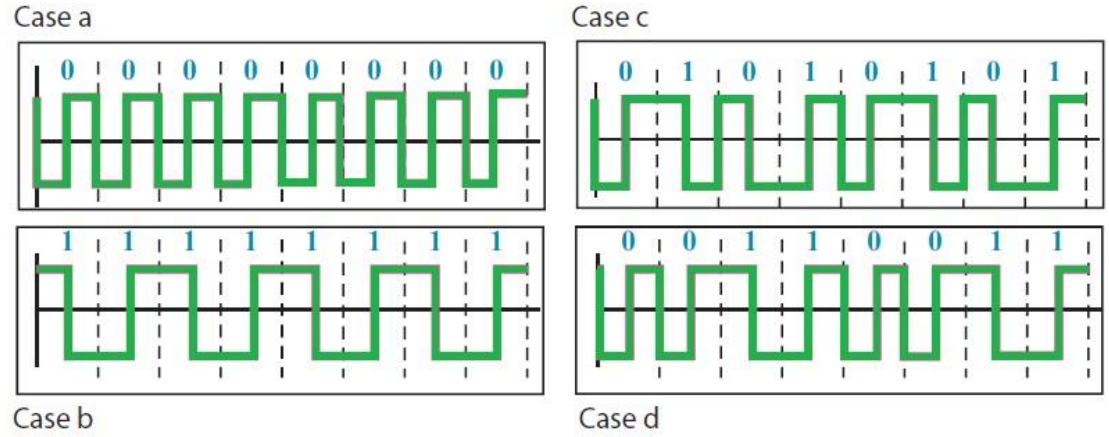
Ans:



Average Number of Changes = (15 + 15 + 8 + 12) / 4 = 12.5 for N = 8
.`. bandwidth, B → (12.5 / 8) N

18. Repeat Exercise 15 for the differential Manchester scheme.

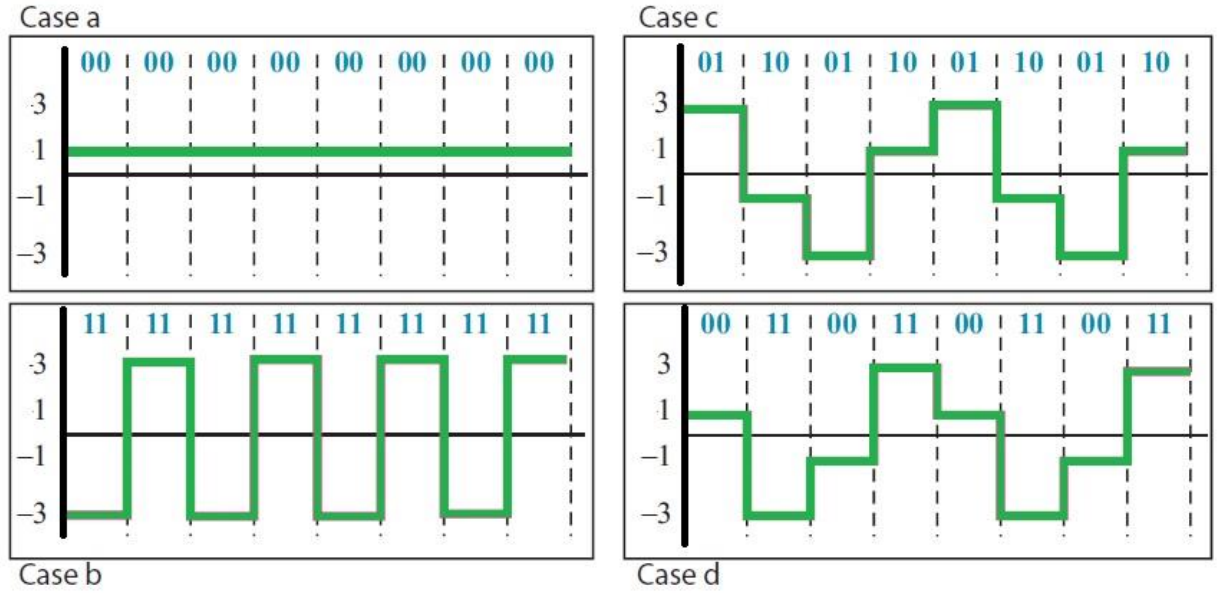
Ans:



Average Number of Changes = (16 + 8 + 12 + 12) / 4 = 12 for N = 8
∴ bandwidth, B → (12 / 8) N

19. Repeat Exercise 15 for the 2B 1Q scheme, but use the following data streams.
a. 0000000000000000
b. 1111111111111111
c. 0101010101010101
d. 0011001100110011

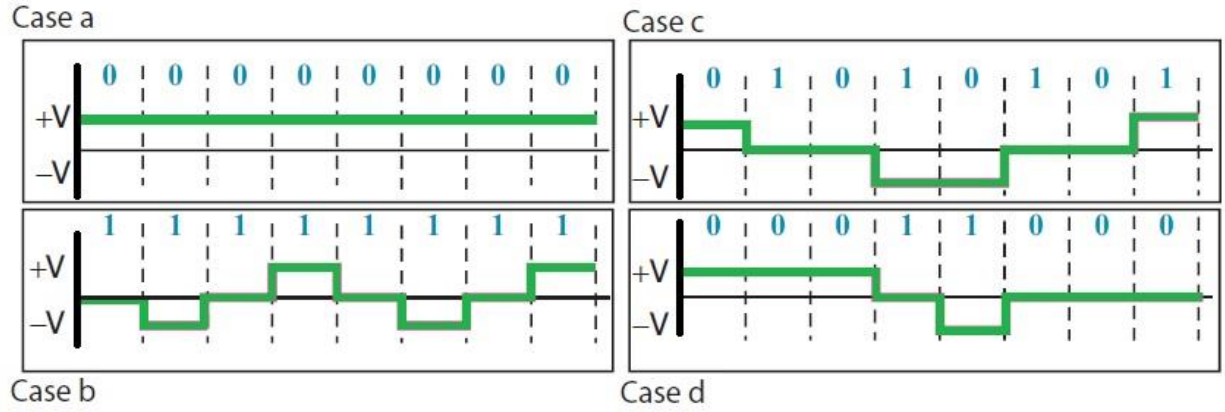
Ans:



Average Number of Changes = (0 + 7 + 7 + 7) / 4 = 5.25 for N = 16
∴ bandwidth, B → (5.25 / 8) N

20. Repeat Exercise 15 for the MLT-3 scheme, but use the following data streams.
a. 00000000
b. 11111111
c. 01010101
d. 00011000

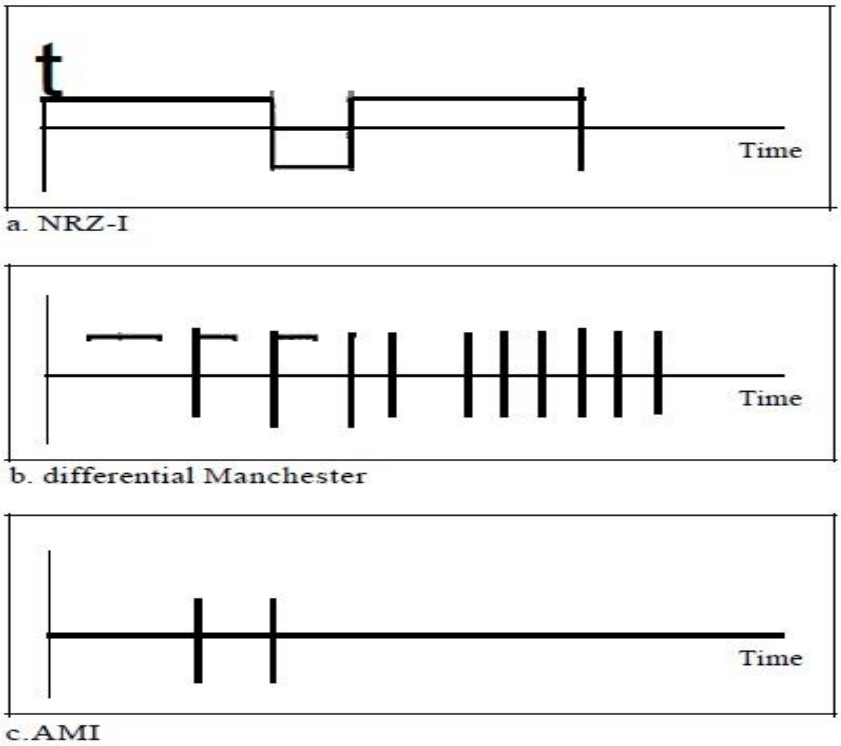
Ans:



Average Number of Changes = (0 + 7 + 4 + 3) / 4 = 4.5 for N = 8
∴ bandwidth, B → (4.5 / 8) N

21. Find the 8-bit data stream for each case depicted in Figure 4.36.

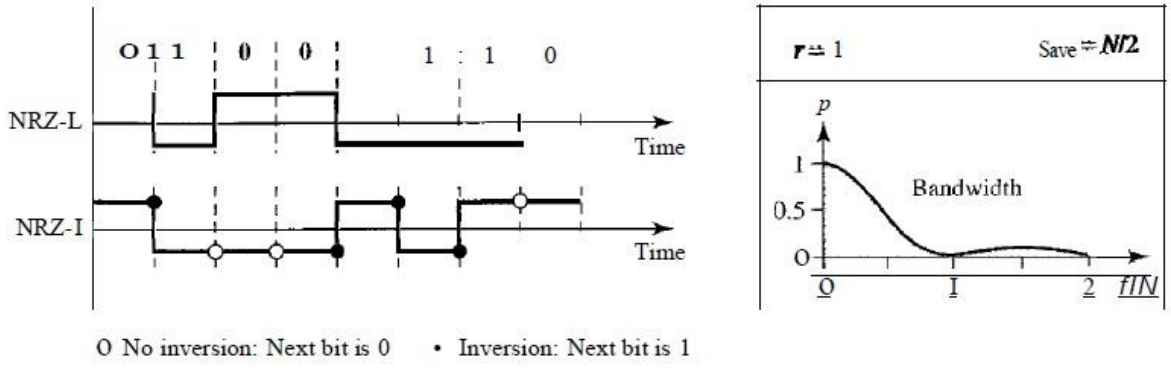
Figure 4.36



Ans: The 8 bit data stream can be found as
a. NRZ-I: 10011001.
b. Differential Manchester: 11000100.
c. AMI: 01110001.

22. An NRZ-I signal has a data rate of 100 Kbps. Using Figure 4.6, calculate the value of the normalized energy (P) for frequencies at 0 Hz, 50 KHz, and 100 KHz.

Figure 4.6 *Polar NRZ-L and NRZ-I schemes*

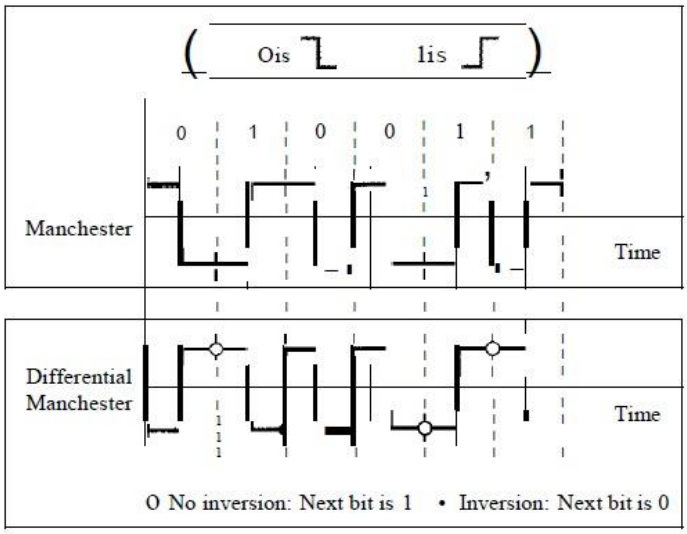


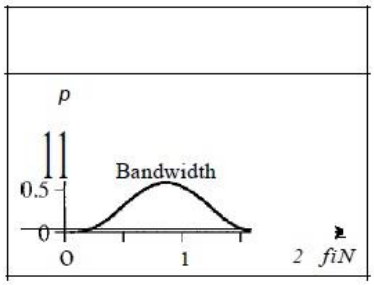
Ans:
The data rate is 100 Kbps. For each case, we first need to calculate the value f / N. We then use Figure 4.6 in the text to find P (energy per Hz). All calculations are approximations.

a. f /N = 0/100 = 0 → P = 1.0
b. f /N = 50/100 = 1/2 → P = 0.5
c. f /N = 100/100 = 1 → P = 0.0

23. A Manchester signal has a data rate of 100 Kbps. Using Figure 4.8, calculate the value of the normalized energy (P) for frequencies at 0 Hz, 50 KHz, 100 KHz.

Figure 4.8 *Polar biphase: Manchester and differential Manchester schemes*





Ans:
The data rate is 100 Kbps. For each case, we first need to calculate the value f/N. We then use Figure 4.8 in the text to find P (energy per Hz). All calculations are approximations.
a. f /N = 0/100 = 0 → P = 0.0
b. f /N = 50/100 = 1/2 → P = 0.3
c. f /N = 100/100 = 1 → P = 0.4
d. f /N = 150/100 = 1.5 → P = 0.0

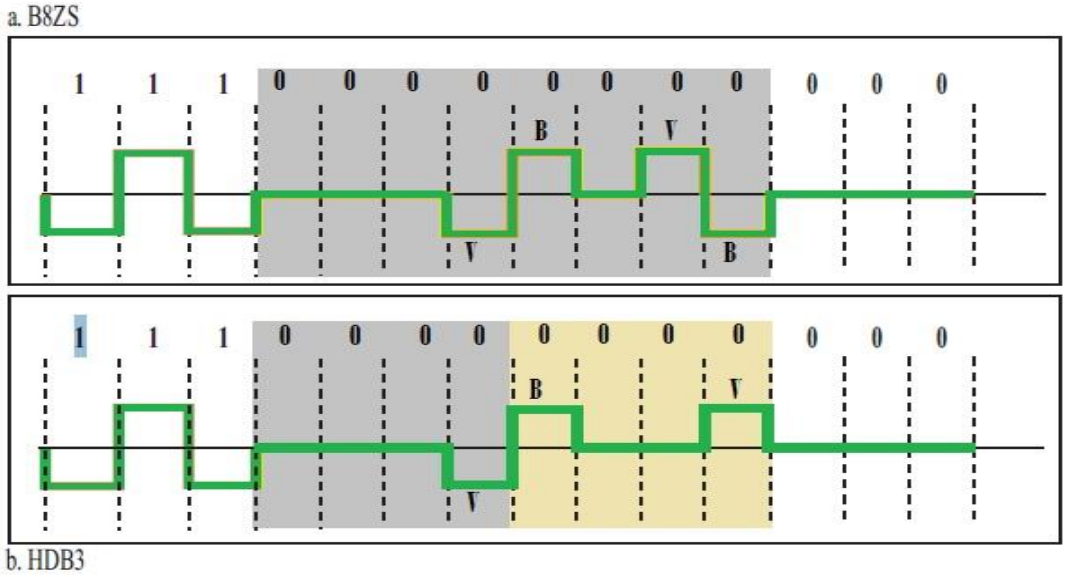
24. The input stream to a 4B/5B block encoder is 0100 0000 0000 0000 0000 0001.
Answer the following questions:
a. What is the output stream?
b. What is the length of the longest consecutive sequence of 0s in the input?
c. What is the length of the longest consecutive sequence of 0s in the output?
Ans: a. The output stream is 01010 11110 11110 11110 11110 01001.
b. The maximum length of consecutive 0s in the input stream is 21.
c. The maximum length of consecutive 0s in the output stream is 2.

25. How many invalid (unused) code sequences can we have in 5B/6B encoding? How many in 3B/4B encoding?

Ans: In 5B/6B, we have 25 = 32 data sequences and 26 = 64 code sequences. The number of unused code sequences is 64 − 32 = 32. In 3B/4B, we have 23 = 8 data sequences and 24 = 16 code sequences. The number of unused code sequences is 16 − 8 = 8.

26. What is the result of scrambling the sequence 11100000000000 using one of the following scrambling techniques? Assume that the last non-zero signal level has been positive.
a. B8ZS
b. HDB3 (The number of nonzero pules is odd after the last substitution)

Ans: See this figure where the last non-zero signal is positive and the first bit is positive.



27. What is the Nyquist sampling rate for each of the following signals?
a. A low-pass signal with bandwidth of 200 KHz?
b. A band-pass signal with bandwidth of 200 KHz if the lowest frequency is 100 KHz?

Ans:

a. Here, Bandwidth = 200 KHz = 200000Hz.
We know that, in a low-pass signal, the minimum frequency = 0.
∴ $f_{max} = 0 + 200000 = 200000$ Hz.
⇨ $f_s = 2 \times 200000 = 400000$ samples/s

b. Here, the lowest frequency = 100 KHz = 100000 Hz.
And, Bandwidth = 200 KHz = 200000Hz
∴ $f_{max} = 100000 + 200000 = 300000$ Hz.
⇨ $f_s = 2 \times 300000 = 600000$ samples /s

28. We have sampled a low-pass signal with a bandwidth of 200 KHz using 1024 levels of quantization.
a. Calculate the bit rate of the digitized signal.
b. Calculate the SNR_{dB} for this signal.
c. Calculate the PCM bandwidth of this signal.

Ans:

a. Here, Bandwidth = 200 KHz = 200000Hz.
We know that, in a low-pass signal, the minimum frequency = 0
∴ $f_{max} = 0 + 200000 = 200000$ Hz
⇨ $f_s = 2 \times 200000 = 400000$ samples/s

The number of bits per sample, and the bit rate are

$n_b = \log_2 1024$

$= 10$ bits/sample

∴ $N = 400000 \times 10 = 4 \times 10^6$ bps = 4 Mbps

b. We get, the value of $n_b = 10$.

∴ $SNR_{dB} = 6.02 \times n_b + 1.76 = 61.96$

c. We get, the value of $n_b = 10$.

∴ The minimum bandwidth can be calculated as,

$B_{PCM} = n_b \times B_{analog} = 10 \times 200000 = 2$ MHz

29. What is the maximum data rate of a channel with a bandwidth of 200 KHz if we use four levels of digital signaling.

Ans: Here, bandwidth = 200 KHz = 200000 Hz

∴ The maximum data rate can be calculated as

$N_{max} = 2 \times B \times n_b = 2 \times 200000 \times \log_2 4 = 8 \times 10^8$ bps = 800 Kbps.

30. An analog signal has a bandwidth of 20 KHz. If we sample this signal and send it through a 30 Kbps channel what is the SNR_{dB} ?

Ans: Given, Bandwidth = 20 KHz = 20000 Hz.

∴ $f_{max} = 0 + 4 = 4$ KHz

⇨ $f_s = 2 \times 4 = 8000$ sample/s

We then calculate the number of bits per sample.

⇨ $n_b = 30000 / 8000 = 3.75$

We need to use the next integer $n_b = 4$. The value of SNR_{dB} is

∴ $SNR_{dB} = 6.02 \times n_b + 1.72 = 25.8$

31. We have a baseband channel with a 1-MHz bandwidth. What is the data rate for this channel if we use one of the following line coding schemes?

a. NRZ-L b. Manchester

c. MLT-3 d. 2B1Q

Ans: Here, bandwidth = 1 MHz = 1000 Hz

a. NRZ-L => $N = 2 \times B = 2 \times 1000 = 2000$ bps

b. Manchester => $N = 1 \times B = 1 \times 1000 = 1000$ bps

c. MLT-3 => $N = 3 \times B = 3 \times 1000 = 3000$ bps

d. 2B1Q => $N = 4 \times B = 4 \times 1000 = 4000$ bps

32. We want to transmit 1000 characters with each character encoded as 8 bits.

a. Find the number of transmitted bits for synchronous transmission.

b. Find the number of transmitted bits for asynchronous transmission.

c. Find the redundancy percent in each case.

Ans:

a. For synchronous transmission, transmitted bits = 1000 × 8 = 8000 bits.

b. For asynchronous transmission, transmitted bits = 1000 × 10 = 10000 bits.

N.B. (8 bits + 1 stop bit & 1 start bit)

c. For case a, the redundancy is 0%.

For case b, we send 2000 extra for 8000 required bits. The redundancy is 25%.

CHAPTER 5
Analog Transmission

Review Questions

1. Define analog transmission.

Ans: Analog transmission means the transmission of analog signals using a band-pass channel. More specifically, Analogue data transmission consists of sending information over a physical transmission medium in the form of a wave.

2. Define carrier signal and its role in analog transmission.

Ans: A carrier signal is a single-frequency signals that has one of its characteristics like as amplitude, frequency, or phase. Its role in analog transmission is changed to represent the baseband signal.

3. Define digital-to-analog conversion.

Ans: Digital-to-analog conversion is the process of changing one of the characteristics of an analog signal based on the information in digital data. The baseband digital signal representing the digital data modulates the carrier to create a broadband analog signal.

4. Which characteristics of an analog signal are changed to represent the digital signal in each of the following digital-to-analog conversion?

   a. ASK
   b. FSK
   c. PSK
   d. QAM.

Ans:

a. ASK changes the amplitude of the carrier.
b. FSK changes the frequency of the carrier.
c. PSK changes the phase of the carrier.
d. QAM changes both the amplitude and the phase of the carrier

5. Which of the four digital-to-analog conversion techniques (ASK, FSK, PSK or QAM) is the most susceptible to noise? Defend your answer.

Ans: I think that, ASK is the most susceptible technique among the four digital-to-analog conversion techniques. Because of the amplitude is more affected by noise than the phase or frequency.

6. Define constellation diagram and its role in analog transmission.

Ans: A constellation diagram can help us define the amplitude and phase of a signal element, particularly when we are using two carriers. The diagram is useful when we are dealing with multilevel ASK, PSK, or QAM. In a constellation diagram, a signal element type is represented as a dot. The bit or combination of bits it can carry is often written next to it. The diagram has two axes. The horizontal X axis related to the in-phase carrier; the vertical Y axis is related to the quadrature carrier.

7. What are the two components of a signal when the signal is represented on a constellation diagram? Which component is shown on the horizontal axis? Which is shown on the vertical axis?
Ans: The two components of a signal are called I and Q. The I component, called inphase, is shown on the horizontal axis; the Q component, called quadrature, is shown on the vertical axis.

8. Define analog-to-analog conversion?
Ans: The process of changing one of the characteristics of an analog signal to represent the instantaneous amplitude of a baseband signal is called analog-to-analog conversion. It is also called the modulation of an analog signal; the baseband analog signal modulates the carrier to create a broadband analog signal.

9. Which characteristics of an analog signal are changed to represent the lowpass analog signal in each of the following analog-to-analog conversions?
a. AM
b. FM
c. PM.
Ans: In analog to analog conversion,
a. AM changes the amplitude of the carrier
b. FM changes the frequency of the carrier
c. PM changes the phase of the carrier

10. Which of the three analog-to-analog conversion techniques (AM, FM, or PM) is the most susceptible to noise? Defend your answer.
Ans: I think that, AM, FM, PM, among this three analog to analog conversion techniques, the most susceptible technique is AM because the amplitude is more affected by noise than the phase or frequency.

Exercises

11. Calculate the baud rate for the given bit rate and type of modulation.
a. 2000 bps, FSK
b. 4000 bps, ASK
c. 6000 bps, QPSK
d. 36,000 bps, 64-QAM
Ans: For baud rate (S), we know that the formula is:

$$S = \frac{N}{r}$$

Here, N = Bit rate, which is given in each case.
r = number of elements, which is unknown. So, at first we need to calculate r for each case.
We know, $r = \log_2 L$.

a. For FSK, $r = \log_2 2 = 1$ ∴ $S = \frac{2000}{1}$ = 2000 baud

b. For ASK, $r = \log_2 2 = 1$ ∴ $S = \frac{4000}{1}$ = 4000 baud

c. For QPSK, $r = \log_2 4 = \log_2 2^2 = 2 \log_2 2 = 2$ $\therefore S = \frac{6000}{2} = 3000$ baud

d. For 64-QAM, $r = \log_2 64 = \log_2 2^6 = 6 \log_2 2 = 6$ $\therefore S = \frac{36000}{6} = 6000$ baud

12. Calculate the bit rate for the given baud rate and type of modulation.
a. 1000 baud, FSK
b. 1000 baud, ASK
c. 1000 baud, BPSK
d. 1000 baud, 16-QAM

Ans: For baud rate (S), we know that the formula is:

$$S = \frac{N}{r}$$

$\therefore N = S * r$

Here, N = Bit rate, which we find out in each case.
r = number of elements, which is unknown. So, at first we need to calculate r for each case.
We know, $r = \log_2 L$.

a. For FSK, $r = \log_2 2 = 1$ $\therefore N = 1000 * 1 = 1000$ bps

b. For ASK, $r = \log_2 2 = 1$ $\therefore N = 1000 * 1 = 1000$ bps

c. For BPSK, $r = \log_2 2 = 1$ $\therefore N = 1000 * 1 = 1000$ bps

d. For 16-QAM, $r = \log_2 16 = \log_2 2^4 = 4 \log_2 2 = 4$ $\therefore N = 1000 * 4 = 4000$ bps

13. What is the number of bits per baud for the following techniques?
a. ASK with four different amplitudes
b. FSK with 8 different frequencies
c. PSK with four different phases
d. QAM with a constellation of 128 points.

Ans: For the number of bits (r) per baud, we use the formula: $r = \log_2 L$

Here, L = type of the signal element, which is given in each case.

a. For ASK, $r = \log_2 4 = \log_2 2^2 = 2 \log_2 2 = 2$
b. For FSK, $r = \log_2 8 = \log_2 2^3 = 3 \log_2 2 = 3$
c. For PSK, $r = \log_2 4 = \log_2 2^2 = 2 \log_2 2 = 2$
d. For QAM, $r = \log_2 128 = \log_2 2^7 = 7 \log_2 2 = 7$

14. Draw the constellation diagram for the following:
a. ASK, with peak amplitude values of 1 and 3
b. BPSK, with a peak amplitude value of 2
c. QPSK, with a peak amplitude value of 3

d. 8-QAM with two different peak amplitude values, I and 3, and four different phases.
Ans: Apologies, Later will solve.

15. Draw the constellation diagram for the following cases. Find the peak amplitude value for each case and define the type of modulation (ASK, FSK, PSK, or QAM). The numbers in parentheses define the values of I and Q respectively.
a. Two points at (2, 0) and (3, 0).
b. Two points at (3, 0) and (-3, 0).
c. Four points at (2, 2), (-2, 2), (-2, -2), and (2, -2).
d. Two points at (0 , 2) and (0, -2).
Ans: Apologies, Later will solve.

16. How many bits per baud can we send in each of the following cases if the signal constellation has one of the following number of points?
a. 2
b. 4
c. 16
d. 1024.

Ans: For the number of bits (r) per baud, we use the formula: $r = \log_2 L$

Here, The number of points define the number of levels, (L) for each case.
a. $r = \log_2 2 = 1$
b. $r = \log_2 4 = \log_2 2^2 = 2\log_2 2 = 2$
c. $r = \log_2 16 = \log_2 2^4 = 4\log_2 2 = 4$
d. $r = \log_2 1024 = \log_2 2^{10} = 10\log_2 2 = 10$

17. What is the required bandwidth for the following cases if we need to send 4000 bps?
Let d = 1.
a. ASK
b. FSK with $2\Delta f = 4$ KHz
c. QPSK
d. 16-QAM.
Ans: Given, bit rate, N = 4000 bps
factor, d = 1

a. For ASK, r = 1 .'. Bandwidth, $B = (1+d)S = (1+d)\frac{N}{r} = (1+1)\frac{4000}{1} = 8000$ bps

b. For FSK, r = 1, .'. $B = (1+d)\frac{N}{r} + 2\Delta f = (1+1)\frac{4000}{1} + 4 * 10^3 = 12000$ bps

c. For QPSK, r = 2 .'. $B = (1+d)\frac{N}{r} = (1+1)\frac{4000}{2} = 4000$ bps

d. For 16-QAM, r = 4 .'. $B = (1+d)\frac{N}{r} = (1+1)\frac{4000}{4} = 2000$ bps

18. The telephone line has 4 KHz bandwidth. What is the maximum number of bits we can send using each of the following techniques? Let d = 0.
a. ASK
b. QPSK
c. 16-QAM
d.64-QAM.

Ans: We know the formula, $B=(1+d)\frac{N}{r}$.'. $N=\frac{B*r}{(1+d)}$

Given, B = 4 KHz; d = 0

a. r = 1 .'. $N=\frac{4*1}{(1+0)}$ = 4 kbps

b. r = 2 .'. $N=\frac{4*2}{(1+0)}$ = 8 kbps

c. r = 4 .'. $N=\frac{4*4}{(1+0)}$ = 16 kbps

d. r = 6 .'. $N=\frac{4*6}{(1+0)}$ = 24 kbps

19. A corporation has a medium with a 1-MHz bandwidth (lowpass). The corporation needs to create 10 separate independent channels each capable of sending at least 10 Mbps. The company has decided to use QAM technology. What is the minimum number of bits per baud for each channel? What is the number of points in the constellation diagram for each channel? Let d =O.

Ans: Given, umber of channel = 10

.'. Bit rate for each channel= $\frac{10\ Mbps}{10}$ = 1 Mbps

.'. bandwidth for each channel = $\frac{1\ MHz}{10}$ = 10^5 Hz. = 100 KHz

Now, We find the value of r for each channel:

$B=(1+d)\frac{N}{r}$ => $r=(1+d)\frac{N}{B}$ = $(1+0)\frac{1\ Mbps}{100\ KHz}$ = 10

.'. For the number of levels, we know formula: $r=\log_2 L$ => $L = 2^r$ = 2^{10} = 1024 This means that we need a 1024-QAM technique to achieve this data rate.

20. A cable company uses one of the cable TV channels (with a bandwidth of 6 MHz) to provide digital communication for each resident. What is the available data rate for each resident if the company uses a 64-QAM technique?

Ans: Given Bandwidth, B = 6 MHz

For 64-QAM, $r = \log_2 64 = 6$

Now, we can use the formula: $B = (1+d)\frac{N}{r}$ => $N = \frac{B*r}{(1+d)}$ ¿ $\frac{6\,MHz*6}{(1+0)}$ = 36 Mbps

So, Data rate is 36 Mbps.

21. Find the bandwidth for the following situations if we need to modulate a 5-KHz voice.
a. AM
b. PM (set β =5)
c. PM (set β =1).

Ans: Given, FCC bandwidth, B = 5 KHz

a. AM Bandwidth formula, $B_{AM} = 2 \times B = 2 \times 5 = 10$ KHz
b. FM Bandwidth formula, $B_{FM} = 2(1+\beta)B = 2\times(1+5)\times5 = 60$ KHz
c. PM Bandwidth formula, $B_{PM} = 2(1+\beta)B = 2\times(1+1)\times5 = 20$ KHz

22. Find the total number of channels in the corresponding band allocated by FCC.
a. AM
b. FM

Ans:

a. According to FCC Bandwidth (5 KHz),
AM Bandwidth is 10 KHz per channel.
We know, carrier frequency of AM stations between 530 KHz to 1700 KHz
∴ Number of Channel, $n = \frac{1700-530}{10} = 117$

b. According to FCC, FM Bandwidth is 200 KHz per channel
We know, carrier frequency of FM stations between 88 MHz to 108 MHz
∴ Number of Channel, $n = \frac{(108-88)\,MHz}{200\,KHz} = \frac{20\,MHz}{200\,KHz} = 100$

CHAPTER 7
Transmission Media

Review Questions

1. What is the position of the transmission media in the OSI or the Internet model?

Ans: The transmission media is located beneath the physical layer and controlled by the physical layer.

2. Name the two major categories of transmission media.

Ans: The two major categories of transmission media are guided media and unguided media.

3. How do guided media differ from unguided media?

Ans:

guided media	Unguided media
Guided media have physical boundaries	unguided media are unbounded

4. What are the three major classes of guided media?.

Ans: The three major classes of guided media are twisted-pair cables, coaxial cables, and fiber optic cables.

5. What is the significance of the twisting in twisted-pair cable?

Ans: The main reason for twisting in a twisted pair cable is cancelling out any electromagnetic interference (EMI) that may be given out by external sources. These external sources could include crosstalk from other nearby pairs of cables or electromagnetic radiation given out by pairs of twisted cables that are not shielded (UTP - unshielded twisted pair). This method was created by Alexander Graham Bell.

6. What is refraction? What is reflection?

Ans:

Reflection: This occurs when a wave travelling in one medium strikes the surface of a different medium and changes direction so that it returns back into the medium in which it was originally travelling in. Simply put the waves bounce back. Examples of reflection are light waves striking a mirror or echoes in which sound waves are reflected of a solid surface.

Refraction: The speed at which a wave travels is dependent upon the medium in which it travels along or through. The speed of a wave changes when a wave moves from one medium to another. This change in wave speed is accompanied by a change in wavelength and change in direction. It is this change of direction or bending of the wave as it passes from one medium to another that is called refraction. Example, light travelling from air into water.

7. What is the purpose of cladding in an optical fiber?

Ans: Optical fiber transmits optical signals using refraction of that signal. For refraction to happen the densities at the refracting media should be different. For this purpose a cladding is used. Cladding is of higher density so that optical signal can undergo refraction and transmit the signal to long distances.

8. Name the advantages of optical fiber over twisted-pair and coaxial cable.

Ans: Advantages of optical fiber over twisted-pair and co -axial cable are:

i. Higher Bandwidth
ii. Less signal attenuation and other losses
iii. Electromagnetic isolation
iv. Less weight
v. Smaller in the size but Great capacity.

9. How does sky propagation differ from line-of-sight propagation?

Ans: Sky propagation is not limited to send signals to receivers, line-of-sight is dependent on direction, range and objects which may occur between sender and receiver.

Sky propagation is not limited in sense of distance of source and destination and not restricted by being in range or in direction with antennas. In this case, signals are sent towards space and then signals have vast range to reach receivers back to the earth. We should consider this thing, Sky is the beyond the troposphere and ionosphere. When signals gone beyond these spheres so when satellite will reflect those signals back, they will have much vast access to receivers.

On other hand line-of-sight propagation is limited because of earth curvature. If antennas (source and target) are not directional, not facing each other or something preventing to establish the connection so communication won't be made.

10. What is the difference between Omnidirectional waves and unidirectional waves?

Ans:

Omnidirectional waves	Unidirectional waves
omnidirections meant that 'different directions'	unidirectional means waves having single direction.
Omnidirectional devices broadcast or receive their signals from all directions.	Unidirectional devices are focused on picking up or transmitting their signals in one direction.
Example: Cell phone antennas will pick up signals from everywhere around the device.	Example: Having a microphone that will give you and your subject undivided attention.

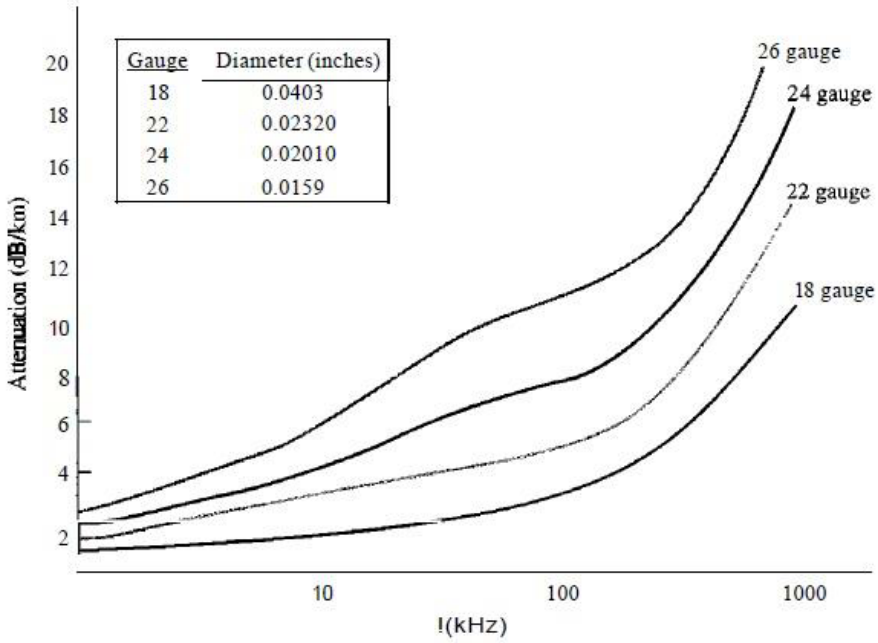
Exercises

11. Using Figure 7.6, tabulate the attenuation (in dB) of a 18-gauge UTP for the indicated frequencies and distances.

Table 7.5 *Attenuation/or I8-gauge UTP*

Distance	*dB at 1 KHz*	*dRat 10KHz*	*dB at 100 KHz*
1 Km			
lOKm			
15 Km			
20Km			

Figure 7.6 *UTP performance*



Ans: Attenuation/or I8-gauge UTP:

Distance	dB at 1 KHz	dB at 10 KHz	dB at 100 KHz
1 Km	-3	-5	-7
10 Km	-30	-50	-70
15 Km	-45	-75	-105
20 Km	-60	-100	-140

12. Use the result of Exercise 11 to infer that the bandwidth of a UTP cable decreases with an increase in distance.

Ans: As the Table 7.1 shows, for a specific maximum value of attenuation, the highest frequency decreases with distance. If we consider the bandwidth to start from zero, we can say that the bandwidth decreases with distance. For example, if we can tolerate a maximum attenuation of 50 dB (loss), then we can give the following listing of distance versus bandwidth.

Distance	**Bandwidth**
1 Km	100 KHz
10 Km	50 KHz
15 Km	1 KHz
20 Km	0 KHz

13. If the power at the beginning of a 1 KIn 18-gauge UTP is 200 mw, what is the power at the end for frequencies 1 KHz, 10 KHz, and 100 KHz? Use the result of Exercise 11.

Ans: We can use Table 7.1 to find the power for different frequencies:

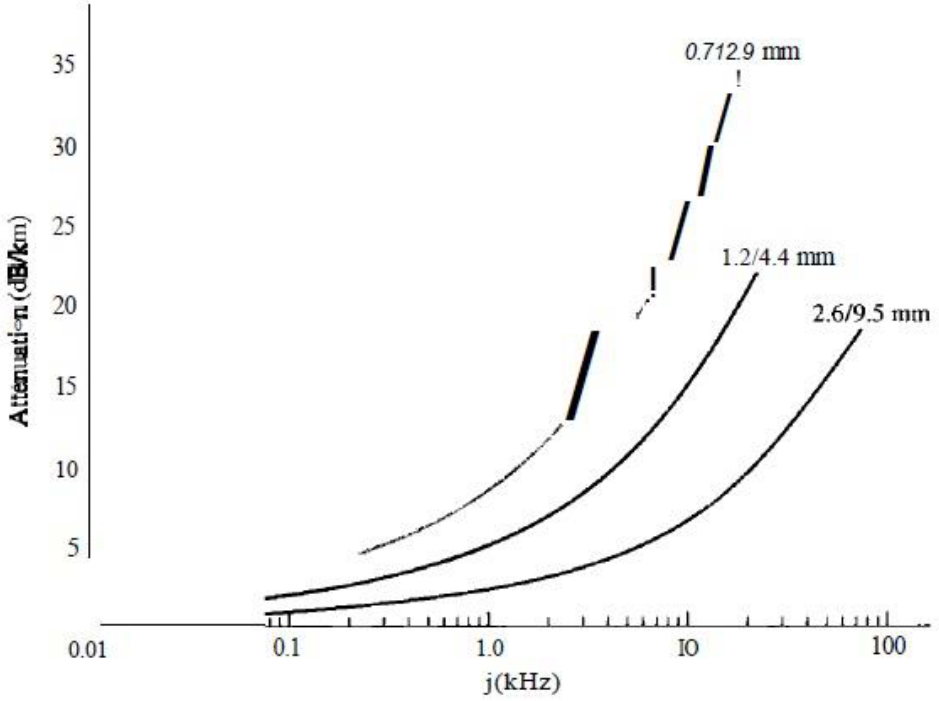
1 KHz	**dB = -3**	**$P_2 = P_1 \times 10^{-3/10}$**	**= 100.23 mw**
10 KHz	dB = -5	$P_2 = P_1 \times 10^{-5/10}$	= 63.25 mw
100 KHz	dB = -7	$P_2 = P_1 \times 10^{-7/10}$	= 39.90 mw

14. Using Figure 7.9, tabulate the attenuation (in dB) of a 2.6/9.5 mm coaxial cable for the indicated frequencies and distances

Table 7.6 *Attenuation/or 2.6/9.5 mm coaxial cable*

Distance	*dB at 1 KHz*	*dB at 10 KHz*	*dB at 100KHz*
1 Km			
lOKrn			
15Km			
20Km			

Figure 7.9 *Coaxial cable peiformance*



Ans: Attenuation/or 2.6/9.5 mm coaxial cable:

Distance	dB at 1 KHz	dB at 10 KHz	dB at 100 KHz
1 Km	-3	-7	-20
10 Km	-30	-70	-200
15 Km	-45	-105	-300
20 Km	-60	-140	-400

15. Use the result of Exercise 14 to infer that the bandwidth of a coaxial cable decreases with the increase in distance.

Ans: As Table 7.2 shows, for a specific maximum value of attenuation, the highest frequency decreases with distance. If we consider the bandwidth to start from zero, we can say that the bandwidth decreases with distance. For example, if we can tolerate a maximum attenuation of 50 dB (loss), then we can give the following listing of distance versus bandwidth.

Distance	Bandwidth
1 Km	100 KHz
10 Km	1 KHz
15 Km	1 KHz
20 Km	0 KHz

16. If the power at the beginning of a 1 KIn 2.6/9.5 mm coaxial cable is 200 mw, what is the power at the end for frequencies 1 KHz, 10KHz, and 100 KHz? Use the result of Exercise 14.

Ans: We can use Table 7.2 to find the power for different frequencies:

1 KHz	**dB = -3**	**$P_2 = P_1 \times 10^{-3/10}$**	**= 100.23 mw**
10 KHz	dB = -7	$P_2 = P_1 \times 10^{-7/10}$	= 39.90 mw
100 KHz	dB = -20	$P_2 = P_1 \times 10^{-20/10}$	= 2.00 mw

17. Calculate the bandwidth of the light for the following wavelength ranges (assume a propagation speed of 2 x 108 m):

a. 1000 to 1200 nm

b. 1000 to 1400 nm.

Ans: We can use the formula $f = \frac{c}{\lambda}$, Here, c is the speed of propagation

a. B = [(2 × 108)/1000×10−9] − [(2 × 108)/ 1200 × 10−9] = 33 THz

b. B = [(2 × 108)/1000×10−9] − [(2 × 108)/ 1400 × 10−9] = 57 THz

18. The horizontal axes in Figure 7.6 and 7.9 represent frequencies. The horizontal axis in Figure 7.16 represents wavelength. Can you explain the reason? lfthe propagation speed in an optical fiber is 2 x 108 ill, can you change the units in the horizontal axis to frequency? Should the vertical-axis units be changed too? Should the curve be changed too?

Ans:

a. The wave length is the inverse of the frequency if the propagation speed is fixed. This means all three figures represent the same thing.

b. We can change the wave length to frequency. For example, the value 1000 nm can be written as 200 THz.

c. The vertical-axis units may not change because they represent dB/km.

d. The curve must be flipped horizontally.

19. Using Figure 7.16, tabulate the attenuation (in dB) of an optical fiber for the indicated wavelength and distances.

Figure 7.16 *Optical fiber performance*

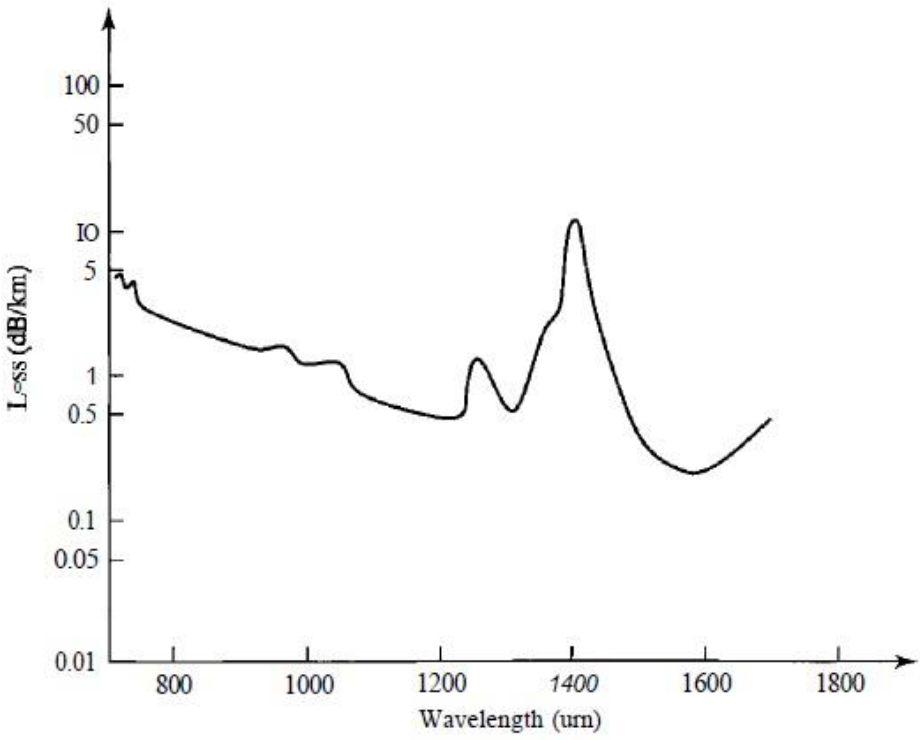


Table 7.7 *Attenuation for optical fiber*

Distance	*dB at 800 nm*	*dB at 1000 nm*	*dB at 1200nm*
1 Km			
1OKm			
15Km			
20Km			

Ans: Attenuation for optical fiber:

Distance	dB at 800 nm	dB at 1000 nm	dB at 1200 nm
1 Km	-3	-1.1	-0.5
10 Km	-30	-11	-5
15 Km	-45	-16.5	-7.5
20 Km	-60	-22	-10

20. A light signal is travelling through a fiber. What is the delay in the signal if the length of the fiber-optic cable is 10 m, 100 m, and 1 Km (assume a propagation speed of 2 x 108 ill)?

Ans: The delay $= \frac{\text{distance}}{\text{propagation speed}}$. Therefore, we have:

a. $Delay = \frac{10}{2*108}$ = 0.05 ms

b. $Delay = \frac{100}{2*108}$ = 0.5 ms

c. $Delay = \frac{1000}{2*108}$ = 5 ms

21. A beam oflight moves from one medium to another medium with less density. The critical angle is 60°. Do we have refraction or reflection for each of the following incident angles? Show the bending of the light ray in each case.

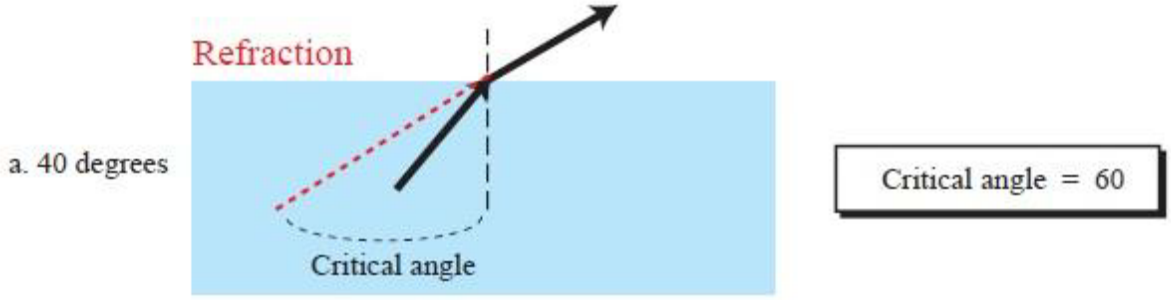
a. 40°

b. 60°

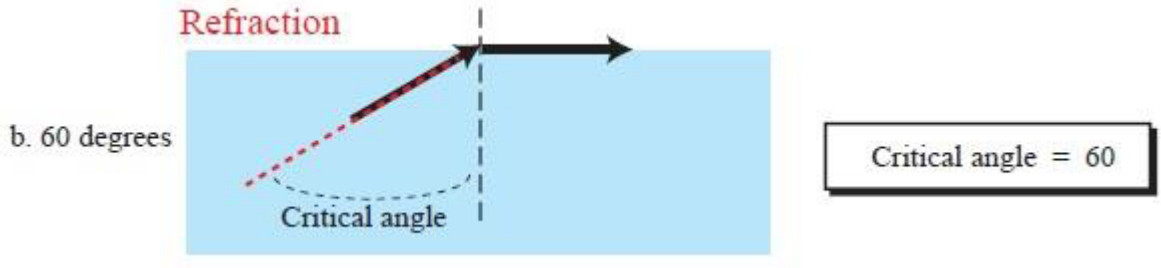
c. 800

Ans:

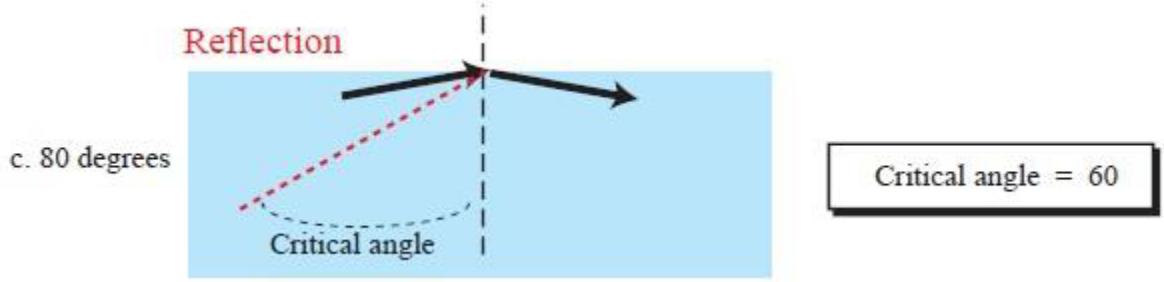
a. The incident angle (40 degrees) is smaller than the critical angle (60 degrees). We have refraction. The light ray enters into the less dense medium.



b. The incident angle (60 degrees) is the same as the critical angle (60 degrees). We have refraction. The light ray travels along the interface.



c. The incident angle (80 degrees) is greater than the critical angle (60 degrees).We have reflection. The light ray returns back to the more dense medium.



Data Communication
MID-TERM Examination
SPRING-2016

1. (a) A digital data stream 0010110101 is passing through a communication system. As we know data stream will be converted to signal using various schemes. Draw the signal of given bit stream using NRZ-I, Manchester and Psuedoternary scheme. 3

   (b) Suppose a signal travels from sender Rahim to receive, Rina. At Rahim's side the signal power is 350 W, at Rina's side power is 230 W. What is the attenuation in dB? 2

2. (a) Contrast the OSI model described with the TCP/IP reference model, Using a diagrarm show the correspondence between relevant protocol layers in the two models. 2

   (b) In OSI model, why are the flow control and error control functionalities implemented both at the data link layer and transport layer? 3

3. (a) Explain the different transmission impairments that affect data communications? 3

   (b) "Any composite signal is a combination of simple sine waves will different frequencies, amplitude and phases ". Justify the statement. 2

4. (a) Draw three sine waves with the same amplitude and frequency using phases 90^0 ,180^0 And 270^0. 2

   (b) Comparing different techniques of sampling for PCM? Find out which one is best and why? 3

5. (a) Differentiate between Synchronous and Asynchronous transmission. Why we need proper Synchronization during transmission? Give an appropriate example. 2

   (b) Draw a hybrid topology with a ring backbone with three bus networks and two mesh networks? Discuss the consequences if a connection fails in the backbone. 3

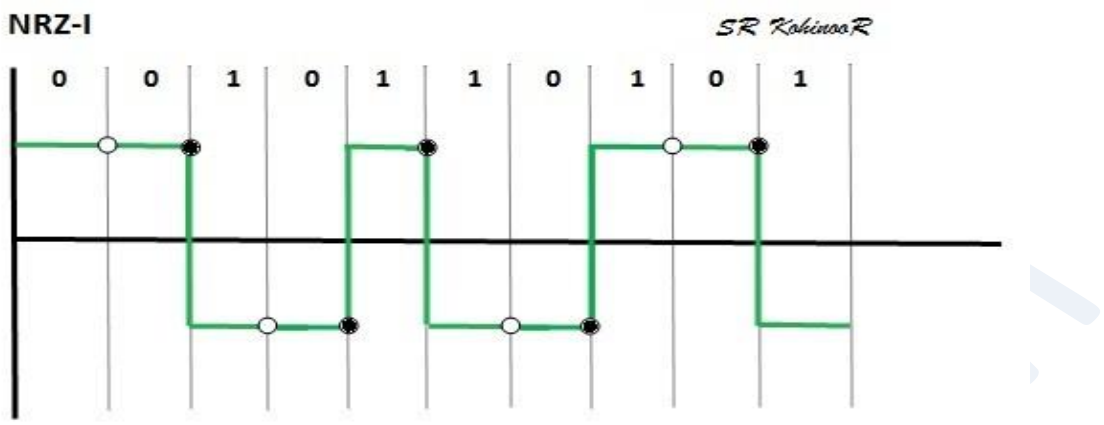
6. (a) A signal with 300 microwatts power passes through 10 devices, each with an average noise of 3 microwatts. Find SNR and SNR_{dB}. 2

   (b) Write short note (with example):- 3
   - i. Logical Address.
   - ii. Port Address.
   - iii. Protocol and Standard.

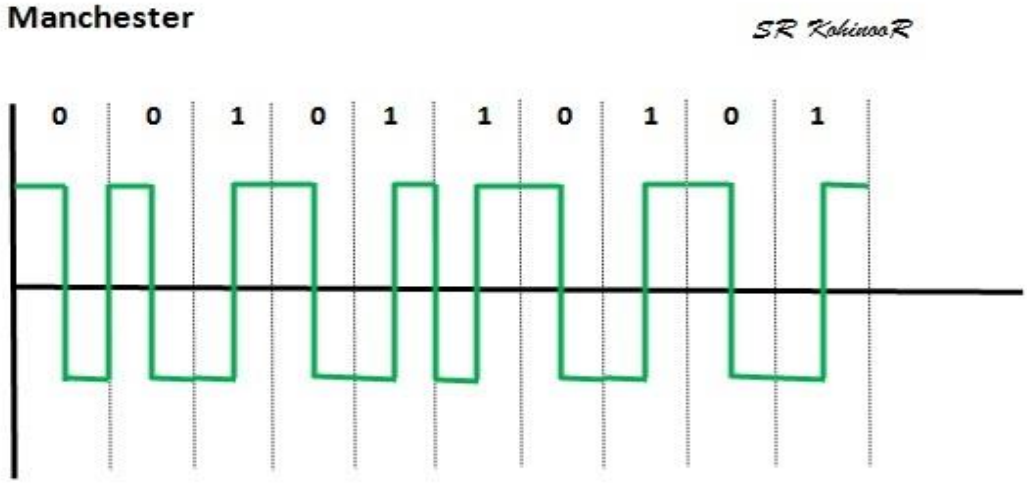
Q-1: (a) A digital data stream 0010110101 is passing through a communication system. As we know data stream will be converted to signal using various schemes. Draw the signal of given bit stream using NRZ-I, Manchester and Psuedoternary scheme.

Ans:

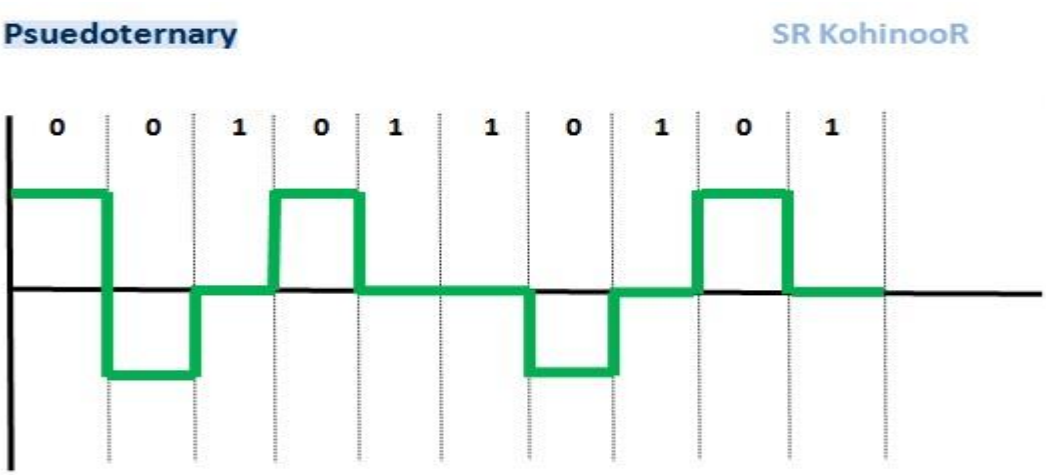
NRZ-I



Manchester



Psuedoternary



Q-1: (b) Suppose a signal travels from sender Rahim to receive, Rina. At Rahim's side the signal power is 350 W, at Rina's side power is 230 W. What is the attenuation in dB?

Ans:

Given, Power P1 = 350 W

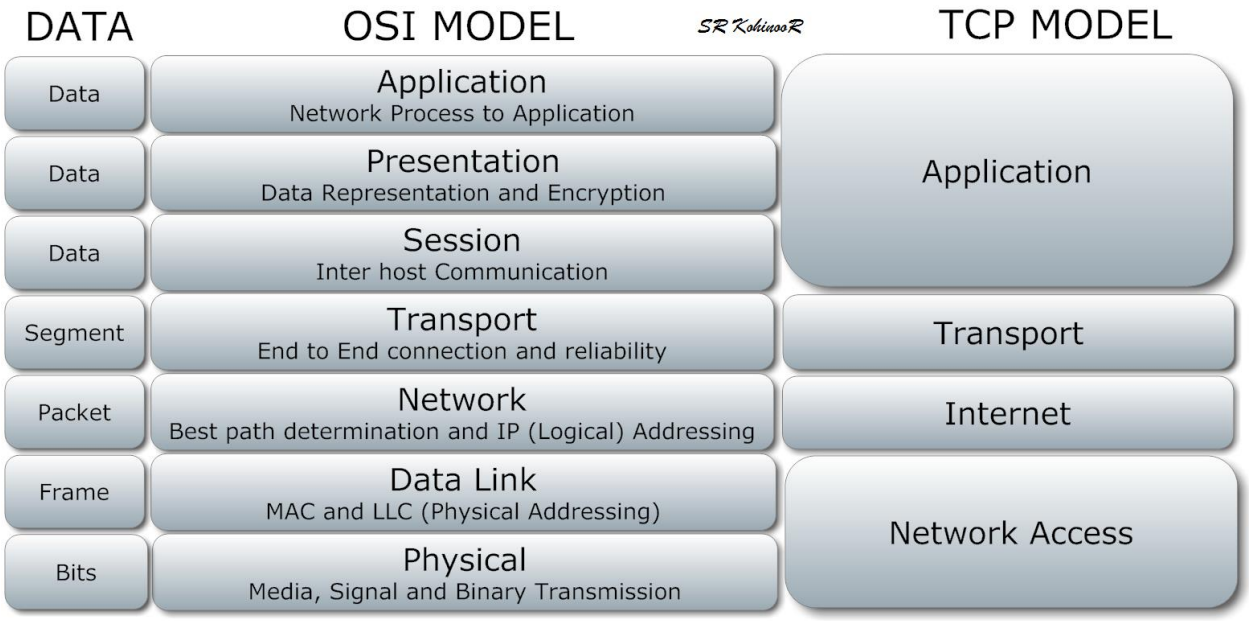
Power P2 = 230 W

∴ We know that,

$$\text{Attenuation dB} = 10 \log_{10} (P2/P1)$$
$$= 10 \log_{10} (230/350)$$
$$= \mathbf{-1.8234}$$

Q-2: (a) Contrast the OSI model described with the TCP/IP reference model, Using a diagrarm show the correspondence between relevant protocol layers in the two models.

Ans:



Q-2: (b) In OSI model, why are the flow control and error control functionalities implemented both at the data link layer and transport layer?

Ans: The errors between the nodes can be detected by the data link layer control, but the error at the node (between input port and output port) of the node cannot be detected by the data link layer. For checking this error, another error control function need in transport layer.

On the other hand, flow control of data link layer work until the sender receives feedback from the receiver, it will not send next data. Flow control of transport layer controls the data rate for sending next data.

Q-3: (a) Explain the different transmission impairments that affect data communications?

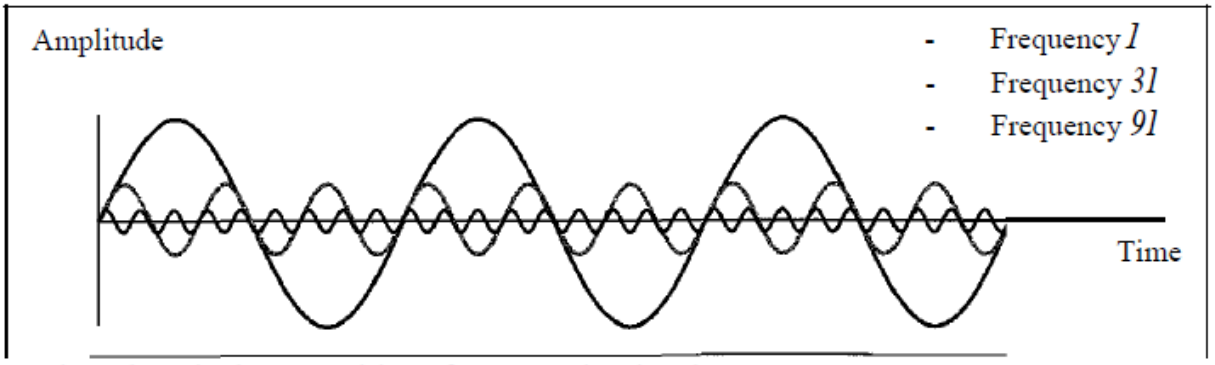
Ans: TRANSMISSION IMPAIRMENT: Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. There are three causes of impairment are attenuation, distortion, and noise.

- Attenuation
  - Loss of Energy
  - When a signal travels through a medium, it looses some of its energy in order to overcome the resistance of the medium
  - That is why wire carrying electric signals get hot
  - Some of the electrical energy in the signal is converted to heat
  - To compensate for this loss Amplifiers are used to amplify the signal to heat
- Distortion
  - Distortion means that the signal changes its form or shape
  - Distortion occurs in a composite signal
  - Signal changes its form or shape
  - Occurs in a composite signal, made of different frequencies
  - Each signal component has its own speed
- NOISE
  - Thermal Noise: Due to random motion of electrons in a wire that creates an extra signal not originally sent by TX
  - Induced Noise: Comes from sources like Motors and Appliances
  - The Formula for finding Noise,

SNR = Average Signal power / Average Noise power

Q-3: (b) "Any composite signal is a combination of simple sine waves with different frequencies, amplitude and phases ". Justify the statement.

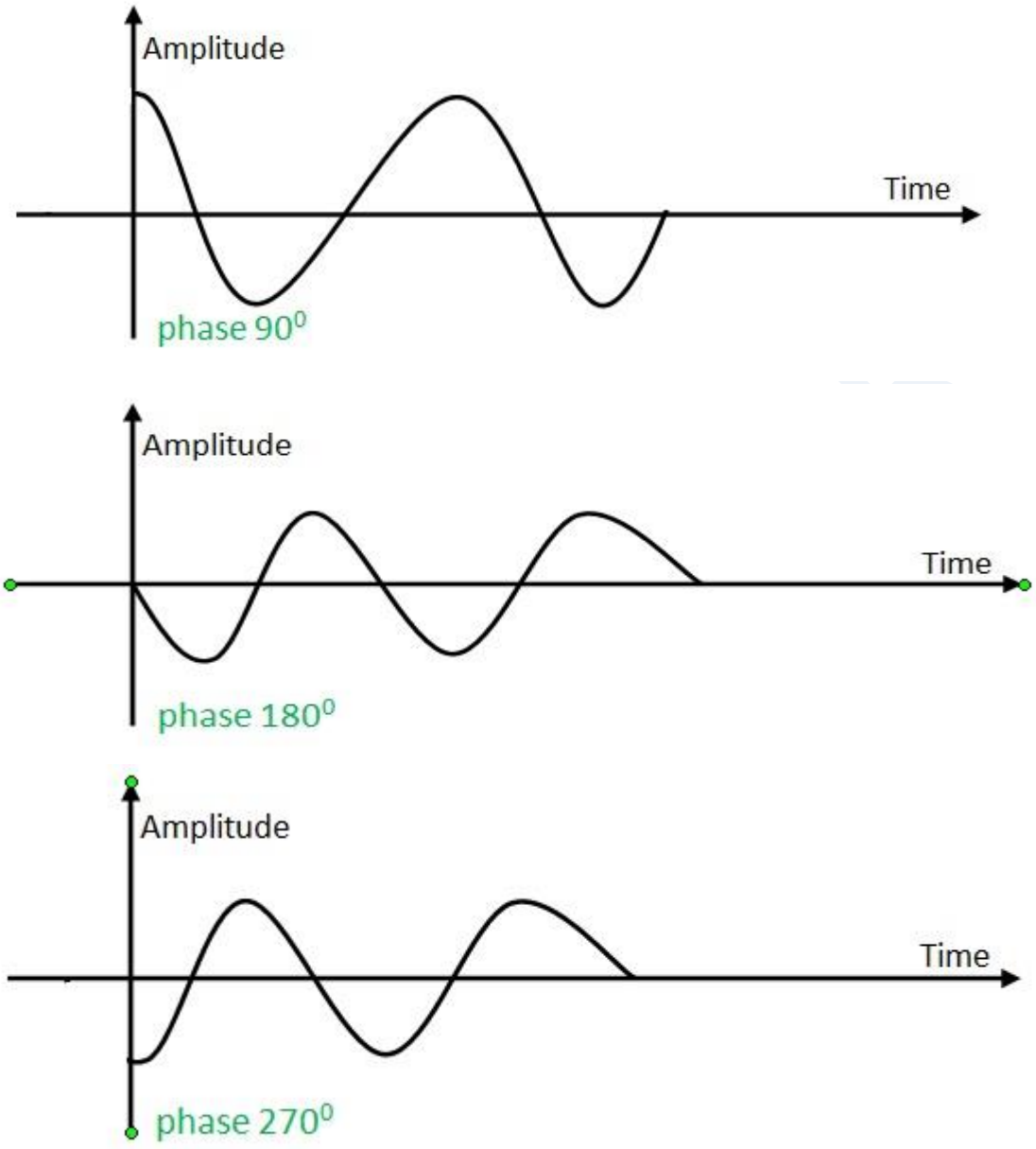
Ans: Composite signal: A composite signal is made of many simple sine waves, where sine waves can vary in frequencies, amplitude and phases. According to Fourier analysis, any composite signal is a combination of simple sine waves with different frequencies, amplitudes, and phases. As an example, If the composite signal is periodic, the decomposition gives a series of signals with discrete frequencies; if the composite signal is non periodic, the decomposition gives a combination of sine waves with continuous frequencies.



a. Time-domain decomposition of a composite signal

Q-4: (a) Draw three sine waves with the same amplitude and frequency using phases 90^0 ,180^0 And 270^0.

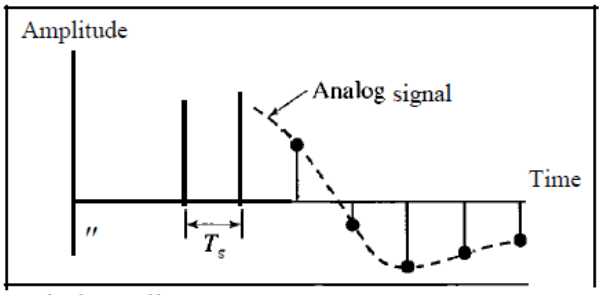
Ans:



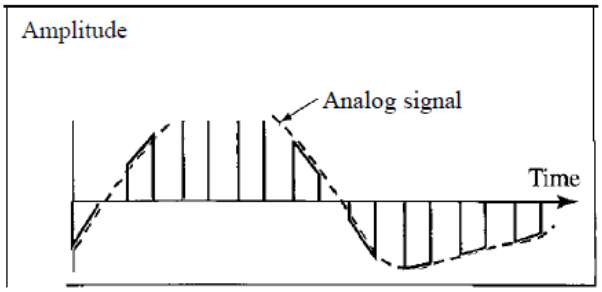
Q-4: (b) Comparing different techniques of sampling for PCM? Find out which one is best and why?

Ans: Different techniques of sampling for PCM: There are three sampling methods-ideal, natural, and flat-top.

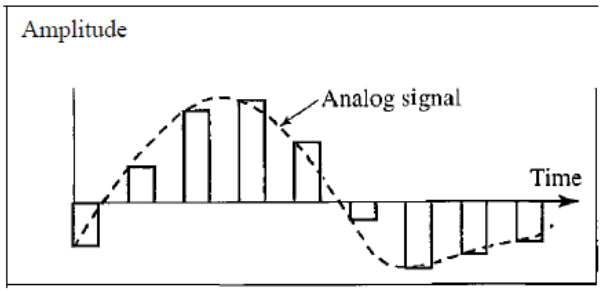
In ideal sampling, pulses from the analog signal are sampled. In natural sampling, a high-speed switch is turned on for only the small period of time when the sampling occurs. In flat-top sampling, a circuit is used and this is the most common sampling method.



a. Ideal sampling



b. Natural sampling



c. Flat-top sampling

Best one: Flat top sampling is best among others because flat-top samples creates by using a circuit. As a result, The sampling process is sometimes referred to as pulse amplitude modulation (PAM). We need to remember, however, that the result is still an analog signal with nonintegral values.

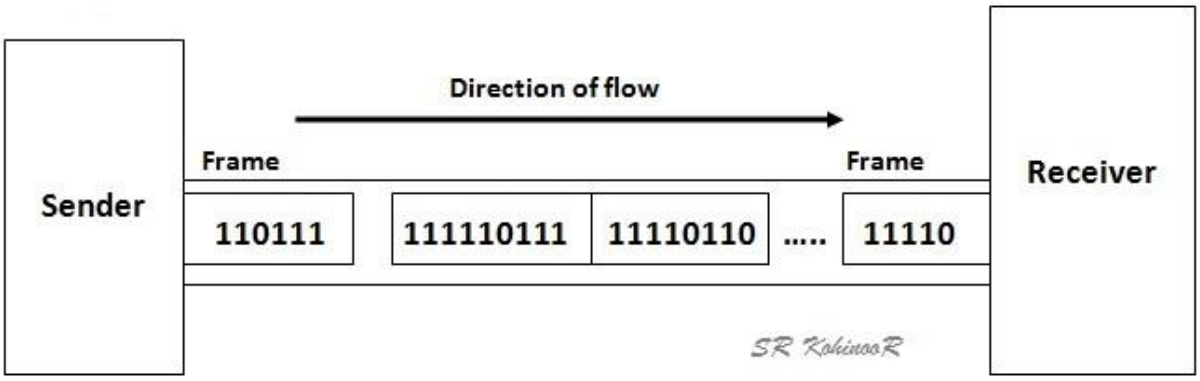
Q-5: (a) Differentiate between Synchronous and Asynchronous transmission. Why we need proper Synchronization during transmission? Give an appropriate example.

Ans:

Synchronous and Asynchronous:

Synchronous	Asynchronous
Send bit one after another without any start or stop bit.	Send one start bit (0) at the beginning and one stop bit (1) at the end of each byte.
Needs a clock signal between the sender and the receiver.	Does not need a clock signal between the sender and the receiver.
Supports high data transfer rate.	Slower data transfer rate
Requires master/slave configuration.	There may be a title between each byte.

Why we need proper Synchronization during transmission: In synchronous transmission, the bit stream is combined into longer frames which may contain multiple bytes. Each byte is introduced onto the transmission link without a gap between it and the next one. That means, data are transmitted as an unbroken string of 1s and 0s, and the receiver separates that string into the bytes or characters. Here is the example-



Q-5: (b) Draw a hybrid topology with a ring backbone with three bus networks and two mesh networks? Discuss the consequences if a connection fails in the backbone.

Ans:

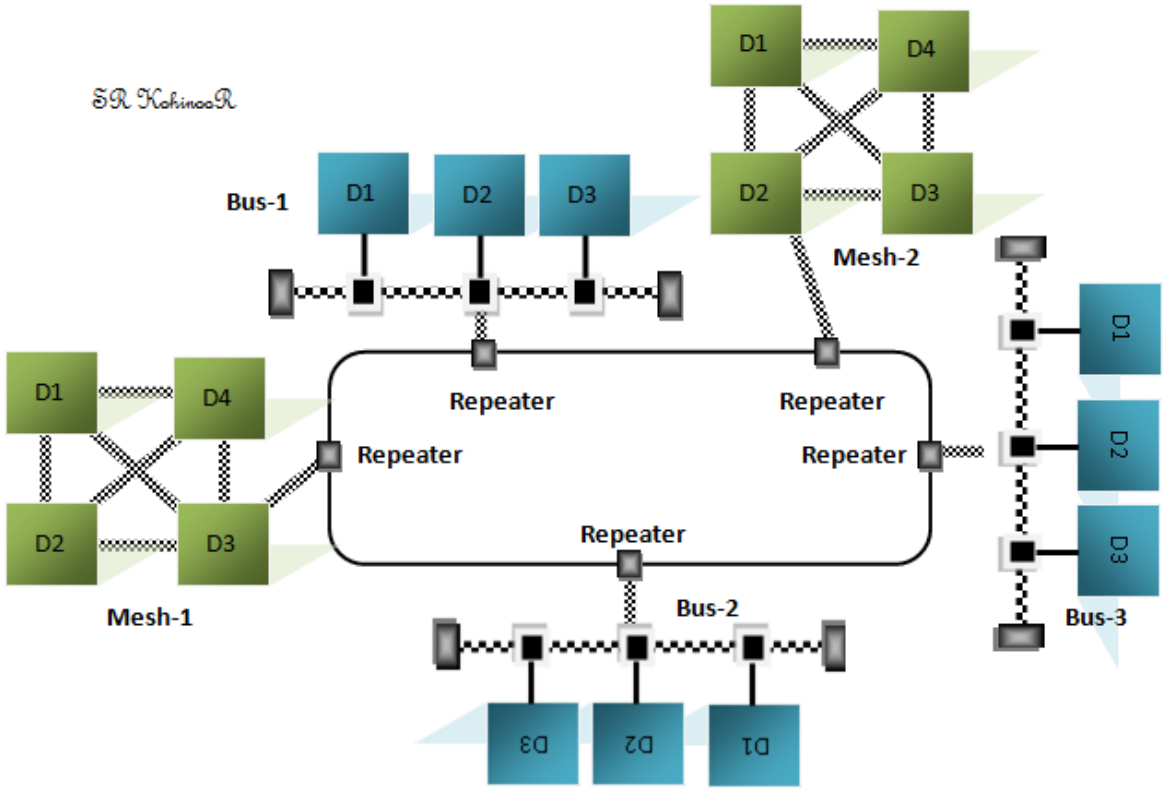


Figure: Ring backbone with 2 mesh and 3 bus Hybrid topology

Q-6: (a) A signal with 300 microwatts power passes through 10 devices, each with an average noise of 3 microwatts. Find SNR and SNR_{dB}.

Ans: Given, Average power of noise = 3 µW

Number of devices = 10

∴ Average power of signal = 300/10 = 30 µW

So, SNR = 30 / 3 = **10**

∴ $SNR_{dB} = 10 \log_{10} 10$

= **10**

Q-6: (b) Write short note (with example):-

i. Logical Address.
ii. Port Address.
iii. Protocol and Standard.

Ans:

Logical Address: The logical address is a 32-bit IP address that is not embedded in the network card, but it is assigned to it for the purpose of routing between networks. This type of address operates at Layer 3 I mean Network Layer of the OSI Model.

Port address: There are many applications running on the computer. Each application runs with a port number (logically) on the computer. This port number is called port address. A port address is a 16-bit address. This type of address operates at Transport Layer of the OSI Model.

Protocol and Standard: Protocol is a set of rules that govern all aspects of data communication between computers on a network. The key elements of a protocol are syntax, semantics and timing.

Standards are developed by cooperation among standards creation committees, forums, and government regulatory agencies. Some Standards Creation Committees are: ISO, ANSI, IEEE, EIA etc..

_____THE END_____

Lab Report: 04

Title: Configuration of Virtual Local Area Network (VLAN) and Inter-VLAN.

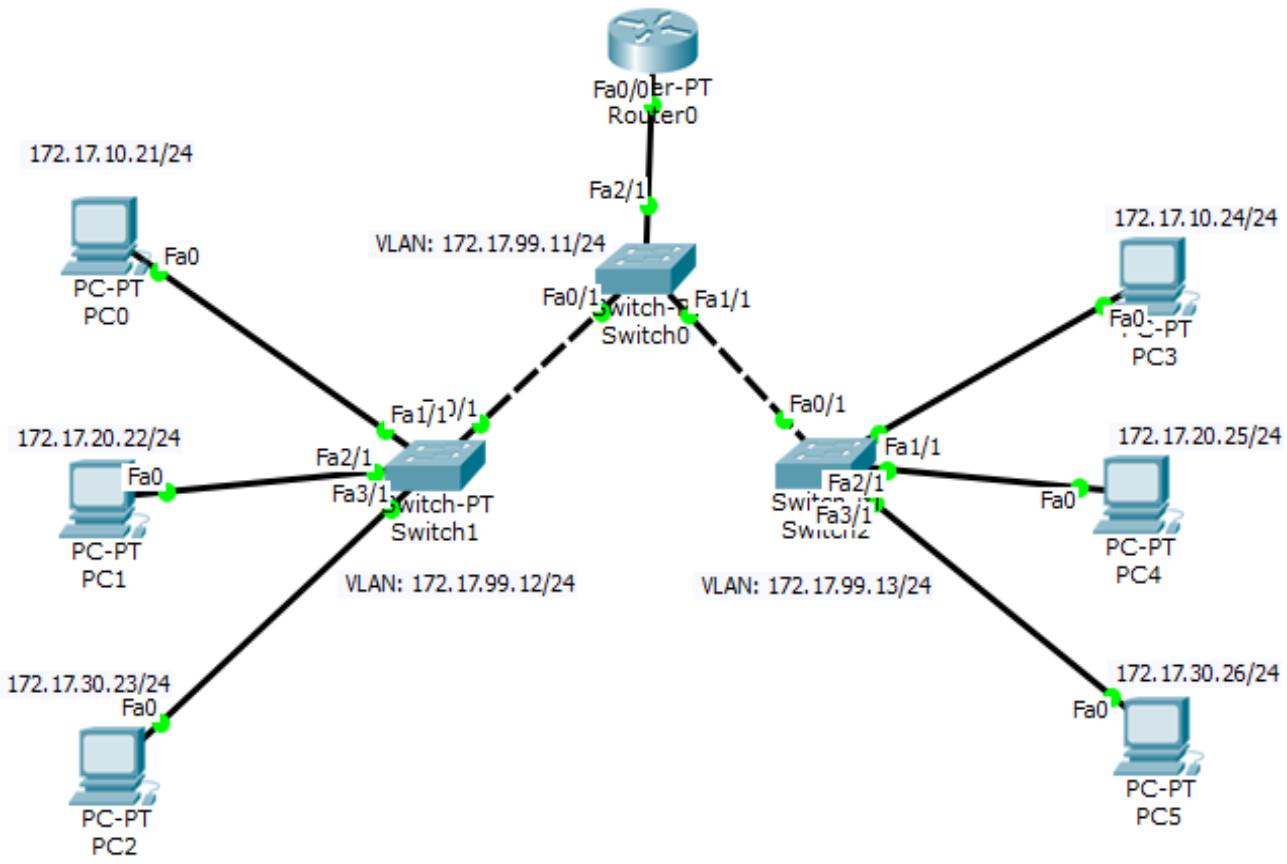
Objective:

- ⇨ Configure and maintain Virtual Local Area Network (VLAN).
- ⇨ Assign switch ports to a VLAN also assign the management VLAN.
- ⇨ Configure trunking and verify that the switches can communicate to each other.
- ⇨ Configuration of Inter-VLAN routing with sub-interfaces corresponding to the configured VLANs.

Tools: CISCO Packet Tracer 6.3.

Simulation:

VLAN is a virtual LAN. In technical terms, a VLAN is a broadcast domain created by switches. For configuring VLAN and Inter-VLAN, create a topology as in following figure.



Addressing Table:

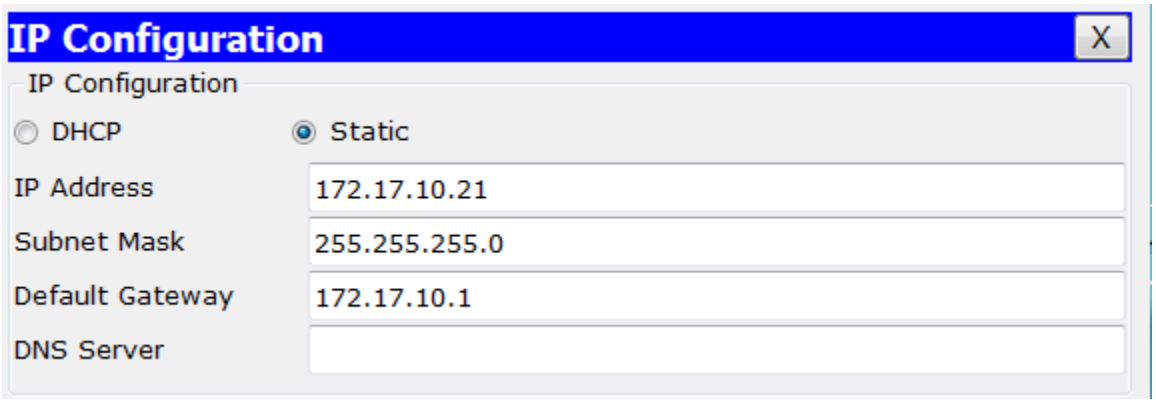
Device	Interface	IP Configuration	Default Gateway
S1	VLAN 99	172.17.99.11/24	-
S2	VLAN 99	172.17.99.12/24	-
S3	VLAN 99	172.17.99.13/24	-
PC0	-	172.17.10.21/24	172.17.10.1
PC1	-	172.17.20.22/24	172.17.20.1
PC2	-	172.17.30.23/24	172.17.30.1
PC3	-	172.17.10.24/24	172.17.10.1
PC4	-	172.17.20.25/24	172.17.20.1
PC5	-	172.17.30.26/24	172.17.30.1

For VLAN configuration, we following the steps one by one,

1. Configure the PCs IP Address.
2. User ports of S1 and S2 are enabled as access ports
3. Create VLAN on switch S0, S1 and S2.
4. Assign switch ports to VLANs on S1 and S2
5. Assign the management VLAN
6. Configure trunking and native VLAN for the Switches

These steps help to easy configuration.

Step 1: Go to the PC0 => Desktop => IP configuration mode and type



Same as configure all other five PCs. [PC1, PC2, PC3, PC4, PC5]

Step 2: Enabling the access ports. Just write these commands,

Switch 1 (S1)

Step 2: Switchport enable

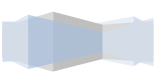
```
Switch>en
Switch#conf t
Enter configuration commands, one per line.  End
with CNTL/Z.
Switch(config)#int f1/1
Switch(config-if)#switchport mode access
Switch(config-if)#exit
Switch(config)#int f2/1
Switch(config-if)#switchport mode access
Switch(config-if)#exit
Switch(config)#int f3/1
Switch(config-if)#switchport mode access
Switch(config-if)#exit
Switch(config)#
```

Switch 2 (S2)

```
Switch>en
Switch#conf t
Enter configuration commands, one per line.  End
with CNTL/Z.
Switch(config)#int f1/1
Switch(config-if)#switchport mode access
Switch(config-if)#exit
Switch(config)#int f2/1
Switch(config-if)#switchport mode access
Switch(config-if)#exit
Switch(config)#int f3/1
Switch(config-if)#switchport mode access
Switch(config-if)#exit
Switch(config)#
```

Step 3: Create VLANs. The commands are same in all switches. So, repeat these commands in S0, S1, and S2.

Switch (S0, S1, S2)



```
Switch(config)#vlan 10
Switch(config-vlan)#name A
Switch(config-vlan)#exit
Switch(config)#vlan 20
Switch(config-vlan)#name B
Switch(config-vlan)#exit
Switch(config)#vlan 30
Switch(config-vlan)#name C
Switch(config-vlan)#exit
Switch(config)#vlan 99
Switch(config-vlan)#name M
Switch(config-vlan)#exit
Switch(config)#
```

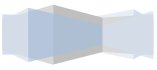
Step 4: Assign switch ports to VLANs.

Switch 1: (S1)

```
Switch(config)#int f1/1
Switch(config-if)#switchport access vlan 10
Switch(config-if)#exit
Switch(config)#int f2/1
Switch(config-if)#switchport access vlan 20
Switch(config-if)#exit
Switch(config)#int f3/1
Switch(config-if)#switchport access vlan 30
Switch(config-if)#exit
Switch(config)#
```

Switch 2: (S2)

```
Switch(config)#int f1/1
Switch(config-if)#switchport access vlan 10
Switch(config-if)#exit
Switch(config)#int f2/1
Switch(config-if)#switchport access vlan 20
Switch(config-if)#exit
Switch(config)#int f3/1
Switch(config-if)#switchport access vlan 30
Switch(config-if)#exit
Switch(config)#
```

Step 5: Assign Management VLAN in all switches (S0, S1, S2)

Switch 1 (S1)

```
Switch(config)#int vlan 99
Switch(config-if)#ip address 172.17.99.12
255.255.255.0
Switch(config-if)#exit
```

Switch 2 (S2)

```
Switch(config)#int vlan 99
Switch(config-if)#ip address 172.17.99.13 255.255.255.0
Switch(config-if)#exit
```

Switch 0 (S0)

```
Switch(config)#int vlan 99
Switch(config-if)#ip address 172.17.99.11
255.255.255.0
Switch(config-if)#exit
```

Step 6: Configuring trunk in S0, S1 and S2

Switch (S1 & S2)

```
Switch(config)#int f0/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk native vlan 99
Switch(config-if)#exit
```

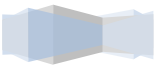
Switch 0 (S0)

```
Switch(config)#int f0/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk native vlan 99
Switch(config-if)#exit
Switch(config)#
Switch(config)#int f1/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk native vlan 99
Switch(config-if)#exit
```

Yes!!! VLAN is done.

Now we configure the Inter-VLAN from the router. At first, enable the router interface by “no shutdown” command like as-

Router 0 (R0)



```
Router>en
Router#conf t
Enter configuration commands, one per line.  End
with CNTL/Z.
Router(config)#int f0/0
Router(config-if)#no shut
```

Now assign default gateway and virtual gateway for VLANs by following commands,

Router 0 (R0)

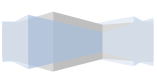
```
Router(config-if)#int f0/0.1
Router(config-subif)#
%LINK-5-CHANGED: Interface FastEthernet0/0.1, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0.1, changed state to up

Router(config-subif)#encapsulation dot1
Router(config-subif)#encapsulation dot1Q 1
Router(config-subif)#ip address 172.17.1.1 255.255.255.0
Router(config-subif)#exit
Router(config)#int f0/0.10
Router(config-subif)#
%LINK-5-CHANGED: Interface FastEthernet0/0.10, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0.10, changed state to up

Router(config-subif)#encapsulation dot1Q 10
Router(config-subif)#ip address 172.17.10.1 255.255.255.0
Router(config-subif)#exit
Router(config-subif)#int f0/0.20
Router(config-subif)#encapsul
Router(config-subif)#encapsulation dot1
Router(config-subif)#encapsulation dot1Q 20
Router(config-subif)#ip address 172.17.20.1 255.255.255.0
Router(config-subif)#exit
Router(config)#int f0/0.30
Router(config-subif)#encapsulation dot1Q 30
Router(config-subif)#ip address 172.17.30.1 255.255.255.0
Router(config-subif)#exit
Router(config)#int f0/0.99
Router(config-subif)#encapsulation dot1Q 99 native
Router(config-subif)#ip address 172.17.99.1 255.255.255.0
Router(config-subif)#exit
Router(config)#
```

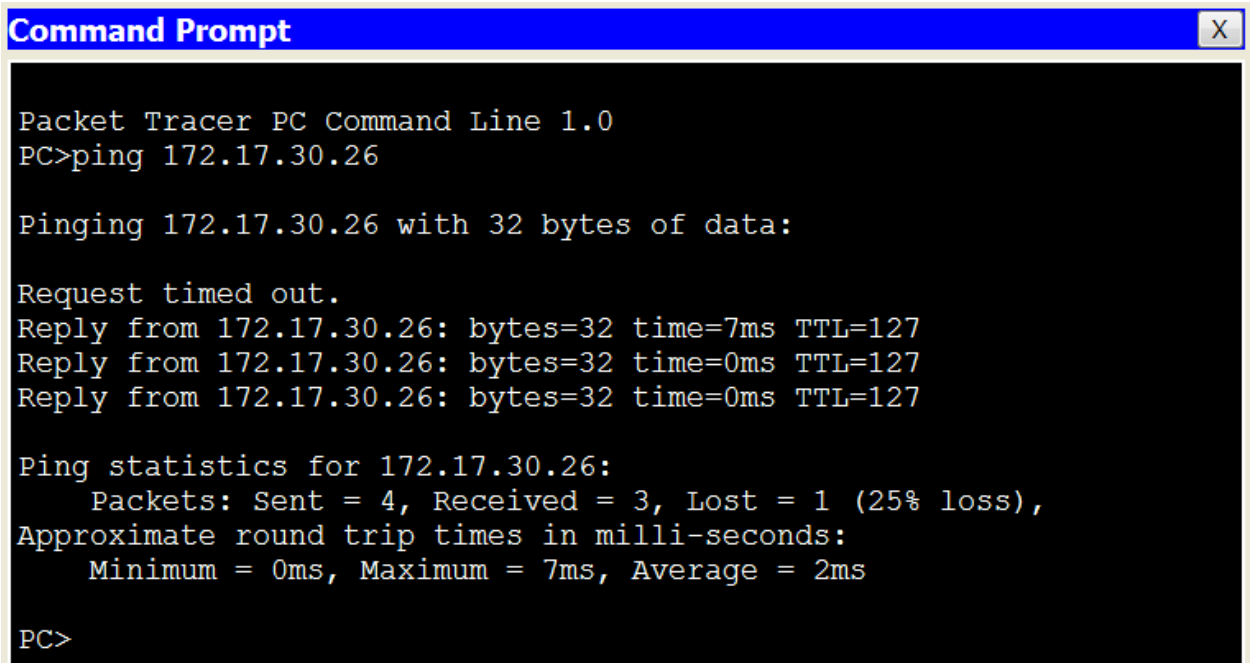



Finally trunk the switch ports which connect with router.

Switch 0 (R0)

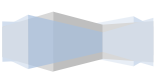
```
Switch(config)#int f1/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk native vlan 99
Switch(config-if)#exit
```

That's it.
Fully complete the configuration of VLAN and Inter-VLAN. For testing the connectivity among PCs, as usual we use the ping command in source PC's command prompt to write destination PC's IP address. For example here ping from PC0 to PC6 and observe the output.



Download Link: Here is the available of configured topology.
https://www.dropbox.com/s/gc2snp1is9yd2yz/VLAN%20and%20Inter%20VLAN.pkt?dl=0

---- The END ----



Lab Report: 05

Title: Configuring Dynamic Host Configuration Protocol and Network Address Translator.

Objective:

- ⇨ Configure PCs to receive an IP address through DHCP where statically does not assigned addresses.
- ⇨ Configure the pool.
- ⇨ Configure of dynamic Network Address Translation (NAT).

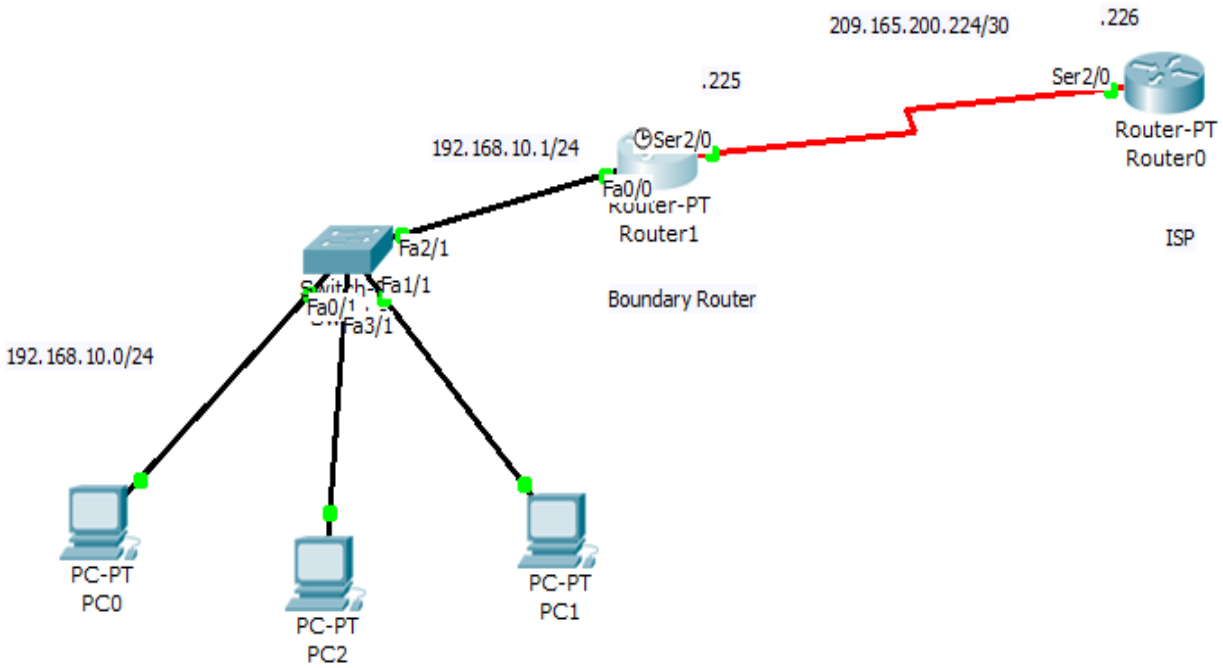
Tools: CISCO Packet Tracer 6.3.

Simulation:

Dynamic Host Configuration Protocol (DHCP) is a protocol for assigning dynamic IP addresses to devices on a network. Same as, Network Address Translation (NAT) is the process where a network device assigns a public address to a computer (or group of computers) inside a private network.

In this report, first of all dynamically configure the host IP addresses with default gateway, and then configure dynamic NAT on a Router which translate a local web server address to global IP address.

At first, create a topology as in following figure.



DHCP configuration:

To configure the DHCP the following commands can be executed at **Router 1**:

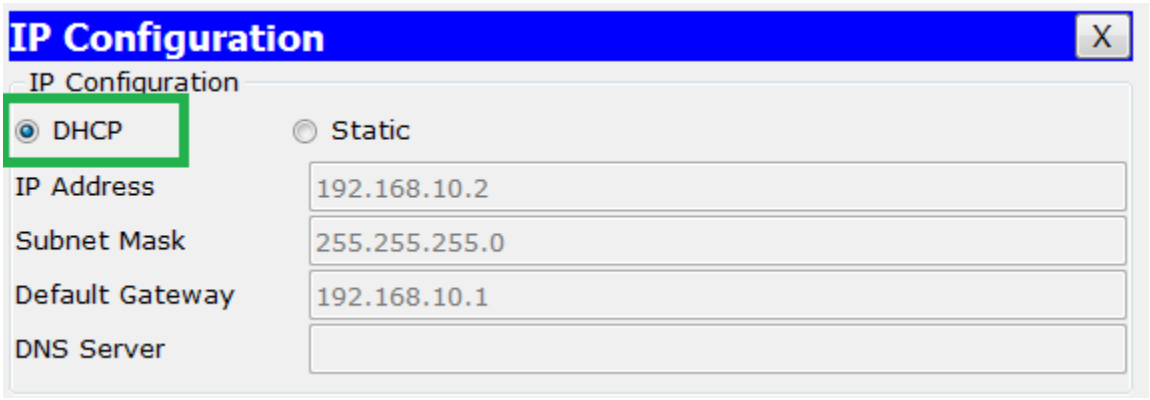
```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#int f0/0
Router(config-if)#ip address 192.168.10.1 255.255.255.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed
state to up

Router(config-if)#exit
Router(config)#ip dhcp excluded-address 192.168.10.1
Router(config)#ip dhcp pool SRK_POOL
Router(dhcp-config)#network 192.168.10.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.10.1
Router(dhcp-config)#exit
```

After that, click on the host PC's and go to their configuration mode. Then click the DHCP radio button like below picture and enjoy the automatic generate IP.



DHCP is Done. Now time for NAT..

NAT (dynamic) Configuration:

To configure the NAT, step by step following these commands:

Step 1: Configure the Routers for their serial interfaces.

Router0 (R0)

Router (config)# interface Serial2/0
Router (config-if)# ip address 209.165.200.226 255.255.255.224
Router (config-if)# no shutdown
Router (config-if)# exit

Router1 (R1)

```
Router (config)# interface Serial2/0
Router (config-if)# ip address 209.165.200.225 255.255.255.224
Router (config-if)# clock rate 64000
Router (config-if)# no shutdown
Router (config-if)# exit
```

Step 2: Define root.

Router0 (R0): define static root on ISP router for accessing the network 192.168.10.0/24

```
Router (config)# ip route 192.168.10.0 255.255.255.0 Serial2/0
```

Router1 (R1): define default root ***(0.0.0.0)*** on Boundary router for accessing the internet **from** network 192.168.10.0/24.

```
Router (config)# ip route 0.0.0.0 0.0.0.0 Serial2/0
```

Step 3: Configure NAT configuration on Boundary Router

Router1 (R1)

```
Router(config)#ip nat pool SRK_pool 209.165.200.226 209.165.200.229 netmask 255.255.255.224
Router(config)#ip access-list standard SRK1
Router(config-std-nacl)#permit 192.168.10.0 0.0.0.255
Router(config-std-nacl)#ip nat inside source list SRK1 pool SRK_pool overload
```

Line 1: define address range for the NAT pool.
Line 2 & 3: Define ACL to permit the hosts; 0.0.0.255 is the wildcard mask.
Line 3: Bound the ACL to the NAT pool.

Step 4: Define the inside and outside interface of the router for the NAT.

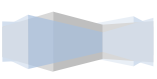
Router1 (R1)

```
Router(config)#interface f0/0
Router(config-if)#ip nat inside
Router(config-if)#no shut
Router(config-if)#exit
Router(config)#
Router(config)#interface s2/0
Router(config-if)#ip nat outside
Router(config-if)#no shut
Router(config-if)#exit
```

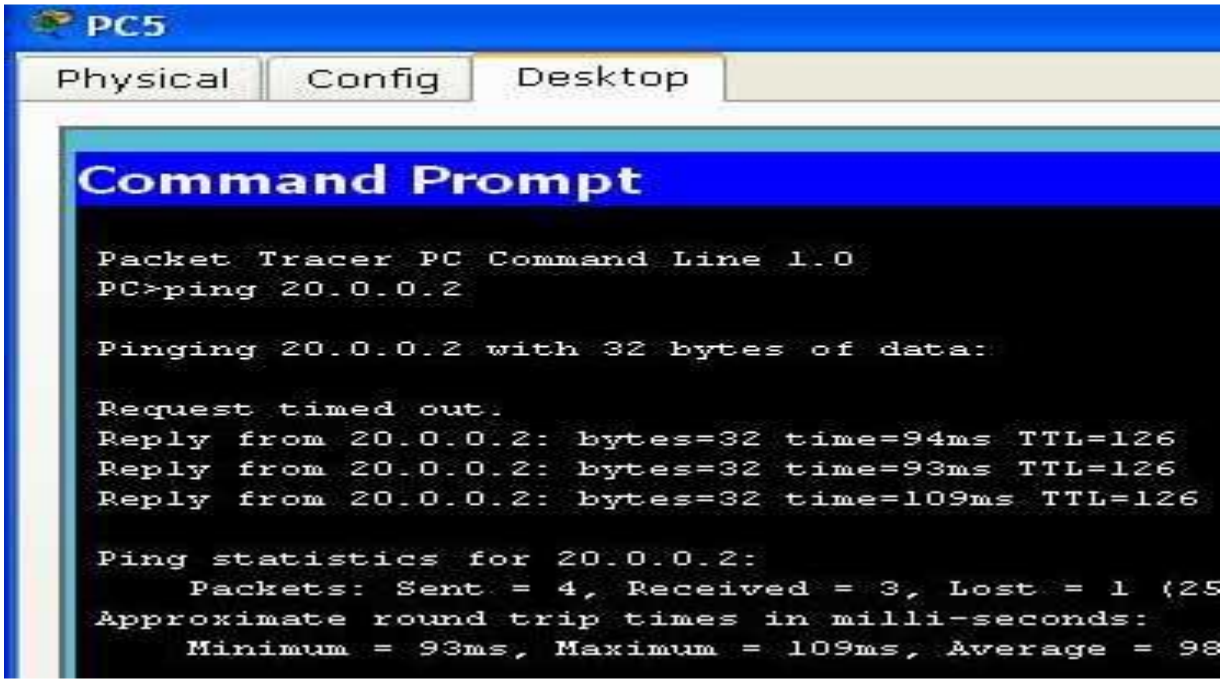
Router1 (R1)

Now, for testing of NAT go to **Router 1** again and enable debug for NAT by this command,

```
Router#debug ip nat
IP NAT debugging is on
Router#
Router#
```

Wow! all work is done. Now, to verify the setup, use **ping** command which is used to test the connectivity between two devices.
So, access the command prompt of PC1 and use ping command to test the connectivity from Server0.



We looking at here that four packets are sent and successfully three packets are received.

Comments:

By using NAT, an administrator can hide their internal network from the outside of the world. So, NAT helps improve security and decrease the number of IP addresses an organization needs.

Download Link: Full Configured of this Topology is available in…
https://www.dropbox.com/s/6029an3u6b6ln4c/NAT%20-%20Configured.pkt?dl=0

----- The END -----